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Research Paper

Seismic Analysis of Earthquake Resistance Structure With And Without Shear Wall Using STAAD.Pro

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ABSTRACT: *Shear wall is a structural element which is provided for resisting horizontal forces (like wind force, earthquake force, etc.) parallel to the plane of the wall and for supporting gravity loads simultaneously. These are basically flexural members which are generally provided in high rise buildings to avoid the total collapse of the building exposed to seismic forces. For seismic design of buildings, RC structural walls or shear walls are major earthquake resisting members which offer lateral load resistance by providing shear wall. The response of the buildings is dominated by the properties of seismic shear walls and so it becomes important to evaluate the seismic response of the shear walls appropriately. In this study, the effect of presence of shear walls in RCC and composite structures in being analyzed on basis of storey displacement, storey drift, stiffness, lateral force and base shear for G+8 buildings. Effectiveness of shear wall is being studied with the help of three different models. Model 1 is RCC building without shear wall, Model 2 is RCC building with shear wall, Model 3 is comparison of RCC building with full shear wall. The earthquake load is applied to a building in zone IV and the analysis is done using static analysis method.*

KEYWORDS: *STAAD.Pro, RCC building, Seismic analysis, Shear wall, Base shear, Storey displacement, Storey drift.*

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I. INTRODUCTION

Earthquake-resistant structure, building designed to prevent total collapse, preserve life, and minimize damage in case of an earthquake or tremor. Earthquakes exert lateral as well as vertical forces, and a structure's response to their random, often sudden motions is a complex task that is just beginning to be understood. Earthquake-resistant structures absorb and dissipate seismically induced motion through a combination of means: damping decreases the amplitude of oscillations of a vibrating structure, while ductile materials (e.g., steel) can withstand considerable inelastic deformation. In earthquake design the building has to go through regular motion at it base, which leads to inertia force in a building that consecutively causes stresses. India has experienced number of earthquakes that cause large damage to residential and industrial structure. For earthquake resistant design the normal building should be able to resist minor, moderate, sever shacking. During earthquake motion, deformation take place across the element of the load – bearing system as the result of the response of the buildings to the ground motion.

As a consequence of this deformation, internal forces developed across the element of the load - bearing system and displacement behavior appears across the buildings. The resultant displacement demand varies depending on the stiffness and mass of the building. In general, building with higher stiffness and lower mass have a smaller horizontal displacement demands. On the contrary, displacement demands are to be increased. On the other hand, each building has a specific displacement capacity.

Shear wall is a vertical structural element used to resist the horizontal forces such as wind force, seismic force. These forces act parallel to the plane of the wall. Shear walls are generally used in high rise buildings where effect of wind forces and seismic forces is more. Shear wall is a structural member in a reinforced concrete framed structure to resist lateral forces such as wind forces. Shear walls are generally used in high-rise buildings subject to lateral wind and seismic forces. In reinforced concrete framed structures, the effects of wind forces increase in significance as the structure increases in height. Codes of practice impose limits on horizontal movement or sway. Shear wall is a structural member used to resist lateral forces, that is, parallel to the plane of the wall. For slender walls where the flexural deformation is more, shear wall resists the loads due to cantilever action. In other words, shear walls are vertical elements of the horizontal force resisting system. In this type, concrete structures are generally designed in such a way that the lateral seismic load and gravity load is bearing by consistent shear walls. These structures have no beams or columns, and the earthquake-resistant system relies solely on concrete shear walls.

II. Methodology

General

For this study, G + 8 RCC structure with 4 m height from ground level to 1st level, also the height from floor to floor 4 m .

Plan size is 20x24 m, total height of the structure is 36 m. regular in plan is modelled. The building is assumed to be fixed at the base.

For this study following Indian standard code of practice are used.

IS 1893 (PART 1): 2016 CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURE.

The building is model using software STAAD PRO.

