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Use of Different Shapes of Twin Towers High Rise Building and Compare it with Simple Type for Seismic Loading-A Review

Akash Pushpad[1], Rahul Sharma[2]

[1]M. Tech scholar, Department of Civil Engineering, Prashanti Institute of technology & Science, Ujjain
[2]Assistant Professor, Department of Civil Engineering, Prashanti Institute of technology & Science, Ujjain

ABSTRACT

This study investigates the seismic response of buildings with non-traditional shapes (triangular, hexagonal, and curved) and compares them with conventional rectangular buildings. Nonlinear dynamic analysis was performed using STAAD PRO software to simulate seismic activity. The results show that buildings with non-traditional shapes exhibit reduced displacement, acceleration, and base shear forces compared to simple rectangular buildings. The triangular shape demonstrated the most significant improvement in seismic performance, followed by the hexagonal and curved shapes. The study highlights the potential benefits of using non-traditional shapes in seismic design, particularly in earthquake-prone regions. The result of this thesis research work will be beneficial for the development of the more numbers of highly improved sustainable building structure designs.

Keywords : seismic analysis, non-traditional shapes, building design, earthquake engineering, structural dynamic

1. INTRODUCTION

In this modern society high-rise buildings and skyscraper construction is normal. To make its construction effective, safe and economical it's necessary to apply some methods and analysis before construction of it. Modeling is the best way to find out its actual calculations and results. Wind load majorly affects skyscrapers and high rises therefore it is necessary to calculate wind load through modeling and analytics. Except from wind load there are several loads and its condition which affect the high rised buildings and they are-

1) Dead load
2) Live load
3) Seismic load
4) Snow load
5) Special loads

1) **Dead load**- Self weight of structure is known as dead load. it is its own weight of structure which can be high rise buildings or skyscrapers etc. Dead load is the first considered vertical load. Permanent load is the dead load which is acting through the whole life. Structural self weight is a dead load. Various load which act permanently throughout the life of the structure is called the dead load. Components of the building or any structure are consisting of dead load.

2) **Live load**- moving objects weight or moving living and non-living things weight are live load. Live load is the another load which is considered during the design of any structure. In fact live is a kind of movable load which is not stationary and is not permanent load . This load generally acting during a particular time of the day or any other schedule of time during the week, month, year or of any season.

3) **Seismic load**- when earthquake occurs it produces seismic waves which affect the structures. the load which is produced by seismic waves is known as seismic load. It can destroy the whole structure and can cause deaths of humans. Therefore it is necessary to conduct the code of seismic loads in seismic zones.

4) **Snow load**- when snow falls on structure its weight produces load which is known as snow load. It is necessary to take snow load as major factor in designing of any structure situated in such area.

$$S = \mu S_0$$

Where, S =Estimated snow load

μ = coefficient of shape

S_0 = snow load on ground.

5) **Special loads-** According to IS code of 456 – 2000, above loads are consider as well as the below mentioned loads are also taken in effect:

(a) Movement of Foundation

(b) shortening due to Elastic axial

(c) fluid and soil pressure

(d) shaking movement

(e) Repeated no. of impact loading(Fatigue)

Objectives of the Study:

The various reviews were carried out and observed the result by comparing them with different results ,which were taken as-

1. To calculate the maximum displacement in Z and X direction for all five selected cases.
2. To show the relation between base shear obtained in Z and X direction for various twin tower cases.
3. To cross check maximum forces at ground level in columns.
4. To obtain and investigate maximum forces or shear forces in columns along Y and Z directions.
5. To display the Bending moments which is maximum in columns for different different cases.
6. To investigate the shear forces which is maximum in beams along X and Z directions.
7. To examine the maximum Torsion moments in beamsand columns along different axis.

To study the maximum Frequency along both X and Z direction

METHODOLOGY

Methodology is a technique through which we can perform our work with a particular process in a proper manner to get the desired results. Here we are comparing the current results with the previous result on which the research had done. And if not getting the desired result then doing the same process with little modification up to desired number of times so to get the results. Problem formulation is a very significant initiative towards the overcoming of the problematic situation than to solve it in a different way. It is good to solve the problems but it is the best to destroy the problem before it originates

3.1 General:

As coming to the building design point of view, various factors are to be considered. One of the important factor is economic factor. Hence designing the building according to the load requirements makes it more economic. So designing the structure members accordingly. When it becomes important to consider the different grades of concrete mix in the different-different members of the building components. Then it is clearly observed that there is a great change in the magnitudes of the shear force and the bending moments and the other important factors which have to be considered.

