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Dynamic Analysis of High Rise Building Structure with Shear Walls at the Centre Core

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Abstract:

In present work, Forty storey buildings (120m) have been modeled using software ETABS by dynamic analysis. All the analyses has been carried out as per the Indian Standard code books. Based on the literature of previous studies most effective positioning of shear walls has been chosen. This study is done on RC framed multistory building with RC shear walls with fixed support conditions. The usefulness of shear walls in the structural planning of multistory buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Incorporation of shear wall has become inevitable in multi-storey building to resist lateral forces. This paper aims to study the behaviour of reinforced concrete building by conducting dynamic analysis for most suited positions and location of shear wall. Estimation of structural response such as, storey displacements, base shear, storey drift is carried out. Dynamic responses under zone V earthquake as per IS 1893 (part 1): 2002 have been carried out. In dynamic analysis, Response Spectrum method is used.

Key words: shear wall, storey displacements, base shear, storey drift, Response Spectrum method, multi-storey building, lateral loads

INTRODUCTION:

Background

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. Properly designed and detailed buildings with shear walls have shown very good performance in past earthquakes. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarised in the quote:"We cannot afford to build concrete buildings meant to resist severe earthquakes without shear walls.":: Mark Fintel, a noted consulting engineer in USA. In modern tall buildings, shear walls are commonly used as a vertical structural element for resisting the lateral loads that may be induced by the effect of wind and earthquakes. Shear walls of varying cross sections i.e. rectangular shapes to more irregular cores such as channel, T, L, barbell shape, box etc. can be used.

Essentials of Structural Systems for Seismic Resistance

The primary purpose of all structural members used in buildings is to support gravity loads. However, buildings may also be subjected to lateral forces due to wind and earthquakes. The effects of lateral forces in buildings will be more significant as the building height increases. All structural systems will not behave equally under seismic excitation. Aspects of structural configuration, symmetry, mass distribution and vertical regularity must be considered. In addition to that, the importance of strength, stiffness and ductility in relation to acceptable response must be evaluated in structural system (Paulay and Priestley, 1992).

METHODOLOGY:

Earthquake motion causes vibration of the structure leading to inertia forces. Thus a structure must be able to safely transmit the horizontal and the vertical inertia forces generated in the super structure through the foundation to the ground. Hence, for most of the ordinary structures, earthquake-resistant design requires ensuring that the structure has adequate lateral load carrying capacity. Seismic codes will guide a designer to safely design the structure for its intended purpose.

1- Dynamic analysis.

    I. Response spectrum method.
    II. Time history method.

Dynamic Analysis

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution in different levels along the height of the building, and in the various lateral load resisting element, for the following buildings:

Regular buildings: Those greater than 40m in height in zones IV and V, those greater than 90m in height in zone II and III.

Irregular buildings: All framed buildings higher than 12m in zones IV and V, and those greater than 40m in height in zones II and III.

The analysis of model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities, as defined in Table 4 of IS code: 1893-2002 cannot be modeled for dynamic analysis. Dynamic analysis may be performed either by the

Time History Method or by the Response Spectrum Method .However in either method, the design base shear V_B shall be compared with a base shear V_B calculated using a fundamental period *Ta*. When V_B is less than V_B all the response quantities shall be multiplied by V_B /*Vb* The values of damping for a building may be taken as 2 and 5 percent of the critical, for the purpose of dynamic analysis of steel and reinforced concrete buildings, respectively.

Time History Method

The usage of this method shall be on an appropriate ground motion and shall be performed using accepted principles of dynamics. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of the structure.

