Project Title

Comparative Study of Shear wall in multi-storied R.C. Building

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Objective

- The main objective of this project is to check and compare the seismic response of multi-storied building for different location of shear wall, so that one can choose the best alternative for construction in earthquake-prone area.

- Different location of shear wall in R.C. Building will be modelled in E-TABS software and the results in terms of natural period, frequency, storey displacement, storey drift, storey shear is compared.

Introduction

- Looking to the past records of earthquake, there is increase in the demand of earthquake resisting building which can be fulfilled by providing the shear wall systems in the building.
- Also due to the major earthquakes in the recent pats the codal provisions revised and implementing more weightage on earthquake design of structure.
- The decision regarding provision of shear wall to resist lateral forces play most important role in choosing the appropriate structural system for given project.

Introduction(con...)

- Generally structures are subjected to two types of loads i.e. Static and Dynamic. Static loads are constant while dynamic loads are varying with time.
- In majority civil structures only static loads are considered while dynamic loads are not calculated because the calculations are more complicated. This may cause disaster particularly during Earthquake due to seismic waves.

- By providing shear wall in multi-storied building we can resist seismic waves of earthquake. The loads are calculated by E-TABS software by providing shear walls at various parts of building.

Procedure :

Literature Review

- Code Provision
- Paper Title

Load Calculation

- Static Method
- Response Spectrum Method

ETABS software Learning

- Modelling of Multi-storey Building
- Seismic Analysis of Building

Literature Review

- **Kevadkar and Kodag (2013)** are investigated The concept of using steel bracing is one of the advantageous concepts which can be used to strengthen structure. Shear wall and steel bracing increases the level of safety since the demand curve intersect near the elastic domain. Capacity of the steel braced structure is more as compare to the shear wall structure. Steel bracing has more margin of safety against collapse as compare with shear wall.

- **Agrawal and Charkha (2012)** are investigation reveals that the significant effects on deflection in orthogonal direction by the shifting the shear wall location. Placing Shear wall away from centre of gravity resulted in increase in most of the members forces.

- **Chandurkar and Pajgade (2013)** are investigated Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position. If the dimensions of shear wall are large then major amount of horizontal forces are taken by shear wall. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake.

- **Greeshma and Jaya (2006)** are investigation the proper connection detailing of shear wall to the diaphragm. The shear wall and diaphragm connection with hook deflects more when compared to the other two configurations. Hence, the shear wall- diaphragm connection with hook was more efficient under dynamic lateral loadings.

Analysis method:

- As per the Indian Standard code for Earthquake IS:1893-2002, seismic analysis can be performed by three methods.

1. Static Method
   A. Equivalent Static Coefficient Method

2. Dynamic Methods
   A. Time history Method
   B. Response Spectrum Method

Software Implementation:

Etabs software is exclusively made for modeling, analysis and design of buildings. Various facilities in the Etabs are listed below.

(1)Etabs has feature known as similar story. By which similar stories can be edited and modeled simultaneously. Due to which building is modeled very speedily.

(2)Etabs can perform various seismic coefficient , Response Spectrum, Static Non-linear, Time History, Construction sequence and many more analysis with good graphics.

Software Implementation(Con...)

(3) Etabs provide object based modeling. It takes slab as area object, column, beam, brace as line object and support, mass, loads as point objects.

(4)Etabs automates templates for typical structures like steel deck, waffle slab, Flat slab, Ribbed Slab etc.

(5)Etabs can do optimization of steel section.

(6)Etabs has a facility to design composite beam. Also composite deck can be modeled in Etabs.

Software validation:

For verification of software a G+6 storey building example is taken from Nicee website. The results of which are compared with the results of Etabs.

Data for Building:

Plan Dimension	: 22.5 x 22.5 m
Typical Storey Height	: 5 m
Bottom storey Height	: 4.1 m
Slab Thickness	: 100 mm
Column Size	: 600 x 600 mm
Main Beam	: 300 x 600 mm
Secondary Beam	: 200 x 500 mm

Data for Building:

Wall	: 230 mm thick about periphery
Load	: Live load 4 kN/m^2 on Floor and 1 kN/m^2 on roof
Floor finish	:1 kN/m^2
Water Proofing	:2 kN/m^2
Earthquake Data	: Zone III, Type II soil and Importance Factor 1.5

ETABS Nonlinear v9.2.0 - Software Validation Problem

File Edit View Define Draw Select Assign Analyze Display Design Options Help

Plan View - STORY7 - Elevation 1188.976

3-D View

Y7 - Elevation 30.2

X277.85 Y-219.19 Z1188.98

Similar Stories GLOBAL Kip-in

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Comparison of Software verification result

Storey	Storey Shear (kN)		Storey Displacement (mm)		Drift (mm)	
	Manual	Etabs	Manual	Etabs	Manual	Etabs
7	480	459.28	79.43	80.80	7.23	7.02
6	860	845.96	72.20	73.81	12.19	12.03
5	1104	1091.95	60.01	61.78	15.68	15.69
4	1242	1231.29	44.33	46.09	17.58	17.79
3	1304	1294.04	26.75	28.30	17.26	17.87
2	1320	1310.22	9.49	10.43	9.08	10.58
1	1320	1310.90	0	0.05	0	0

Stepwise Procedure for modeling of Building in ETABS :

Step 1: Define Storey data like storey height, no. of storey etc.

