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Effective Location of Shear Wall of Varying Thickness for A Multistorey Building Under Seismic Loading

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Abstract
Shear wall systems are one of the most commonly used lateral load resisting systems in high-rise buildings. It is very necessary to determine effective and ideal location of shear wall and its thickness. In this project, shear wall of different shapes is placed at different locations with varying thickness in multistoried framed building. The effective location with suitable thickness is determined based on top storey maximum displacement criteria. The project is done using the software ETABS 9.6.0 and for analysis IS 1893:2002 equivalent static method is adopted.

Keywords: *Shear wall, stotry drift, storey displacement and thickness.*

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I. INTRODUCTION

Lateral forces on buildings such as wind, earthquake and blast forces can be produced critical stresses in the buildings that it cause excessive lateral sway of the buildings and undesirable stresses and vibrations in the buildings. Design and structural evaluation of the building systems subjected to lateral loads form the important task of the present generation and the designers are faced with problems of providing adequate strength and stability of buildings against lateral loads. Different lateral loads resisting systems are used in high-rise building as the lateral loads due to earthquakes are a matter of concern. Steel plate shear walls system and steel bracings system are used in steel structures buildings and their effect shows unequal variations and behaviour against seismic loads. Recently, laminated composite plate shear walls are used as a lateral loads resisting system where the laminated composite plates are used as infill plate in shear walls. The laminated composite plates are created by constructing plates of two or more thin bonded layers of materials and it can be either cross-ply laminates or angle-ply laminates.

The major criteria now-a-days in designing RCC structures in seismic zones is control of lateral displacement resulting from lateral forces. In this thesis effort has been made to investigate the effect of Shear Wall position on lateral displacement in RCC Frames. Eight models of various shapes of shear walls with varying thickness are arranged at different locations of elevenstorey framed building and performed linear static analysis, obtained displacements is compared with the corresponding frame without shear wall.

II. METHODOLOGY

For the purpose of study a plan of eleven storey frame were considered. For linear elastic study, RC plane frames with and without shear wall were analyzed and designed for gravity loads as per IS 456:2000 and lateral loads (earthquake loads) as per IS 1893 (part-1):2002. Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral load acting on a structure.Shear wall buildings are usually regular in plan and in elevation. However, in some buildings, lower floors are used for commercial purposes and the buildings are characterized with larger plan dimensions at those floors.

2.1 Equivalent static analysis

The equivalent static lateral force method is a simplified technique to substitute the effect of dynamic loading of an expected earthquake by a static force distributed laterally on a structure for design purposes. The total applied seismic force V is generally evaluated in two horizontal directions parallel to the main axes of the building. It assumes that the building responds in its fundamental lateral mode. we consider that the structure remains elastic and the seismic demands on the structure is reduced using response reduction factor which assumes that the structure has the capacity to go beyond elastic limit but the performance is never checked. This analysis is based on an assumption of static cantilever beam. There is a slight effect of second mode of the structure taken into consideration in the story shear distribution but nothing more than that. The amount of seismic base shear consider for designing the building is on the basis of approximate period of the building, site specific ground acceleration and response spectrum curve, site class of the site and type of building system used to resist the lateral forces. This type of analysis should only be used when the building is symmetric, torsion is minimal, no vertical or horizontal irregularities and no discontinuities in the system and where the primary mode of the structure governs the structural dynamics.

