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Seismic Effects on Building with & Without Shear Wall Using Strap

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Abstract

This paper deals with the effects of seismic forces on building with shear wall and building without shear wall like modal mass, story drift, weak stories etc.. And differentiates the observations between in them. Planning & analyzing of Multistoried building with and without shear wall. Building contains Stilt + Five floors. All external walls will be of 0.23m thick & internal walls will be of 0.115m thick. Each floor is assumed to be of height 3.0mIt is proposed as a framed structure one with Shear wall and another Without Shear wall. Analysis of the framed structure will be carried out by using STRAP - 2016.

Key Words: Shear wall, Seismic Effects, Strap, Modal Mass, Soft storey, Story drift, Structural Analysis Program.

1. INTRODUCTION

About STRAP

***STRAP* flagship program, covers the entire design process from analysis to the production of drawings and schedules. The program includes:**

- Design modules for calculating structural steel, reinforced concrete and post-tensioned elements subjected to static, dynamic, wind and seismic loads.
- A bridge load and analysis module.
- Auto STRAP, a BIM (Building Information Modeling) module to create a structural model from structural drawings.

*STRAP (*Structural Analysis Programs) is a Windows based suite of finite element static and dynamic analysis programs for buildings, bridges and other structures. It also includes modules for the design of steel sections (rolled and cold formed) and reinforced concrete (beams, columns, slabs, walls, footings) in accordance with Indian, American, European, Canadian and other international codes.

About Shear wall

In structural engineering, a shear wall is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on a structure. Wind and seismic [1] loads are the most common loads that shear walls are designed to carry. Under several building codes, including the International Building Code (where it is called a braced wall line) and Uniform Building Code, all exterior wall lines in wood or steel frame construction must be braced. Depending on the size of the building some interior walls must be braced as well.A structure of shear walls in the center of a large building—often encasing an elevator shaft or stairwell—forms a shear core.Yasser Alashker1, said In modern world, challenges for structural engineer increased due to various types of irregularities involve in the buildings as designed by the architects. In more slendrical buildings, the horizontal movement of the floors increases significantly which may lead to increment in drift and overturning effects of the earthquake. Therefore, damaging effects are more in short but long buildings during earthquake shaking. Generally, seismic calculations are done by assuming ground as a solid elastic base under the building. This assumption is applicable in buildings with small plan area.

2. IMPORTANT DEFINITIONS

Soft Storey: It is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storey’s above.

Storey Drift: It is the displacement of one level relative to the other level above or below.

Storey Shear: (Vi) It is the sum of design lateral forces at all levels above the storey under consideration.

Weak Storey: It is one in which the storey lateral strength is less than 80 percent of that in the storey above. The storey lateral strength is the total strength of all seismic force resisting elements sharing the storey shear in the considered direction.\

Number of Storey's: (n) Number of storeys of a building is the number of levels above the base. This excludes the basement storey's, where basement walls are connected with the ground floor deck or fitted between the building columns. But, it includes the basement storeys, when they are not so connected.

Shear Wall: It is a wall designed to resist lateral forces acting in its own plane.

Seismic Mass: It is the seismic weight divided by acceleration due to gravity

Seismic Weight: It is the total dead load plus appropriate amounts of specified imposed load.

1) Method For Frame Analysis:

Strap software is used for frame analysis. The soft ware is based on stiffness matrix method. The soft ware can be used for 2D & 3D analysis. However, for analysis is adjusted for 2D& 3D analysis is used.

INPUT/OUTPUT: As explained in load calculations live loads + dead loads as Vertical loads and earthquake loads as horizontal loads used for the analysis.

2) **Input data for Strap & considerations**

Load calculations
Dead load:
Dead load of walls:
Floor height = 3.00 - 0.60 = 2.40m
Dead load of 0.23 m thk. Wall = 0.23 x 2.40 x 19 = 11.40 KN/m
Parapet wall load = 0.23 x 0.9 x 19 = APROX 4.5 KN/m
Floor finishing Assuming = 1.6 KN/m2

Live loads:
For Typical floors = 4.0 KN/m2
For staircase live load = 4.0 KN/m2

Load Combinations:

Partial safety factors for limit state design of reinforced concrete and pre stressed concrete structures In the limit state design of reinforced and pre stressed concrete structures, the following load combinations shall be accounted for:

1.5(DL+lL)
2) 1.2(DL+ZL+EL)
3) 1.5(DL+EL)
4) 0.9DL*1.5EL

Table 18 Values of Partial Safety Factor γ_f for Loads
(*Clauses* 18.2.3.1, 36.4.1 *and* B-4.3)

Load Combination	Limit State of Collapse			Limit States of Serviceability		
	DL	*IL*	*WL*	*DL*	*IL*	*WL*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
DL + *IL*	1.5		1.0	1.0	1.0	-
DL + *WL*	1.5 or 0.9[1)]	-	1.5	1.0	-	1.0
DL + *IL* + *WL*	1.2			1.0	0.8	0.8

NOTES
1 While considering earthquake effects, substitute *EL* for *WL*.
2 For the limit states of serviceability, the values of γ_f given in this table are applicable for short term effects. While assessing the long term effects due to creep the dead load and that part of the live load likely to be permanent may only be considered.
[1)] This value is to be considered when stability against overturning or stress reversal is critical.