Step 2: Select Code preference from option and then define material properties from define Menu

Step 3: Define Frame Section from Define menu like column, beam,

Step 4: Define Slab Section

Step 5: Draw building Elements from draw menu

Step 6: Give Support Conditions

Procedure(con…)

Step 7 : Define Load cases and Load combinations

Step 8 : Assign Load

Step 9 : Define Mass Source

Step 10 : Give structure auto line constraint

Step 11 : Give renumbering to the whole structure.

Step 12 : Select analysis option and Run Analysis

Problem Statement

In present work in order to compare the response of reinforced concrete shear wall for use in Earthquake prone area multi storey building having plan dimension 18m x18m is modeled and analyzed in ETABS 9.2 Non Linear Version software. Equivalent static analysis and dynamic Response spectrum analysis is performed on the structure.

In present work total 2 models are prepared. Two models of G+9 storey buildings, which includes shear wall in different position at core of building and at edge of building. And for both the models Equivalent static analysis and dynamic Response spectrum analysis is performed.

Models of Building

1. 10 storey building with RCC shear wall at core (static analysis)
2. 10 storey building with RCC shear wall at Edges (static analysis)
3. 10 storey building with RCC shear wall at core (dynamic analysis)
4. 10 storey building with RCC shear wall at Edges(dynamic analysis)

Geometrical Data

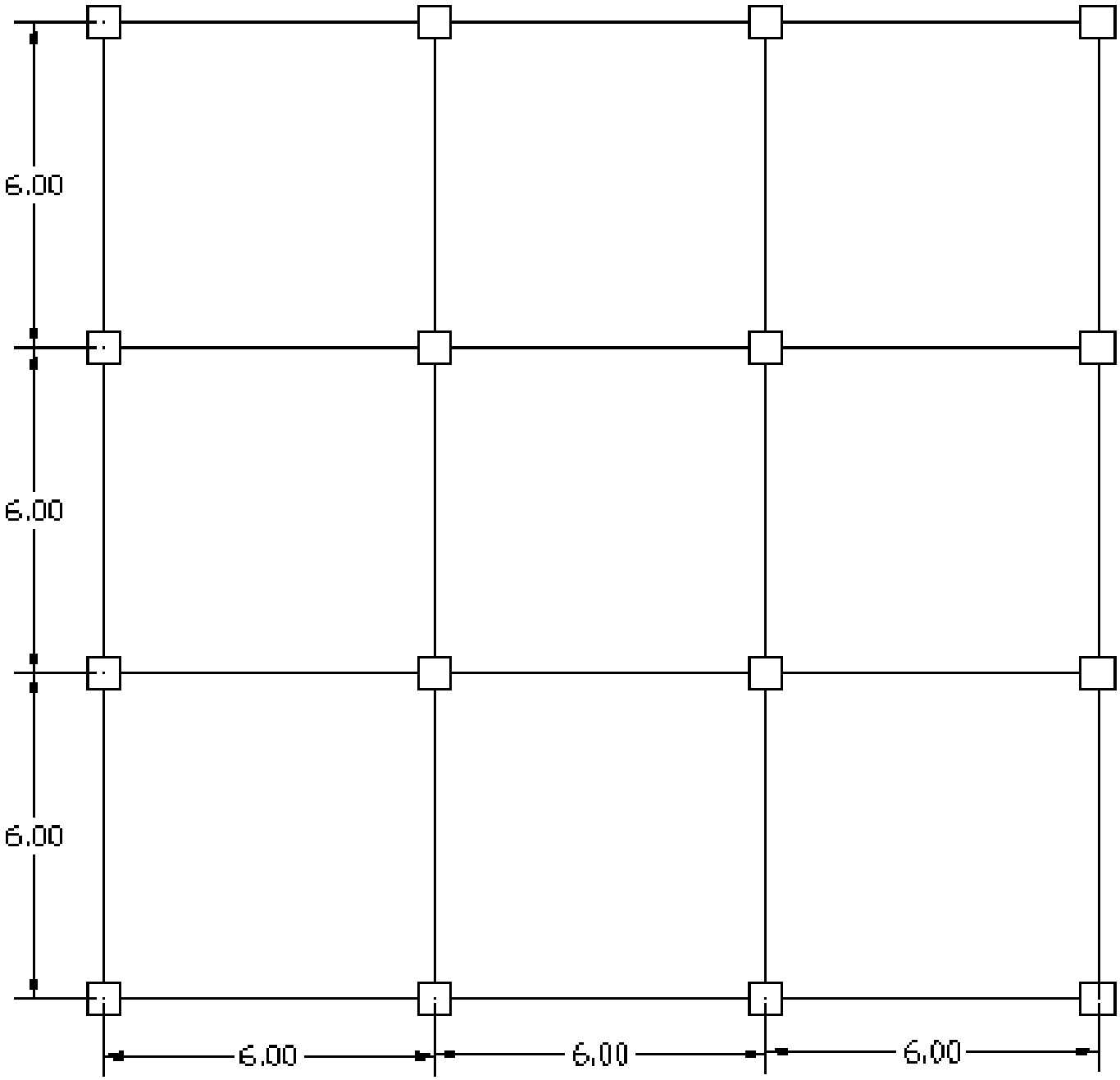
Type of Building	: Commercial building
Location of Building	: Ahmedabad
Typical Storey Height	: 3 m
Bottom Storey Height	: 3.5 m