2.2 Modelling

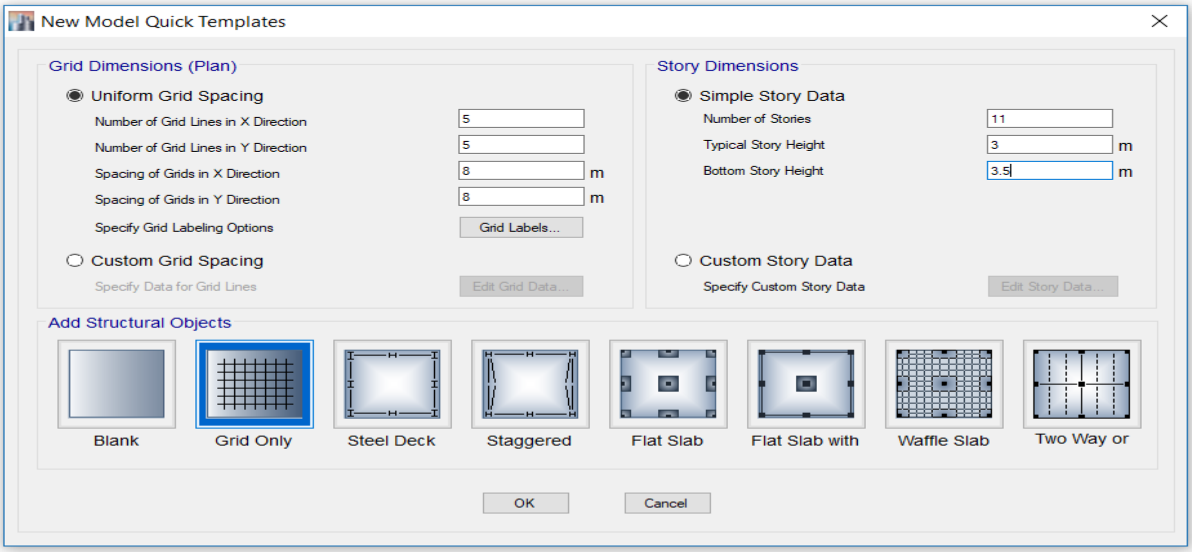


Figure1: Dimensional details of the multistorey grid

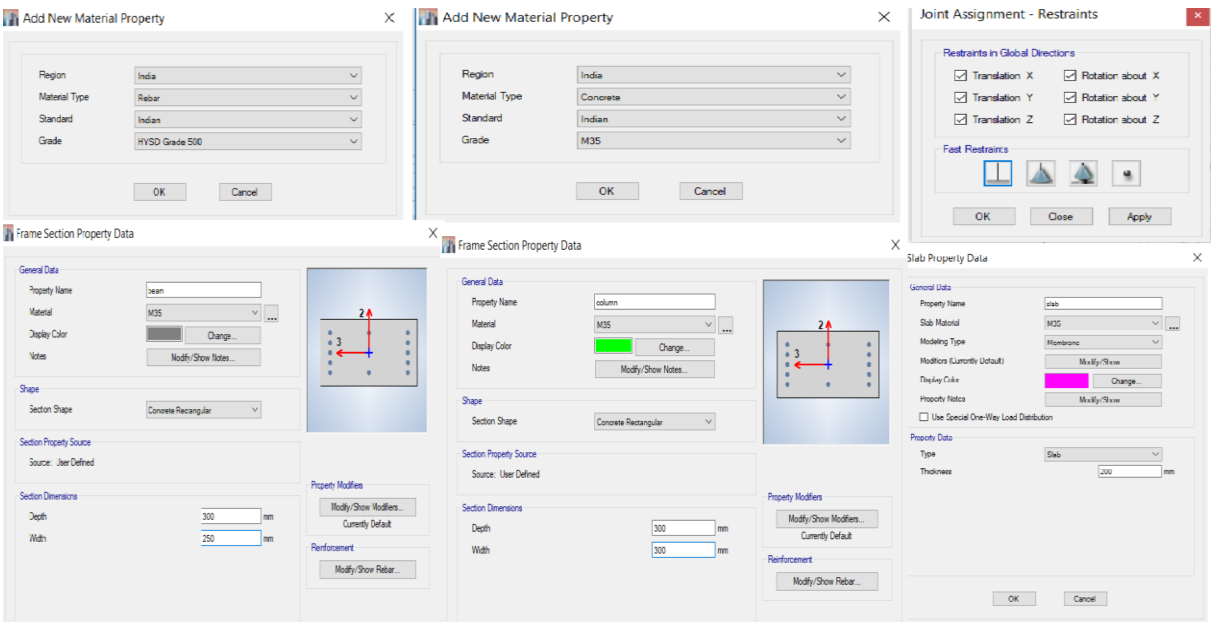
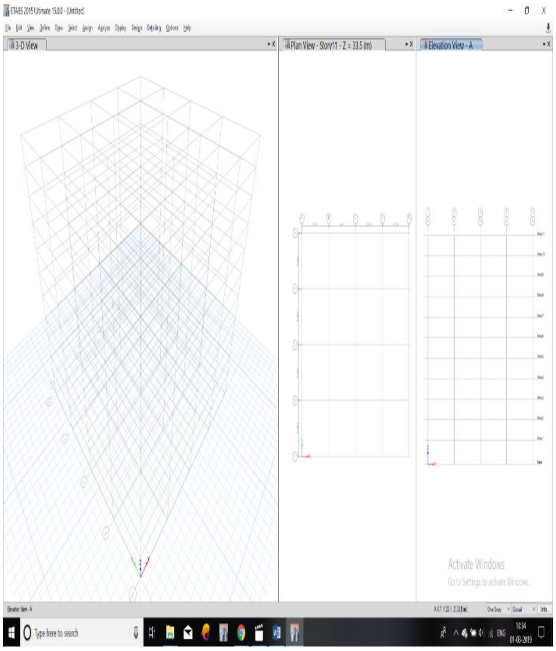
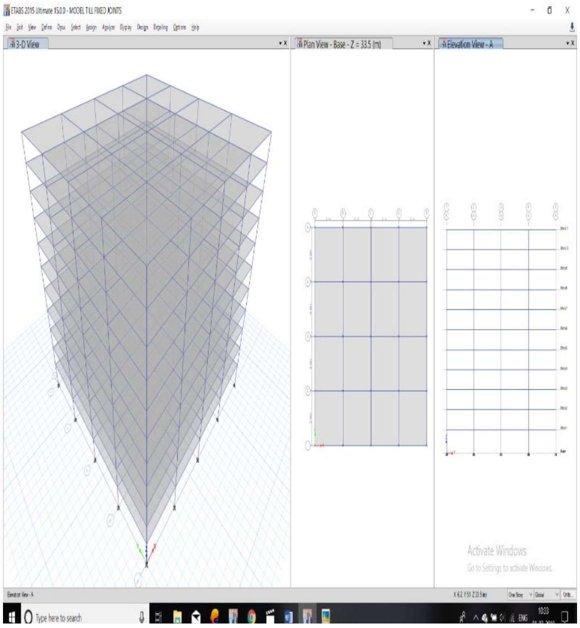


Figure2: Material details of the multistorey





Before and after assigning the structural units

2.3 Details of structural elements

- Beam size: 250mmx300mm
- Column size : 300mmx300mm
- Slab size : 150 mm
- Grade of cement : M35
- Yield strength of steel :500 N/mm^2

2.4 Loads

- Dead Load = 3 KN/m^2
- Wall load = 12 KN/m
- Live Load = 4 KN/m^2
- Earthquake Loading------ as per IS-code:1983-2002
- Wind Loading------ as per IS875:1987

The load combinations considered in the analysis according to IS 1893:2002 are given below. COMB1 = 1.2(DL+LL) + EQx + Wx + 0.3(EQy + Wy)

2.5 Seismic pattern

We assumed Vijayawada as location of framed building. It is under seismic zone **III** with zone factor **0.16** and taking importance factor as **1.5** and with SMRF (Steel Building with Special Moment resisting Frame) with response reduction factor as **5**.

2.6 Wind pattern

- Wind speed : 12 m/sec
- Terrain category : 3
- Structure class : B
- Risk coefficient : 1
- Topography : 1

III. ANALYSIS

The following are the deformed shapes of multistorey building with shearwalls of different shapes are placed at different locations.