Data for model

Building description

Geometrical data

No of stories	G + 8
No of bay in X direction	6
No of bay in Y direction	5
Type of building used	Hospital
Plan dimensions	20 x 24 m
Typical storey height	4 m
Bottom storey	4 m
Height of structure	36 m
Location	Delhi
Live load	4 KN/m^2

Table 1 Geometrical data

Member properties

Thickness of slab	150 mm
Column size	350 x 600 mm
Beam size	300 x 450 mm
Shear wall	120 mm

Table 2 Member properties

3.2.3 Seismic load

Zone	IV
Zone factor	0.24
Response Reduction factor	5
Importance factor	1.5
Structure type	SMRF
Soil condition	Medium
Building	RCC

Table 3 Seismic load

Plan of Structure

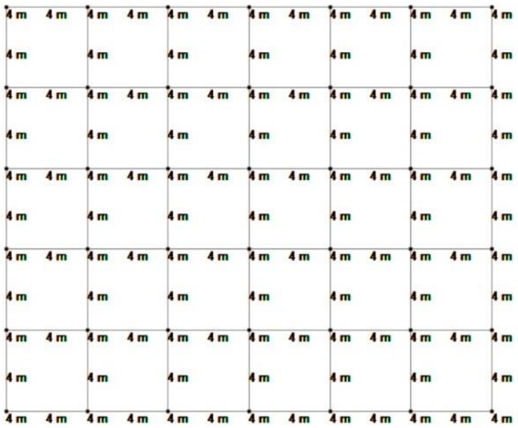


Fig 1 Plan of Model Fig
Without Shear Wall

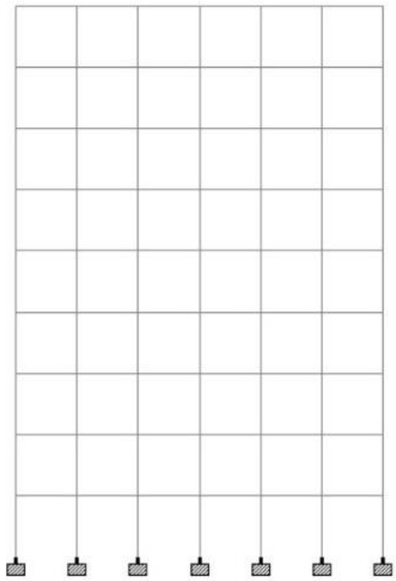


Fig 2 Elevation of Building

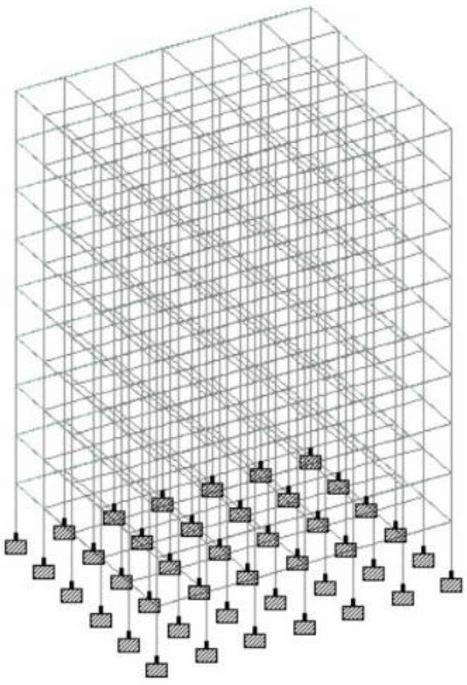


Fig 3 3D View of Building
without Shear Wall

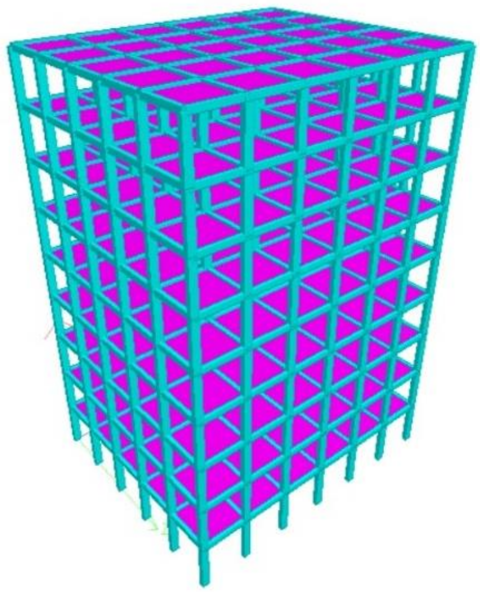


Fig 4 Rendered View of Building
without Shear Wall

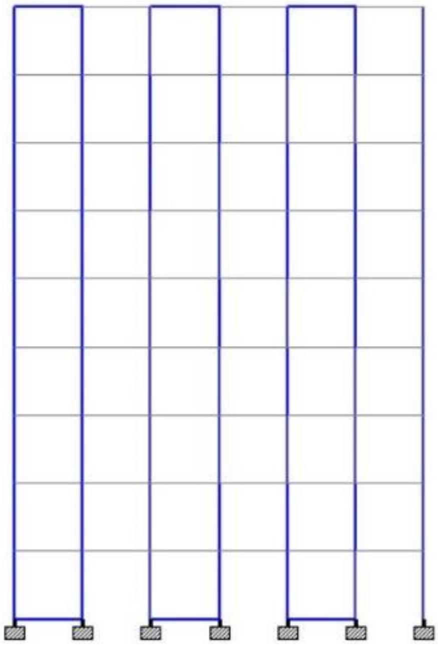


Fig 5 Elevation View of Building
With Shear wall (alternate)