Response Spectrum Method

The word spectrum in engineering conveys the idea that the response of buildings having a broad range of periods is summarized in a single graph. This method shall be performed using the design spectrum specified in code or by a site-specific design spectrum for a structure prepared at a project site. The values of damping for building may be taken as 2 and 5 percent of the critical, for the purposes of dynamic of steel and reinforce concrete buildings, respectively. For most buildings, inelastic response can be expected to occur during a major earthquake, implying that an inelastic analysis is more proper for design. However, in spite of the availability of nonlinear inelastic programs, they are not used in typical design practice because:

1- Their proper use requires knowledge of their inner workings and theories. design criteria, and
2- Result produced are difficult to interpret and apply to traditional design criteria , and
3- The necessary computations are expensive.

Therefore, analysis in practice typically use linear elastic procedures based on the response spectrum method. The response spectrum analysis is the preferred method because it is easier to use.

NUMERICAL ANALYSES:

Structural Modeling of Building

Due to time limitations, it was impossible to account accurately for all aspects of behavior of all the components and materials even if their sizes and properties were known. Thus, for simplicity, following assumptions were made for the structural modeling:

1. The materials of the structure were assumed as homogeneous, isotropic and linearly elastic.
2. The effects of secondary structural components and non structural components such as staircase, masonry infill walls were assumed to be negligible.
3. Floors slabs were assumed rigid in plane.
4. Foundation for analysis was considered as rigid.

Beams and columns were modeled as frame elements. Shear walls were modeled as plate elements. Floor slabs were modeled as rigid horizontal plane.

Details of the Building

A symmetrical building of plan 24.5m X 22.5m located with location in zone V, India is considered. Seven bays of length 3.5m along X - direction and five bays of length 4.5m along Y - direction are provided. Shear Wall is provided at the center core of the building model.

Table I: Details of the building

Building Parameters	Details
Type of frame	Special RC moment resisting frame fixed at the base
Building plan	24.5m X 22.5m
Number of storeys	Forty
Floor height	3.0 m
Depth of Slab	150 mm
Size of beam	(230 × 450) mm
Size of column (exterior)	(400 × 700) mm
Size of column (interior)	(500 × 500) mm
Spacing between frames	3.5 m along x - direction
	4.5m along y - direction
Live load on floor	2 KN/m2
Floor finish	1.0 KN/m2
Wall load	10 KN/m
Grade of Concrete	M 30 concrete
Grade of Steel	Fe415
Thickness of shear wall	230mm
Seismic zone	V
Density of concrete	25 KN/m3
Type of soil	Medium
Response spectra	As per IS 1893(Part-1):2002
Damping of structure	5 percent

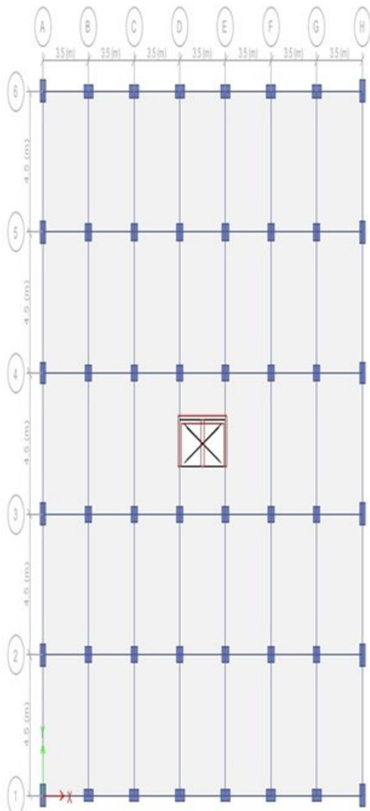
Structural Analysis

Initial dimensions of the structural elements for the buildings were assumed on the basis of gravity loads and imposed loads. Since, the buildings were assumed as apartment buildings, imposed load of 2 kN/m^2 and load due to floor finish were taken as 1.0 kN/m^2 as per Indian Standard, IS 875 (part2) : 1987. Lateral loads due to earthquake (EL) were calculated considering full dead load (DL) plus 25% of imposed load (IL), using seismic coefficient method given in IS 1893 (Part 1) : 2002.Since the buildings were assumed as apartment buildings with dual system (shear wall and special moment resisting frame) situated in seismic zone V, importance factor (I) = 1, zone factor (Z) = 0.36 and response reduction factor (R) = 5 as given in IS code were used for lateral load calculations.

