International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

WIND LOAD ANALYSIS OF HIGH RISE BUILDING WITH AND WITHOUT SHEAR WALL AND ITS COMPARISON

Kamla patel[1] , Sumit gupta[2]
[1]Mtech scholar, structural engineering, BIT-Durg, C.G. [2]Ast. Professor, structural engineering, BIT-Durg, C.G.

ABSTRACT-Indian standard code IS 875(part-3)-1987 gives the specifications for wind load analysis on the different structures. The analysis is based on various steps provided for wind pressure intensity, wind load calculation by wind coefficients. Behaviour of building by the wind pressure is dependent on the angle on which the wind is striking the structure.Wind load is dangerous for the high rise building ,hence various techniques are used to reduce its effects. Shear wall is a good option for this, which is effected up to approximate 70 stories. It is expected in this study that a shear walled structure will show the better result and stability against normal building without shear wall.This study compares the performance of buildings with and without shear wall in terms of deflection of at the different stories and various parameters. As a case study, a 40 storey building designed for Gravity loads(dead load +live load) as well as lateral load (wind load) as per IS:875(part-3)-1987 for wind zone IV is considered. This paper also provides other important conclusions on wind load design provisions and shear wall specifications.

Keywords- wind velocity, wind pressure intensity, gravity loads, wind force at diff. Height, etc.

INTRODUCTION-The necessity of high rise building in urban areas is to minimise the land requirements. The wind force acts on high rise building structure very high compared to low rise building. Worldwide as it's necessity has increased hence the various code are adopted in different country to analyse and design of high rise structure. According national building code 2005 of India, the building of height more than 15 m is called high rise building. Many techniques are used to minimise the wind effect on high rise building like Rigid frames, braced hinge frame, Shear wall /hinged frame, Outrigger Structures. Shear wall / Rigid frame of the concrete shear wall and concrete frame is effective up to 70 stories. It creates shear wall-frame interaction that resist the lateral load by wind or earthquake. The main objective of every structural system is to transfer gravity load to the foundation of building. Dead load and live load are the primary load created from the gravity effect. The lateral loads like wind or earthquake also affects the building other than this dead and live load. High stresses are developed due to these lateral loads and also these create sway movement and cause vibration in the structure. Therefore, the building must have sufficient strength and stiffness to encounter the vertical loads and lateral loads respectively.

1.1Specific iObjectives

The iprimary objective of this study is to analyse the building with and without shear wall and compare the results of deflection and other parameters. In the analysis frame elements were used instead of plane stress elements in analysis and modelling of shear walls to reduce the time requirements and to increase the performance of the building.

1.2Experimental Study Plan

Dead load and live load have been taken as per IS 875 (Part 1) (1987) and IS 875 (Part 2) (1987) respectively. Wind load calculation has been done based on the IS 875 (Part 3) (1987). Analysis is being done by STAD-PRO by providing adequate material properties and dimension as per the required building standard.

1.3Layout

This study report is summarised in total 6 chapters, each chapter deals with specific objective and divided according to specific work area. Chapter 1 gives the general information and introduction about the work also about the objective and procedure. Chapter 2 is about the literature work, terms used in the study and work of the previous studies. Chapter 3 deals with the methodology adopted for analysing the structure and also about the detailing of the problem. Chapter 4 gives the modelling done in STAAD-PRO software and analysis separately of both buildings and about the results obtained from the analysis. Chapter 5 is about the comparisons of the results obtained from chapter 4 and a discussion is also made to discuss the results. Chapter 6 is concluded the whole study work.

LITERATURE REVIEW- The elevator and the introduction of structural steel, towers and skyscrapers have continued to soar skyward, where they are buffeted in the wind's complex environment. Unfortunately, these advances in height are often accompanied by increased flexibility and a lack of sufficient inherent damping, increasing their susceptibility to the actions of wind. While major innovations in structural systems have permitted the increased lateral loads to be efficiently carried, the dynamic nature of wind is still a factor, causing discomfort to building occupants and posing serious serviceability issues. The next generation of tall buildings research has been devoted in part to the mitigation of such wind-induced motions via global design modifications to the structural system.

2.1 Codal Provision

In the totally different countries, totally different codes are adopted to design shear wall structure system and wind load consideration and its specification. Some vital code details are enclosed for this study, these ar as follows:

2.1.1 AS/NZS 1170.2:2011

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee, BD-006, General Design Requirements and Loading on Structures, to supersede AS/NZS 1170.2:2002.

The objective of this Standard is to provide wind actions for use in the design of structures subject to wind action. It provides a detailed procedure for the determination of wind actions on structures, varying from those less sensitive to wind action to those for which dynamic response must be taken into consideration.

The objectives of this revision are to remove ambiguities, to incorporate recent research and experiences from recent severe wind events in Australia and New Zealand.

2.1.2 IS 875(Part-3)-1987

This Part (Part 3) deals with wind load to be considered when designing buildings, structures and components thereof. In this revision, many important modifications have been made from those covered in the 1964 version of IS :875

This standard gives wind forces and their effects (static and dynamic) that should he taken into account when designing buildings, structures and components thereof.

2.1.3 IS 456-2000

This standard was first published in 1953 under the title 'Code of practice for plain and reinforced concrete for general building construction' and subsequently revised in 1957. The code was further revised in 1964 and published under modified title 'Code of practice for plain and reinforced concrete', thus enlarging the scope of use of this code to structures other than general building construction also. The third revision was published in 1978, and it included limit state approach to design. This is the fourth revision of the standard. This revision was taken up with a view to keeping abreast with the rapid development in the field of concrete technology and to bring in further modifications/improvements in the light of experience gained while using the earlier version of the standard.