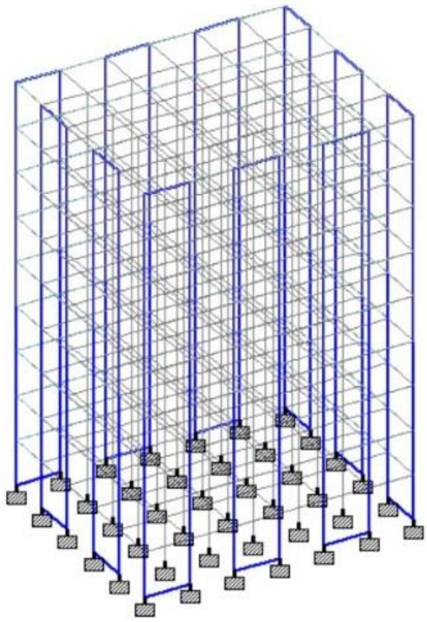


Fig 6 3D View of Building
with Shear Wall (alternate)

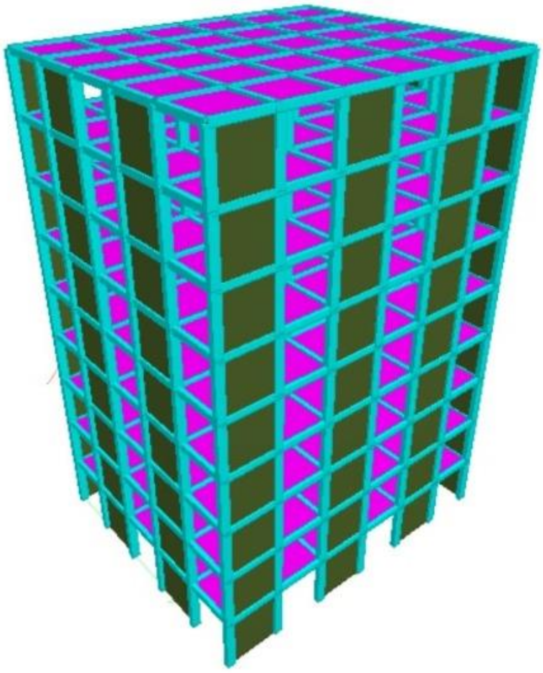


Fig 7 Rendered View of Building
With Shear Wall (alternate)

