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# OPTIMUM LOCATION OF SHEAR WALLS IN HIGH RISE R.C.C BUILDINGS SUBJECTED TO STATIC AND DYNAMIC LOADING IN SEISMIC ZONES

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***Abstract***
***R.C.C structures are subjected to vertical loads such as self weight of structural members, self weight of brick work, live load on floors etc. and horizontal loads such as seismic and wind forces. Due to these lateral loads, lateral deflection and support reaction increases. The behaviour of RCC structures is different under horizontal and vertical loads. The RCC moment -resisting frame are observed to be vulnerable in seismic active areas or locations. India is divided into four seismic zones based on past earthquake history and are been published in IS 1893(PART-1)-2002 Code of practise for seismic design. In the present study, shear wall is provided for lateral strengthening of high rise structure and it is observed that the structures with provision of shear walls have increased stiffness in the directions parallel to the length of the shear walls. But the optimum location and position of shear walls is to be identified based on the lateral forces. In order to find the optimum location of the shear walls in the present study four structures of G+6 storeys with and without shear walls are considered in various seismic zones II, III, IV, V. Analysis is carried out using staad.pro(v8i ss5) software. Height, length and width of the structures are kept constant and seismic loads are calculated as per IS 1893(PART-1) 2002 and wind pressures across the height of the structure is calculated as per IS 875-1987 (PART III).***

***Keywords: Shear wall, Regular buildings, Staad.pro, Seismic, High rise buildings.***

## INTRODUCTION:

RCC Shear walls are vertical structural members also called as vertical slab and extended columns provided in the high rise buildings to resists the shear, bending and in-plane loads developed due to lateral wind and seismic forces at different storey heights. These lateral loads are transferred to shear walls from the floor diaphragm. Provision of shear walls is also effective in resisting the lateral sway and storey drifts (relative displacement between two adjective stories) by increasing the overall stiffness of the structure. Shear walls are generally cast-in-situ and are monolithically casted with the storeys. Shear walls also resists the vertical loads originated from self weight of structural members, shear walls, floor loads etc. Generally shear walls are categorized based on the cross sectional area (simple rectangular shear wall, flanged shear wall, rigid frame shear wall and core type shear wall) and type of material (RC shear wall, steel plate shear wall and plywood shear wall) used for the construction of shear walls, the location and selection of type of shear wall is an important criteria to make an efficient and economical design, the behaviour of solid shear walls is better when compared with shear walls with openings. Shear walls usually starts from the foundation and extends up to the top most storey and thickness of the shear walls usually varies between 150 mm-400 mm and the RC shear wall is designed as per IS:13920. Shear walls are used in the retro fitting of the RCC buildings to increase the lateral strength. Krishnan and Jose (2016) has investigated the optimum location of RC shear wall for a five storey symmetrical framed structure for efficient seismic design using pushover analysis and concluded in finding the optimum location of shear wall for a five storey building by proving shear walls in different locations using the software SAP 2000. Sardar and Karadi (2013) has investigated effect of change in shear wall location on storey drift of multi storey building subjected to lateral loads and concluded that the study of 25 storeys building in Zone V is presented with some investigation which is analyzed by changing various location of shear wall using standard package ETAB. Patil and Deshpande (2016) has investigated the optimal location of shear wall in high rise building subjected to seismic loading and concluded the study of high rise building with 15 storey in Zone IV is considered for all the symmetrical as well as unsymmetrical building models using standard package ETAB-2013.

## MAIN OBJECTIVES:

Main objectives of this study are,
1. The best optimum location of the shear wall for the given lateral loading.

2. Comparison of building with and without shear walls to find the necessity of providing the shear walls in buildings.
3. Comparisons of lateral storey displacements, bending moments and shear forces etc.
4. To find the location of maximum storey drift.