2.1.4IS 1893(Part-1)-2002

Part 1 contains provisions that are general in nature and applicable to all structures. Also, it contains provisions that are specific to buildings only. Unless stated otherwise, the provisions in Parts 2 to 5 shall be read necessarily in conjunction with the general provisions in Part 1.

2.1.5 IS 13920-1993

Whilst the common methods of design and construction have been covered in this code, special systems of design and construction of any plain or reinforced concrete structure not covered by this code may be permitted on production of satisfactory evidence regarding their adequacy for seismic performance by analysis or tests or both.

METHODOLOGY-Analysis is being done by STAD-PRO by providing adequate material properties and dimension as per the required building standard.

The aim of the project is to briefly know about the shear wall concepts and structural concepts through computer aid STAAD-PRO software and the previous study and theory. Briefly I have gone through following points through out of project work-

- ✓ Understanding of design and detailing concept.
- ✓ Main objective i.e. using STAAD-pro software for the analysis of wind load and shear wall.
- ✓ Learning of analysis and design methodology which can be very useful in the field.
- ✓ Understanding of wind load design concept on the building.
- ✓ Approach for professional practice in the field of structural engineering.

3.1 Methodology Of The Work

The whole analysis is done by the STAAD-PRO.V8i software, in which pressure intensity at different height of the building is predefined for the American code ASCE-07, but not for any other code. This analysis is done on the basis of Indian standard code IS- 875(part-3) for which the intensity values were calculated through the codal provisions.

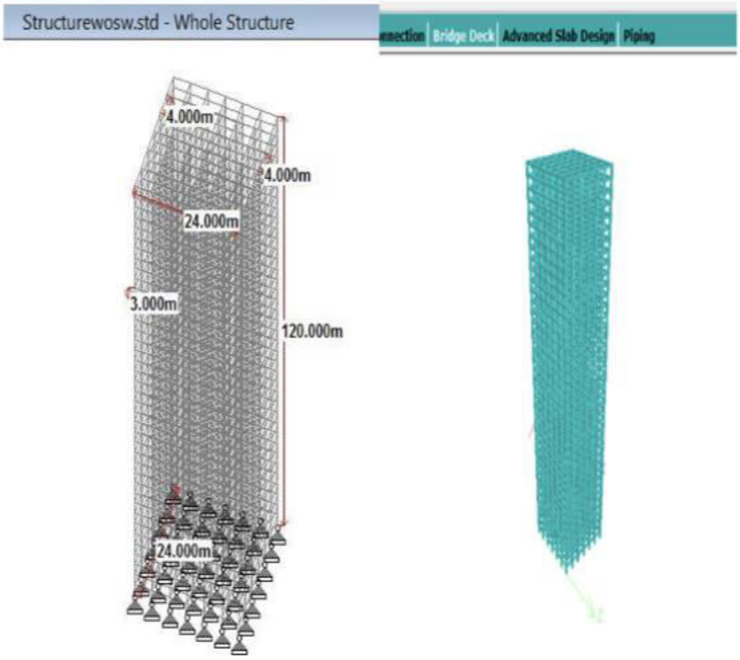
3.2 Building Details

In this work following building details are to be considered:
No. of stories=40
Length=24m, each bay @4m
Height=120m, each bay @3m
Width=24m, each bay @4m
Live Load; Area load= 2.5Kn/m^2 Location – Delhi
Wind zone –IV
wind speed =47m/s
Wind Load; as per the IS-875(Part-3) Concrete grade M30
Steel grade Fe415
Risk coefficient ,k1=1.07(considered to be an important building with design life = 100 years)
Terrain Coefficient, k2= as per the table-2 [Building is to be considered in terrain type- 3{surrounding structures are the height of between 10m to 25m} and class-B {glazing or roofing type of structural components having its maximum dimension(horizontal or vertical) between 20 to 50m]