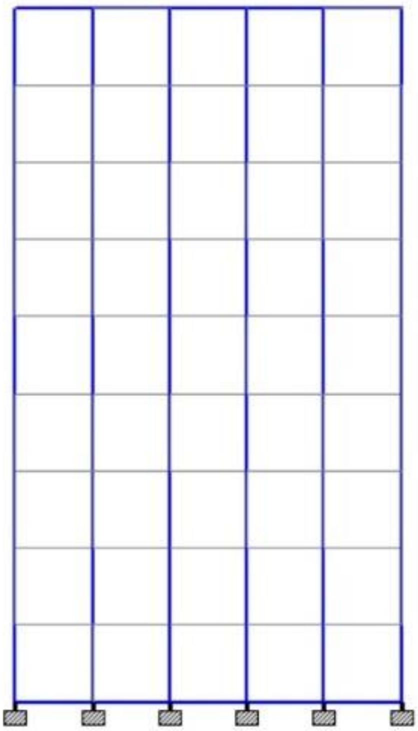


Fig 8 Elevation View of Building
with whole shear wall

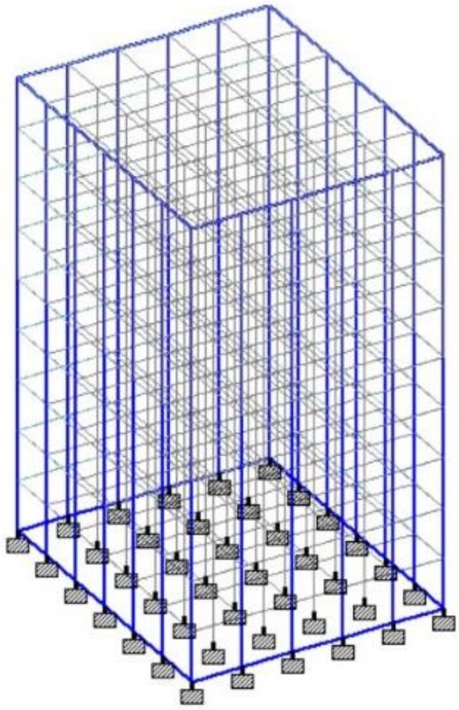


Fig 9 3D View of Building
With whole Shear Wall

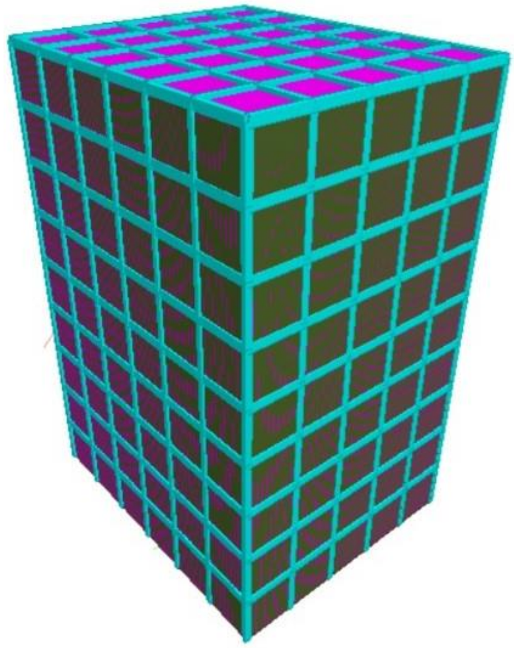


Fig 10 Rendered View of Building
with whole Shear Wall

III. Method of Analysis

The analysis may be performed on the basis of external action, the behavior of structure or structural materials, and the type of structural model selected. Based on the type of external action and behavior of structure, Equivalent Linear Static Analysis method is used.

Equivalent Linear Static Analysis

All design against earthquake effects must consider the dynamic nature of the load. But, for simple regular structures analysis by equivalent linear static methods is sufficient. This is allowed in most codes of practice for regular, low-to medium rise buildings. In this method of analyzing multi storey buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels which include that weight of columns and walls in any storey should be equally distributed to the floors above and below the storey. In addition, the appropriate amount of imposed load at the floor is also lumped with it. Initially, design base shear is computed for the whole building, and then it is distributed along the height of the building. The lateral forces at each floor thus obtained are distributed to individual lateral load resisting elements. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the around moves. The response is read from a design response spectrum, given the natural frequency of the building either calculated or defined by the building code. Then Linear Static Procedure ignores the non-linearity of the structure and the dynamic effect.

Seismic Base Shear

According to IS: 1893 (Part l)-2016, the base shear (VB) is given by the following formula:

$$VB= A_h \text{ X } W$$

(Clause 7.5.3, IS: 1893 (Part l)-2016)

Where,

A_h = Design horizontal acceleration spectrum value using the fundamental natural period

T' = in the considered direction of vibration

W = seismic weight of the building

The A_h shall be determined by the following expression,

$$A_h = \frac{\underline{(Z/2) \text{ x } (Sa/g)}}{(R/I)}$$

(Clause 6.4.2, IS: 1893 (Part I 2016)
Where,
Z = Zone factor as per Table 3 of IS:
1893 R = Response Reduction factor as per Table 9 of IS code 1893 (2016)
I = Importance factor as per Table 8 of IS: 1893
Sg/g = Average response acceleration coefficient as per Clause 6.4.5 of the Indian standard IS:1893 (Part l)-2016.

Seismic Weight

The seismic weight of the entire building is that the sum of the seismic weights of all the floors. As per (Clause 7.4.2, IS: 1893 (Part l)-2016) the seismic weight of each floor is sum of its full dead load and the appropriate amount of imposed load, the latter being that part of the imposed loads that may reasonably be expected to be attached to the structure at the time of earthquake shaking. It includes the weight of permanent and movable partitions permanent equipment, part of live load, etc. While computing the seismic weight of each floor, the weight of columns and walls in any storey should be equally distributed to the floors above and below the storey. Any weight supported in between storeys should be distributed to the floors above and below in inverse proportion to its distance from the floors. As per IS:1893 (Part l)-2016, the percentage of imposed load as given in code should be used. For calculating the design seismic forces of the structure, the imposed load on the roof need not be considered.

