COMPARATIVE STUDY ON SEISMIC ANALYSIS OF MULTISTOREY BUILDING STIFFENED WITH BRACING AND SHEAR WALL.

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Abstract - *This research work focuses on comparison of seismic analysis of G+15 building stiffened with bracings and shear wall. The performance of the building is analyzed in Zone II, Zone III, Zone IV, Zone V. The study includes understanding the main consideration factor that leads the structure to perform poorly during earthquake in order to achieve their appropriate behavior under future earthquakes. The analyzed structure is symmetrical, G+15, Ordinary RC moment-resting frame (OMRF). Modelling of the structure is done as per staad pro. V8i software. Time period of the structure in both the direction is retrieve from the software and as per IS 1893(part 1):2002 seismic analysis has undergone. The Lateral seismic forces of RC frame is carried out using linear static method as per IS 1893(part 1) : 2002 for different earthquake zones. The scope of present work is to understand that the structures need to have suitable Earthquake resisting features to safely resist large lateral forces that are imposed on them during Earthquake. Shear walls are efficient, both in terms of construction cost and effectiveness in minimizing Earthquake damage in structure. Also the braced frames can absorb great degree of energy exerted by earthquake.. The results of the performance and the analysis of the models are then graphically represented and also in tabular form and is compared for determining the best performance of building against lateral stiffness by arrangement of three different types of bracings with three different orientation of bracings and shear wall. A comparative analysis is done in terms of Base shear, Displacement, Axial load, Moments in Y and Z direction in columns and shear forces, maximum bending moments, max Torsion in beams.*

Key Words: *Seismic analysis, Bracings, Shear Wall, Lateral Stiffness, Indian code IS 1893:2002 and OMRF.*

1. INTRODUCTION
1.1 Overview

The tallness of a building is relative and cannot be defined in absolute terms either in relation to height or the number of stories. But, from a structural engineer's point of view the tall building or multi-storied building can be defined as one that, by virtue of its height, is affected by lateral forces due to wind or earthquake or both to an extent that they play an important role in the structural design. Tall structures have fascinated mankind from the beginning of civilization. The Egyptian Pyramids, one among the seven wonders of world, constructed in 2600 B.C. are among such ancient tall structures. Such structures were constructed for defense and to show pride of the population in their civilization. The growth in modern multi-storied building construction, which began in late nineteenth century, is intended largely for commercial and residential purposes.
The design of tall buildings essentially involves a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The design criteria are, strength, serviceability, stability and human comfort.

Earthquakes have become a frequent event all over the world. It is very difficult to predict the intensity, location, and time of occurrence of earthquake. Structures adequately designed for usual loads like dead, live, wind etc may not be necessarily safe against earthquake loading. It is neither practical nor economically viable to design structures to remain within elastic limit during earthquake. The design approach adopted in the Indian Code IS 1893(Part I): 2002 'Criteria for Earthquake Resistant Design Of Structures' is to ensure that structures possess at least a minimum strength to withstand minor earthquake occurring frequently, without damage; resist moderate earthquakes without significant structural damage though some non-structural damage may occur; and aims that structures withstand major earthquake without collapse.

Structures need to have suitable earthquake resistant features to safely resist large lateral forces that are imposed on them during frequent earthquakes. Ordinary structures for houses are usually built to safely carry their own weights. Low lateral loads caused by wind and therefore, perform poorly under large lateral forces caused by even moderate size earthquake. These lateral forces can produce the critical stresses in a structure, set up undesirable vibrations and, in addition, cause lateral sway of structure, which could reach a stage of discomfort to the occupants.

Shear wall is one of the most commonly used lateral load resisting element in high rise building. Shear wall (SW) has high in plane stiffness and strength which can be used simultaneously to resist large horizontal load and support gravity load. The scope of present work is to study and investigate the effectiveness of RC shear wall in medium rise building.

Reinforced concrete shear walls are used in Bare frame building to resist lateral force due to wind and earthquakes. They are usually provided between column lines, in stair wells, lift wells, in shafts. Shear wall provide lateral load resisting by transferring the wind or earthquake load to foundation. Besides, they impart lateral stiffness to the system and also carry gravity loads. But bare frame with shear wall still become economically unattractive. If the structural engineers consider property the non-structural element in structural design along with other elements like shear wall gives better results.

The most effective and practical method of enhancing the seismic resistance is to increase the energy absorption capacity of structures by combining bracing elements in the frame. The braced frame can absorb a greater degree of energy exerted by earthquakes. Bracing members are widely used in steel structures to reduce lateral displacement and dissipate energy during strong ground motions. This concept extended to concrete frames. The various aspects such as size and shape of building, location of shear wall and bracing in building, distribution of mass, distribution of stiffness greatly affect the behaviors of structures. Bracing system improves the seismic performance of the frame by increasing its lateral stiffness and capacity. To the addition of bracing system load could be transferred out of the frame and into the braces, by passing the weak columns. The stiffness added by the bracing system is maintained almost up to the peak strength. Stiffness is particularly important at serviceability state, where deformations are limited to prevent damage.