Earthquake Data

Frame	: Special moment Resisting Frame
Location	: Ahmedabad (Zone III)
Importance Factor	: 1.5
Response Reduction Factor	: 5
Type of Soil	: Medium (Type 2)

Table 1 : Material Data

Material	Weight (kN/m3)	Modulus of Elasticity (E) (kN/m2)	Shear Modulus (G)	Poissons Ratio	Coeffi. Of Thermal Expansion
Concrete (fck=M25)	25	$25x10^{6}$	10416666.7	0.2	$9.9x10^{-6}$
Steel (Fe-415)	78.5	$2x10^{8}$	76884615	0.3	$11.7x10^{-6}$



plan View of Building

Loading Data

Live load : On floor 4 kN/m^2

On roof 1 kN/m^2

Floor Finish : 1.5 kN/m^2

Earthquake load in X and Y direction

RCC
1.5 (DL + LL)
1.2 (DL + LL ± EQx)
1.2 (DL + LL ± EQy)
1.5 (DL ± EQx)
1.5 (DL± EQy)
0.9 DL ± 1.5 EQx
0.9 DL ± 1.5 EQy

Table 2 : Element Sizes

Slab Depth : 125 mm

Element	10 Storey
Column	600 mm X 600 mm
Main Beam	350 mm X 600 mm
Shear Wall	200 mm thick (RCC)

Modeling of Building Using ETABS

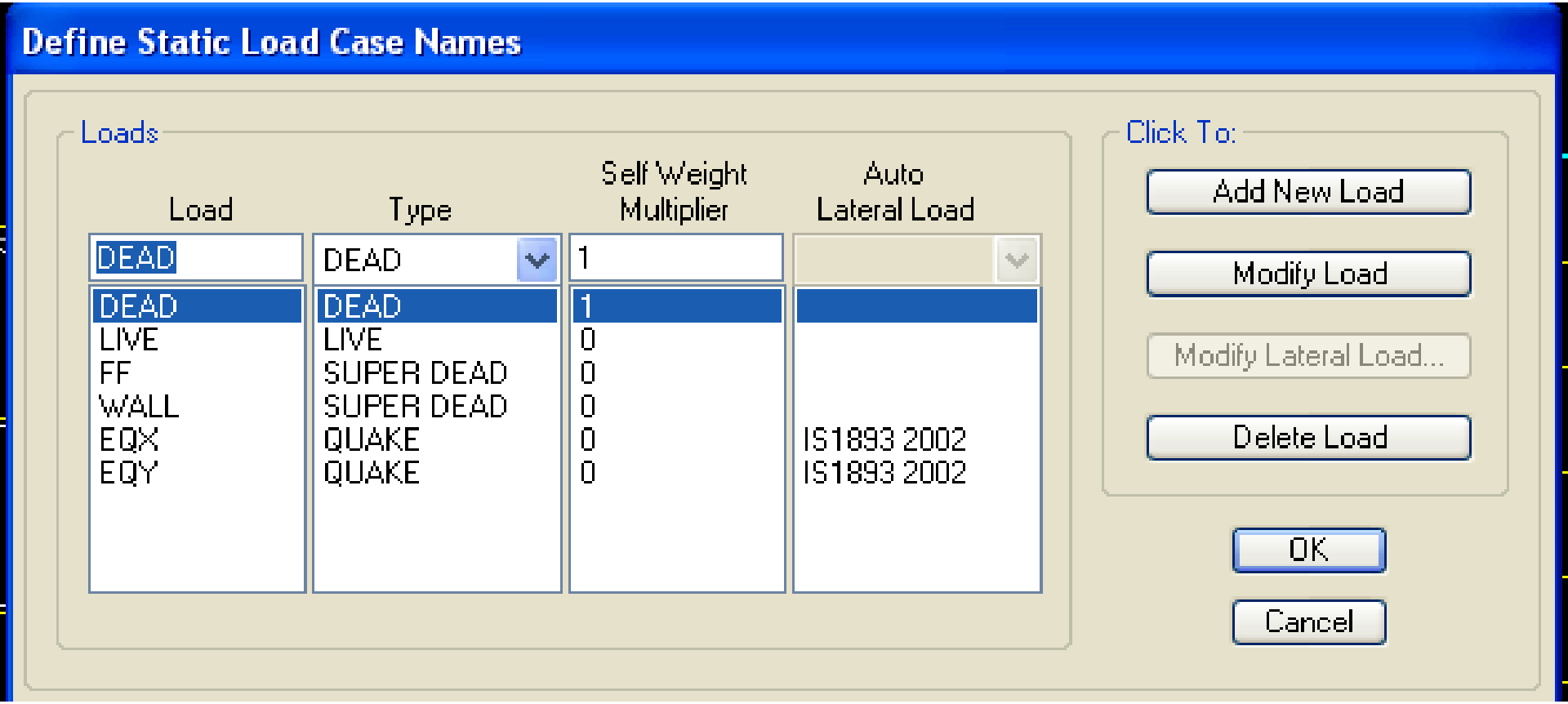
The building is modeled using the Software ETABS nonlinear v9.2. Different elements of building are modeled as below.