Distribution of Design Force

Buildings and their elements should be designed and constructed to resist the effects of design lateral force. The design lateral force is first computed for the building as a whole and then distributed to various floor levels. The overall design seismic force hence obtained at every floor level is then distributed to different lateral load-resisting elements, depending on the floor diaphragm action. Vertical distribution of base shear to different floor levels, the design base shear (Vg) is distributed along the height of the building as per the following expression: -

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

(Clause 7.7.1, IS: 1893 (Part 1)-2016)
Where, Qi is the design lateral force at floor i, wi is the seismic weight of floor i, hi is the height of floor i measured above the base, and n is the number of storeys in the building i.e., the number of levels at which the masses are located.

IV. ANALYSIS OF RESULTS

General

A G+8 storied structure is analysed with and without shear wall. For seismic analysis using STADD-Pro software.
These models are analysed and designed as per the specifications of Indian Standard codes IS 1893:2016. These models are analyzed using STAAD PRO software in zone IV.

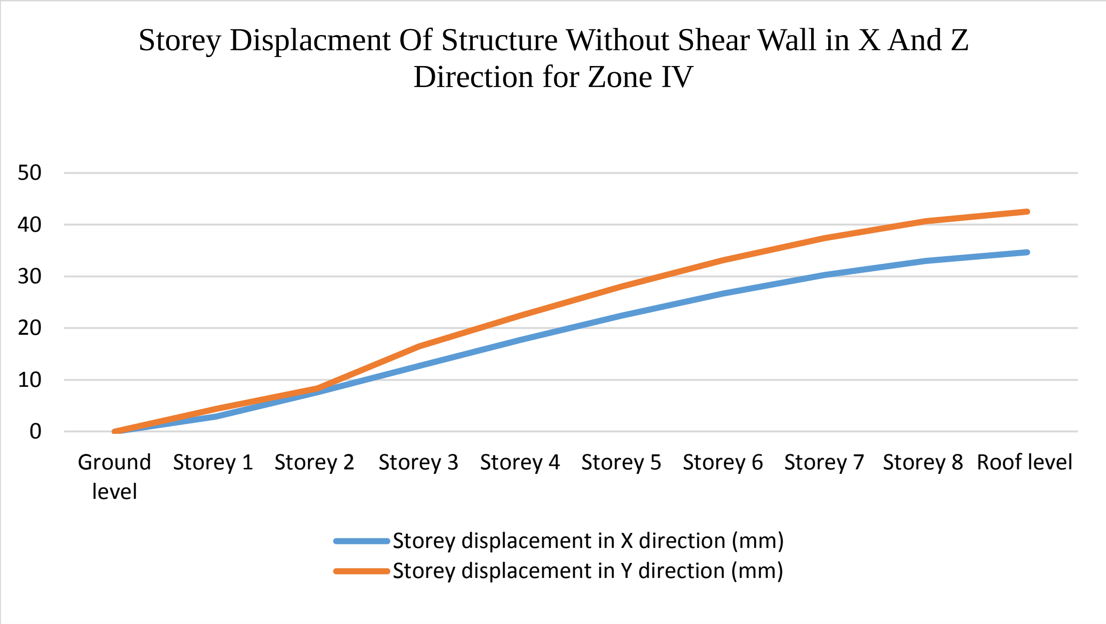
Results

G+8 structure without and with shear wall is model and analyzed with STADD PRO. And the various results are found such as weight of Structure, Base Shear, Story Displacement, Story Drift.