1.2 Objective of the Project

Tall building developments have been rapidly increasing worldwide. The growth of multistory building in the last several decades is seen as the part of necessity for vertical expansion for business as well as residence in major cities. It is observed that there is a need to study the structural systems for R.C.C framed structure, which resists the lateral loads due to seismic effect. Safety and minimum damage level of a structure could be the prime requirement of tall buildings. To meet these requirements, the structure should have adequate lateral strength, lateral stiffness and sufficient ductility. Among the various structural systems, shear wall frame or braced concrete frame could be a point of choice for designer. Therefore, it attracts to review and observe the behavior of these structural systems under seismic effect. Hence, it is proposed to study the dynamic behavior of reinforced concrete frame with and without shear wall and steel braced frame. The purpose of this study is to compare the seismic response of above structural systems. Axial forces and moments in members and floor displacements will be compared.

The most effective and practical method of enhancing the seismic resistance is to increase the energy absorption capacity of structures by combining bracing elements in the frame. The braced frame can absorb a greater degree of energy exerted by earthquakes.

The present study is an effort towards analysis of the structure during the earthquake. G+15stories residential building is considered. To analyze a multi-storeyed RC framed building considering different earthquake intensities II, III, IV and V by response spectra method and find the base shear value for different structures.

Seismic analysis of RC frame with bare and different position of shear wall and braced frame is carried out using Linear static analysis method as per IS 1893 (Part I): 2002[22] by using STAAD-PRO software .For this analysis different types of models are considered and comparison of seismic performance is carried out.

1.3 Methodology

The methodology worked out to achieve the mentioned objectives is as follows:

1. Modeling of the selected building in Staad pro. V8i Software.
2. Retrieved time period of structure from the software.
3. Thirteen models as per the Indian code specification were prepared. Models including Bare frame, frames with shear walls and frames with bracings.
4. Applied calculated Lateral seismic forces and load combinations as per IS 1893-2002.

Analyzed the models for axial forces, moments, lateral displacements, max shear force and max torsion and graphical and tabular representation of the data is presented.

1.3.1 Time period

The Equivalent static methods works on seismic coefficient, which rely on the natural time period of vibration of the structure, the earthquake resistance design of the structures requires time period to calculate the base shear. The time period of the structure has been taken from the Staad pro software.

Time period in X- direction = 1.02
Sa/g = 1.33
Time period in Y- direction= 1.44
Sa/g = 0.94

1.3.2 Load Combinations

Load combinations that are to be used for Limit state Design of reinforced concrete structure are listed below.

(1) 1.5(DL + LL)
(2) 1.2(DL + LL ± EQ - X)
(3) 1.2(DL + LL ± EQ - Y)
(4) 1.5(DL ± EQ - X)
(5) 1.5(DL ± EQ - Y)
(6) 0.9DL ± 1.5EQ - X
(7) 0.9DL ± 1.5EQ – Y

1.3.2 Distribution of the horizontal seismic forces:

Load and base shear calculation has been done as per IS 1893-2002. The base shear is calculated and distributed throughout the height at each floor of the building and the lateral seismic force induced at any level is determined.

Indian standards IS-1893:2002:

IS 1893:2002 is denoted as "Criteria for earthquake resistant Design of structures" Part 1 General provisions and buildings.
The design lateral force shall first be computed for the building as a whole. Thedesign lateral force shall then be distributed to the various floor levels. This overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action.
The design base shear calculated shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i h_i^k}{\sum_{j=1}^{n} W_j h_j^k}$$

1.3.3 Mass and Base shear calculatons:

ZONE	MODEL TYPE	TOTAL MASS KN	BASE SHEAR in X- dir KN	BASE SHEAR in Z- dir KN
II	BF	51161.4	1136.64	804.94
	DB1	51246.58	1138.53	806.28
	DB2	51225.29	1138.06	805.94
	DB3	51246.58	1138.53	806.28
	VB1	51331.76	1140.42	807.62
	VB2	51289.17	1139.47	806.95
	VB3	51331.76	1140.42	807.62
	XB1	51331.76	1140.42	807.62
	XB2	51289.17	1139.47	806.95
	XB3	51331.76	1140.42	807.62
	SW1	37518	833.52	587.78
	SW2	36557.55	812.19	572.73
	SW3	46864.05	1041.16	737.33
III	BF	51161.4	1818.62	1287.9
	DB1	51246.58	1821.65	1290.05
	DB2	51225.29	1820.89	1289.51
	DB3	51246.58	1821.65	1290.05
	VB1	51331.76	1824.67	1292.19
	VB2	51289.17	1823.16	1291.12
	VB3	51331.76	1824.67	1292.19
	XB1	51331.76	1824.67	1292.19
	XB2	51289.17	1823.16	1291.12
	XB3	51331.76	1824.67	1292.19
	SW1	37518	1333.64	940.45
	SW2	36557.55	1299.5	916.38
	SW3	46864.05	1665.86	1179.72
IV	BF	51161.4	2727.93	1931.85
	DB1	51246.58	2732.47	1935.07
	DB2	51225.29	2731.33	1934.27
	DB3	51246.58	2732.47	1935.07
	VB1	51331.76	2737.01	1938.29
	VB2	51289.17	2734.74	1936.68
	VB3	51331.76	2737.01	1938.29
	XB1	51331.76	2737.01	1938.29
	XB2	51289.17	2734.74	1936.68
	XB3	51331.76	2737.01	1938.29
	SW1	37518	2000.46	1410.68
	SW2	36557.55	1949.25	1374.56
	SW3	46864.05	2498.79	1769.59