Fig1: Load combinations

Wind Load Calculations:

Wind loads will be calculated in accordance with IS 875: Part 3.

Design wind speed Vz = Vb x K1 x K2 x K3

For Main Tower Area

Vb Basic wind velocity for Hyderabad = 44 m/s
k1 Risk coefficient for a design life of 50 years = 1.00
k3 Topography factor = 1.00
K2 = 1.05
Vz = 44 x 1.00 x 1.05 x 1 =46.20m/sec
Design wind pressure (Pz) = 0.6 x Vz2
Pz = 0.6 x 46.202 =1281 N/m2 = 1.28 kN/m2

Seismic Parameters:

Seismic zone – II
Seismic ZONE FACTOR – 0.10
DAMPING RATIO- 5%
Response Reduction Factor- 3
Importance Factors- 1

Natural period of vibration (T,), in second
(T=0.09h/(√d))
= 0.09*18 / √40
= 0.25

The design horizontal seismic coefficient Ah for a structure shall be determined by the following expression

$$A_h = \frac{Z I S_a}{2 R g}$$

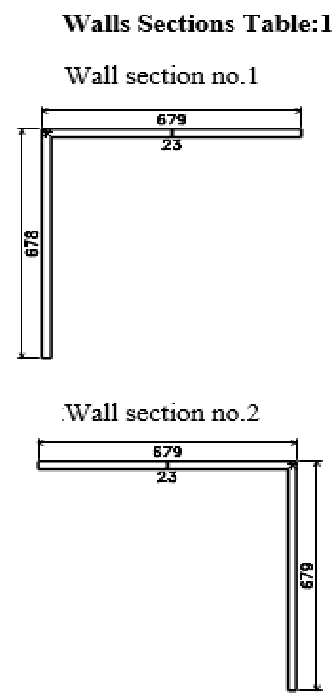
Where

Z = Zone factor given in table 2,(IS1893-2002) is for the maximum considered earthquake (MCE) nad service life of structure in a zone. The factor 2 in the denominator of Z is used so as to reduce the maximum considered earthquake (MCE) zone factor to the factor for design basis earthquake (DBE).

I = Importance factor, depending upon the functional use of the structures characterized by hazardous consequence of its failure, post-earthquake functional needs, historical value, or economic importance (table 6 of 1893-2002).

R = response reduction factor, depending on the perceived seismic damage performance of the structure, characterized by the ratio (I/R) shall not be greater than 1.0(table 7 1893-2002). The values of R for buildings are given in table 7.

Sa/g = Average response acceleration coefficient.



Walls Sections Table: 1

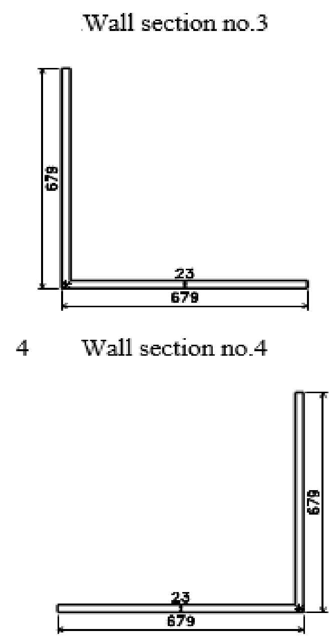


Fig2: Shear wall sketches

Planning of the building without shear wall

- We assumed an area of 40x40 i.e., 1600 square meters for the construction of a five storey Building.
- After this geometry is created in strap 2016 using nodes and connecting them with beams.
- We assumed an elevation of 18m, plinth height-1.5m; ground floor height -3m and typical floorheight-3m.
- The plan of the building can be seen below.

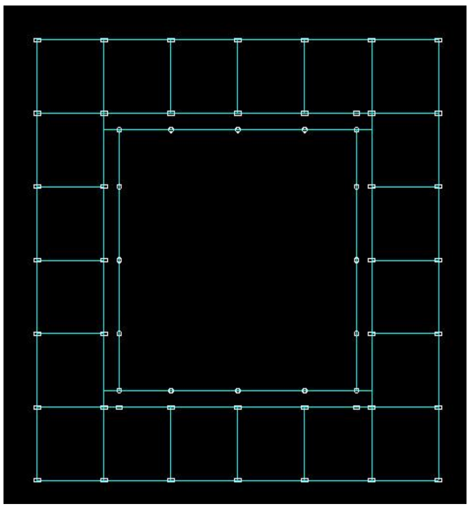


Fig3: Planning of the building without shear wall

Planning of the building with shear wall

- We assumed an area of 40x40 i.e., 1600 square meters for the construction of a five storey Building.
- After this geometry is created in strap 2016 using nodes and connecting them with beams & columns & shear wall.
- We assumed an elevation of 18m, plinth height-1.5m; ground floor height -3m and typical floorheight-3m.