Result of Base Shear for Zone IV

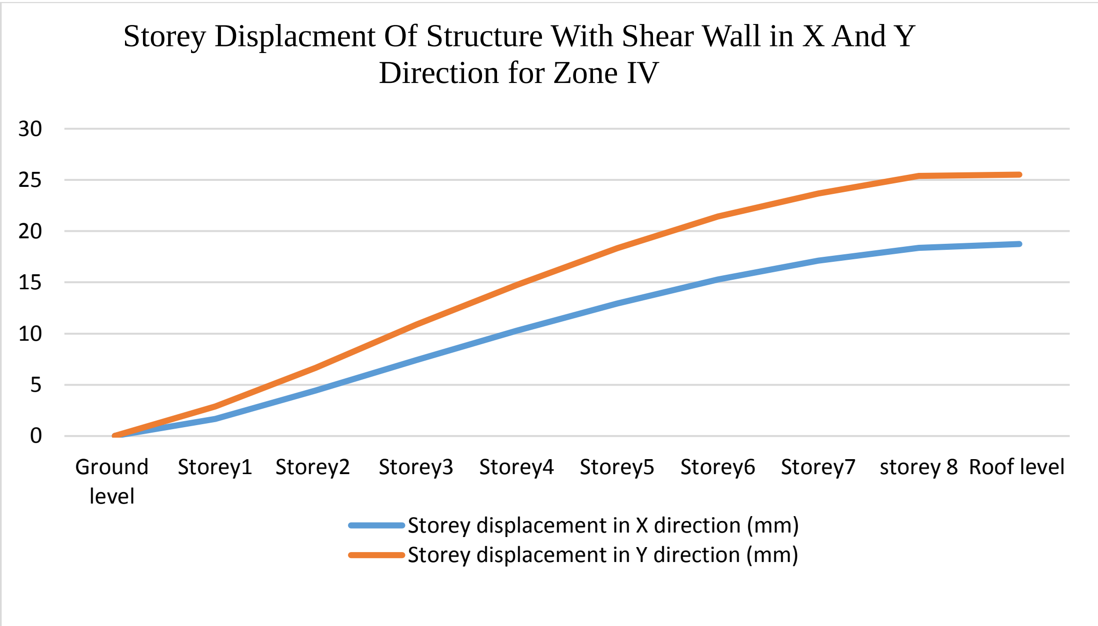
Type of Structure	Base Shear in X direction	Base Shear in Y direction
Base Shear	3858.23 KN	3858.23 KN
Base Shear (STADD-pro)	3847.22KN	3847.22KN
With Shear wall (alternate)	3904.12 KN	3904.12 KN
With Shear wall (full)	4716.84 KN	4716.84 KN

Table 4 Result of Base Shear



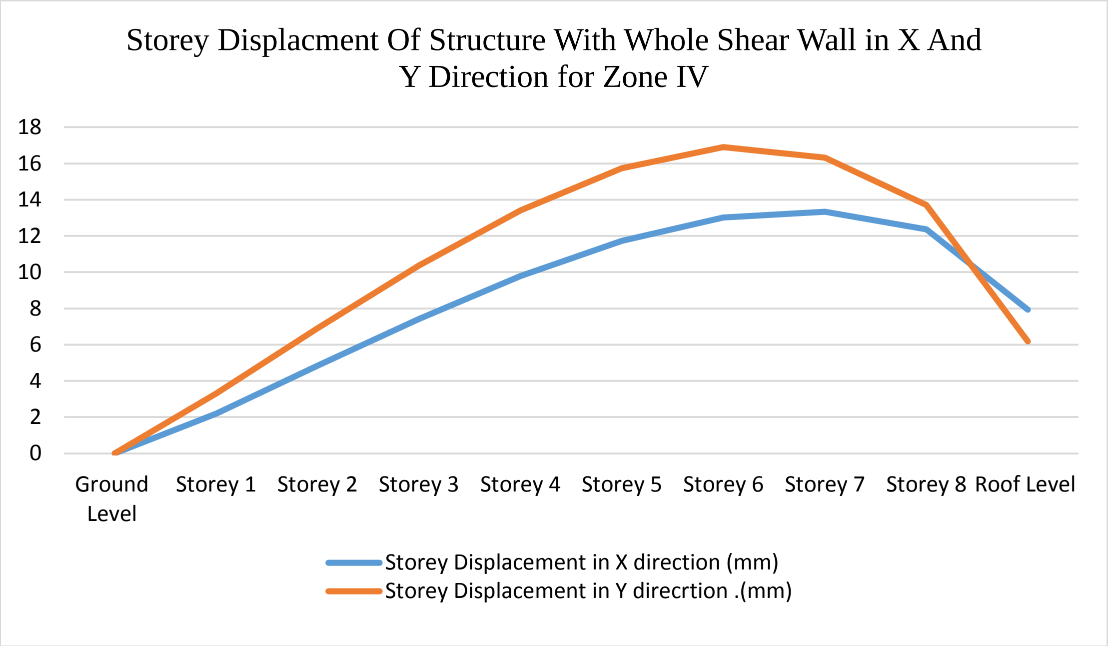
X-axis- No of Floor, Y-axis- Storey Drift (mm)

Graph 1 Comparison of Storey Displacement of Structure without shear wall in X and Z direction for Zone IV. From the analysis result it is observed that the Storey Displacement get increased as same as with shear wall structure in both X and Z direction. The increase in storey displacement is 54.05% as compared to with shear wall structure.