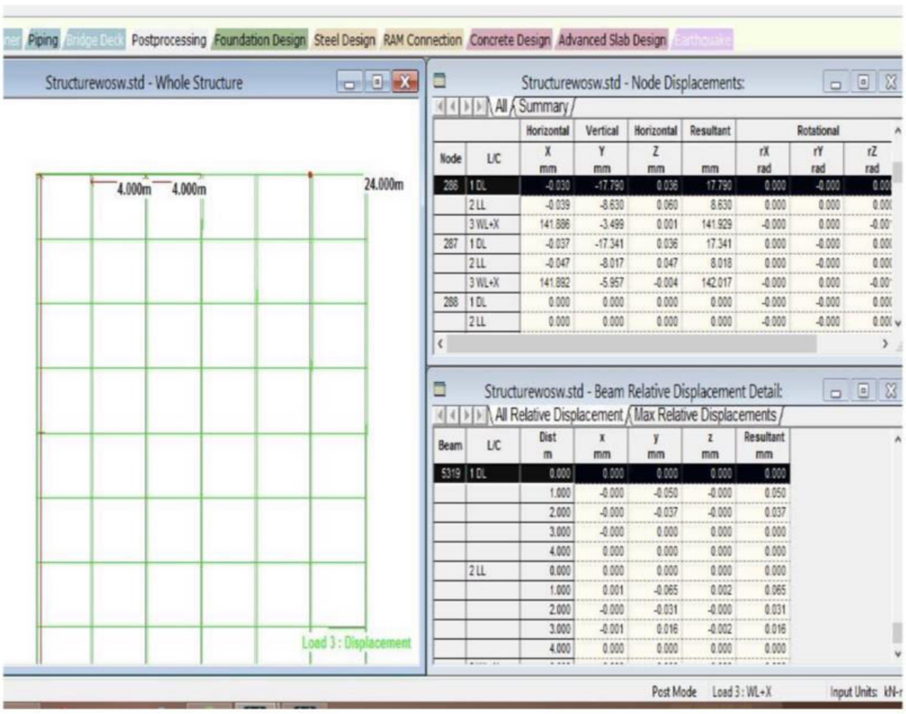
∟ Topography Factor, k3=1.0(upwind slope is assumed to be less than 3o)
∟ For the given structures ,wind pressure is calculated separately (manually) and these values were added in the analysis by staad-pro by providing 80%exposure to the wind.
∟ To see the effect of wind , a separate envelope of wind load in +X direction was added in the modeling.
∟ Concrete design as per the IS-800 ,was added in modeling to perform concrete design.
∟ A comparative analysis is also done after obtaining all results of both buildings ie; with shear wall and without shear wall.

