Dynamic Analysis of Multi-Storey Building for Minimization of Lateral Displacement using Shear Wall

Kushalkumar Yadav *, _Dr. R. L. Sharma_ **

** Ph.D Scholar at Lovely Professional University, Punjab*

*** Professor, Department of Civil Engineering at Lovely Professional University, Punjab*

Abstract. Shear walls are one of the most commonly used elements in Multi-Storey buildings to resist the lateral loads due to earthquakes. In this paper, a multistorey building (with and without shear walls) is modeled and analyzed using STAAD-Pro. The prototype models are also tested on a shake table in the structural dynamics lab. The results of STAAD-Pro and Shake tables are compared. The main focus of the study is to investigate the seismic behavior of shear walls in multi-storey buildings and the applicabilty of the STAAD-Pro simulation to multi-storey buildings with shear walls. The modelling was done as per the Indian Standard Code IS 1893:2002, criteria for earthquake resistant design of structures part 1 general provisions and buildings. The materials used for modelling the building conforms to Indian Standard codes IS456:2000 and IS875:1987. The displacements and storey drifts computed using STAAD-Pro and shake table laboratory testing are compared. It has been found that there is complete agreement of the results. It is therefore concluded that the STAAD-Pro analysis can be used to analysed multi-stored buildings.

Index Terms- Shear Wall, STAAD Pro software,Storey drift, Lateral Displacement, Shake Table

I. Introduction

It is now modern trend to design tall and high rise structures and architecturally designed structures. The buildings are get damage by different environmental factors like wind, earthquake and waterways. Due to damage of buildings, annually millions of people die due to earthquakes and this is responsible for billions of rupees of property damage. Therefore to protect the buildings from collapse, the study of Earthquake Engineering is necessary. However, study and research in the field of high rise Buildings under seismic conditions is increasing day by day. The building becomes more effective and economical by using shear wall in building. In this paper, a multi storey building in Zone V is designed using shear wall to reduce the effect of Lateral Displacement in Multi-Storey Building due to Earthquake.

Shear walls are generally a vertical member and also resist the combination of shear force, moments and axial load generated by lateral loadings and due to gravity load. Shear wall are used to stiffen the structure, because of shear wall the rigidity of buildings and lateral load resistance get increases.

II. METHODOLOGY

Method of Analysis

Multi storey building is analysed using STAAD-Pro software

Type of building considered

Multi storey building =(10Storey)

Storey =3m

Grade of Concrete

For M40 grade of concrete, Fc = 40N/mm^2

Grade of Steel

For Fe500 grade of steel, Fy=500N/mm^2

The dimensions of building element

Size of beam= 0.3m x 0.4m

Size of Column= 0.35m x 0.45m

Thickness of Slab=0.15m

Thickness of shear wall= 0.23m

Load Applied: Dead Load

Self weight of beam= 0.3x0.4x25 = 3kN/m

Self weight of column= 0.35x 0.45x25 = 3.9375kN/m

Slab Load/ Plate Load = 0.15x25 = 3.75kN/m^2

Shear wall Dead Load/Surface load = 0.23x25 = 5.75kN/m^2

Live Load

As per IS 875 (Part 2) 1987

Floor Load = 3kN/m^2

Seismic Design

IS 1893-2002

Zone =5

Zone factor, Z=0.36

Special RC Moment Resisting Frame (SMRF)=5

Importance Factor=1

Soil Type= Medium soil

Damping Ratio = 5% (IS 1893:2002 Table-3)

Response Reduction Factor (RF)=5

Load Combinations:
As per **IS 1893 (Part 1): 2002** Criteria 6.3.1.1
the following load combinations shall be Considered

- 1.5(DL + IL)
- 1.2(DL + IL ± EL)
- 1.5(DL ± EL)
- 0.9(DL ± 1.5EL)

Performance Criteria:

Maximum permissible storey displacement is limited to H/500. Where, H is total height of building. (**IS 456:2000, Clause 20.5**)
Maximum permissible storey drift is limited to 0.004 h (**IS 1893 (Part 1): 2002** Criteria 6.3.1.1) Where h is height of each storey.