Assuming medium type of soil on which the foundations rest and the damping ratio of 5% for concrete structure, average response acceleration coefficient (Sa/g) was obtained from IS code, depending on the approximate fundamental natural time period of the structure estimated. Assuming the floor is capable of providing rigid diaphragm action, total shear in any horizontal plane is distributed to the various vertical elements according to their relative stiffness. After several analyses in ETABS using equivalent static lateral force analysis for various load combinations given in IS 1893 (Part 1): 2002, final dimensions of the structural elements for further analyses of the buildings were obtained. The maximum percentage of reinforcements for structural elements was limited to 4% of concrete gross area as per IS 456 : 2000. Concrete grade of M30 i.e. characteristic compressive strength (fck) of 30 N/mm^2 was assumed for all structural elements. Material properties were assumed same for all structural elements used in both all the buildings. The material properties assumed for final structural analysis are as follows:

Modulus of elasticity (E) = 2.5×10^7 kN/m^2
Poisson's ratio (v) = 0.17
Unit weight of concrete (γ) = 25 kN/m^3

Layout of the Buildings



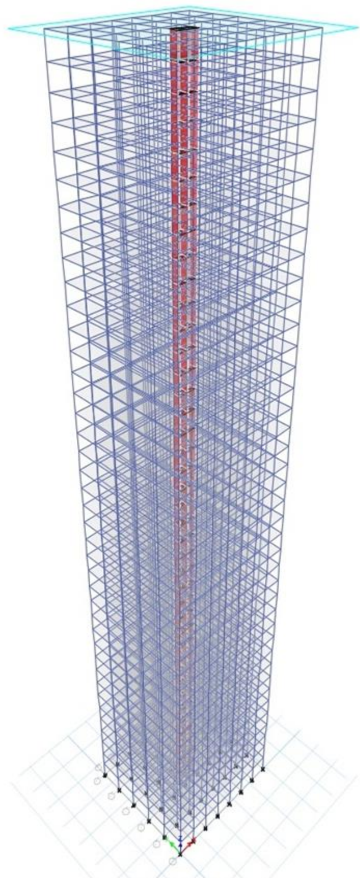


Figure 1, Plan of the building **Figure2, 3D view of the building**

Building Design Requirements

The proposed reinforced concrete shear wall buildings are located in zone V, India. Code requirements from IS 456 : 2000, IS 13920 : 1993 and IS 1893 (part 1) : 2002 were used for structural design.

In the ETABS design model, modeling was done in order to verify sufficient strength and stiffness. Rigid diaphragms, along with lumped masses, were assigned at each level.

Load combinations

As per IS 1893 (Part 1): 2002 Clause no. 6.3.1.2, the following load cases have to be considered for analysis:

1.5 (DL + IL)

1.2 (DL + IL ± EL)

1.5 (DL ± EL)

0.9 DL ± 1.5 EL

Earthquake load must be considered for +X, -X, +Y and –Y directions.

Design of beams

The flexural members shall fulfil the following general requirements. (IS 13920; Clause 6.1.2)

$$\frac{b}{D} \geq 0.3$$

In the present study beam of size (230 X 450) mm has been used.

Here, $\frac{b}{D} = \frac{230}{450} = 0.51 > 0.3$.

Hence, ok.

As per IS 13920; Clause 6.1.3

b ≥ 200 mm

Here b = 300 mm ≥ 200 mm

Hence, ok.

As per IS 13920; Clause 6.1.4

The depth D of the member shall preferably be not more than ¼ of the clearspan.

Here, D=450 mm and clear span length is 3000 mm.

¼ (clear span) = 3000/4 =750 mm > 450 mm

Hence, ok.