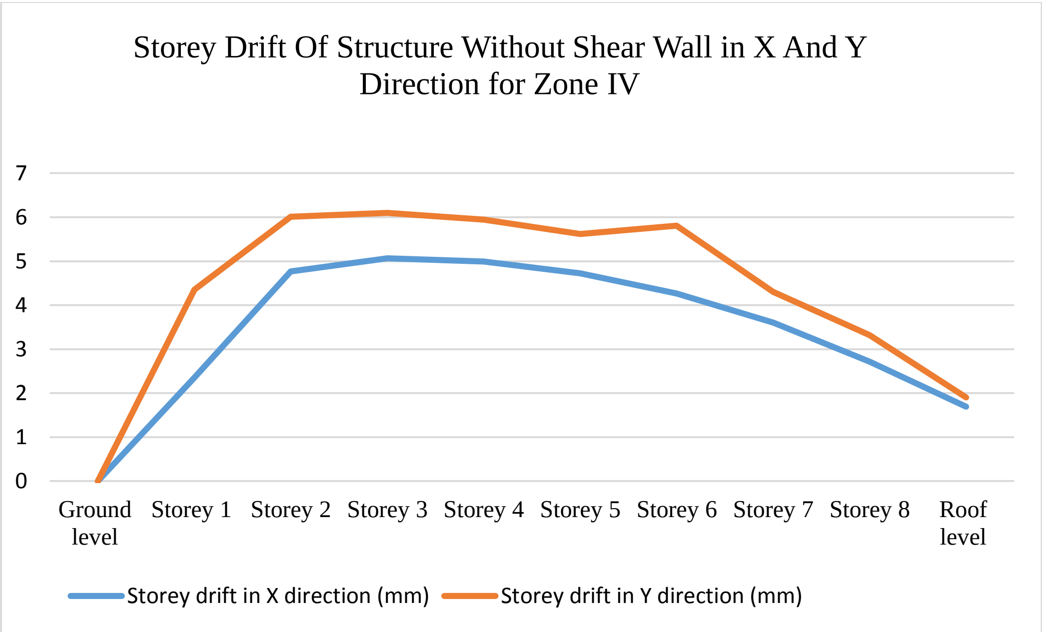
X-axis- No of Floor, Y-axis- Storey Displacement (mm)
Graph 2 Comparison of Storey Displacement of structure with shear wall in X and Y direction for Zone IV

From the analysis result it is observed that, storey displacement goes on increasing from ground floor to upper floors in both X and Y direction. The increase in storey displacement is 54.05% as compared to with shear wall structure.



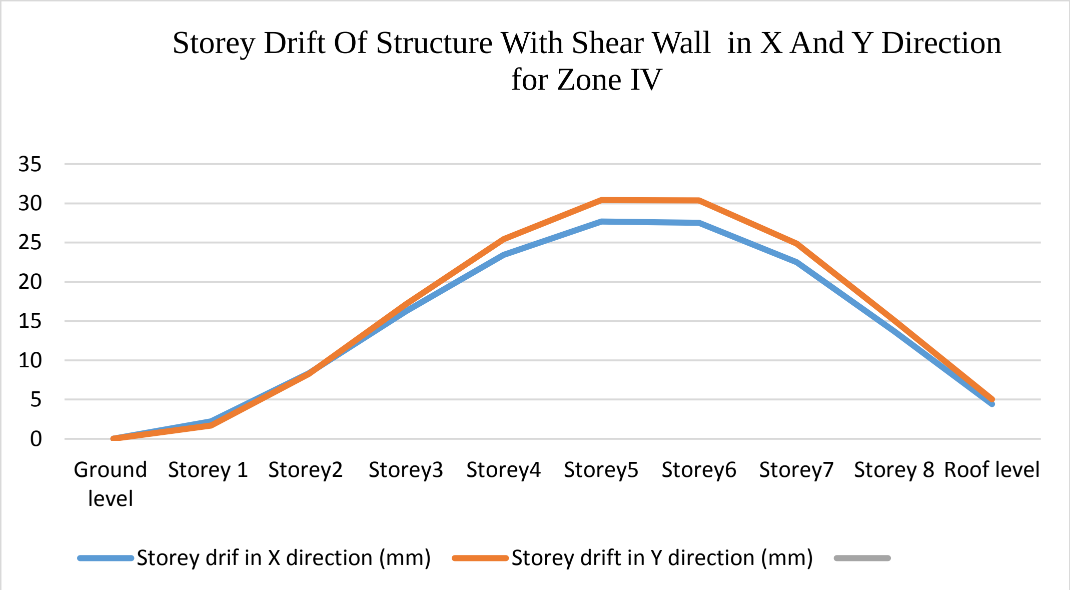
X-axis- No of Floor, Y-axis- Storey Drift (mm)
Graph 3 Comparison of Storey Displacement of Structure with whole shear wall in X and Y direction for Zone IV.