FIGURE 1: Building Plan

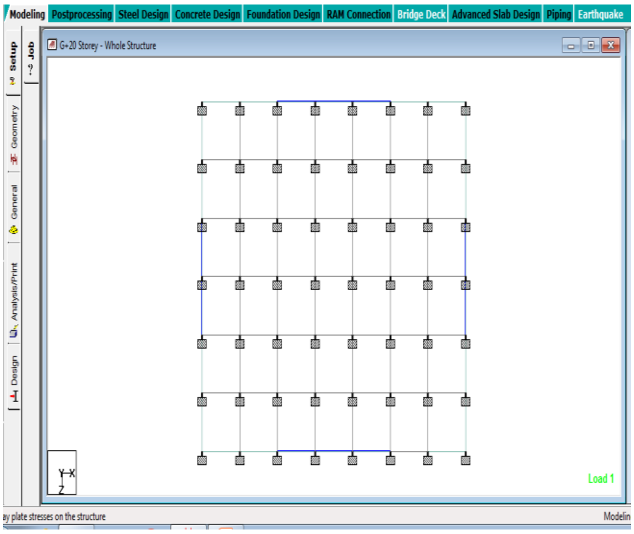
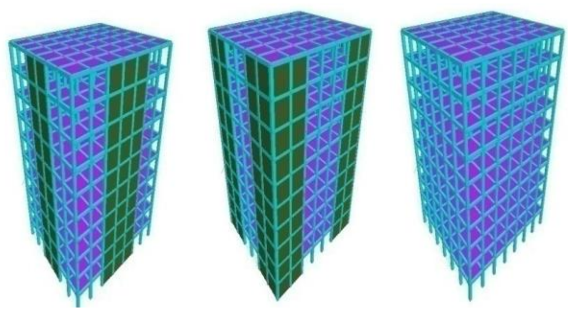


FIGURE 2: 10 Storey Building Model in STAAD-Pro



(a)Shear wall at mid outer wall(b) Shear wall at corner outer wall (c) Model without Shear wall

Dimensions of Model
Size of Shake Table=40cm x40cm =0.4m x0.4m
Height of each storey= 40cm =0.4m
Width= 150cm = 0.15m
Length= 300cm= 0.3m
Size of beam and Column= 0.3cm x 2.5cm = 0.003m x 0.025m
Thickness of slab= 1cm = 0.1m

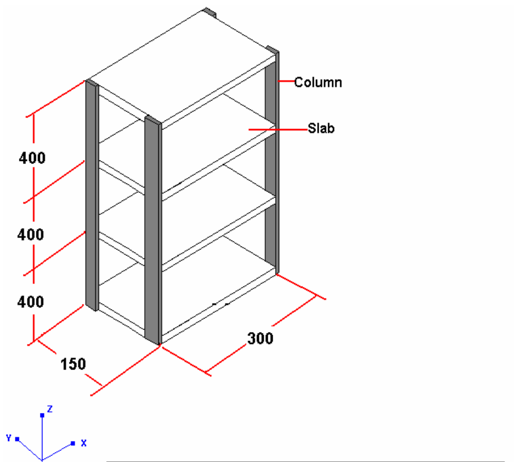
Shake Table Test
In this study, three-story frame Structure. Each storey of 400 mm tall, and the width of the frame was 300 mm. The beams were thick plates and were considered to be axially and flexural rigid. On the other hand, the columns are 4 mm-thick, 25 mm-wide.

Dimensions of Model
Size of Shake Table= 400mm x400mm
= 0.4m x0.4m
Width slab = 150cm = 0.15m
Length of slab = 300mm= 0.3m
C/S Column = 3mm x 25mm
= 0.003m x 0.025m
Height of each storey= 400mm =0.4m
Thickness of slab = 12.7mm = 0.0127m

Equipments used in the test of three-storey building

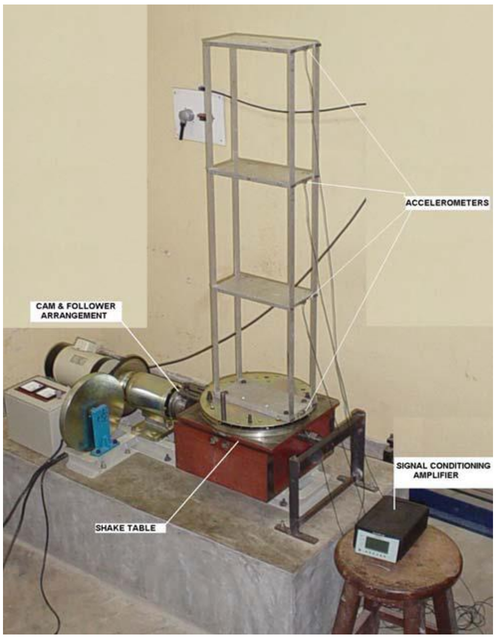
Sr. No.	Equipments	Quantity
1	Oscilloscope	1
2	Accelerometers	3
3	Transducers conditioning amplifiers	1
4	Shake table	1