MODEL-1 WITHOUT SHEAR WALL

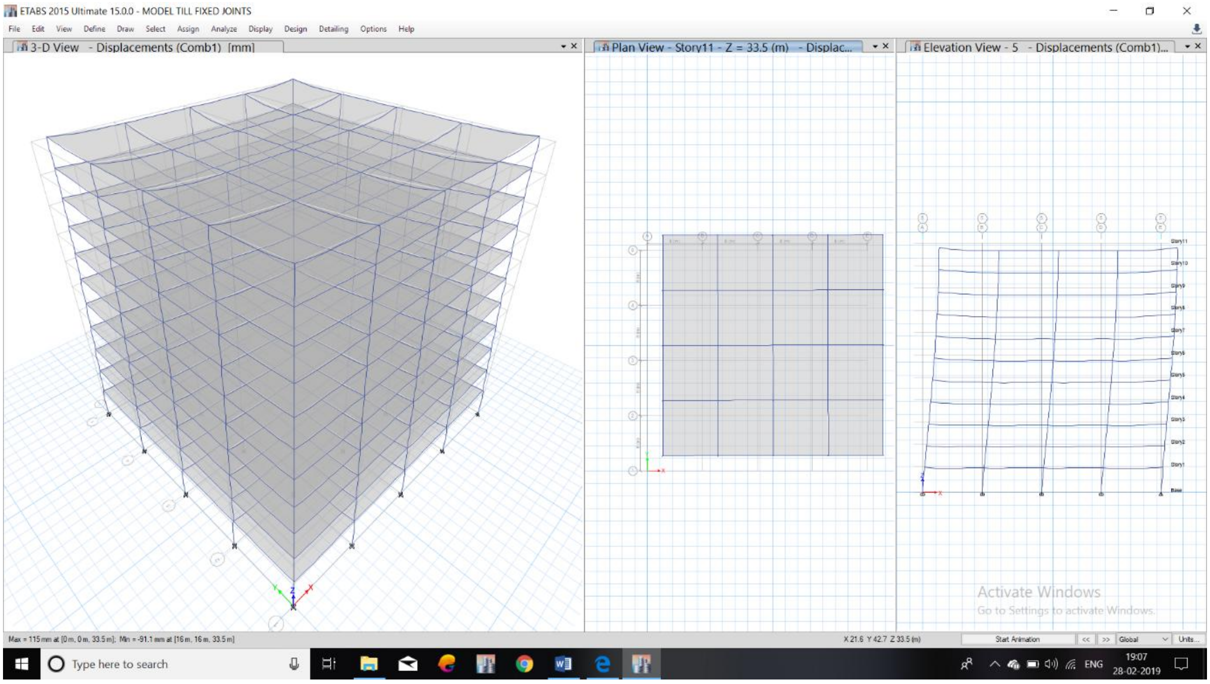


Figure3: Deformed shape of Model-1

Model-2 L SHAPE AT FOUR CORNERS

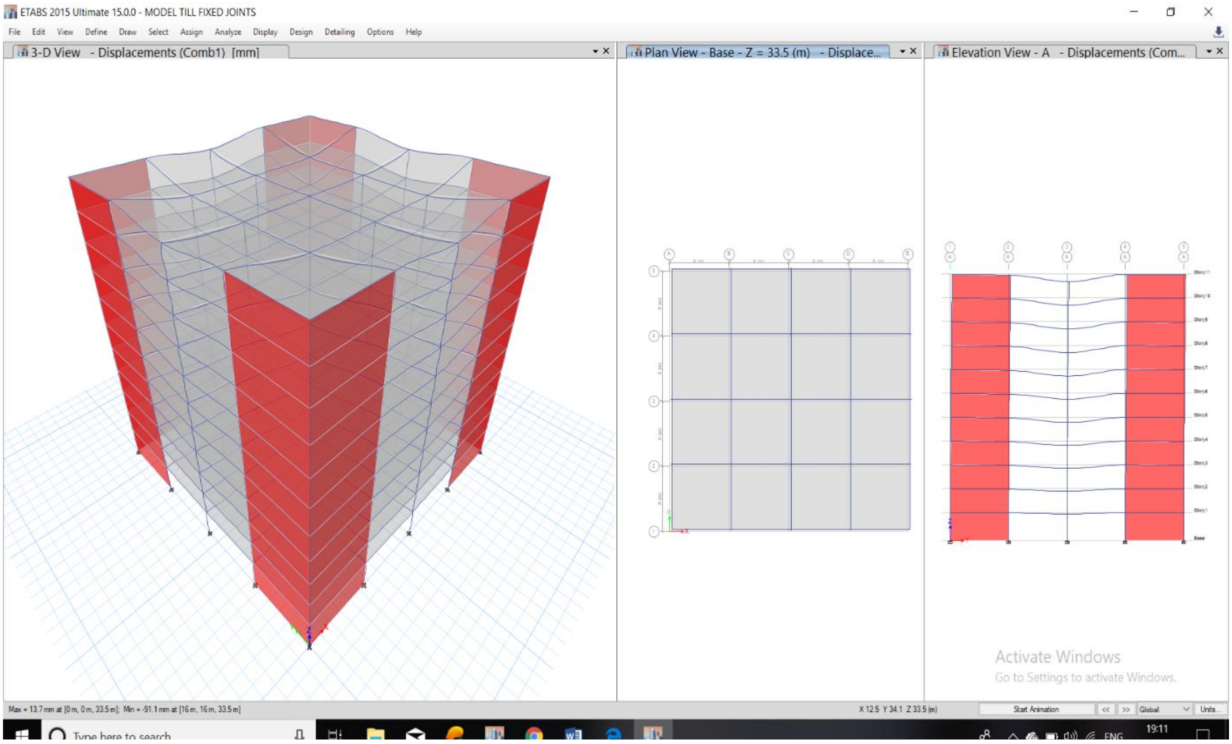


Figure4: Deformed shape of Model-2