**METHODOLOGY:**

In this study a G+6, G+9 and G+12 storied buildings having the plan dimensions of 40m*25m with bay length of 5m in both directions, and a typical floor height of 3m is considered. Four structures with different heights are considered for analysis and complete analysis was done in STAAd.pro software. The structures considered for the analysis are,
Structure-I: Without shear wall.
Structure-II: Shear wall is placed at four corner sides of the structure along the length and direction.
Structure-III: Shear wall is placed at four corner sides of the structure along the width and direction.
Structure-IV: Shear wall is placed at centre core part of the structure.

The table1 shows the geometric considerations. The 4 structures considered are shown in fig.1.

Table 1. Geometric considerations

| | |
|---|---|
| Materials | M30,fe415 |
| Loadings | Dead, live, wind, earth quake load |
| Buildings Considered | G+6, G+9, G+12 |
| Length of building | 8x5 = 40m |
| width of building | 5x5 = 25m |
| Foundation of depth | 2.0m |
| Seismic zones | II,III,IV,V |
| C/C Column spacing | 5m |
| Brick Wall thickness | 0.15m |
| Shear wall thickness | 0.15m |
| Floor to floor height | 3.0m |
| Thickness of slab | 0.15m |
| Support conditions | Fixed |
| Size of beam | 0.45mx0.23m |
| Size of column | 0.6mx0.6m |
| Number of shear walls | 04 No’s |
| Total Shear wall length | 4x5m = 20m |
| Structure type | RC Frame Building |
| Response reduction | OMRF with ordinary shear walls |
| Type of building | General |
| Type of soil condition | Hard soil |
| Exposure to wind load | 100% |