MODELING AND ANALYSIS

4.1 Model of building without shear wall



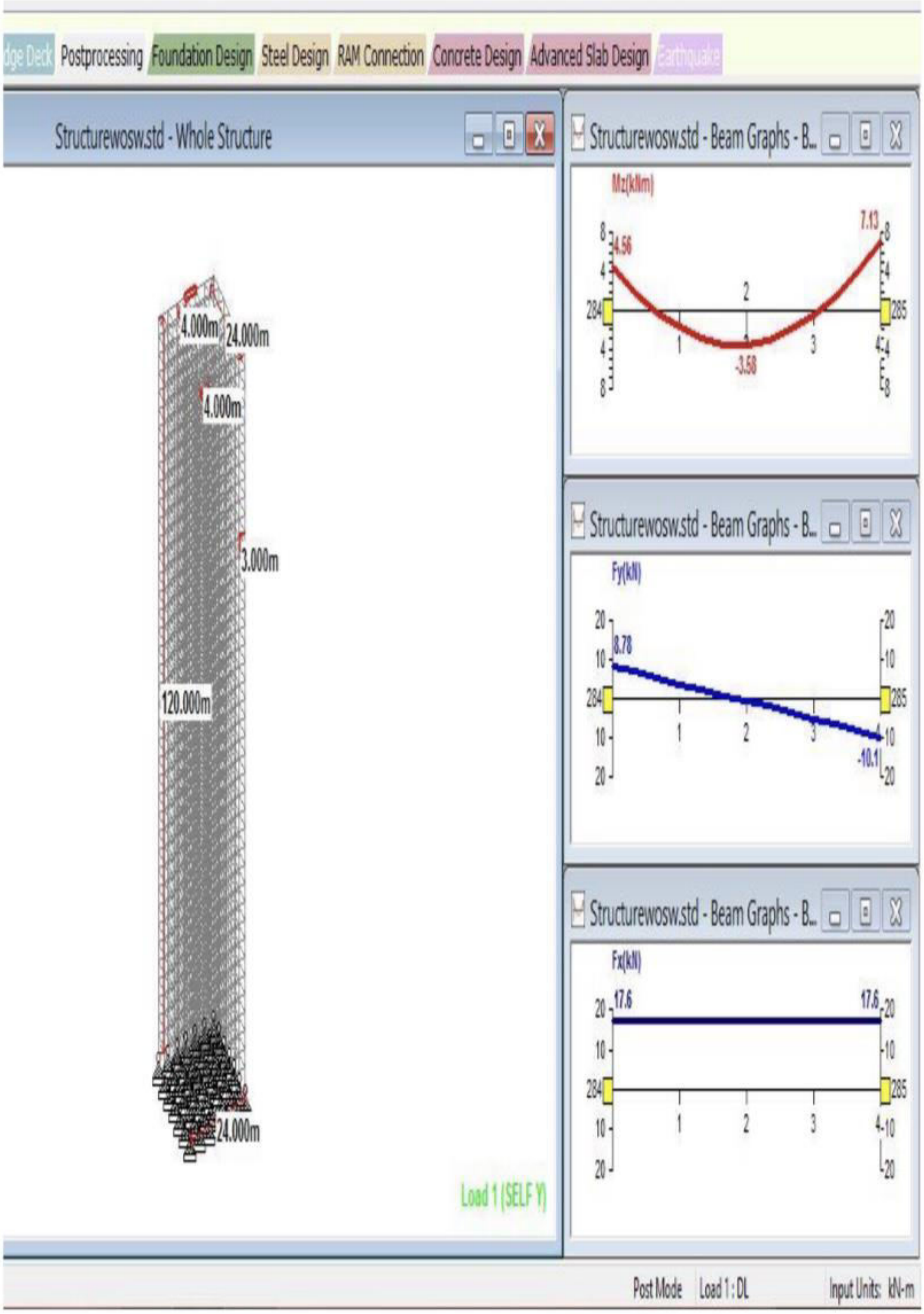
4.2 STAAD-Pro result



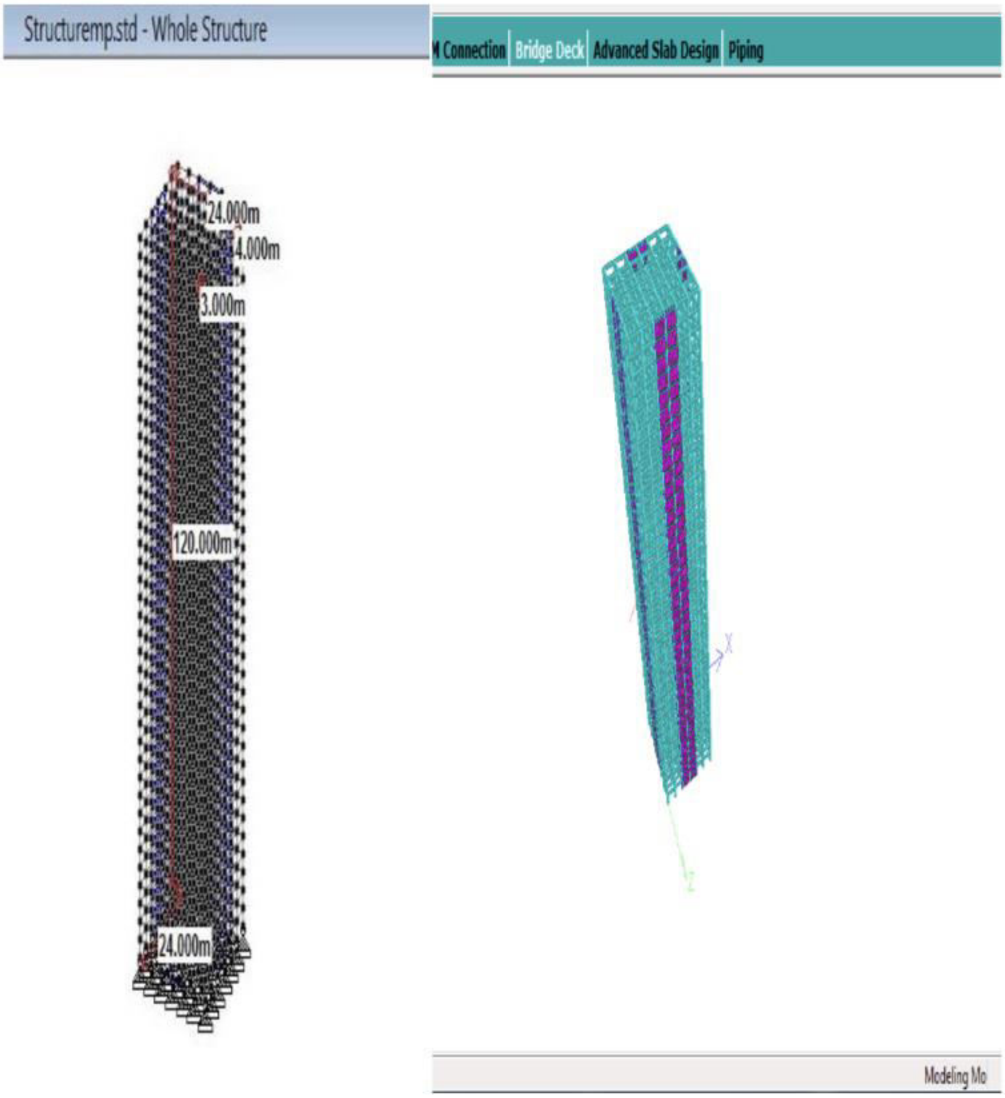
		Horizontal	Vertical	Horizontal	Resultant	Rotational		
Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
286	1 DL	-0.030	-17.790	0.036	17.790	0.000	-0.000	0.00
	2 LL	-0.039	-8.630	0.060	8.630	0.000	0.000	0.00
	3 WL+X	141.886	-3.499	0.001	141.929	-0.000	0.000	-0.00
287	1 DL	-0.037	-17.341	0.036	17.341	0.000	-0.000	0.00
	2 LL	-0.047	-8.017	0.047	8.018	0.000	-0.000	0.00
	3 WL+X	141.892	-5.957	-0.004	142.017	-0.000	0.000	-0.00
288	1 DL	0.000	0.000	0.000	0.000	-0.000	-0.000	0.00
	2 LL	0.000	0.000	0.000	0.000	-0.000	-0.000	0.00

Beam	L/C	Dist m	x mm	y mm	z mm	Resultant mm
5319	1 DL	0.000	0.000	0.000	0.000	0.000
		1.000	-0.000	-0.050	-0.000	0.050
		2.000	-0.000	-0.037	-0.000	0.037
		3.000	-0.000	0.000	0.000	0.000
		4.000	0.000	0.000	0.000	0.000
	2 LL	0.000	0.000	0.000	0.000	0.000
		1.000	0.001	-0.065	0.002	0.065
		2.000	-0.000	-0.031	-0.000	0.031
		3.000	-0.001	0.016	-0.002	0.016
		4.000	0.000	0.000	0.000	0.000