The plan of the building can be seen below.

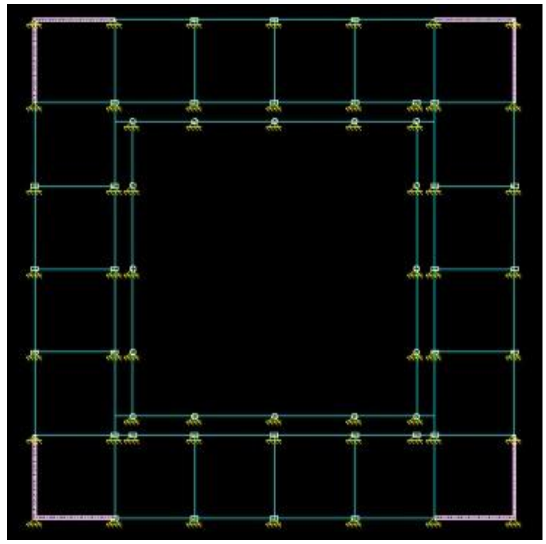


Fig4: Planning of the building without shear wall

Analysis results Comparison

Modal Results Output From Strap

Table: 1 Modal Results without Shear Wall

MODAL RESULTS WITHOUT SHEAR WALL							
Mo	*T*	*Wn/*	*Fn (kN)*	*On (m)*	*Vn (m/s*	*An (m/s**	*Fn'/ (Ah)*
1	1.4	0.85	5451.02	0.0526	0.07	0.10	0.02
2	1.1	0.00	0.01	0.0001	0.00	0.00	0.02
3	1.0	0.00	0.03	0.0000	0.00	0.00	0.03
4	0.4	0.09	1504.93	0.0048	0.02	0.08	0.06
Total sum		0.943	6956.00				
CQC		5654.95		0.0529	0.07	0.135	
	The Indian Standard IS 1893 (2002)						
Direction:		X2		Dampi	0.050		
	Type=Med I=1.5			3.	R=3.0		
100%		3.414 Ta=					

Table: 2 Modal Results with Shear Wall

MODAL RESULTS WITH SHEAR WALL							
Mode	*T*	*Wn/Wtot*	*Fn (kN)*	*Qn (m)*	*Vn (m/s)*	*An (m/s**2)*	*Fn'/Wn (Ah)*
1	0.4607	0.745	5476.20	0.006	0.0268	0.1167	0.062
2	0.4487	0.000	0.00	0.000	0.0000	0.0000	0.062
3	0.26	0.000	0.00	0.000	0.00	0.00	0.06
4	0.1129	0.192	1410.55	0.000	0.0027	0.0481	0.062
Total sum		0.937	6886.76				
CQC results			5654.95	0.0062	0.0269	0.1262	

The Indian Standard IS 1893 (2002)
Direction: X2 Damping= 0.050
Type=Medium I=1.5 Z=0.100R= 3. R=3.0
100% Scaling: 1.2992 Ta= 0.2500

Observations:

1. Modal mass participation is 90% in only 4 modes in both models**.**
2. Scaling factor changed with shear wall which is less than the model without shear wall.

3. **SHEAR FORCES RESULTS OUTPUT FROM STRAP**

Table: 3 Shear Forces without Shear W`1all

SHEAR FORCES WITHOUT SHEAR W`1ALL					
No.	*Level*	*Story forces*		*Base shear*	
		V1	*V2*	*V1*	*V2*
0	0.00				
1	3.00	0.89	869.76	15.07	5643.73
2	6.00	1.77	1320.67	14.21	5147.67
3	9.00	2.56	1294.40	12.49	4471.34
4	12.00	3.20	1162.07	9.98	3773.28
5	15.00	3.68	1442.76	6.81	2830.91
6	18.00	3.15	1410.40	3.15	1410.40

Table: 4 Shear Forces with Shear Wall

SHEAR FORCES WITH SHEAR WALL					
No.	*Level*	*Story forces*		*Base shear*	
		V1	*V2*	*V1*	*V2*
0	0.00				
1	3.00	0.60	549.78	3.43	5644.69
2	6.00	0.88	861.16	3.09	5321.03
3	9.00	0.87	1025.05	2.66	4765.71
4	12.00	0.71	1165.90	2.30	3997.81
5	15.00	0.85	1472.16	1.85	2950.49
6	18.00	1.03	1501.58	1.03	1501.58

Observations:

1. Base shears V1 with shear wall which is less than the model without shear wall.
2. Story forces V1 with shear wall which is less than the model without shear wall.