Check for reinforcement

As per IS 13920; Clause 6.2.1 (b)

The tension steel ratio on any face, at any section, shall not be less than $p_{min} = 0.24 \sqrt{f_{ck}}/f_y$

Therefore, $p_{min} = 0.361$ %

As per IS 13920; Clause 6.2.2

The maximum steel ratio on any face at any section, shall not exceed $p_{max} = 0.025$ or 2.5 %.

Design was carried out by the software and p_t values for critical members were noted down as follows;

Table (1) p_t values of most critical member of building model.

Building Model	p_t values
Model	**2.38**

Therefore, the model pass the reinforcement check.

Design of columns

Check for axial stress

As per IS 13920; Clause 6.1.1

The factored axial stress on the member under earthquake loading shall not exceed $0.1f_{ck}$ (=3 Mpa)

The factored axial stress values for the most critical member of each model were noted down as follows;

Table (2) Axial stress values of most critical member of building model.

Building Model	$Axial\ Stresses\ (Mpa)$
Model	**5.41**

The model does not satisfy the above clause. However, IS 13920 specifies another clause for this case.

Design requirements which have axial stress in excess of $0.1f_{ck}$

In the present study, the minimum dimension of the member provided is 500 mm. Also the shortest dimension provided is 500 mm. As per IS 13920; Clause 7.1.2, the minimum dimension of the member shall not be less than 200 mm.

Hence the above clause is in fulfillment of the building models.
Two types of columns were provided in the present study.
Column 1 has a cross section of 400 X 700 mm while Column 2 has 500 X 500 mm
Column 1; 400/700 =0.57 > 0.4.
Column 2; 500/500 = 1 > 0.4
As per IS 13920; Clause 7.1.3, the ratio of the shortest cross sectional dimension to the perpendicular dimension shall preferably not be less than 0.4.
Hence, both the columns satisfy the clause.
The column section shall be designed just above and just below the beam column joint, and larger of the two reinforcements shall be adopted. This is similar to what is done for design of continuous beam reinforcements at the support. The end moments and end shears are available from computer analysis.
The design moment should include:
(a) The additional moment if any, due to long column effect as per clause 39.7 of IS 456:2000.
(b) The moments due to minimum eccentricity as per clause 25.4 of IS 456:2000.
The longitudinal reinforcements are designed as per IS 456 : 2000

Reinforcement check:

Design was carried out by the software and p_t values for critical members were noted down as follows;

Table (3) p_t values of most critical member of building model

Building Model	**p_t values**
Model	**3.61**

As per IS 456 : 2000; Clause 26.5.3.1(a) the cross sectional area of longitudinal reinforcement, shall not be less than 0.8 % nor more than 6 % of the gross cross sectional area of the column. It should be noted that percentage of steel should not exceed 4 %

since it may involve practical difficulties. Therefore, all the models pass the reinforcement check.

Results and Discussions:

Table (4) Storey Maximum Displacement in X and Y directions

Storey	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
Storey40	120	Top	159.7	184.7
Storey39	117	Top	157.7	182.6
Storey38	114	Top	155.6	180.4
Storey37	111	Top	153.3	177.9
Storey36	108	Top	150.9	175.2
Storey35	105	Top	148.4	172.4
Storey34	102	Top	145.6	169.3
Storey33	99	Top	142.7	166
Storey32	96	Top	139.6	162.6
Storey31	93	Top	136.4	158.9
Storey30	90	Top	133	155.1
Storey29	87	Top	129.5	151.1
Storey28	84	Top	125.8	146.9
Storey27	81	Top	122	142.5
Storey26	78	Top	118	138
Storey25	75	Top	113.9	133.3
Storey24	72	Top	109.7	128.5
Storey23	69	Top	105.4	123.5
Storey22	66	Top	101	118.5
Storey21	63	Top	96.5	113.3
Storey20	60	Top	91.9	108
Storey19	57	Top	87.2	102.5
Storey18	54	Top	82.4	97
Storey17	51	Top	77.6	91.4
Storey16	48	Top	72.7	85.8
Storey15	45	Top	67.7	80
Storey14	42	Top	62.7	74.2
Storey13	39	Top	57.6	68.4
Storey12	36	Top	52.6	62.5
Storey11	33	Top	47.5	56.6
Storey10	30	Top	42.3	50.7
Storey9	27	Top	37.2	44.8
Storey8	24	Top	32.2	39
Storey7	21	Top	27.1	33.1
Storey6	18	Top	22.2	27.3
Storey5	15	Top	17.4	21.6
Storey4	12	Top	12.8	16.1
Storey3	9	Top	8.5	10.8
Storey2	6	Top	4.6	5.9
Storey1	3	Top	1.6	2
Base	0	Top	0	0