- Beams and Columns are modeled as line element.
- Slab is modeled as shell element. Shell element has both in plane and out of plane stiffness while membrane element has only out of plane stiffness.
- Shear wall is modeled as pier object in Etabs.

Fixing Of Member Sizes

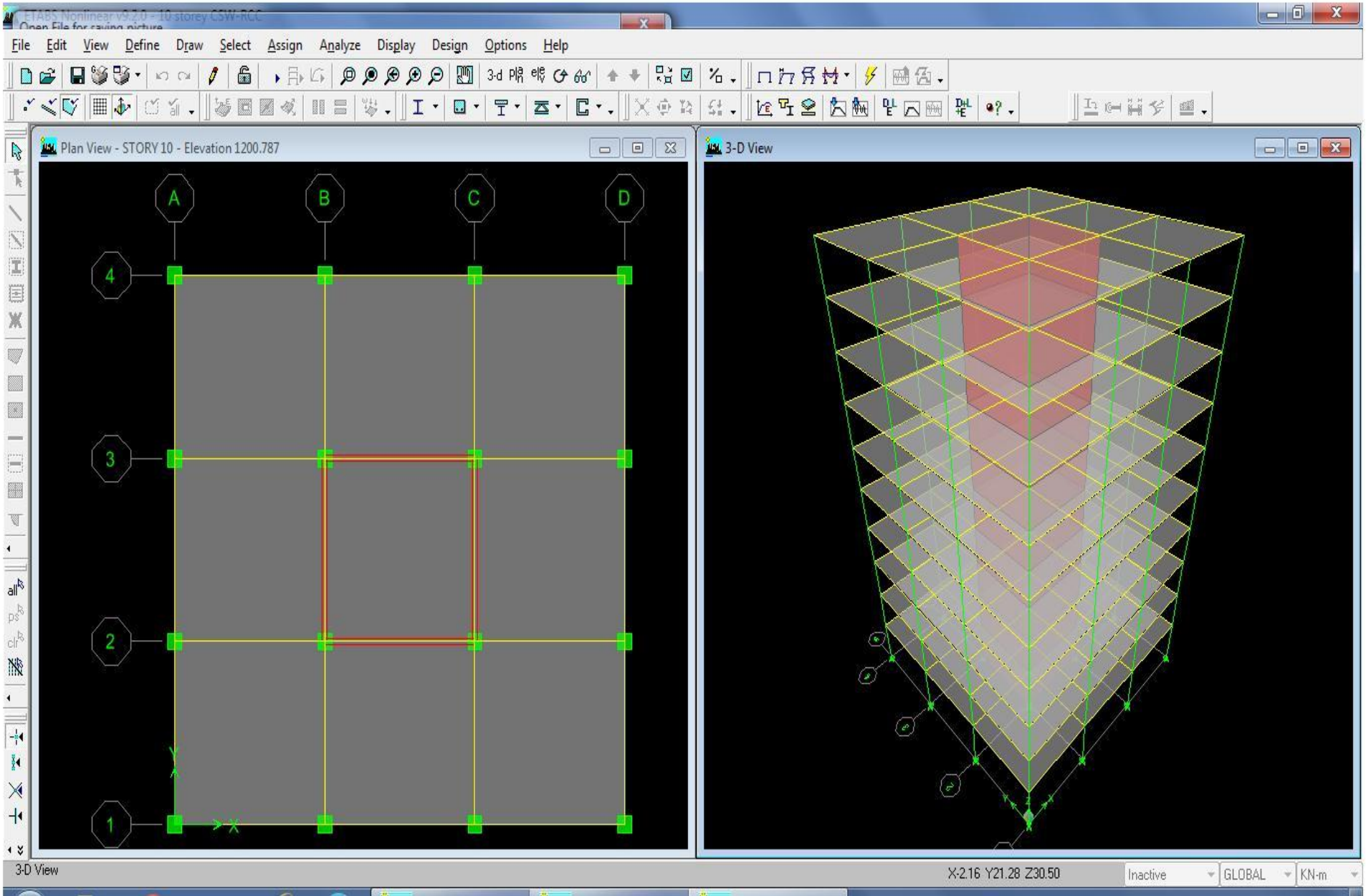
- For shear wall minimum thickness required as per IS:13920 is 150 mm. So 200 mm thickness is taken. As panel size of building for shear wall is same for all type of models, thickness of shear wall is kept same for all.

- For loading purpose Live load, Dead load are applied as area load. Earthquake load is applied as per IS 1893-2002. For defining load only once in dead load case self weight multiplier is taken one.