Mass calculations and base shear are summarized as:

ZONE	MODEL TYPE	TOTAL MASS KN	BASE SHEAR in X- dir KN	BASE SHEAR in Z- dir KN
V	BF	51161.4	4091.89	2897.78
	DB1	51246.58	4098.7	2902.61
	DB2	51225.29	4097	2901.4
	DB3	51246.58	4098.7	2902.61
	VB1	51331.76	4105.51	2907.43
	VB2	51289.17	4102.11	2905.02
	VB3	51331.76	4105.51	2907.43
	XB1	51331.76	4105.51	2907.43
	XB2	51289.17	4102.11	2905.02
	XB3	51331.76	4105.51	2907.43
	SW1	37518	3000.69	2116.02
	SW2	36557.55	2923.87	2061.85
	SW3	46864.05	3748.19	2654.38

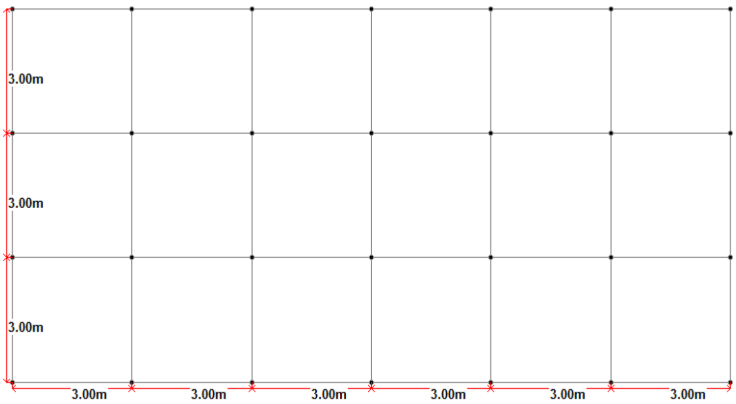
1.3.3 Specifications

The specifications used in modeling are

Sr. No	Parameters	Dimensions/Type
1	Plan dimension	18m x 9 m
2	Number of stories	G+15
3	Total height of building	48m
4	Height of each storey	3m
5	Column size	230 X 600 mm
6	Beam size	230 x 400 mm
7	Grade of concrete	M20
8	Frame type	OMRF
9	Soil type	Medium soil
10	Live load	3 KN/sq.m
11	Floor finish	1 KN/sq.m
12	Inner wall	230 mm
13	Outer wall	230 mm
14	Slab thickness	230mm
15	Unit weights of Concrete	25 KN/Cum
16	Unit weights of brick work	19 KN/Cum
17	Shear wall thickness	200mm
18	Section for steel bracing	ISA 110 X 110 X 10mm

1.3.4 Modeling:

This building has been modeled as 3D Space frame model with six degree of freedom at each node using STAAD - PRO, software for stimulation of behavior under gravity



and seismic loading. The isometric 3D view and plan of the building model is shown as figure. The support condition is considered as fully fixed.

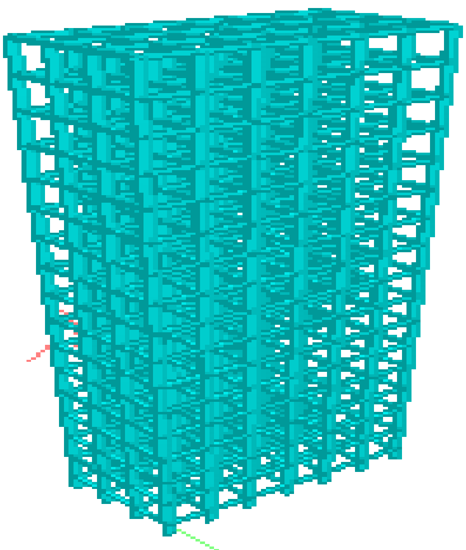
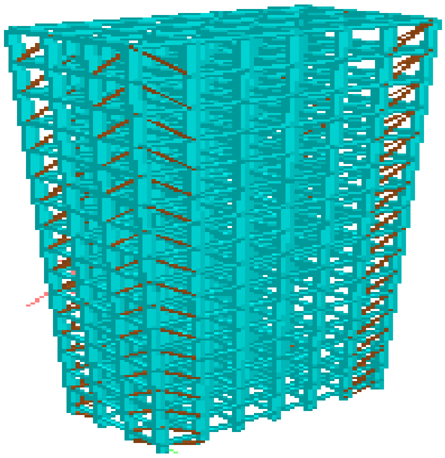


Fig-1: Plan of the selected building

Fig-2: 3D View of the selected building



ig-3: Building with diagonal bracings at corner (DB1)

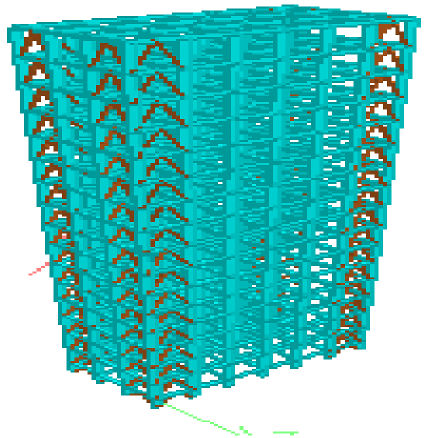


Fig-5: Building with diagonal bracings at outer and inner position (DB3)