MODEL-3 PLUS SHAPE AT FOUR SLAB MEETING JOINT

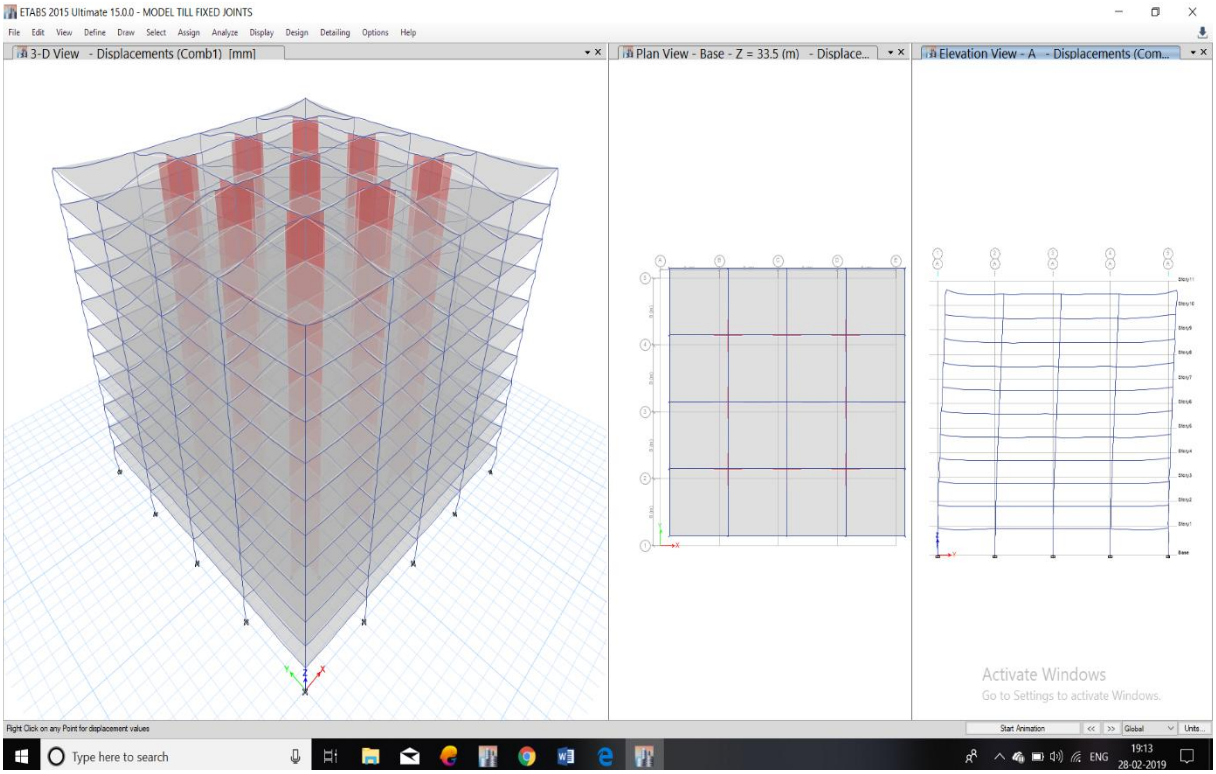


Figure5: Deformed shape of Model-3

MODEL-4 TWO E-SHAPE AND TWO L-SHAPE

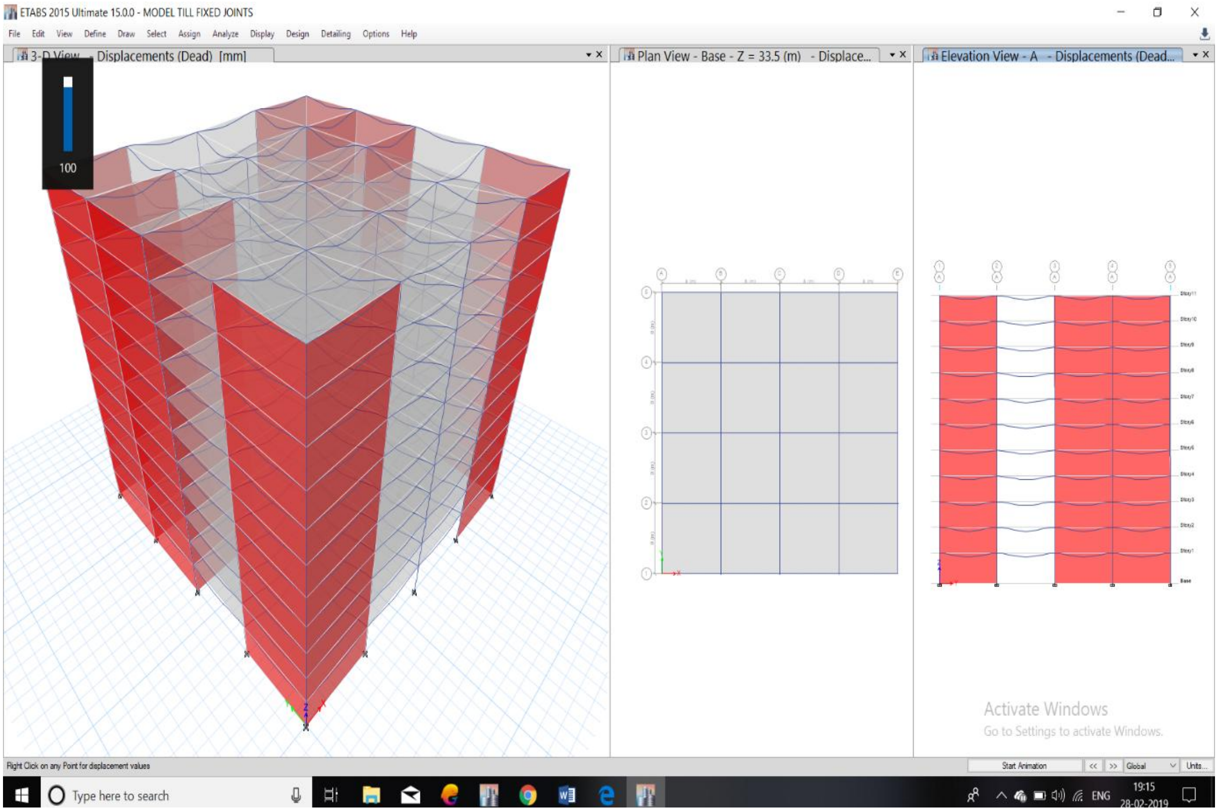


Figure6: Deformed shape of Model-4

MODEL-5 STRAIGHT WALL WITH OPENINGS