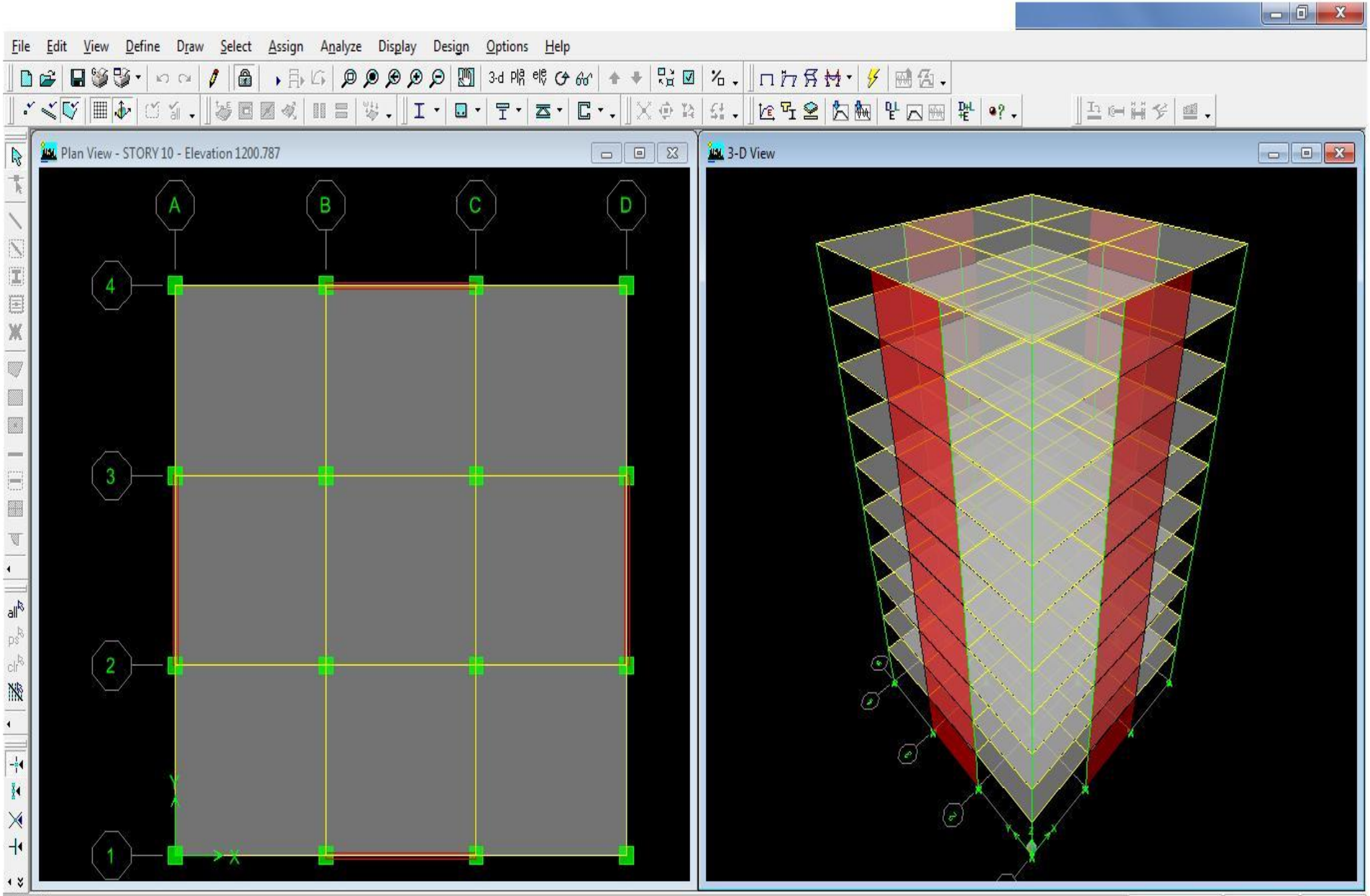


Defining Load cases in ETABS

ETABS model of 10 Storey CSW



ETABS model of 10 Storey ESW



Analysis, Result and Discussion

- Storey drift, Base shear distribution, Storey displacement, time period, frequency, stiffness are tabulated and compared. As building symmetrical about X and Y axis, all comparison is made for X direction.
- Seismic response is checked for different location of shear wall. Shear walls are provided at centre and at edge. Now onwards shear wall at core is referred as CSW (Core Shear Wall) and at edge as ESW (Edge shear Wall).

Table 3: Storey Shear In 10 Storey building for CSW and ESW (KN)

Storey	Static	Dynamic
10	247.13	204.06
9	509.11	424.57
8	717.04	605.25
7	877.17	755.46
6	995.73	880.85
5	1078.96	982.95
4	1133.09	1063.54
3	1164.35	1123.94
2	1178.99	1163.56
1	1183.30	1183.30

Table 4: Comparison Table of Storey Shear for static and dynamic analysis (%ge)