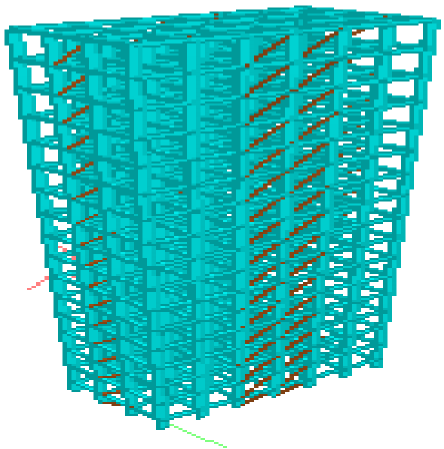


Fig-4: Building with diagonal bracings at periphery (DB2)

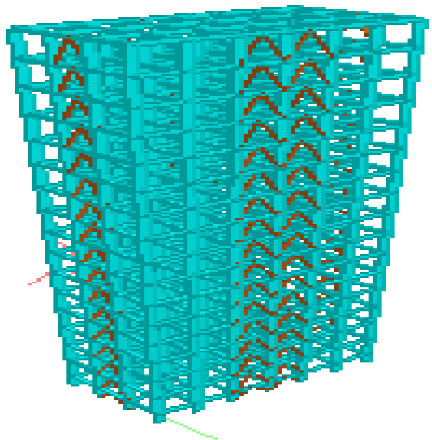


Fig-6: Building with V- bracings at corner (VB1)

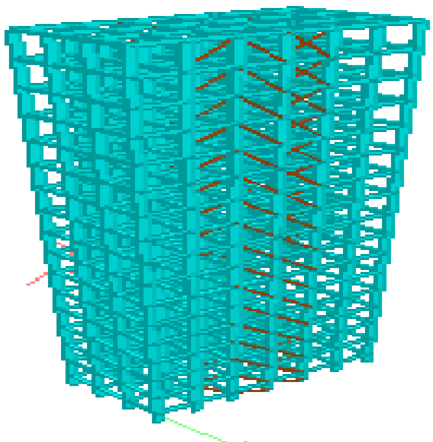


Fig-7: Building with V- bracings at periphery (VB2)

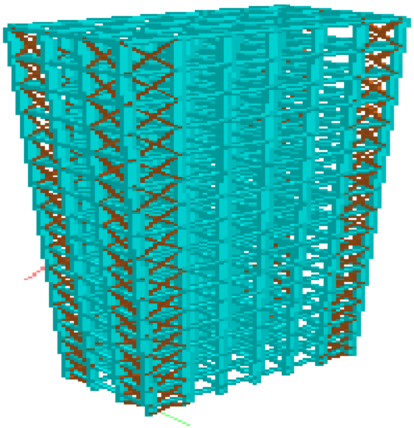


Fig-8: Building with V- bracings at outer and inner position (VB3)

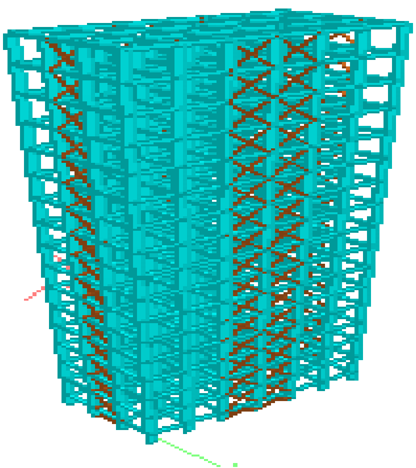


Fig-9: Building with X- bracings at corner (XB1)

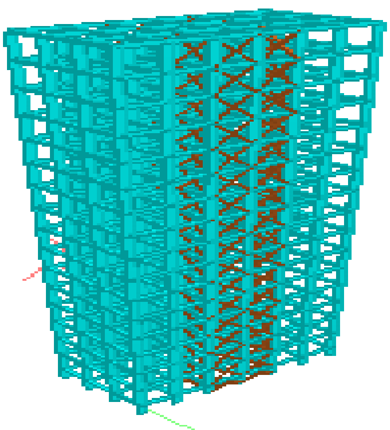
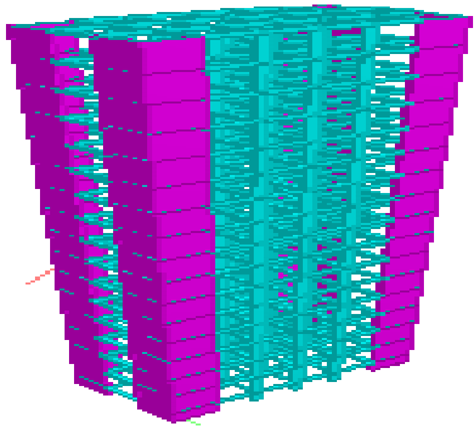


Fig-10: Building with X- bracings at periphery (XB2)