Since a large numbers of research papers are available in this field, so we can get many research papers for the reference purpose. Also we have to complete our research with some assumptions and IS codes. As our topic plays a significant role in the construction field hence research is to be done. Now a days people are designing their houses by the well skilled architecture or the structure engineer but sometimes keeping in mind some exceptions are there, in such a situation this topic helps the people and the various innovators to do something new in this industry. This research should be done with considering economic factors as an important considerations.

3.2 Methodology approach &Modelling approach

Fundamentally thinking on this point, the very first step to analyse the structure is to be by software or by manual approach. Various constraints and factors are there to select the method for the analysing of the structure. Economic consideration is too taken while its selection. Availability of the resources is seen, lack of which it will be difficult to analyse the structure. There are various methods approaches are also recommended by the Indian standards. In this study various cases are study on the staddpro software which shows the variation of the results.

3.4 Contemplation of loads

1.Dead load- The intrinsic self-weight of any building or any kind of structure is termed as dead load in which all other loads like residents and goods are excluded. In the present case study software is used to take out the dead load of structure.

2.Live load- This is simply the amalgamation of all load bear by the structure or applied on the structure after eliminating dead loads. In this study IS 875(part-II) is taken as reference for taking live loads of various kinds of objects. In this study IS 875(part-II) is taken as reference for taking live loads of various kinds of objects.

3.Earthquake load- Seismic loads are developed in all three perpendicular directions due to movements of tectonic plates. In this study all seismic parameters are taken in accordance to IS1893(part I):2016.

3.4.1 Load combination taken for analysis of models

1. Seismic load in direction +x

2. Seismic load in direction -x

3 Seismic load in direction +z

4. Seismic load in direction -z

5. Permanent load

6. Movable load

7. Response spectrum in direction x

8. Response spectrum in direction z

9. Response spectrum in direction y

10. 1.2DL + 1.2LL + 1.2EQ_x +0 .36 EQ_z

11. 1.2DL + 1.2LL + 1.2EQ_x - 0.36 EQ_z

12.1.2DL + 1.2LL - 1.2EQ_x +0 .36 EQ_z

13. 1.2DL + 1.2LL - 1.2EQ_x -0 .36 EQ_z

14. 1.2DL + 1.2LL + 1.2EQ_x +0 .36 EQ_z

15. 1.2DL + 1.2LL + 1.2EQ_x -0 .36 EQ_z

16. 1.2DL + 1.2LL - 1.2EQ_x +0 .36 EQ_z

17. 1.2DL + 1.2LL - 1.2EQ_x -0 .36 EQ_z

18. 1.5DL + 1.5EQ_x +0 .45EQ_z

19. 1.5DL + 1.5EQ_x -0 .45EQ_z

20. 1.5DL -1.5EQ_x -0 .45EQ_z

21. 1.5DL -1.5EQ_x +0 .45EQ_z

22. 1.5DL + 1.5EQ_z +0 .45EQ_x

23. 1.5DL + 1.5EQ_z -0 .45EQ_x

24. 1.5DL -1.5EQ_z -0 .45EQ_x

25. 1.5DL -1.5EQ_z +0 .45EQ_x

26. 0.9DL + 1.5 EQ_x+0.45EQ_z

27. 0.9DL + 1.5 EQ_x-0.45EQ_z

28. 0.9DL - 1.5 EQ_x+0.45EQ_z

29. 0.9DL - 1.5 EQ_x-0.45EQ_z

30. 0.9DL +1.5 EQ_z+0.45EQ_x

31. 0.9DL +1.5 EQ_z-0.45EQ_x

32. 0.9DL -1.5 EQ_z+0.45EQ_x

33. 0.9DL -1.5 EQ_z-0.45EQ_x

3.5 Parameters and different aspects of study-

For the analysis, here G+17 building is specially modelled in special way in different shapes so as to counteract or minimize the seismic parameters and also some other stability parameters. Various dimensions of the building elements are taken in the special consideration with the thought that it might reduce the effects of various magnitude of the various factors.