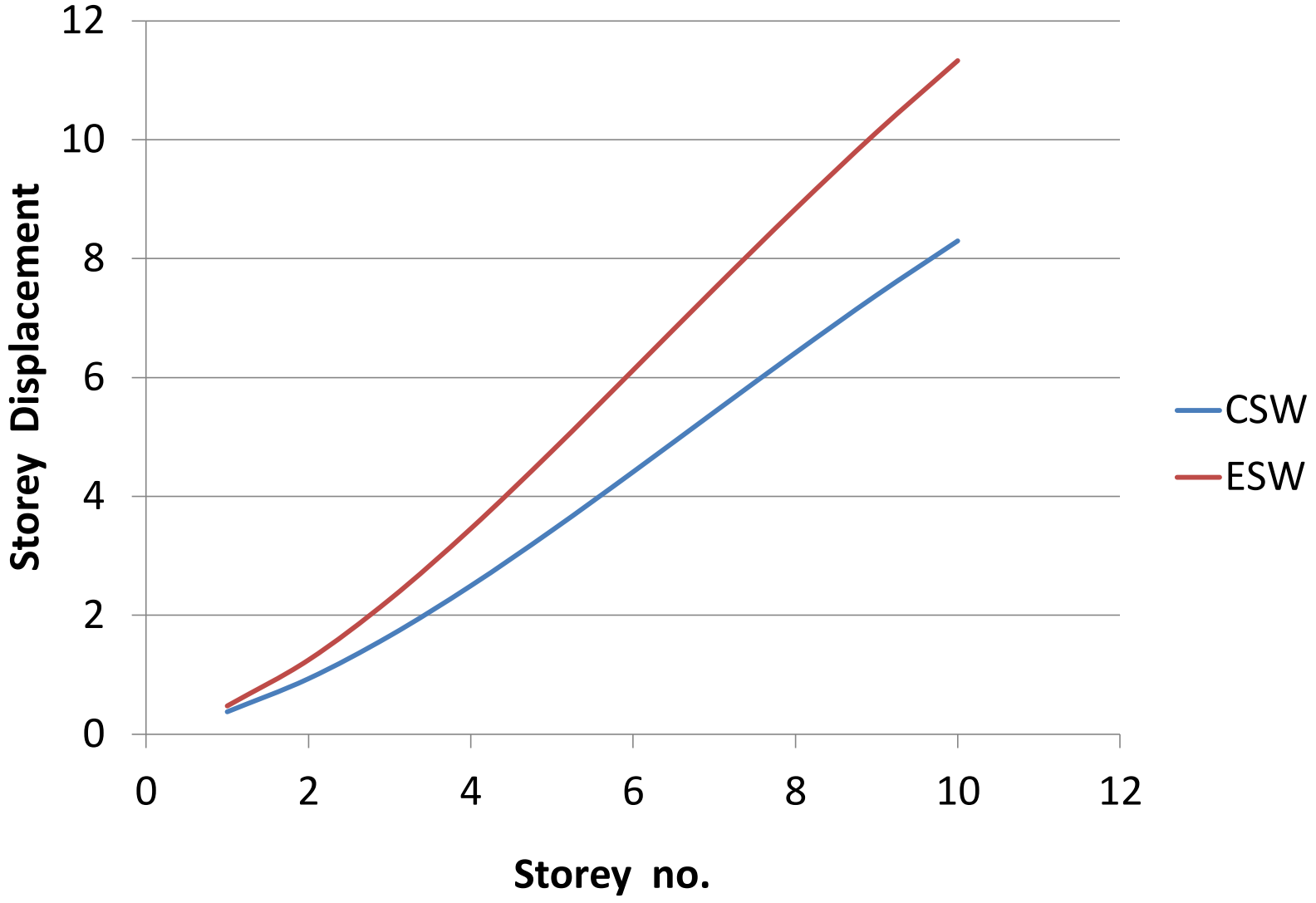
Storey	RCC
10	-17.43
9	-16.60
8	-15.59
7	-13.88
6	-11.54
5	-8.90
4	-6.14
3	-3.47
2	-1.31
1	0.00

Storey Displacement

Storey drift is calculated from the storey displacement. More storey displacement indicates less stiffness of structure.

Table 5. Maximum Storey Displacement for 10 Storey (mm)

Storey	Core Shear Wall(CSW)	Edge Shear Wall(ESW)
10	8.2970	11.3295
9	7.3834	10.1229
8	6.4141	8.8344
7	5.4158	7.4925
6	4.4103	6.1215
5	3.4259	4.7600
4	2.4946	3.4556
3	1.6510	2.2637
2	0.9323	1.2469
1	0.3760	0.4741