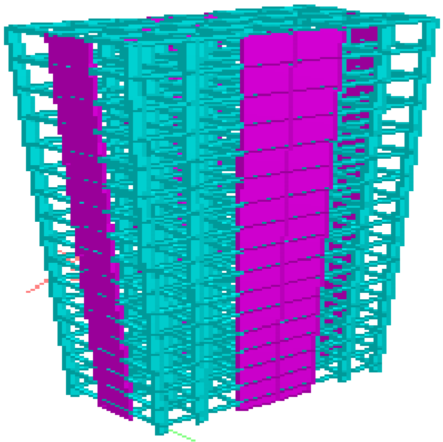


Fig11
: Building with X- bracings at outer and inner position(XB3)

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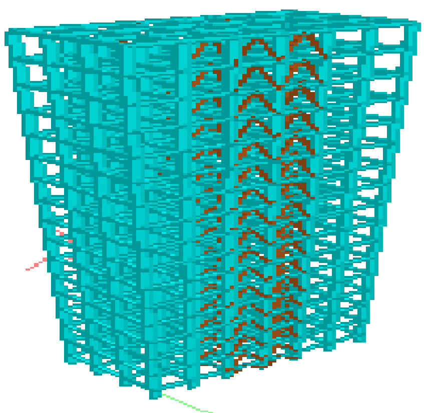
ig-12: Building with Shear walls at corner (SW1)



ZONE	SOIL TYPE	TYPE	MAX DEFL. mm
II	MEDIUM	BF	143.817
		DB1	98.138
		DB2	108.318
		DB3	123.313
		VB1	88.8
		VB2	99.947
		VB3	111.55
		XB1	83.841
		XB2	96.093
		XB3	105.852
		SW1	52.917
		SW2	92.278
		SW3	49.041

ZONE	SOIL TYPE	TYPE	MAX DEFL. mm
III	MEDIUM	BF	228.391
		DB1	150.545
		DB2	167.972
		DB3	191.079
		VB1	138.947
		VB2	158.558
		VB3	173.403
		XB1	130.711
		XB2	151.497
		XB3	163.853
		SW1	80.695
		SW2	146.63
		SW3	75.721

Fig-13: Building with Shear Walls at periphery (SW2)

Fig13: Building with Shear walls at outer and inner pos. (SW3)

2 ANALYSIS AND RESULTS

2.1 OVERVIEW

A G+15 building is analyzed and compared with shear wall and three different patterns of bracings with three different positioning of it during the earthquake considering all the four zones. Parameters like displacement, axial force, bending moment for columns and shear, moment, torsion for beams are calculated. Graphical and Tabular representation of data is discussed in this chapter.

2.2 Column

2.2.1 Maximum Displacements

Table-1: Maximum lateral displacement

ZONE	SOIL TYPE	TYPE	MAX DEFL. mm
		BF	511.748
		DB1	329.173
		DB2	369.401
		DB3	419.241
		VB1	309.157
		VB2	353.998
		VB3	381.551
		XB1	290.725
		XB2	337.882
		XB3	359.278
		SW1	329.173

ZONE	SOIL TYPE	TYPE	MAX DEFL. mm
V	MEDIUM	BF	341.641
		DB1	222.012
		DB2	247.796
		DB3	282.161
		VB1	207.066
		VB2	236.085

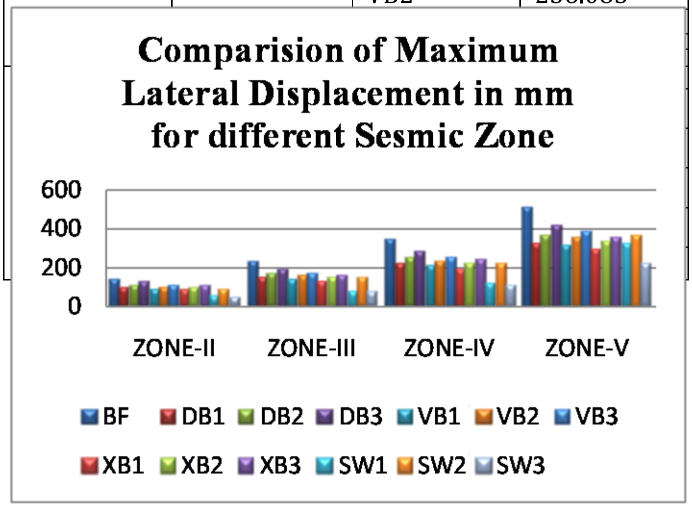


Fig-2.2.1: Comparison of Maximum lateral displacement.