From the analysis result it is observed that, storey displacement goes on increasing upto a certain level (i.e. 6th floor)and then declines upto roof level. The increase in storey displacement is 54.05% as compared to with shear wall structure.



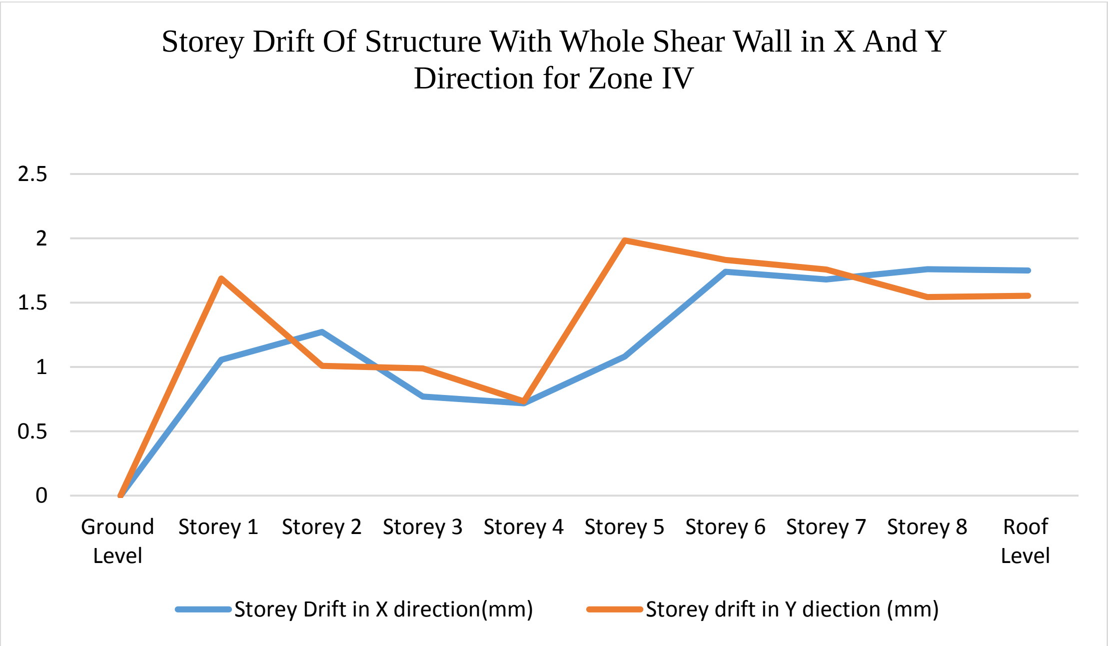
X-axis- No of Floor, Y-axis- Storey Drift (mm)
Graph 4 Comparison of Storey Drift of Structure without shear wall in X and Y direction for Zone IV

From the analysis result it is observed that the storey drift is get increased from ground floor to 2nd floor and slightly decreased up to roof level of structure in both X and Y direction.



X-axis- No of Floor
Y-axis- Storey Drift (mm)
Graph 5 Comparison of Storey Drift of structure with shear wall in X and Y direction for Zone IV.

From the analysis result it is observed that the storey drift is get increased from ground floor and slightly decreased up to roof level of structure in both X and Y direction.



X-axis- No of Floor
Y-axis- Storey Drift (mm)
Graph 6 Comparison of Storey Displacement of Structure with whole shear wall in X and Y direction for Zone IV

II. CONCLUSION

1. The base shear calculated by manually and with the help of STADD pro found out nearly same. Base shear increases after the application of shear wall.
2. Storey displacement goes on increasing from ground level to roof level in both X and Y direction for structure with shear wall and without shear wall.

3. Storey drift increases up to a certain height from ground level and then start reducing in both X and Y direction for structure without shear wall and with shear wall.
4. Storey displacement increased up to certain height from ground level to 6^{th} floor and start reducing up to roof level in both X and Y direction for structure having whole shear wall.

FUTURE SCOPE

1. Further study can be carried out for asymmetric plan.
2. Analysis can be done by using different software SAP 2000, ETAB etc.
3. Further study can be done by providing shear walls at alternate floors.

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