FIGURE 3: Shake Table Test



Part	Dimensions in mm		
	Depth (D)	Width (B)	Length (L)
Column	D_A =3.00	B_A =25.11	L_A = 400.00
Slab	D_B =12.70	B_B =150.00	L_B =300.00

(a)



(b)

III. RESULTS OF ANALYSIS

TABLE 1: Displacement (10 Storey building)

Storey	Height (m)	Displacement without shear wall (mm)		Displacement with shear wall at Corner (mm)		Displacement with shear wall at mid (mm)	
		X	Z	X	Z	X	Z
1	0	0	0	0.003	0.003	0.003	-0.034
2	3	6.78	9.311	0.941	1.069	0.68	1.274
3	6	17.089	22.332	2.587	2.87	1.822	3.266
4	9	27.835	35.673	4.588	5.04	3.141	5.593
5	12	38.481	48.858	6.877	7.522	4.6	8.18
6	15	48.759	61.59	9.384	10.246	6.164	10.946
7	18	58.388	73.527	12.029	13.124	7.784	13.795
8	21	67.038	84.264	14.714	16.05	9.397	16.609
9	24	74.331	93.328	17.325	18.897	10.918	19.243
10	27	79.852	100.195	19.708	21.492	12.238	21.533
11	30	83.284	104.406	21.749	23.71	13.259	23.347

Result of Analysis of 10 Storey
FIGURE 3: Displacement Graph (10 Storey building Displacement

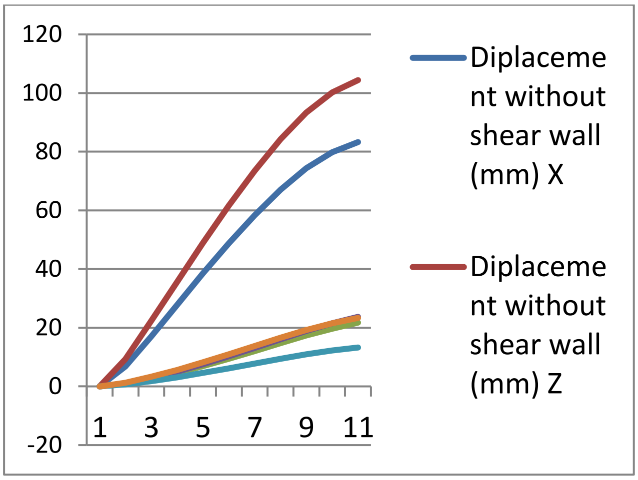
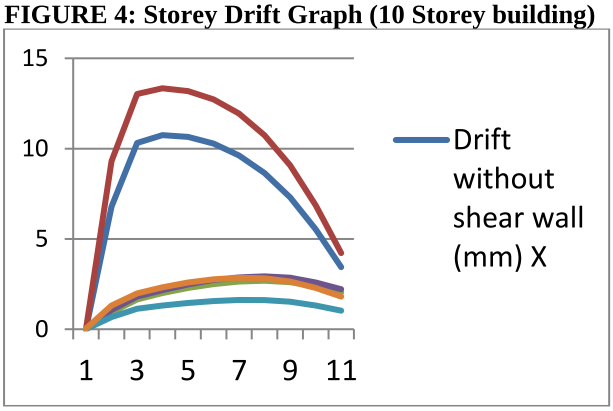