2.2.2 Maximum Axial Force on columns

Table-2: Maximum Axial Force

ZONE	SOIL TYPE	TYPE	MAX. AXIAL FORCE KN
II	MEDIUM	BF	3754.125
		DB1	3676.076
		DB2	3633.57
		DB3	4365.885
		VB1	3662.431
		VB2	3600.98
		VB3	4205.122
		XB1	3660.097
		XB2	3616.189
		XB3	4368.47
		SW1	3446.125
		SW2	3009.234
		SW3	2703.727

ZONE	SOIL TYPE	TYPE	MAX. AXIAL FORCE KN
III	MEDIUM	BF	3754.125
		DB1	3676.076
		DB2	3779.796
		DB3	5143.843
		VB1	3662.431
		VB2	3732.18
		VB3	4947.643
		XB1	3660.097
		XB2	3965.621
		XB3	5141.555
		SW1	3446.125
		SW2	3009.234
		SW3	2703.727

ZONE	SOIL TYPE	TYPE	MAX. AXIAL FORCE KN
IV	MEDIUM	BF	4080.79
		DB1	4470.95
		DB2	4483.657
		DB3	6188.884
		VB1	4130.686
		VB2	4465.085
		VB3	5976.484
		XB1	4320.864
		XB2	4787.607
		XB3	6211.149
		SW1	3453.888
		SW2	3016.997
		SW3	2830.39

ZONE	SOIL TYPE	TYPE	MAX. AXIAL FORCE KN
V	MEDIUM	BF	4806.754
		DB1	5684.934
		DB2	5532.102
		DB3	7744.801
		VB1	5300.399
		VB2	5561.863
		VB3	7461.526
		XB1	5530.95
		XB2	6019.381
		XB3	7757.32
		SW1	5684.934
		[illegible]	[illegible]

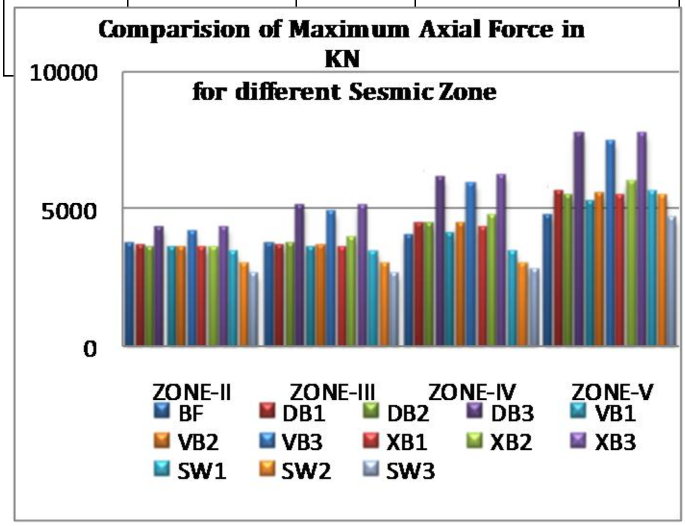


Fig-2.2.2: Comparison of Maximum Axial force

2.2.3 Maximum Moment in columns

Table-3: Maximum Moment in columns

ZONE	SOIL TYPE	TYPE	MAX.MOMENT KN-m
II	MEDIUM	BF	126.818
		DB1	129.019
		DB2	166.199
		DB3	123.71
		VB1	108.32
		VB2	98.933
		VB3	108.921
		XB1	104.818
		XB2	106.402
		XB3	112.518
		SW1	153.471
		SW2	78.053
		SW3	125.172

ZONE	SOIL TYPE	TYPE	MAX.MOMENT KN-m
III	MEDIUM	BF	200.963
		DB1	197.255
		DB2	261.507
		DB3	200.578
		VB1	154.956
		VB2	142.515
		VB3	150.414
		XB1	155.434
		XB2	161.543
		XB3	166.58
		SW1	183.425
		SW2	100.503
		SW3	143.837

ZONE	SOIL TYPE	TYPE	MAX.MOMENT KN-m
IV	MEDIUM	BF	301.426
		DB1	288.603
		DB2	388.063
		DB3	303.525
		VB1	223.593
		VB2	205.561
		VB3	209.105
		XB1	222.093
		XB2	233.728
		XB3	238.316
		SW1	223.069
		SW2	133.891
		SW3	178.032

ZONE	SOIL TYPE	TYPE	MAX.MOMENT KN-m
V	MEDIUM	BF	451.383
		DB1	425.079
		DB2	567.75
		DB3	472.812
		VB1	326.99
		VB2	307.431
		VB3	310.17
		XB1	324.714
		XB2	342.01
		XB3	346.378
		SW1	425.079
		SW2	367.75
		SW3	412.812

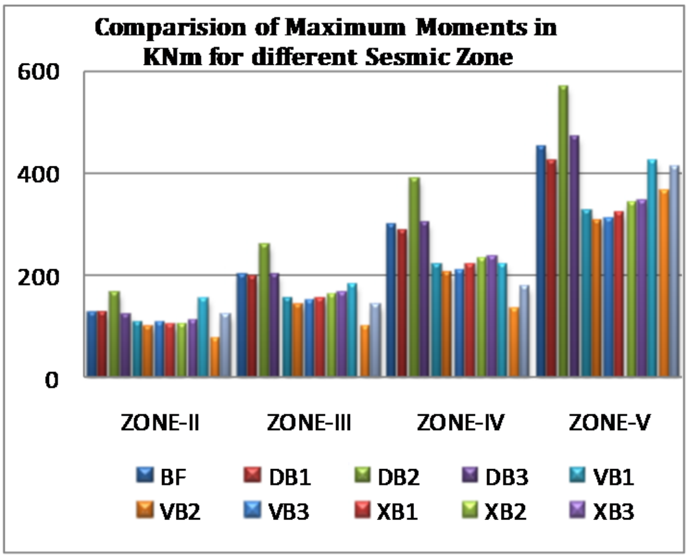


Fig-2.2.3: Comparison of Maximum moments(KN-M)