3.5.1 Maximum displacement values-

Maximum displacement values signify by which amount the nodes are dislocated with respect to their previous position while counteracting various loads that are applied on the structure. These values are examined and compared for various load cases modelled and analysed in accordance to IS1893(part-1):2016. This investigation will leads to conclude the status of node and so the structure whether the model is able to carry the desired load or it may fall and if so then the analysis is repeated again investigated for the same as per code. So the resultant displacement values are taken for consideration as it may be proved to be a very significant deciding parameter o objectives of the study and also safety of structure.

3.5.2 Story drift values

Story drift values are one of those seismic parameter which directly signify the structural safety of the structure in terms of fraction. Ratio of two consecutive floor levels within the multi-storey building or any skyscraper having different kinds of irregularity, is demarcated as story drift. As per IS for a given structure the limiting value is must be a multiple of 0.004 times of single story height for load factor of 1 and not more than that otherwise the model is assumed failed and needed to be redesigned. Due to this limiting value structural stability is confirmed along with comfort to occupants in both residential as well as commercial building. Also the effect of story drift is not encountered and necessary for single storied buildings as per seismic code of India.

3.5.3 Maximum displacement values

Base shear values are the function of mass of structure, fundamental natural period of vibration of the structure and conforming mode shape relevant to that structure taken for analysis or consideration. Mathematically it was calculated by the summation of total horizontal force applied on the structure. While calculating for a multi-storey tower its value is calculated by assuming the full building height as a whole and afterwards its value is distributed along the building height with the help of some standard equation with regular distribution of mass and stiffness.

3.5.4 Frequency

Frequency implies to number of occurrence of a repeating event with respect to time. In structural analysis frequency entails the count of repetition of number of seconds required to vibrate back and forth in the building when subjected to lateral loads i.e. earthquake loads for this study.

3.5.5 Time period

Time period is also termed as “Fundamental natural period” in IS code 1893(1):2016 primarily the time period is inverse of the frequency which imply that time required by the rotation of vibration to pass from a single point taken at a time for study. In according to the seismic code of India. Fundamental natural period is a function of physical parameters of the building i.e. height and depth. Its value should varies from 0.05 to 2.00 sec in range.

3.7 Using STAAD PRO, Building analysis Steps are as follows-

1. Using STAADPRO software, firstly making new file.

2. Creating the structure by node & co-ordinates and other input members along with the column and the beam with specification make the new frame.

3. Now the members which are created label them with the dimensions & give them input properties.

4. Provide fixed or hinged support etc as per the structure type.

5. Specify and provide various forces combination with following forces- such as permanent load, movable load or seismic load etc on the structure.

6. Show the analysis type & also the behaviour of structure then to get various parameters such as storey drift, various stresses & the deflection values.

7. Now perform the analysis and run the analysis. In case if error occurs then we have to remove the error & further repeat the same process.

8. Now observe the result file & Note the various design parameters of structure parts such as column & beam etc. Also you can save the file for further use.

RESULT & DISCUSSIONS

As per the objectives, for earthquake analysis the Response Spectrum Observation is made on different staad pro shapes of twins tower consist of structure made up of G+17 storey building in Zone III, building made up of G+17 storey building in Zone III with three floor podium and after that twins tower starts These building model SHAPEs are assumed to be situated in earthquake Zone III.

Since for the analysis of seismic effects, all the SHAPEs of the structures have been analyzed for seismic vibrate for longitudinal along with transverse direction. Various loads along with load combinations applied on all the SHAPEs and reflective result parameters have been analyzed with each other to determine the efficient SHAPE. Results are shown both in tabular form as well as graphical form. The analysis results obtained using Staad pro software is shown in tabular form along with various graphs with various parameters .

4.2 Result analysis for various models

4.2.1 Results for SHAPE U

Table 4.1: Maximum Displacement in X and Z direction for SHAPE U in Zone IV

SHAPE No.	**Maximum Displacement (mm)**	
	For X Direction	**For Z Direction**
U	333.739	311.785

Table 4.2: Storey Drift in X and Z direction for SHAPE U in Zone IV

S. No.	**Height (m)**	**Storey Drift (cm)**	
		For X Direction	**For Z Direction**
1	0	0	0
2	3	0.1515	0.1212
3	4.58	0.5762	0.3073
4	8.24	0.6318	0.3962
5	11.90	0.7276	0.4884
6	15.56	1.0686	0.9967
7	19.22	1.1580	1.1891
8	22.88	1.2580	1.2954
9	26.54	1.3347	1.3967
10	30.20	1.1550	1.4232
11	33.86	1.4154	1.4406
12	37.52	1.4152	1.4341
13	41.18	1.4176	1.4074
14	44.84	1.1627	1.3630
15	48.50	1.3605	1.3036
16	52.16	1.3164	1.2321