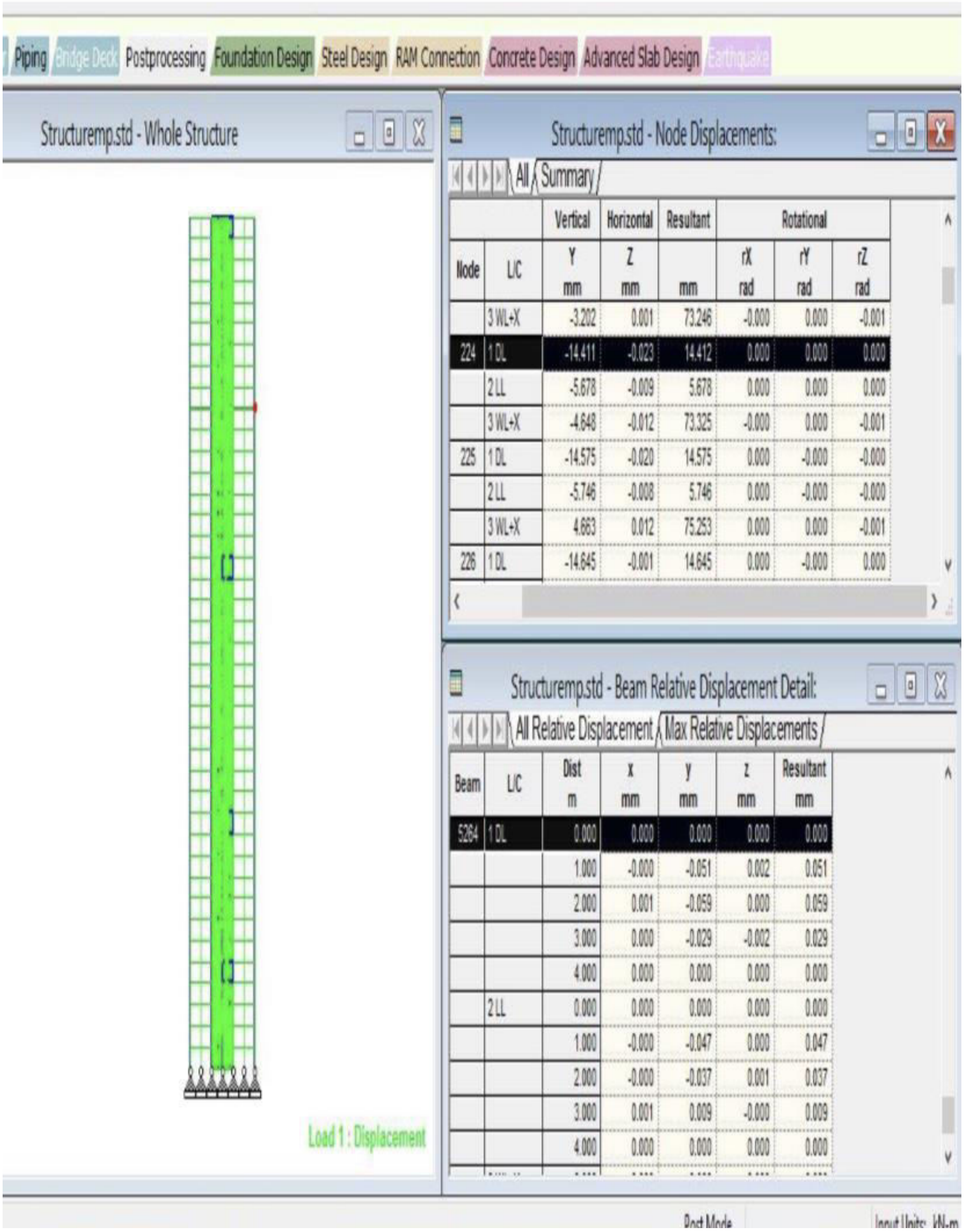
4.3 Beam results graph


Postprocessing
Foundation Design
Steel Design
RAM Connection
Concrete Design
Advanced Slab Design
Structurewoswstd - Whole Structure
4.000m
24.000m
4.000m
3.000m
120.000m
24.000m
Load 1 (SELF Y)
Structurewoswstd - Beam Graphs - B...
Mz(kNm)
4.56
7.13
-3.58
Fy(kN)
8.78
-10.1
Fx(kN)
17.6
17.6
Post Mode
Load 1 : DL
Input Units: kN-m