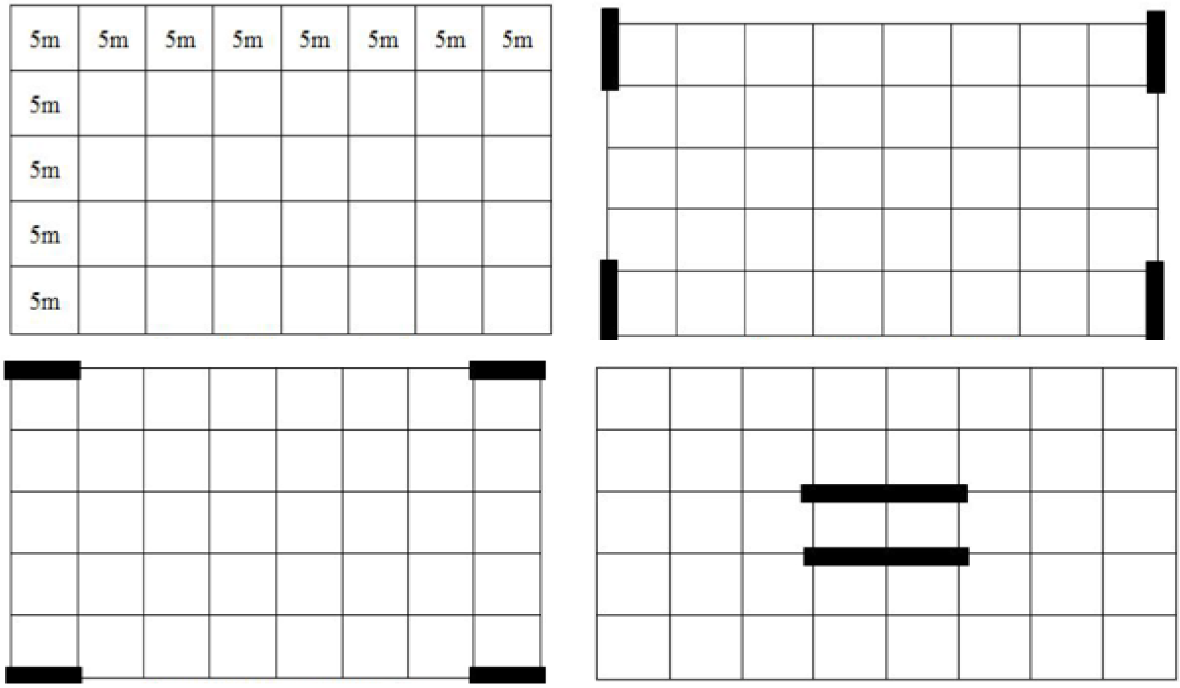



Fig.1Plan of all the structural models

**Analysis of structure**

In this study, analysis of structure-1, structure-2, structure-3 and structure-4 of different heights of buildings (G+6 , G+9 and G+12) in various seismic zones (II, III, IV & V) and wind load is carried out using STAAD.Pro(v8i SS5). The results obtained from the analysis are shown in the form of tables and graphs.

**Load Calculations**

The structures are subjected to four types of primary loads as per the provisions of IS Code of practice.
They are:
Dead Load (From IS: 875-1987(Part-I))
Live Load (From IS: 875-1987(Part-II))
Wind Load (From IS: 875-1987(Part-II))
Seismic Load (From IS: 1893-2002(Part-I))
Loads and Load Combinations as per codes considered are shown in table.2

Table 2 Load Combinations according to IS codes

| As Per IS: 1893:2002 | As Per IS: 875(Part-5) |
|---|---|
| 1.7(DL+LL) | DL |
| 1.7(DL±EL) | DL+LL |
| 1.3(DL+LL±EL) | DL+WL |
| 1.5(DL+LL) | DL+EL |
| 1.2(DL+LL±EL) | DL+LL+WL |
| 1.5(DL±EL) | DL+LL+EL |
| 0.9DL±1.5EL | - |

**Method of Analysis**

In the study the analysis of the high rise structure is carried out for lateral loads using Equivalent Static Force Method.

**Assumptions**

Material: Concrete is assumed to behave linearly elastic. The modulus of elasticity $E_c$ =5000 $f_c$ where the specified compressive strength of concrete $f_c$ is assumed equal to 25Mpa.
Wind Calculations:
As per IS: 875 (PART 3) – 1987

**Design data:**

Type of structure: RCC Building (G+5); Terrain category = 1
Length = 42m, Width = 36m, Height=20m; Class-A (< 20m)

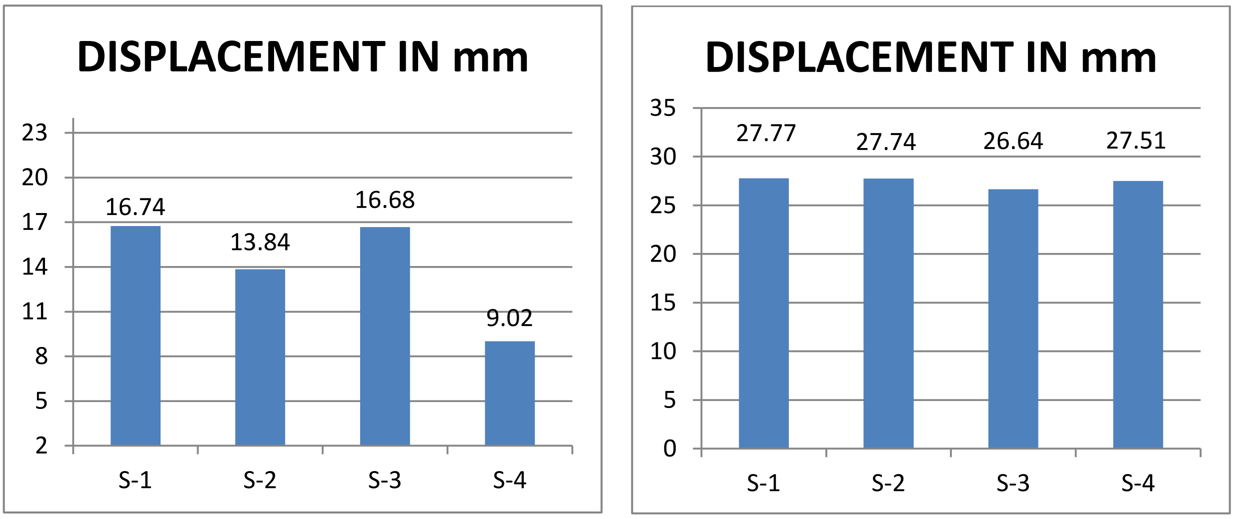
Type of city = VISAKHAPATNAM
Basic WIND SPEED ($V_b$) = 60m/sec, the basic wind speed during HUD-HUD was 55m/sec, so we have assumed basic wind speed has 60m/sec
$K_1$= Risk coefficient for important buildings/towers = 1
$K_2$ = terrain, structure height and size factor
$K_3$ = topography factor = 1.0 (upwind slope < $3^o$)
Design WIND SPEED = $V_Z = V_B K_1 K_2 K_3$
Design WIND PRESSURE = Pz = $0.6V_Z^2$
The wind pressure calculations are shown in table3.