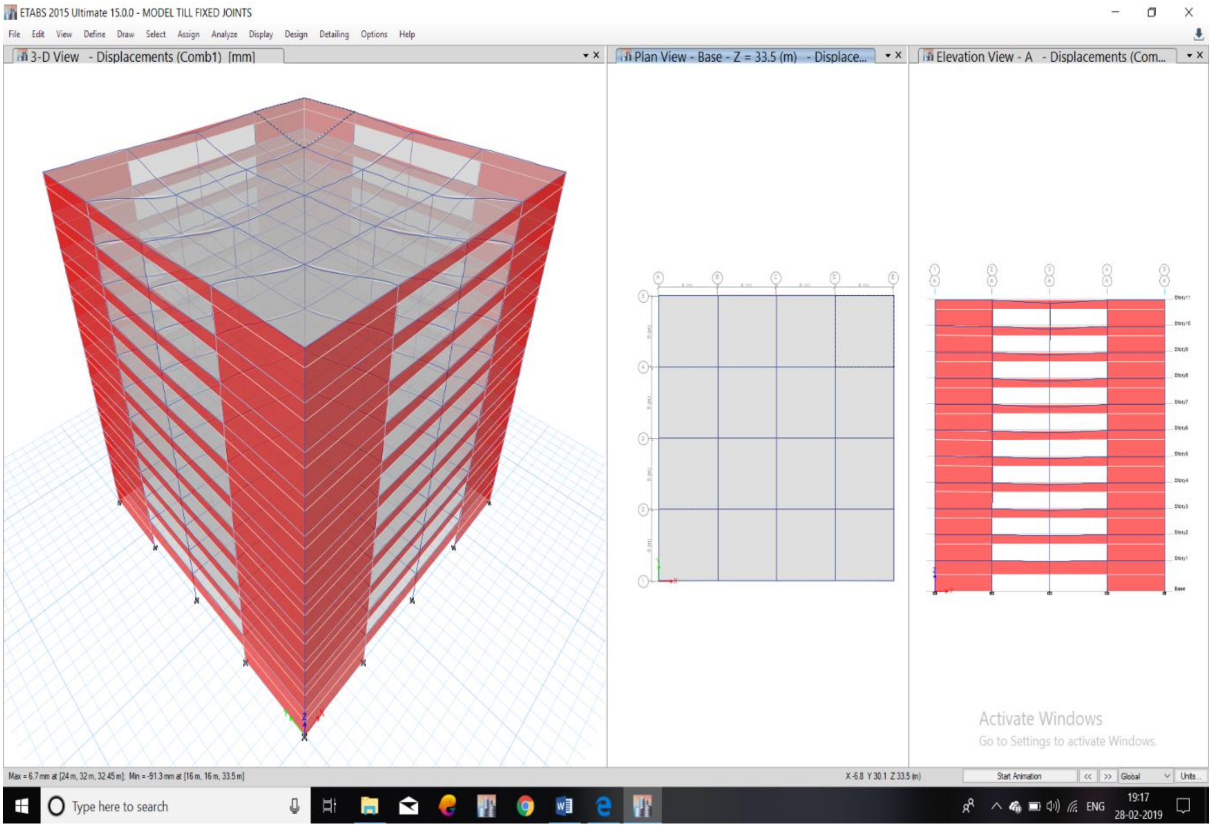


Figure7: Deformed shape of Model-5

MODEL-6 LONG STRAIGHT WALLS AT CENTRAL PERIPHERY

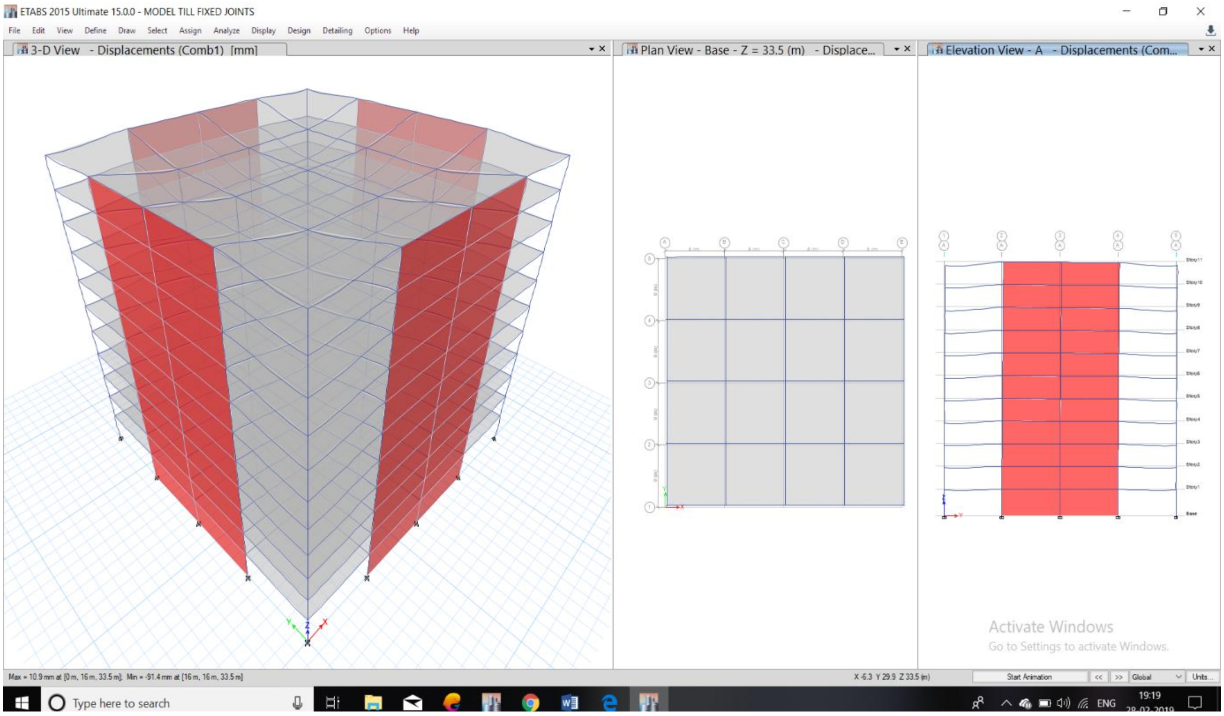


Figure8: Deformed shape of Model-6

MODEL-7(F-SHAPE)