4.4 model of the building with shear wall



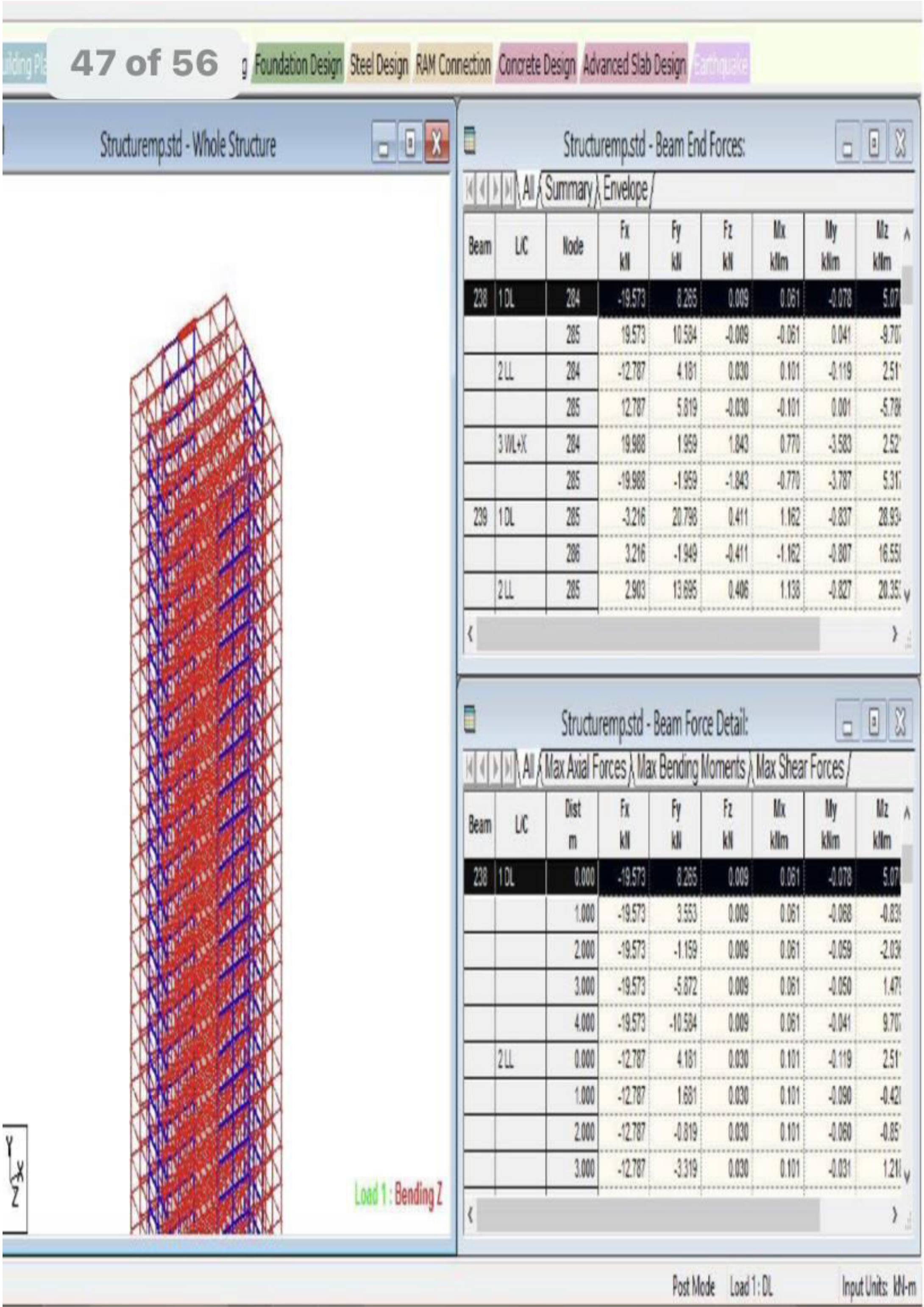
4.5 STAAD-Pro result



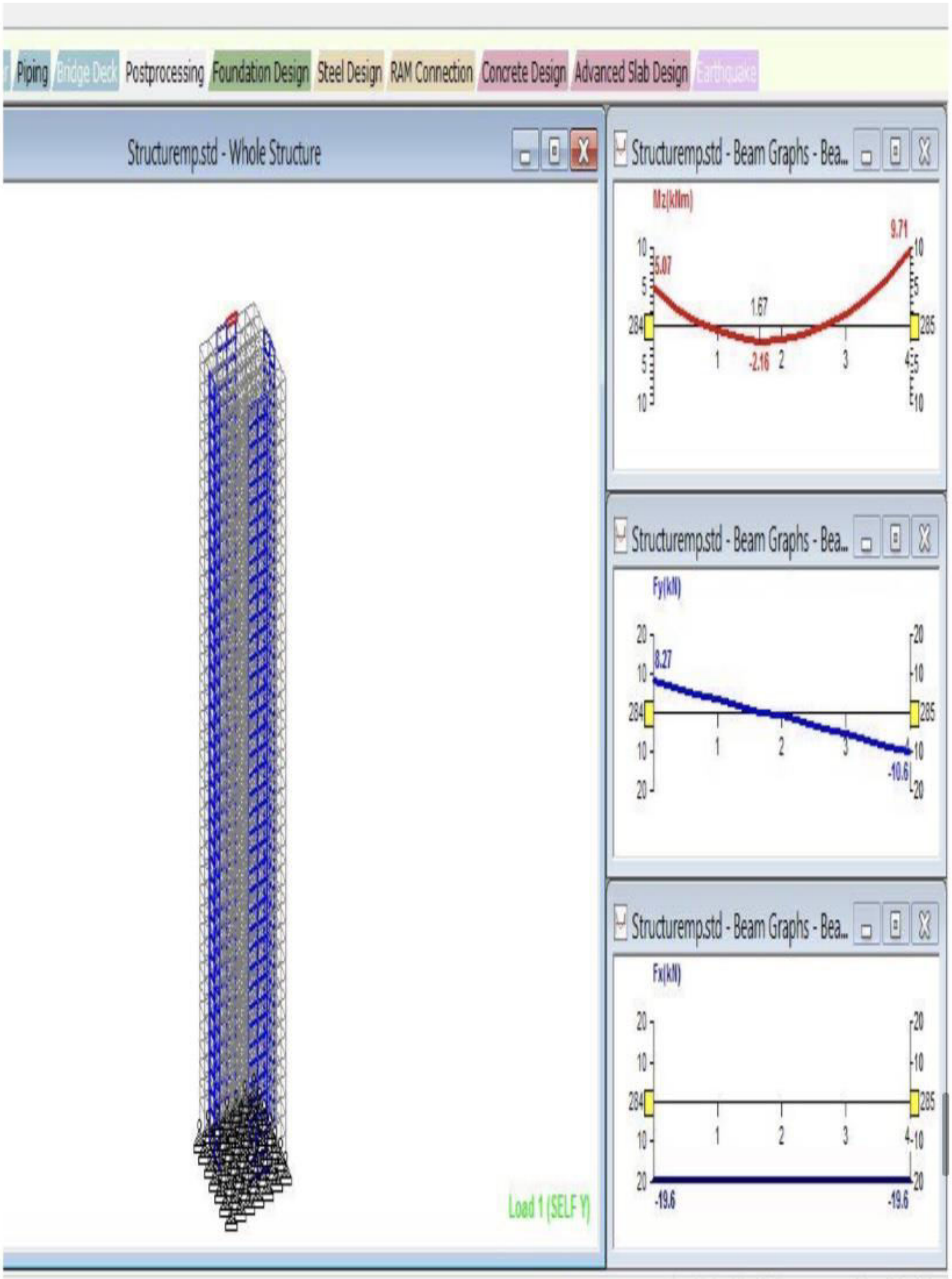
Node	L/C	Vertical Y mm	Horizontal Z mm	Resultant mm	Rotational rX rad	rY rad	rZ rad
	3 WL+X	-3.202	0.001	73.246	-0.000	0.000	-0.001
224	1 DL	-14.411	-0.023	14.412	0.000	0.000	0.000
	2 LL	-5.678	-0.009	5.678	0.000	0.000	0.000
	3 WL+X	-4.648	-0.012	73.325	-0.000	0.000	-0.001
225	1 DL	-14.575	-0.020	14.575	0.000	-0.000	-0.000
	2 LL	-5.746	-0.008	5.746	0.000	-0.000	-0.000
	3 WL+X	4.663	0.012	75.253	0.000	0.000	-0.001
226	1 DL	-14.645	-0.001	14.645	0.000	-0.000	0.000