Table 3 Wind pressure calculations for different heights

| S.NO | HEIGHT (m) | $V_B$ (m/sec) | $K_1$ | $K_2$ | $K_3$ | $V_z$ (m/sec) | $P_z$ ($KN/m^2$) |
|---|---|---|---|---|---|---|---|
| 1 | 3 | 60 | 1 | 1.03 | 1 | 61.8 | 2.29 |
| 2 | 6 | 60 | 1 | 1.03 | 1 | 61.8 | 2.29 |
| 3 | 9 | 60 | 1 | 1.03 | 1 | 61.8 | 2.29 |
| 4 | 12 | 60 | 1 | 1.04 | 1 | 62.76 | 2.36 |
| 5 | 15 | 60 | 1 | 1.07 | 1 | 64.2 | 2.47 |
| 6 | 18 | 60 | 1 | 1.08 | 1 | 65.28 | 2.56 |
| 7 | 21 | 60 | 1 | 1.10 | 1 | 66.18 | 2.63 |
| 8 | 24 | 60 | 1 | 1.11 | 1 | 66.66 | 2.66 |

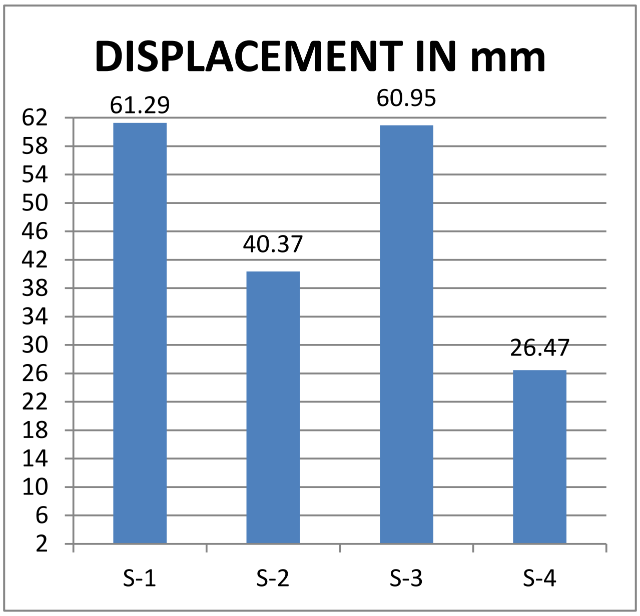
**RESULTS AND DISCUSSIONS:**
In this study, lateral displacement due to wind load and storey drift due to earthquake load is calculated for all four structures with different heights. These results are presented in the form of charts and shown in fig 2 to fig 6.