Table (5) Storey Stiffness, Shears and Drifts in X and Y directions

Storey	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
	kN	mm	kN/m	kN	mm	kN/m
Storey40	224.6334	2.1	106307.139	194.5015	2.2	88031.566
Storey39	443.2425	2.3	195016.253	389.4282	2.4	161363.415
Storey38	637.7084	2.4	261581.299	568.8191	2.7	214551.185
Storey37	806.8778	2.6	308049.421	730.7175	2.9	251906.2
Storey36	951.2061	2.8	339543.957	874.444	3.1	278086.943
Storey35	1073.134	3	360441.836	1000.917	3.4	296554.211
Storey34	1176.979	3.1	374417.592	1112.579	3.6	309873.71
Storey33	1268.349	3.3	384388.695	1212.988	3.8	319962.958
Storey32	1353.151	3.4	392553.909	1306.153	4	328241.104
Storey31	1436.4	3.6	400386.497	1395.742	4.2	335690.413
Storey30	1521.226	3.7	408639.048	1484.384	4.3	342889.012
Storey29	1608.437	3.9	417436.469	1573.274	4.5	350065.026
Storey28	1696.791	4	426475.143	1662.203	4.7	357191.568
Storey27	1783.816	4.1	435274.537	1749.961	4.8	364108.108
Storey26	1866.842	4.2	443402.097	1834.945	5	370636.368
Storey25	1943.911	4.3	450618.709	1915.772	5.1	376663.712
Storey24	2014.334	4.4	456933.201	1991.716	5.2	382183.284
Storey23	2078.822	4.5	462580.025	2062.89	5.3	387294.099
Storey22	2139.191	4.6	467941.743	2130.155	5.4	392171.171
Storey21	2197.755	4.6	473439.62	2194.797	5.5	397018.197
Storey20	2256.577	4.7	479419.93	2258.084	5.6	402016.538
Storey19	2316.811	4.8	486068.409	2320.852	5.7	407284.919
Storey18	2378.365	4.8	493380.872	2383.232	5.8	412861.881
Storey17	2439.979	4.9	501199.478	2444.63	5.8	418715.994
Storey16	2499.693	4.9	509299.44	2503.945	5.9	424779.242
Storey15	2555.535	4.9	517494.738	2559.959	5.9	430991.51
Storey14	2606.19	5	525731.383	2611.762	6	437342.242
Storey13	2651.475	5	534148.295	2659.09	6	443898.53
Storey12	2692.458	5	543099.449	2702.47	6	450814.369
Storey11	2731.201	4.9	553142.432	2743.108	6	458321.329
Storey10	2770.149	4.9	565010.475	2782.558	6	466706.627
Storey9	2811.343	4.9	579602.554	2822.226	5.9	476292.461
Storey8	2855.673	4.8	598051.895	2862.865	5.9	487443.142
Storey7	2902.432	4.7	621970.298	2904.202	5.8	500650.2
Storey6	2949.333	4.5	654040.791	2944.837	5.7	516803.882
Storey5	2992.997	4.3	699360.509	2982.452	5.5	537941.987
Storey4	3029.794	3.9	768740.752	3014.301	5.3	569394.702
Storey3	3056.803	3.4	888768.447	3037.887	4.8	627225.11
Storey2	3072.701	2.7	1140590.018	3051.77	3.9	772771.069
Storey1	3078.425	1.4	2222044.018	3056.555	2	1563559.018