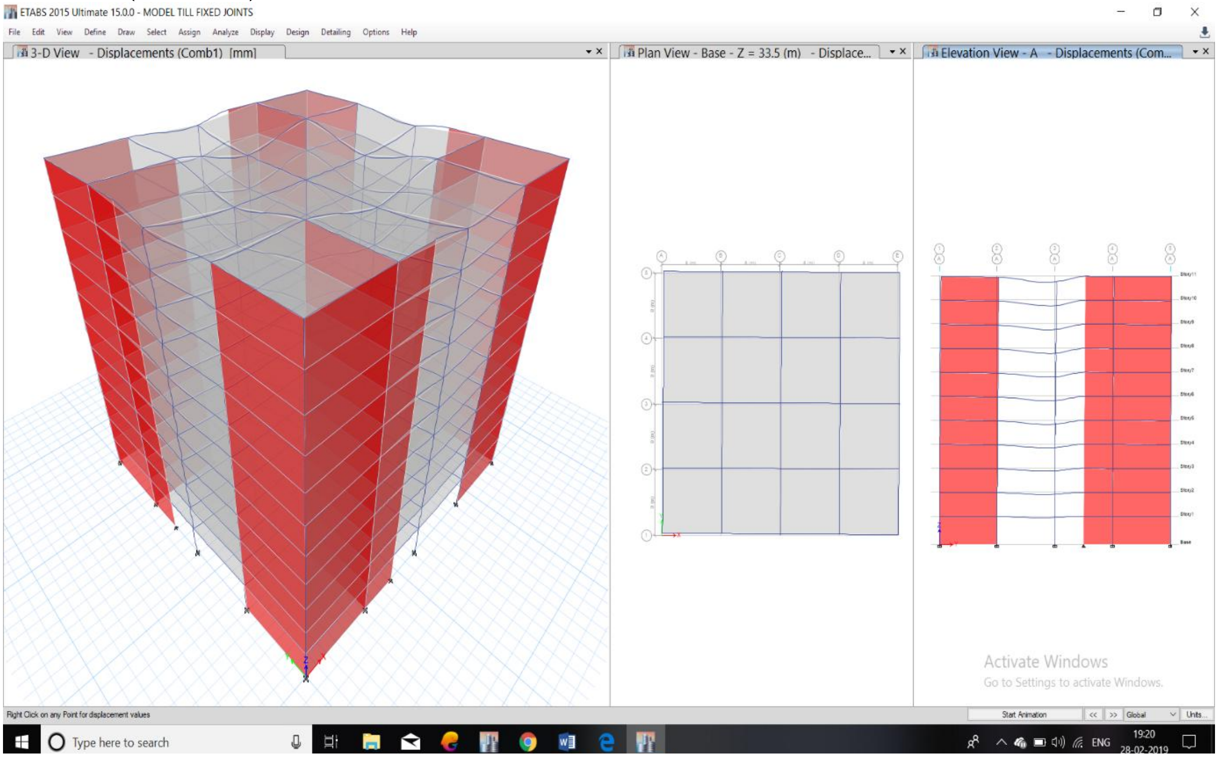


Figure9: Deformed shape of Model-7

MODEL-8(I SHAPE)

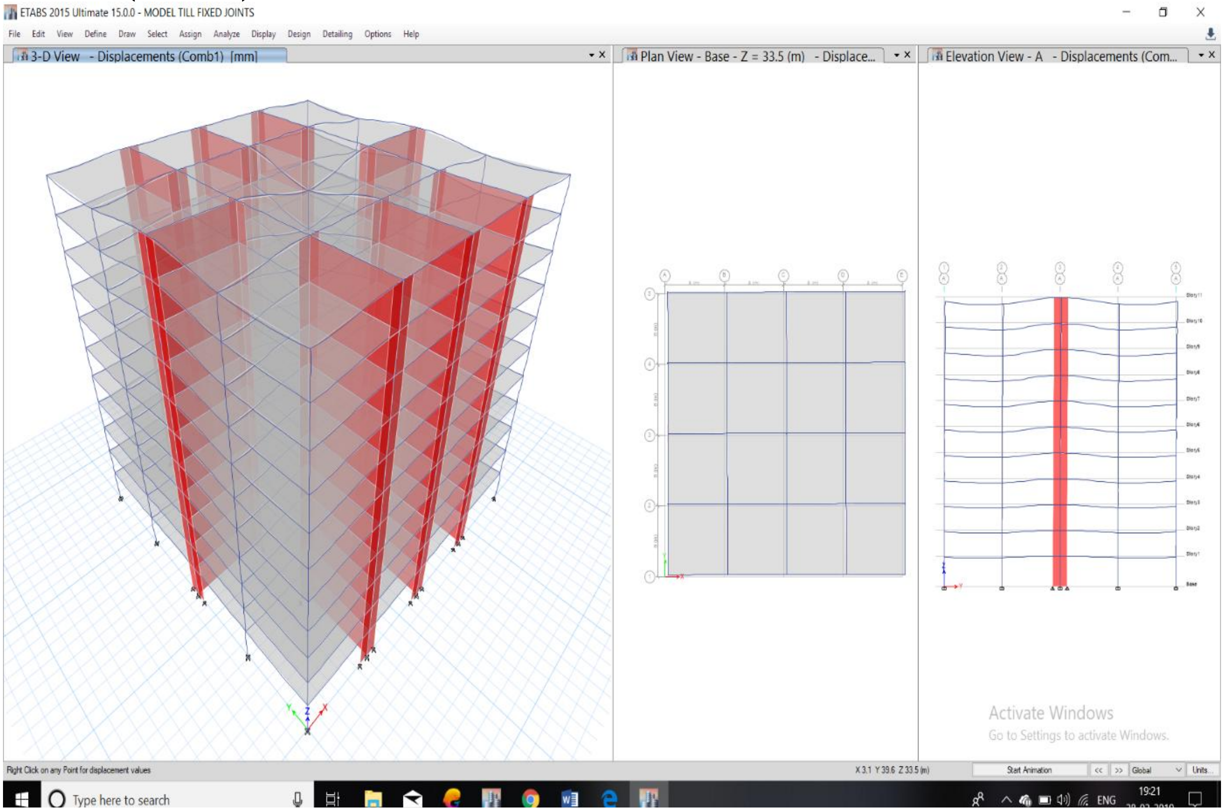


Figure10: Deformed shape of Model-8

MODEL-9(L SHAPE AND I SHAPE COMBINATION)