2.2.4 Maximum Torsion in beams

Table-4: Maximum Torsion in beams

ZONE	SOIL TYPE	TYPE	MAX. Torsion KN-M
II	MEDIUM	BF	3.406
		DB1	22.653
		DB2	14.706
		DB3	16.154
		VB1	26.626
		VB2	20.413
		VB3	24.628
		XB1	22.407
		XB2	14.117
		XB3	17.523
		SW1	32.284
		SW2	38.478
		SW3	16.891

ZONE	SOIL TYPE	TYPE	MAX. Torsion KN-M
III	MEDIUM	BF	3.406
		DB1	27.095
		DB2	20.588
		DB3	22.448
		VB1	30.704
		VB2	24.187
		VB3	29.526
		XB1	26.304
		XB2	18.601
		XB3	24.425
		SW1	32.284
		SW2	53.168
		SW3	19.831

ZONE	SOIL TYPE	TYPE	MAX. Torsion KN-M
IV	MEDIUM	BF	3.406
		DB1	33.18
		DB2	28.509
		DB3	30.891
		VB1	36.264
		VB2	29.15
		VB3	36.265
		XB1	32.218
		XB2	24.595
		XB3	33.627
		SW1	36.752
		SW2	72.754
		SW3	23.75

ZONE	SOIL TYPE	TYPE	MAX. Torsion KN-M
V	MEDIUM	BF	3.406
		DB1	42.358
		DB2	40.439
		DB3	43.631
		VB1	44.923
		VB2	36.656
		VB3	46.489
		XB1	41.29
		XB2	33.664
		XB3	47.43
		SW1	48.252
		SW2	102.134
		SW3	29.63

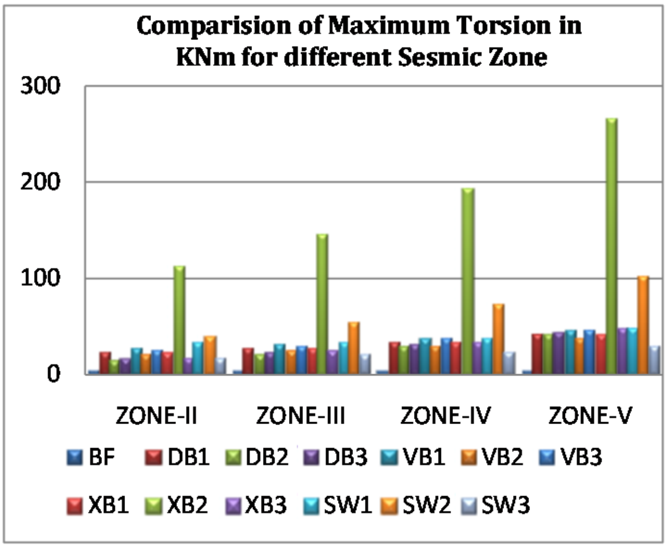


Fig-2.2.4: Comparison of Maximum Torsion in KN-M

2.2.5 Maximum Shear Force in beams

Table5: Maximum Shear Force in beams

ZONE	SOIL TYPE	TYPE	MAX. Shear Force KN
II	MEDIUM	BF	124.754
		DB1	131.386
		DB2	129.777
		DB3	127.152
		VB1	123.726
		VB2	138.309
		VB3	161.741
		XB1	126.963
		XB2	111.387
		XB3	127.548
		SW1	154.856
		SW2	161.105
		SW3	161.183

ZONE	SOIL TYPE	TYPE	MAX. Shear Force KN
III	MEDIUM	BF	162.906
		DB1	171.271
		DB2	178.986
		DB3	168.9
		VB1	159.966
		VB2	164.224
		VB3	187.604
		XB1	163.927
		XB2	145.142
		XB3	170.622
		SW1	174.066
		SW2	184.836
		SW3	177.274

ZONE	SOIL TYPE	TYPE	MAX. Shear Force KN
IV	MEDIUM	BF	218.074
		DB1	225.548
		DB2	244.451
		DB3	226.616
		VB1	208.606
		VB2	199.395
		VB3	222.312
		XB1	212.821
		XB2	192.901
		XB3	230.083
		SW1	232.594
		SW2	217.858
		SW3	226.96

ZONE	SOIL TYPE	TYPE	MAX. Shear Force KN
V	MEDIUM	BF	301.32
		DB1	306.635
		DB2	343.052
		DB3	313.19
		VB1	282.809
		VB2	263.032
		VB3	307.138
		XB1	287.62
		XB2	264.539
		XB3	319.274
		SW1	327.298
		SW2	268.88