Table (6) Modes and periods

Case	Mode	Period sec	UX	UY	Sum UX	Sum UY
Modal	1	6.669	0	0.7617	0	0.7617
Modal	2	6.046	0.7471	0	0.7471	0.7617
Modal	3	5.318	0.0031	0	0.7502	0.7617
Modal	4	2.117	0	0.1201	0.7502	0.8818
Modal	5	1.887	0.1191	0	0.8693	0.8818
Modal	6	1.758	0.0036	0	0.8729	0.8818
Modal	7	1.165	0	0.0382	0.8729	0.92
Modal	8	1.05	0.0072	0	0.8801	0.92
Modal	9	1.004	0.0327	0	0.9128	0.92
Modal	10	0.797	0	0.02	0.9128	0.9399
Modal	11	0.738	0.0014	0	0.9142	0.9399
Modal	12	0.671	0.0206	0	0.9348	0.9399

Here the minimum modal mass for accelerations Ux and Uy is 93.48 % and 93.99 % respectively.

Mode Shape

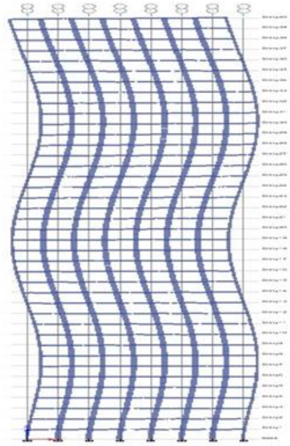


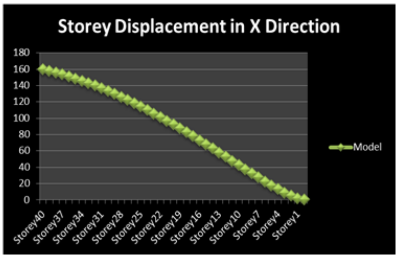
Figure3, Mode shape for model

Storey Maximum Displacements

Table (7) Maximum Storey Displacements in X Direction for model

Storey level	Elevation(m)	Model
Storey40	120	159.7
Storey39	117	157.7
Storey38	114	155.6
Storey37	111	153.3
Storey36	108	150.9
Storey35	105	148.4
Storey34	102	145.6
Storey33	99	142.7
Storey32	96	139.6
Storey31	93	136.4
Storey30	90	133
Storey29	87	129.5
Storey28	84	125.8
Storey27	81	122
Storey26	78	118
Storey25	75	113.9
Storey24	72	109.7
Storey23	69	105.4
Storey22	66	101
Storey21	63	96.5
Storey20	60	91.9
Storey19	57	87.2
Storey18	54	82.4
Storey17	51	77.6
Storey16	48	72.7
Storey15	45	67.7
Storey14	42	62.7
Storey13	39	57.6
Storey12	36	52.6
Storey11	33	47.5
Storey10	30	42.3
Storey9	27	37.2
Storey8	24	32.2
Storey7	21	27.1
Storey6	18	22.2
Storey5	15	17.4
Storey4	12	12.8
Storey3	9	8.5
Storey2	6	4.6
Storey1	3	1.6
Base	0	0

All values are in mm



COMPARISON OF RESULTS:

Storey Maximum Displacements

Table (8) Maximum Storey Displacements in Y Direction for model

Storey Level	Elevation (m)	Model
Storey40	120	184.7
Storey39	117	182.6
Storey38	114	180.4
Storey37	111	177.9
Storey36	108	175.2
Storey35	105	172.4
Storey34	102	169.3
Storey33	99	166
Storey32	96	162.6
Storey31	93	158.9
Storey30	90	155.1
Storey29	87	151.1
Storey28	84	146.9
Storey27	81	142.5
Storey26	78	138
Storey25	75	133.3
Storey24	72	128.5
Storey23	69	123.5
Storey22	66	118.5
Storey21	63	113.3
Storey20	60	108
Storey19	57	102.5
Storey18	54	97
Storey17	51	91.4
Storey16	48	85.8
Storey15	45	80
Storey14	42	74.2
Storey13	39	68.4
Storey12	36	62.5
Storey11	33	56.6
Storey10	30	50.7
Storey9	27	44.8
Storey8	24	39
Storey7	21	33.1
Storey6	18	27.3
Storey5	15	21.6
Storey4	12	16.1
Storey3	9	10.8
Storey2	6	5.9
Storey1	3	2
Base	0	0

All values are in mm

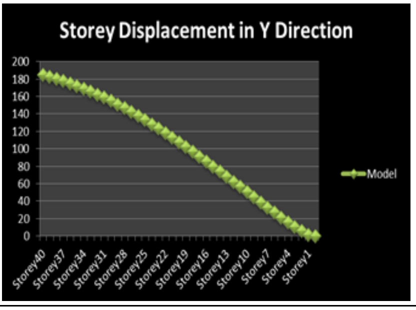


Table (9) Storey drifts in X direction

Storey	Model
Storey40	2.1
Storey39	2.3
Storey38	2.4
Storey37	2.6
Storey36	2.8
Storey35	3
Storey34	3.1
Storey33	3.3
Storey32	3.4
Storey31	3.6
Storey30	3.7
Storey29	3.9
Storey28	4
Storey27	4.1
Storey26	4.2
Storey25	4.3
Storey24	4.4
Storey23	4.5
Storey22	4.6
Storey21	4.6
Storey20	4.7
Storey19	4.8
Storey18	4.8
Storey17	4.9
Storey16	4.9
Storey15	4.9
Storey14	5
Storey13	5
Storey12	5
Storey11	4.9
Storey10	4.9
Storey9	4.9
Storey8	4.8
Storey7	4.7
Storey6	4.5
Storey5	4.3
Storey4	3.9
Storey3	3.4
Storey2	2.7
Storey1	1.4

All values are in mm

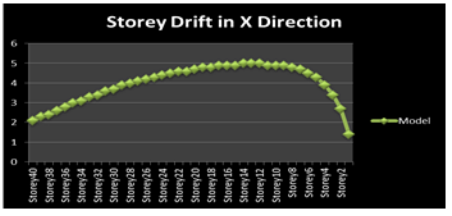
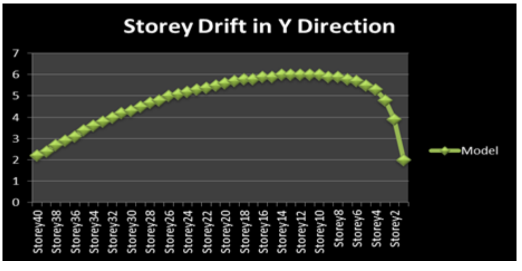


Table (10) Storey drifts in Y direction

Storey	Model
Storey40	2.2
Storey39	2.4
Storey38	2.7
Storey37	2.9
Storey36	3.1
Storey35	3.4
Storey34	3.6
Storey33	3.8
Storey32	4
Storey31	4.2
Storey30	4.3
Storey29	4.5
Storey28	4.7
Storey27	4.8
Storey26	5
Storey25	5.1
Storey24	5.2
Storey23	5.3
Storey22	5.4
Storey21	5.5
Storey20	5.6
Storey19	5.7
Storey18	5.8
Storey17	5.8
Storey16	5.9
Storey15	5.9
Storey14	6
Storey13	6
Storey12	6
Storey11	6
Storey10	6
Storey9	5.9
Storey8	5.9
Storey7	5.8
Storey6	5.7
Storey5	5.5
Storey4	5.3
Storey3	4.8
Storey2	3.9
Storey1	2

All values are in mm



As per Indian standard, Criteria for earthquake resistant design of structures, IS 1893 (Part 1): 2002, the story drift in any story due to service load shall not exceed 0.004 times the story height.