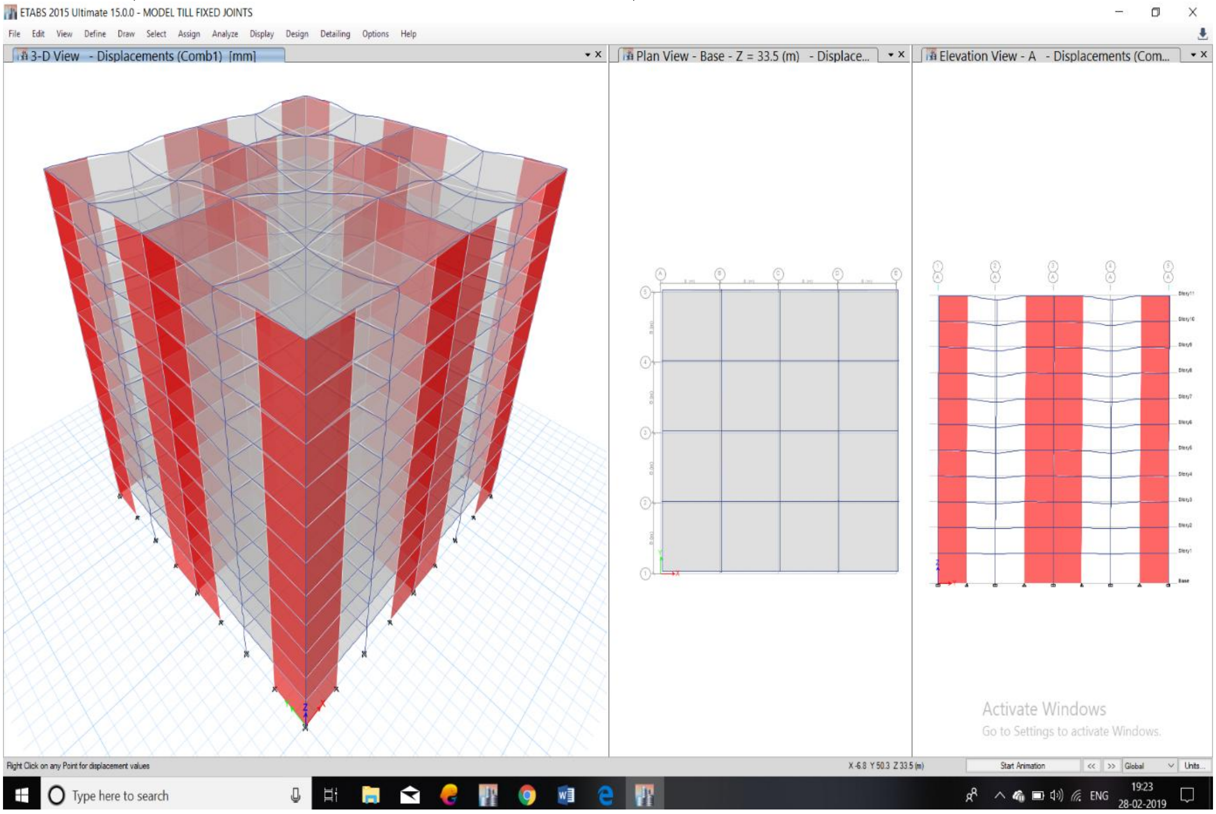


Figure11: Deformed shape of Model-9

MODEL-10(C SHAPE)

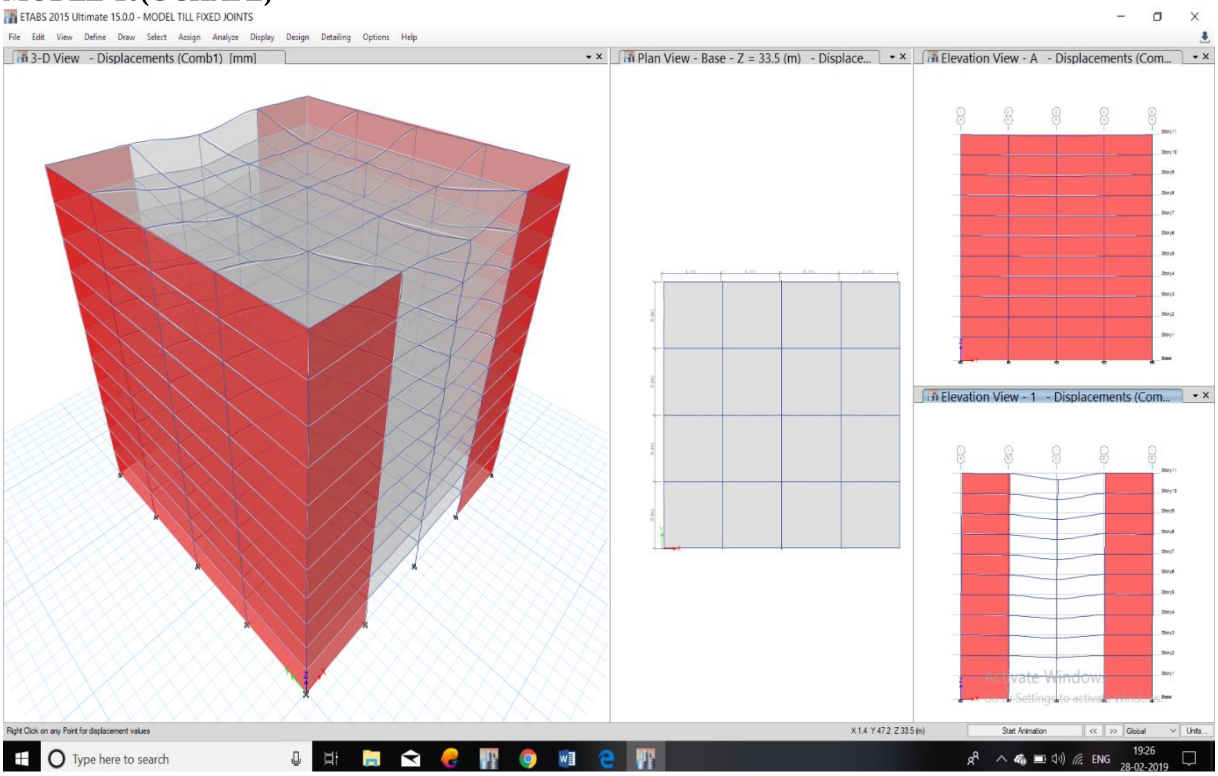


Figure12: Deformed shape of Model-10

IV. RESULT AND DISCUSSION

The results obtained are as discussed below

Table 3.1 Displacement of shear wall thickness 150mm

MODEL	DISPLACEMENT	PERCENTAGE REDUCTION IN DISPLACEMENT COMPARED TO WITHOUT SHEAR WALL
1.WITHOUT SHEAR WALL	115	
2.L SHAPE AT FOUR CORNERS	13.7	88.08
3.PLUS SHAPE AT FOUR SLAB MEETING JOINT	30.1	73.82
4. 2 E AND 2 L	10.4	90.95
5.STRAIGHT WALL WITH OPENINGS	8.2	92.86
6. STRAIGHT WALLS AT CENTER	10.9	90.52
7. F SHAPED	12.1	89.47
8. I SHAPE AT DIFFERENT JOINTS	15.4	86.6
9. L AND I	11.2	90.26
10. C SHAPE	12.9	88.78

Table 3.2 Displacement of shear wall thickness 170mm

MODEL	DISPLACEMENT	PERCENTAGE REDUCTION IN DISPLACEMENT COMPARED TO WITHOUT SHEAR WALL
1.WITHOUT SHEAR WALL	115	-
2.L SHAPE AT FOUR CORNERS	13.2	88.52
3.PLUS SHAPE AT FOUR SLAB MEETING JOINT	29.4	74.43
4. 2 E AND 2 L	9.6	91.65
5.STRAIGHT WALL WITH OPENINGS	7.5	93.47
6. STRAIGHT WALLS AT CENTER	10.2	91.13
7. F SHAPED	11.1	90.34
8. I SHAPE AT DIFFERENT JOINTS	14.6	87.3
9. L AND I	10.7	90.69
10. C SHAPE	12.4	89.21