**Wind Displacement:**
As per IS: 456:2000, clause (20.5), Maximum lateral sway at the top should not exceed (H/500) for wind loads, where H is the height of small building. Maximum allowable displacement for G+6, G+9 and G+12 are 46mm, 64mm and 82mm respectively. From this study all results are falling under the permissible displacement. But, lateral displacement in structure 4 i.e. shear wall placed at the centre of the building gives very less displacement and structure 2 i.e. shear wall placed along length direction also gives less displacement when compared to structures 1 and 3. Displacement for lateral wind load along two different directions for four structures are plotted and shown in fig 2 and fig 3.

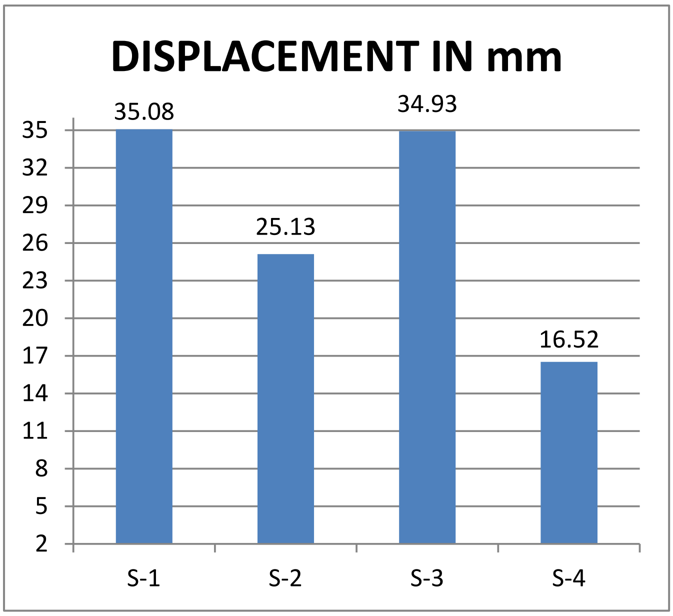



(a) (b)

Fig. 2 Displacement for lateral wind load along (a) length=40m, Direction: X
(b) width=25m, Direction: Z




(a)




(b)

Fig.3 Displacement of structures for lateral wind load (a) G+9 along X (b) G+12 along X

| | |
|---|---|
| S-1 : Structure 1 | S-2 : Structure 2 |
| S-3 : Structure 3 | S-4 : Structure 4 |

**Storey Drift**

As per IS: 1893(part 1):2002 Clause 7.11.1, The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times of the storey height. In this study 3m of storey height is considered and for this height of storey maximum allowable storey drift is 12mm. From the results of this study it is observed that for structure 1 and structure 3 it goes beyond the allowable limit and in structure 4 storey drift is very compared all other structures. The storey drift for different heights of all the structures subjected to earthquake loads are plotted in fig 4, 5&6.