Story Drifts Results Output From Strap

Table5: Story Drifts without Shear Wall

STORY DRIFTS WITHOUT SHEAR WALL								
Height direction=X3, CQC over 1 to 1								
No.	*Level m*	*Height m*	*Drift mm*	*Max. Defl. mm*	*Min. Defl. mm*	*X1-Drift mm*	*X2-Drift mm*	*Weight X1/X2*
	0.00							
1	3.00	3.00	11.6	13.5	13.5	0.0	11.6	13293.
2	6.00	3.00	12.0	25.5	25.4	0.0	12.0	13293.
3	9.00	3.00	10.6	35.8	35.6	0.0	10.6	13293.
4	12.00	3.00	8.9	44.0	43.8	0.0	8.9	13293.
5	15.00	3.00	6.6	49.8	49.6	0.0	6.6	13293.
6	18.00	3.00	3.7	52.9	52.6	0.0	3.7	10408.
STORY DRIFTS WITH SHEAR WALL								
Height direction=X3, CQC over 1 to 1								
No.	*Level m*	*Height m*	*Drift mm*	*Max. Defl. mm*	*Min. Defl. mm*	*X1-Drift mm*	*X2-Drift mm*	*Weight X1/X2*
	0.00							
1	3.00	3.00	0.7	0.8	0.8	0.1	0.7	15217.
2	6.00	3.00	0.9	1.7	1.7	0.0	0.9	15217.
3	9.00	3.00	1.1	2.8	2.7	0.0	1.1	15217.
4	12.00	3.00	1.2	3.9	3.9	0.0	1.2	15217.
5	15.00	3.00	1.2	5.1	5.0	0.0	1.2	15217.
6	18.00	3.00	1.1	6.2	6.2	0.0	1.1	11890.

Observations:

1. Story drift with shear wall which is less than the model without shear wall.

Weak Stories Results Output From Strap

Table6:

WEAK STORIES WITHOUT SHEAR WALL						
Height direction=X3						
Allowable shear stress(mPa):Concrete= 0.60,Steel= 100.00						
No.	*Level* *m*	*Height* *m*	*X1-Shear*	*Ratio*	*X2-Shear*	*Ratio*
	0.00					
1	3.00	3.00	5560.09	1.00	3238.09	1.00
2	6.00	3.00	5560.09	1.00	3238.09	1.00
3	9.00	3.00	5560.09	1.00	3238.09	1.00
4	12.00	3.00	5560.09	1.00	3238.09	1.00
5	15.00	3.00	5560.09	1.00	3238.09	1.00
6	18.00	3.00	5560.09		3238.09	

Table7:

WEAK STORIES WITH SHEAR WALL						
Height direction=X3						
Allowable shear stress(mPa):Concrete= 0.60,Steel= 100.00						
No.	*Level* *m*	*Height* *m*	*X1-Shear*	*Ratio*	*X2-Shear*	*Ratio*
	0.00					
1	3.00	3.00	7944.09	1.00	6270.14	1.00
2	6.00	3.00	7944.09	1.00	6270.14	1.00
3	9.00	3.00	7944.09	1.00	6270.14	1.00
4	12.00	3.00	7944.09	1.00	6270.14	1.00
5	15.00	3.00	7944.09	1.00	6270.14	1.00
6	18.00	3.00	7944.09		6270.14	

Observations:

1. Story Resistance with shear wall is more than the model without shear wall. 13

Advantages and Disadvantages of Shear Walls in Reinforced Concrete Buildings:

Advantages:

1. Properly designed and detailed buildings with shear walls have shown very good performance in past earthquakes.
2. Shear walls are easy to construct, because reinforcement detailing of walls is relatively straightforward and therefore easily implemented at site.
3. Shear walls are efficient, both in terms of construction cost and effectiveness in minimizing earthquake damage in structural and nonstructural elements (like glass windows and building contents).

Disadvantages:

1. Shear walls present barriers, which may interfere with architectural and services requirement.
2. Lateral load resistance in shear wall buildings is usually concentrated on a few walls rather than on large number of columns.

4. Conclusion

The followings are the conclusions drawn from the study of seismic effects on buildings with and without shear walls. It is observed that the buildings with shear walls have more resistance towards the seismic effects compared to the buildings without shear walls. Story drift with shear wall which is less than the model without shear wall. Base shears V1 with shear wall which is less than the model without shear wall. Story forces V1 with shear wall which is less than the model without shear wall. Modal mass participation is 90% in only 4 modes in both models**.** Scaling factor changed with shear wall which is less than the model without shear wall.

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