Table 3.3 Displacement of shear wall thickness 190mm

MODEL	DISPLACEMENT	PERCENTAGE REDUCTION IN DISPLACEMENT COMPARED TO WITHOUT SHEAR WALL
1.WITHOUT SHEAR WALL	115	-
2.L SHAPE AT FOUR CORNERS	12.7	88.95
3.PLUS SHAPE AT FOUR SLAB MEETING JOINT	28.8	74.95
4. 2 E AND 2 L	9	92.17
5.STRAIGHT WALL WITH OPENINGS	6.9	94
6. STRAIGHT WALLS AT CENTER	9.5	91.73
7. F SHAPED	10.3	91.04
8. I SHAPE AT DIFFERENT JOINTS	14	87.82
9. L AND I	10.4	90.95
10. C SHAPE	12	89.56

Table 3.4 Displacement of shear wall thickness 210mm

MODEL	DISPLACEMENT	PERCENTAGE REDUCTION IN DISPLACEMENT COMPARED TO WITHOUT SHEAR WALL
1.WITHOUT SHEAR WALL	115	-
2.L SHAPE AT FOUR CORNERS	12.4	89.21
3.PLUS SHAPE AT FOUR SLAB MEETING JOINT	28.3	75.39

4. 2 E AND 2 L	8.7	92.43
5.STRAIGHT WALL WITH OPENINGS	6.5	94.34
6. STRAIGHT WALLS AT CENTER	9	92.17
7. F SHAPED	9.9	91.39
8. I SHAPE AT DIFFERENT JOINTS	13.6	88.17
9. L AND I	9.7	91.56
10. C SHAPE	11.6	89.9

Table 3.5 Displacement of shear wall thickness 230mm

MODEL	DISPLACEMENT	PERCENTAGE REDUCTION IN DISPLACEMENT COMPARED TO WITHOUT SHEAR WALL
1.WITHOUT SHEAR WALL	115	-
2.L SHAPE AT FOUR CORNERS	12.1	89.47
3.PLUS SHAPE AT FOUR SLAB MEETING JOINT	27.8	75.82
4. 2 E AND 2 L	8.2	92.86
5.STRAIGHT WALL WITH OPENINGS	6.2	94.6
6. STRAIGHT WALLS AT CENTER	8.4	91.82
7. F SHAPED	9.5	91.73
8. I SHAPE AT DIFFERENT JOINTS	13.1	88.6
9. L AND I	9.1	92.08
10. C SHAPE	11.1	90.34

Table 3.6 Displacement of shear wall thickness 250mm

MODEL	DISPLACEMENT	PERCENTAGE REDUCTION IN DISPLACEMENT COMPARED TO WITHOUT SHEAR WALL
1.WITHOUT SHEAR WALL	115	-
2.L SHAPE AT FOUR CORNERS	11.7	89.82
3.PLUS SHAPE AT FOUR SLAB MEETING JOINT	27.3	76.26
4. 2 E AND 2 L	7.8	93.21
5.STRAIGHT WALL WITH OPENINGS	5.9	94.86
6. STRAIGHT WALLS AT CENTER	7.9	93.13
7. F SHAPED	8.9	92.26
8. I SHAPE AT DIFFERENT JOINTS	12.9	88.78
9. L AND I	8.6	92.52
10. C SHAPE	10.9	90.52

Table 3.7 Displacement of shear wall thickness 270mm

MODEL	DISPLACEMENT	PERCENTAGE REDUCTION IN DISPLACEMENT COMPARED TO WITHOUT SHEAR WALL
1.WITHOUT SHEAR WALL	115	-
2.L SHAPE AT FOUR CORNERS	11.3	90.17
3.PLUS SHAPE AT FOUR SLAB MEETING JOINT	26.9	76.6
4. 2 E AND 2 L	7.4	93.56
5.STRAIGHT WALL WITH OPENINGS	5.5	95.21
6. STRAIGHT WALLS AT CENTER	7.5	93.47
7. F SHAPED	8.2	92.86
8. I SHAPE AT DIFFERENT JOINTS	12.5	89.13
9. L AND I	8	93.04

10. C SHAPE	10.5	90.86

Table 3.8 Displacement of shear wall thickness 300mm

MODEL	DISPLACEMENT	PERCENTAGE REDUCTION IN DISPLACEMENT COMPARED TO WITHOUT SHEAR WALL
1.WITHOUT SHEAR WALL	115	-
2.L SHAPE AT FOUR CORNERS	10.9	90.52
3.PLUS SHAPE AT FOUR SLAB MEETING JOINT	26.2	77.21
4. 2 E AND 2 L	6.9	94
5.STRAIGHT WALL WITH OPENINGS	5.1	95.56
6. STRAIGHT WALLS AT CENTER	7	93.91
7. F SHAPED	7.7	93.3
8. I SHAPE AT DIFFERENT JOINTS	12.1	89.47
9. L AND I	7.7	93.3
10. C SHAPE	10.1	91.21

Storey displacement

It is the total displacement of ithstorey with respect to ground. In our project we taken the top storey displacements for all the models.

Storey drift

It is the ratio of difference of two consecutive floor to height of that floor.

Base shear

It is an estimate of the maximum expected lateral force that will occur due to seismic ground motion.

As per IS:13920 minimum thickness of shear wall is 150 mm

From IS 1893 (Part 4):2005, clause 18.7 Deflection criteria: The maximum lateral deflection of.the top of a stacklike structure under all service conditions, prior to the application of load factors, shall not exceed the limits set forth by the following equation:

$D_{Max} = 0.003$ h

where D=Max maximum lateral -deflection, and

h = height of structure above the base

So,the maximum lateral permissible deflection according to code = 0.003[(10*3) + (3.5)]

= 0.1005 meter =100.5 mm

But here the frame model-1 i.e, without shear wall framed building the maximum lateral deflection is 115 mm,which is not acceptable..

From the results it is clear that introducing the shear wall reduces the storey displacement. The increase in shear wall thickness further reduces the storey displacement.

V. CONCLUSION

1. From the above results introducing shear wall reduces the sway or displacement.
2. It can be concluded that small dimension of shear wall is not more effective then large dimension of shear wall to control the lateral displacement.
3. In our project model-5(straight wall with openings) model-4(combination of E and L shape),model-6(straight walls at central periphery) has less storey displacement compared to other models followed by model-7(F shape) and model-9(combination of L and I shape)
4. Maximum Storey displacement got reduced more when shear walls are placed at edge regions than in core regions.
5. Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position.
6. If the dimensions of shear wall are large then major amount of horizontal forces are taken by shear wall.
7. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake.
8. Displacement and stiffness are inversely proportional. It can be concluded that structures with least maximum storey displacement has high stiffness.

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