Beam	L/C	Dist m	x mm	y mm	z mm	Resultant mm
5264	1 DL	0.000	0.000	0.000	0.000	0.000
		1.000	-0.000	-0.051	0.002	0.051
		2.000	0.001	-0.059	0.000	0.059
		3.000	0.000	-0.029	-0.002	0.029
		4.000	0.000	0.000	0.000	0.000
	2 LL	0.000	0.000	0.000	0.000	0.000
		1.000	-0.000	-0.047	0.000	0.047
		2.000	-0.000	-0.037	0.001	0.037
		3.000	0.001	0.009	-0.000	0.009
		4.000	0.000	0.000	0.000	0.000

4.6 moment diagram of the building



4.7 Beam results graph



COMPARISONS OF RESULTS AND DISCUSSIONS

It took time to run the analysis as the basic version of the software was used. Results of deflection, shear force, moment of the entire building and individual member were analysed; also the graphical diagrams of deflection, shear force, moment of each member and of whole structure were analysed.

Advantages of shear wall

∟ Effectively resists lateral loads by producing shear truss - frame interacting system.
∟ It provides large stiffness and strength.
∟ Symmetric location of shear wall along the perimeter of building is desirable.

Disadvantages of shear wall

∟ Interior planning limitations due to shear trusses.
∟ Unsymmetrical location of shear wall along the perimeter of building is not desirable.
∟ The opening provided in shear wall should be symmetrical.
∟ Shear wall is effective only when it is located along the perimeter not interior.

4.1 Shear Wall Effect On Deflection

Storey drift also known as shear wall deflection is limited by two primary causes. The first is for limiting cracks in wall by plaster, gypsum, and paint in serviceability. The second is for limiting the shear wall's maximum inelastic response, which is important in the seismic or wind design of wood buildings. Furthermore, the relative flexibility and rigidity of shear wall and diaphragms is also calculated by storey drift.

4.2 Deflection result on both analysis

TABLE- 4.1 Deflection Values comparison

storey	w/o shear wall (mm)	with shear wall(mm)	%Reduction
40	141.908	88.621	37.55038476
39	140.297	87.093	37.92240746
38	138.601	85.486	38.32223433
37	136.786	83.855	38.6962116
36	134.85	82.194	39.04783092
35	132.793	80.496	39.38234696
34	130.614	78.752	39.7063102
33	128.314	76.958	40.02369188
32	125.894	75.108	40.34028627
31	123.355	73.199	40.65988407
30	120.7	71.229	40.98674399
29	117.929	69.195	41.32486496
28	115.046	67.095	41.6798498
27	112.052	64.931	42.05279692
26	108.952	62.7	42.45172186
25	105.748	60.405	42.87835231
24	102.442	58.046	43.33769352
23	99.038	55.626	43.83368
22	95.538	53.145	44.37291968
21	91.947	50.608	44.95959629
20	88.267	48.017	45.60028097
19	84.503	45.375	46.30368153

18	80.659	42.689	47.07472198
17	76.739	39.964	47.92217777
16	72.746	37.204	48.85766915
15	66.692	34.418	48.39261081
14	64.575	31.614	51.04297329
13	60.403	28.801	52.31859345
12	56.181	25.981	53.75482814
11	51.916	23.196	55.32013252
10	47.812	20.432	57.26595834
9	43.278	17.715	59.06696243
8	36.921	15.066	59.19395466
7	34.547	12.51	63.7884621
6	30.164	10.073	66.60588781
5	25.781	7.789	69.78782825
4	21.397	5.696	73.37944572
3	16.997	3.835	77.4371948
2	12.483	2.263	81.87134503
1	7.363	1.034	85.95681108
Supports	0	0	0