TABLE 2: Storey Drift (10 Storey building

Storey	Height (m)	Drift without shear wall (mm)		Drift with shear wall at corner(mm)		Drift with shear wall at mid (mm)	
		X	Z	X	Z	X	Z
1	0	0	0	0.003	0.003	0.003	0.034
2	3	6.78	9.311	0.938	1.066	0.677	1.308
3	6	10.309	13.021	1.646	1.801	1.142	1.992
4	9	10.746	13.34	2.001	2.17	1.319	2.328
5	12	10.646	13.185	2.289	2.482	1.459	2.587
6	15	10.278	12.732	2.507	2.724	1.564	2.766
7	18	9.629	11.938	2.645	2.878	1.621	2.849
8	21	8.65	10.736	2.685	2.927	1.613	2.814
9	24	7.293	9.065	2.611	2.847	1.521	2.634
10	27	5.521	6.866	2.383	2.595	1.319	2.29
11	30	3.432	4.211	2.041	2.218	1.021	1.814

FIGURE 4: Storey Drift Graph (10 Storey building)



IV. RESULTS AND CONCLUSION:

TABLE 3: Effect of the location of the shear wall on the displacement of the top storey

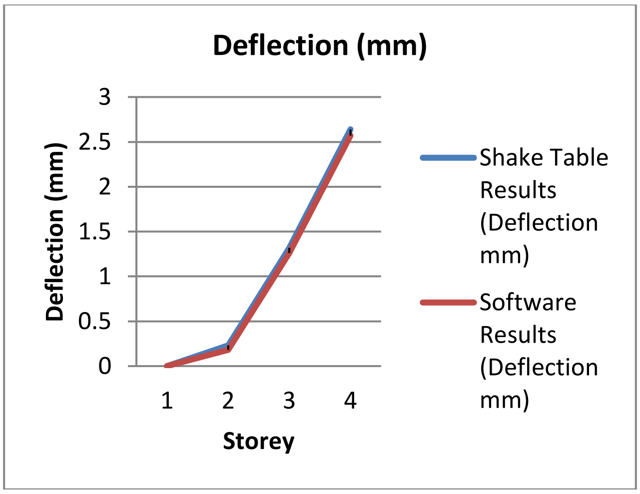
Storey	Height (m)	Displacement without shear wall (mm)		Displacement with shear wall at Corner (mm)		Displacement with shear wall at mid outer wall (mm)	
		X	Z	X	Z	X	Z
10	30	83.284	104.406	21.749	23.71	13.259	23.347

In 10 Storey building

- Displacement is reduced by 77.28%, when shear wall is used at the corners of the outer wall of building.
- Displacement is reduced by 77.63%, when shear wall is used at the mid of the outer wall of building.

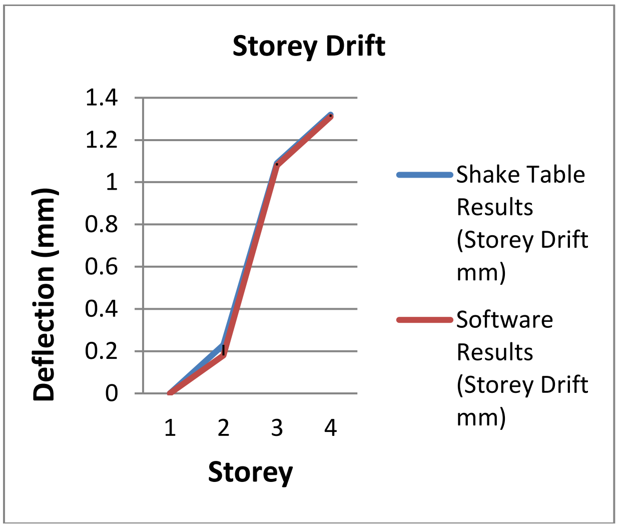
Shake Table Test Results

Storey	Height (mm)	Shake Table Results (Deflection mm)	Software Results (Deflection mm)
0	0	0	0
1	400	0.23	0.18
2	800	1.32	1.26
3	1200	2.64	2.57



Storey Drift (mm)

Sr. No.	Height (mm)	Shake Table Results (Storey Drift mm)	Software Results (Storey Drift mm)
0	0	0	0
1	400	0.23	0.18
2	800	1.09	1.08
3	1200	1.32	1.31



- Three storey building is modeled and analysed on STAAD-Pro Software and got the similar results of Displacement and storey Drift as of Shake Table Results.

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AUTHORS

First Author – **Kushalkumar** Yadav, Ph.D Scholar at Lovely Professional University, Punjab
ykushal94@gmail.com.

Second Author – Dr. R. L. Sharma, qualifications, Professor, Department of Civil Engineering at Lovely Professional University, Punjab
Sharma.23743@lpu.co.in.