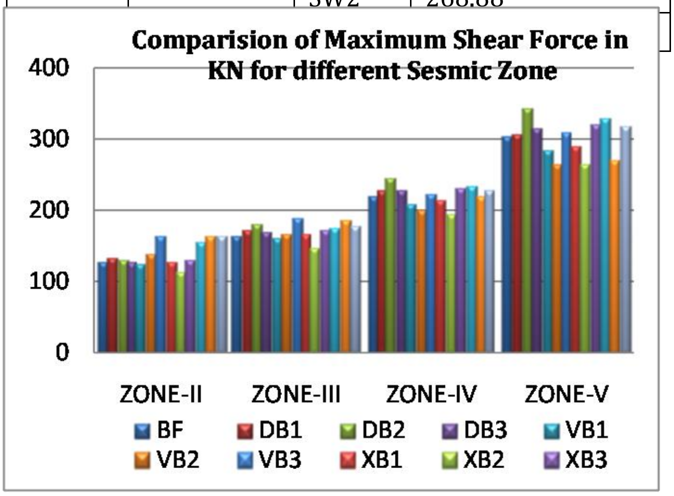


Fig-2.2.5: Comparison of Maximum Shear Force in KN

2.2.6 Maximum Banding Moments in beams

Table-6: Maximum Bending Moments in beams

ZONE	SOIL TYPE	TYPE	MAX.Bending Moment (KN-M)
II	MEDIUM	BF	140.675
		DB1	156.132
		DB2	148.978
		DB3	139.584
		VB1	143.332
		VB2	124.651
		VB3	136.62
		XB1	149.443
		XB2	120.803
		XB3	140.255
		SW1	184.371
		SW2	219.48
		SW3	195.675

ZONE	SOIL TYPE	TYPE	MAX.Bending Moment (KN-M)
III	MEDIUM	BF	199.346
		DB1	216.778
		DB2	226.704
		DB3	199.148
		VB1	198.372
		VB2	171.62
		VB3	184.174
		XB1	205.821
		XB2	175.778
		XB3	202.523
		SW1	218.915
		SW2	264.667
		SW3	220.104

ZONE	SOIL TYPE	TYPE	MAX.Bending Moment (KN-M)
IV	MEDIUM	BF	279.626
		DB1	299.361
		DB2	325.499
		DB3	285.92
		VB1	272.145
		VB2	244.727
		VB3	269.389
		XB1	280.431
		XB2	248.03
		XB3	291.714
		SW1	307.192
		SW2	326.849
		SW3	289.273

ZONE	SOIL TYPE	TYPE	MAX.Bending Moment (KN-M)
V	MEDIUM	BF	403.62
		DB1	422.737
		DB2	474.302
		DB3	416.078
		VB1	384.955
		VB2	352.464
		VB3	397.211
		XB1	394.331
		XB2	356.408
		XB3	425.501
		SW1	449.248
		SW2	423.028
		SW3	421.859

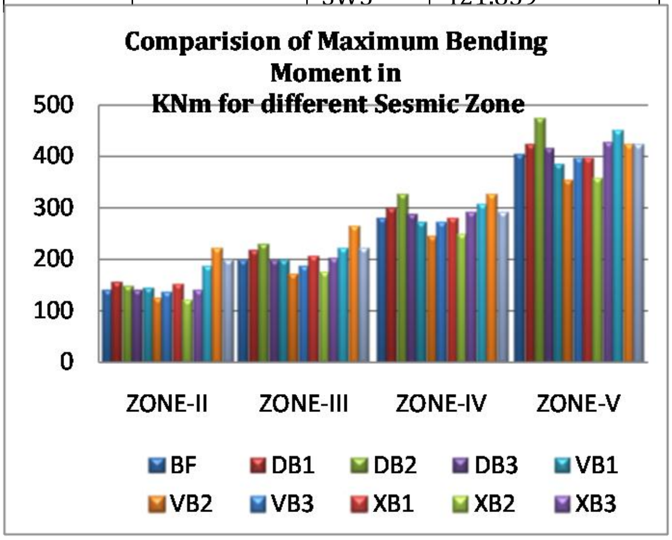


Fig-2.2.6: Comparison of Max Bending Moment in KNM

CONCLUSIONS

1. Shear wall elements are very much efficient in reducing lateral displacement of frame as drift and horizontal deflection induced in shear wall frame are much less than that induced in braced frame and plane frame.
2. The location of shear-wall and brace member has significant effect on the seismic response than the plane frame.
3. The location of shear-wall- 3 is favorable as they are effective in reducing actions induced in frame with less horizontal deflection and drift.

% REDUCTION OF MAXIMUML LATERAL DSLACEMENT in mm			
ZONE	**BF**	**SW3**	**% Reduction**
ZONE-II	143.817	49.041	65.90%
ZONE-III	228.391	75.721	66.85%
ZONE-IV	341.641	112.107	67.19%
ZONE-V	511.748	219.241	57.16%

4. Shear wall construction will provide large stiffness to the building by reducing the damage to the structure.
5. The concept of using steel bracing is one of the advantageous concepts which can be used to strengthen or retrofit the existing structures.
6. Steel bracings can be used as an alternative to the other strengthening or retrofitting techniques available as the total weight on the existing building will not change significantly.
7. Steel bracings reduce flexure and shear demands on beams and columns and transfer the lateral loads through axial load mechanism.
8. The lateral displacements of the building studied are reduced by the use of X type of bracing systems.
9. The building frames with X bracing system will have minimum possible bending moments in comparison to other types of bracing systems.
10. Using steel bracings the total weight on the existing building will not change significantly.
11. The lateral displacement of the building is reduced by 35% to 45 % by the use of X Type steel bracing system, and X bracing type reduced maximum displacement.

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