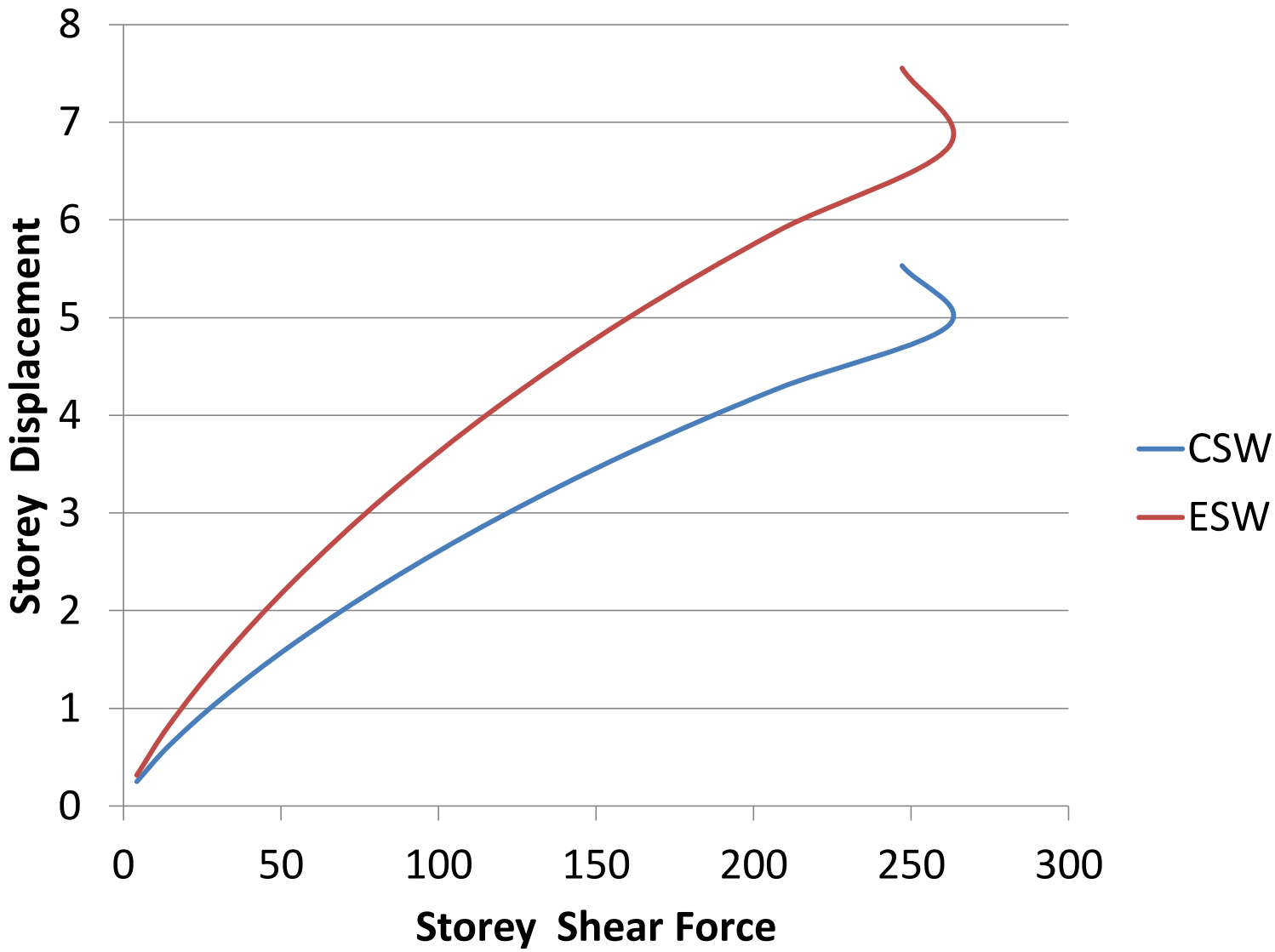

12
10
8
6
4
2
0
Storey Displacement
0
2
4
6
8
10
12
Storey no.
CSW
ESW

Storey Stiffness

- Stiffness is calculated by assuming that supports are fixed and load is applied at floor level. Horizontal displacement is measured at floor level and lateral stiffness is calculated by dividing horizontal deflection to lateral load. In other words stiffness is the force needed to cause unit displacement and is given by slope of force displacement relationship.
- Strength is a maximum force that a system can take.

Table 6. Storey Stiffness for 10 Storey CSW (mm)

Storey	CSW		ESW	
	Force	Displacement	Force	Displacement
10	247.13	5.53133	247.13	7.55297
9	261.98	4.92228	261.98	6.74858
8	207.94	4.27607	207.94	5.88961
7	160.13	3.61053	160.13	4.99499
6	118.56	2.94020	118.56	4.08098
5	83.23	2.28396	83.23	3.17334
4	54.13	1.66307	54.13	2.30376
3	31.26	1.10069	31.26	1.50914
2	14.64	0.62156	14.64	0.83124
1	4.31	0.25069	4.31	0.31605


8
7
6
5
4
3
2
1
0
Storey Displacement
0
50
100
150
200
250
300
Storey Shear Force
CSW
ESW

Time Period, Frequency and Storey Drift

- The stiffer structures have lesser natural period and their response is governed by the ground acceleration; most buildings fall in this category. The flexible structures have larger natural period and their response is governed by the ground displacement, for example, large span bridges.
- Storey drift is directly related to the stiffness of the structure. The higher the stiffness lowers the drift and higher the lateral loads on the structure.

Table 7 : Time Period for 10 Storey (mm)