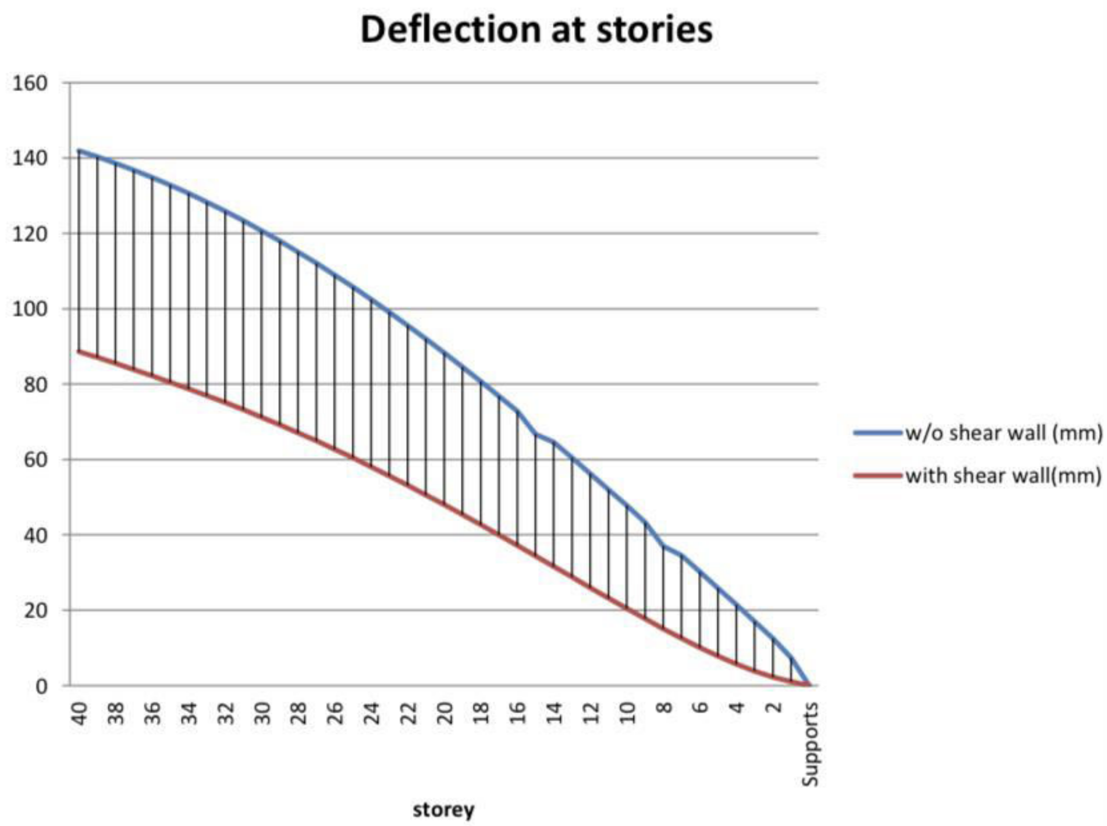


Fig 5.1 : Graph of Deflection At Different Stories

• Deflection values in the building with shear wall are significantly less than the building withoutshear wall, at the top of building deflection of thestorey has been reduced upto 37.55% .

• Moment value for beam and nodes has also been reduced in shear wall building ,that shows its more reliability to the load as compared to without shear wall building.

• By this analysis and study in the urban areas to reduce the requirement of space for the building, high rise buildings are used; and to prevent danger against wind load on those buildings ,shear wall is a good and easy choice in the construction.

CONCLUSION -

∟ From the above study work, it is observed that in 40 story building, constructing building with shear wall in short span at middle is economical and effective as compared with the building without shear wall. From this it can be concluded that large dimension of shear wall is not effective in less number of stories of any building but it is effective in high number of stories.

• Software does not take direct values from IS-875(3) for the wind load; hence must be improved.

• Software does not support Indian codes like IS-456 for concrete design and IS -13920 for shear wall design, hence must be improved.

• Results are acceptable in both building and very significantly loss (37.55% in top story) in deflection in shear wall building has been shown compared to normal building without shear wall.

REFERENCES-

∟ Text Book On Tall Building Structures –Analysis And Design By BRAYN STAFFORD SMITH & ALEX COULL

∟ Journal Study Of Seismic And Wind Effect On Multi Storey R.C.C., Steel And Composite Building(International Journal of Advances in Engineering & Technology, Sept. 2013.)
∟ Estimation of Wind Load on a Tall Building under Interference Effects: A Case Study , Pallab Kheyari 1) and Sujit Kumar Dalui 2)*
∟ Structural Developments in Tall Buildings: Current Trends and Future Prospects ,Mir M. Ali† and Kyoung Sun Moon
∟ Alfa Rasikan, M G Rajendran / International Journal of Engineering Research and Applications (IJERA)
∟ http://www.engineeringcivil.com/deflections-of-bents-and-shear- walls.html

∟ https://en.wikipedia.org/wiki/Shear_wall

∟ CODES:-
AS/NZS 1170.2:2011 SEI/ASCE 7-02
EN 1991-1-4:2005+A 1 IS 875(Part-3)-1987
IS 456-2000
IS 1893(Part-1)-2002 IS 13920-1993