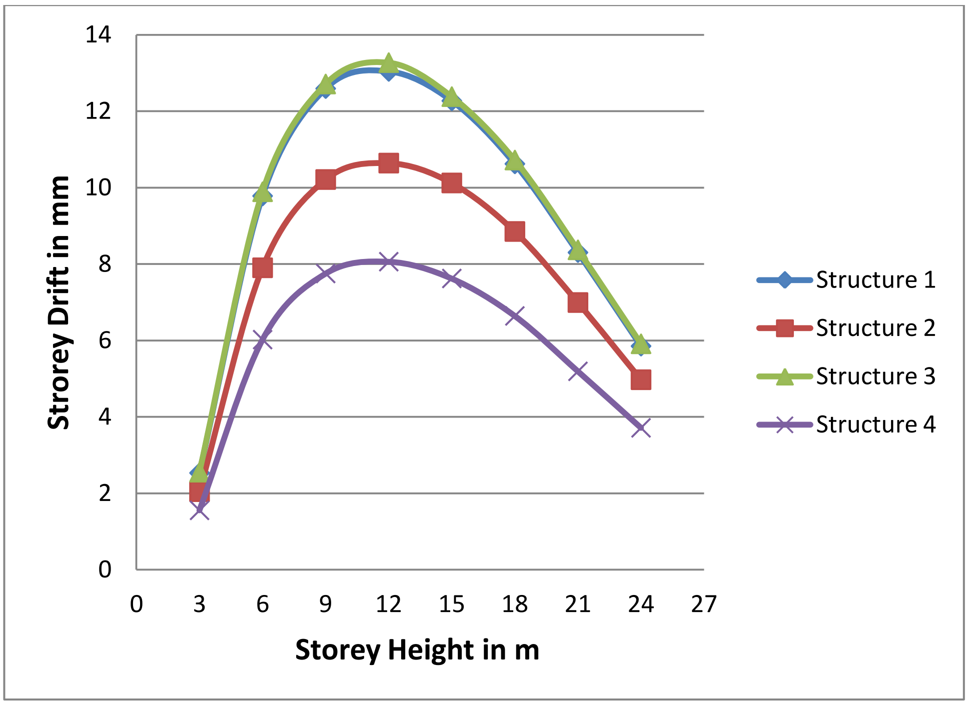



Fig 4 Storey drift for G+6 in Zone-5 under earthquake loads for all the four Structures

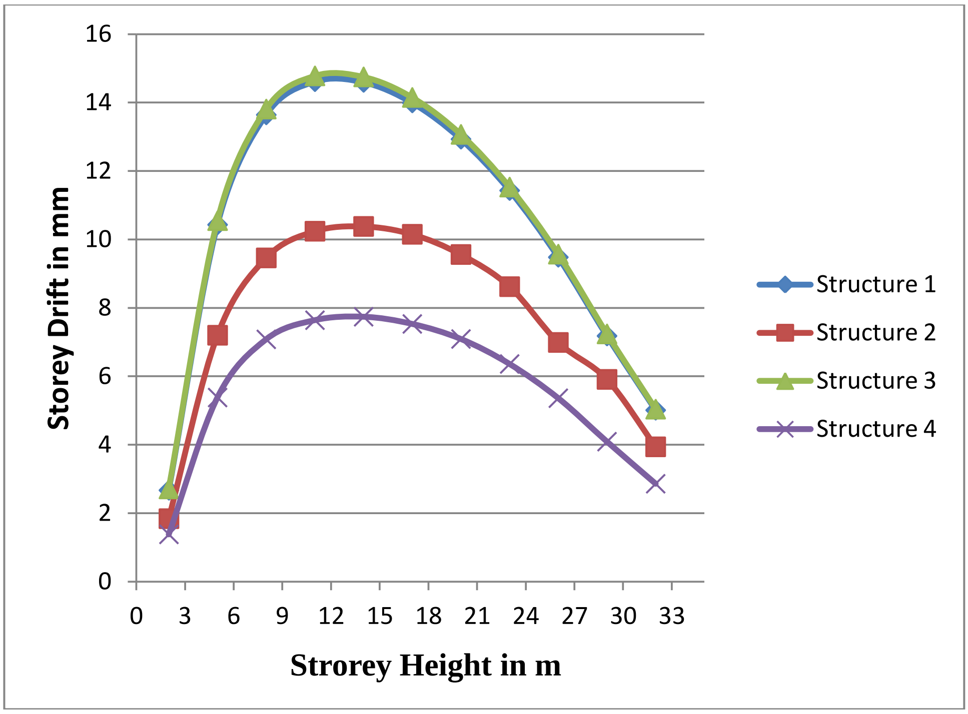



Fig 5 Storey drift for G+9 in Zone-5 under earthquake loads for all the four Structures