The height of the each storey is 3 m. So, the drift limitation as per IS 1893 (part 1): 2002 is 0.004 X 3 m = 12 mm. The model show a similar behaviour for storey drifts as shown in graph.

Base Shears

Table (11) Base shears in X&Y direction

Model	**Base Shears in X (kN)**
Model	3078.425
Model	**Base Shears in Y(kN)**
Model	3056.555

Modal Results

Table (12) Modes and natural periods

Case	Mode	Natural Periods(sec)
Modal	1	6.669
Modal	2	6.046
Modal	3	5.318
Modal	4	2.117
Modal	5	1.887
Modal	6	1.758
Modal	7	1.165
Modal	8	1.05
Modal	9	1.004
Modal	10	0.797
Modal	11	0.738
Modal	12	0.671

Table (13) Modal Masses

Model	**Dynamic %**	
	Acceleration Ux	**Acceleration Uy**
Model	93.48	93.99

According to IS-1893:2002 the number of modes to be used in the analysis should be such that the total sum of modal masses of all modes considered is at least 90 percent of the total seismic mass.

CONCLUSION AND RECOMMENDATIONS:

Conclusions

In this paper, reinforced concrete shear wall buildings were analyzed with the procedures laid out in IS codes.

From the above results and discussions, following conclusions can be drawn:

1. For both X and Y directions, the behaviour of the graph is similar for the model as shown. The Maximum Storey Displacement was observed for model at 159.7 mm and 184.7 mm in X and Y direction respectively. The order of maximum storey displacement in both the directions for model is same.
2. The location of shear walls in the outermost perimeter considerably reduce the effects of displacements and drifts.
3. Shear Walls must be coinciding with the centroid of the building for better performance. It follows that a centre core Shear wall should be provided.
4. Shear walls are more effective when located along exterior perimeter of the building. Such a layout increases resistance of the building to torsion.
5. Based on the analysis and discussion ,shear wall are very much suitable for resisting earthquake induced lateral forces in multistoried structural systems when compared to multistoried structural systems whit out shear walls. They can be made to behave in a ductile manner by adopting proper detailing techniques.
6. The vertical reinforcement that is uniformly distributed in the shear wall shall not be less than the horizontal

reinforcement .This provision is particularly for squat walls (i.e. Height-to-width ratio is about 1.0).However ,for walls whit height-to-width ratio less than 1.0, a major part of the shear force is resisted by the vertical reinforcement. Hence ,adequate vertical reinforcement should be provided for such walls.

7. Shear walls must provide the necessary lateral strength to resist horizontal earthquake forces.
8. When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path below them, such as other shear walls, floors, foundation walls, slabs or footings.
9. Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive side-sway.

Recommendations

Different assumptions and limitations have been adopted for simplicity in modeling the proposed structures. In reality, it might affect on results. Thus, all factors which may influence on the behaviour of the structures should be considered in the modeling. For the further study, to obtain the real responses of the structures, the following recommendations are made:

1. Since the study was performed for only one type of shear wall, the further investigations should be made for different types of shear walls.
2. Further investigations should be done for shear walls with different aspect ratio (h/L), in frame-shear wall structures.
3. A flexible foundation will affect the overall stability of the structure by reducing the effective lateral stiffness. So the soil structure interaction should be considered in further study.
4. Shear wall structure have been shown to perform well in earthquakes, for which ductility becomes an important consideration. Thus, further study should be made

considering geometric and material non-linear behavior of the members concerned.

The study was performed for a damping ratio of 5% for all models. Further studies should be carried out for damping ratious of 10%, 15% and so on.

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