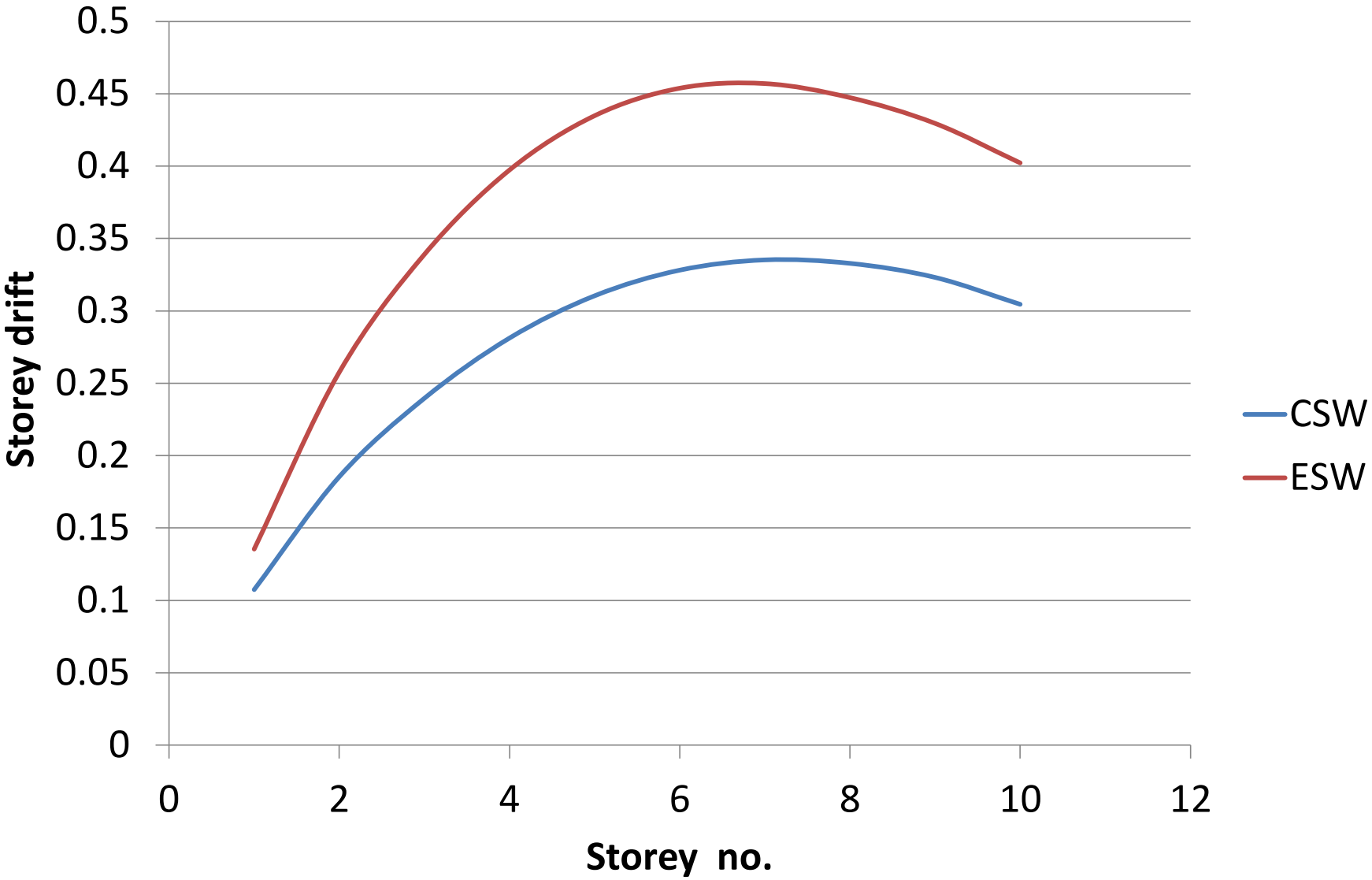
Mode	Core Shear Wall(CSW)	Edge Shear Wall(ESW)
	RCC	RCC
1	0.5450	0.6397
2	0.5450	0.6397
3	0.1779	0.1775
4	0.1779	0.1775
5	0.1761	0.1702
6	0.1525	0.1545
7	0.1374	0.1545
8	0.1374	0.0754
9	0.0668	0.0754
10	0.0668	0.0700
11	0.0668	0.0666
12	0.0604	0.0556

Table 8 : Maximum Storey Drift for 10 Storey (mm)

Storey	Core Shear Wall(CSW)	Edge Shear Wall(ESW)
10	0.3045	0.4022
9	0.3231	0.4295
8	0.3328	0.4473
7	0.3352	0.4570
6	0.3281	0.4538
5	0.3104	0.4348
4	0.2812	0.3973
3	0.2396	0.3390
2	0.1854	0.2576
1	0.1074	0.1354

Table 9: Comparison of storey Drift when shear wall is placed on Edge (%ge)

Storey	**RCC**
10	32.07
9	32.92
8	34.42
7	36.35
6	38.31
5	40.05
4	41.30
3	41.49
2	38.91
1	26.07


0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Storey drift
0
2
4
6
8
10
12
Storey no.
CSW
ESW

Concluding Remarks

- The analysis of building with Core shear wall and edge shear wall shows that Shear wall at core shows stiffer behaviour.
- When shear walls are provided on edge maximum storey displacement of buildings is increased comparing to when shear walls are provided on center portion.
- When dynamic analysis is done storey drift decreases.
- When shear wall is placed on edge time period of building increases.
- When shear walls are provided on edge storey drift of buildings is increased comparing to when shear walls are provided on center portion.

- For good seismic performance a building should have adequate lateral stiffness. Low lateral stiffness leads to large deformation and strains, damage to non-structural component, discomfort to occupant.

- Stiff structures though attracts the more seismic force but have performed better during past earthquake (Jain S.K. and Murty C V R, 2002).

- So from above results Building with shear wall at core proves to be a better alternative for building in earthquake prone area.

- Dynamic analysis reduces storey shear, storey displacement, storey drift etc; this shows that dynamic analysis gives improved estimate of forces and therefore analysis of building become more accurate as well as economical.

Future Scope

- Nonlinear analysis by push over.
- Effect of shear wall on seismic performance of building.
- Dynamic nonlinear analysis by time history method.
- Parametric study of models by varying height of building, number of bays of building etc.
- Performance-based or capacity based design of structure.
- Continue to innovate new systems.
- FEM analysis to understand beam-column junction behavior under earthquake for RCC, Steel and Composite building .

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