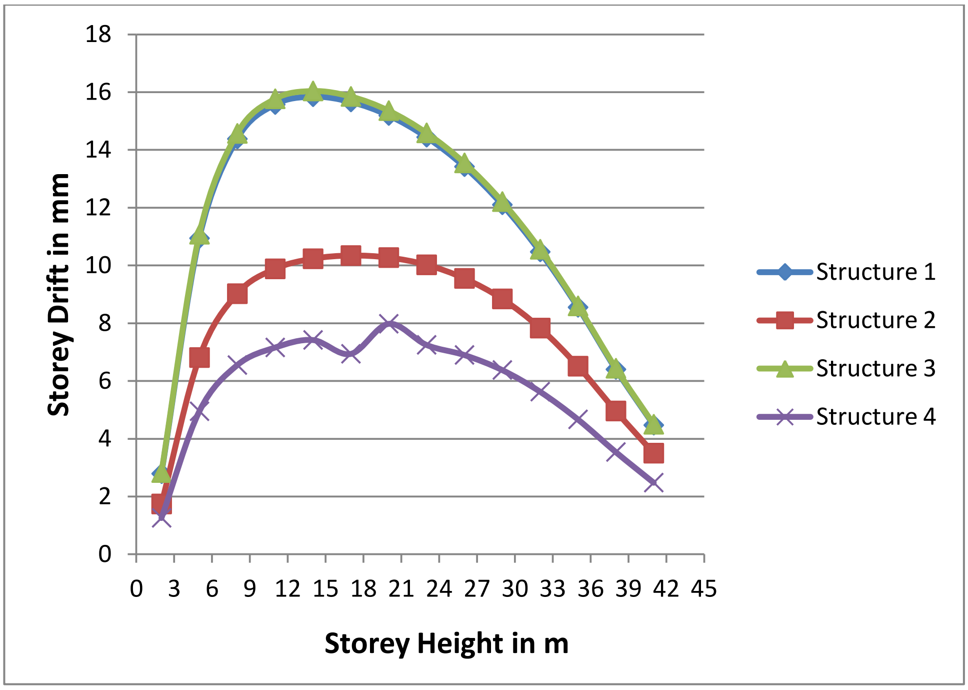



Fig 6 Storey drift for G+12 in Zone-5 under earthquake loads for all the four Structures

## CONCLUSIONS:

As per IS: 456:2000, clause (20.5), Maximum lateral sway at the top should not exceed (H/500) for wind loads, where H is the height of the building 23m.Maximum Displacement= 46mm. As per IS: 1893(part 1):2002 Clause 7.11.1, The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times of the storey height, Height of the storey = 3000mm Maximum Storey Drift = 12mm.

- The maximum wind Displacement is in limits for Structures – 1, 2, 3& 4.
- The maximum Wind Displacement occurs in Structure -1(Without Shear wall) which is 16.74mm (X-Direction), 27.77mm (Z -Direction).
- The Lateral Drift is in Limits for Structures -2 & 4 but it exceeds its limits for Structure -1&3.
- The maximum lateral Drift for Structure -1 occurs in Storey -3 (13.04mm).
- The maximum lateral Drift for Structure -2 occurs in Storey -3 (10.64mm).

- The maximum lateral Drift for Structure -3 occurs in Storey -3 (13.27mm).
- The maximum lateral Drift for Structure -4 occurs in Storey -3 (8.06mm).
- Therefore the maximum lateral Drift for all Structures occurs at Storey -3.
- For Axial Forces and Support Reactions, Considering Structure-1(121.743 KN), Structure-2 (470.484), Structure-3 (342.979), Structure-4(484.934) Seismic Zone –II as reference the values for Zone –III, IV, V increases by 60%, 140%, 260% times of reference structures respectively.
- Governing Load case for structure-1, 2, 3&4 in Zone –V is **1.5D.L+1.5E.L.**

From all the above conclusions it is concluded that Structure-4(Shear walls placed at the centre core of the structure) is the best optimum location for the construction of shear wall.

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[9] IS 456:2000 "Plain and reinforced concrete-code of practice"

[10] IS: 13920:1993 it gives the ductile detailing of shear wall.