17	55.82	1.2664	1.1520
18	59.48	1.2142	1.0691
19	63.14	1.1678	0.9891
20	66.80	1.1073	0.8786

Table 4.3: Base Shear in X and Z direction for SHAPE U

SHAPE	**Base Shear (KN)**	
	X direction	**Z direction**
SHAPE U	17224.46	14850.59

Table 4.4: Time Period and Mass Participation Factor for SHAPE U

Mode No.	**Time Period (Seconds)**	**Participation X %**	**Participation Z %**
	SHAPE U		
1	2.973	0	23.065
2	2.914	0	0
3	2.764	50.919	0
4	2.357	0	0
5	1.634	0	0
6	1.610	0	28.276

Table 4.5: Maximum Axial Forces, Shear Force and Bending Moment in Column at ground level for SHAPE U

SHAPE	**Column Axial Force (KN)**	**Column Shear Force (KN)**		**Column Bending Moment (KNm)**	
		Shear along Y	**Shear along Z**	**Moment along Y**	**Moment along Z**
SHAPE U	11713.396	2943.599	4813.633	6891.483	2990.166

Table 4.6: Maximum Shear Forces in beams parallel to X and Z direction for SHAPE U

SHAPE	**Beam Shear Force (KN) (parallel to X direction)**	**Beam Shear Force (KN) (parallel to Z direction)**
SHAPE U	48.778	83.160

Table 4.7: Maximum Moment in beams parallel to X and Z direction for SHAPE U

SHAPE	**Beam Bending Moment (KNm) (parallel to X direction)**	**Beam Bending Moment (KNm) (parallel to Z direction)**
SHAPE U	12.650	0.038

Table 4.8: Maximum Torsional Moment in beams parallel to X and Z direction for SHAPE U

SHAPE	**Beam Torsional Moment (KNm) (parallel to X direction)**	**Beam Torsional Moment (KNm) (parallel to Z direction)**
SHAPE U	61.761	0.039

4.2.2 Results for SHAPE V

Table 4.9: Maximum Displacement in X and Z direction for SHAPE V in Zone IV

SHAPE	Maximum Displacement (mm)	
	For X Direction	For Z Direction
V	308.525	304.022

Table 4.10: Storey Drift in X and Z direction for SHAPE V in Zone IV

S. No.	Height (m)	Storey Drift (cm)	
		For X Direction	For Z Direction
1	0	0	0
2	3	0.0480	0.1062
3	4.58	0.4910	0.3441
4	8.24	0.5326	0.3533
5	11.90	0.6014	0.4375
6	15.56	0.9332	0.3853
7	19.22	1.0123	1.2095
8	22.88	1.1015	1.3148
9	26.54	1.1722	1.3955
10	30.20	1.22	1.4421
11	33.86	1.2480	1.4578
12	37.52	1.2583	1.4482
13	41.18	1.2531	1.4171
14	44.84	1.2344	1.3677
15	48.50	1.2047	1.3028
16	52.16	1.1664	1.2253
17	55.82	1.1227	1.1394
18	59.48	1.0769	1.0510
19	63.14	1.0365	0.9621
20	66.80	0.9781	0.8372

Table 4.11: Base Shear in X and Z direction for SHAPE V

SHAPE	Base Shear (KN)	
	X direction	Z direction
SHAPE V	17901.00	15519.22

Table 4.12: Time Period and Mass Participation Factor for SHAPE V

Mode No.	**Time Period (Seconds)**	**Participation X %**	**Participation Z %**
	SHAPE V		
1	2.788	0	26.480
2	2.725	0	0
3	2.517	48.699	0
4	2.164	0	0
5	1.401	0	0
6	1.378	0	23.128

Table 4.13: Maximum Axial Forces, Shear Force and Bending Moment in Column at ground level for SHAPE V

SHAPE	**Column Axial Force (KN)**	**Column Shear Force (KN)**		**Column Bending Moment (KNm)**	
		Shear along Y	**Shear along Z**	**Moment along Y**	**Moment along Z**
SHAPE V	12447.030	362.629	359.766	733.600	663.914

Table 4.14: Maximum Shear Forces in beams parallel to X and Z direction for SHAPE V

SHAPE	**Beam Shear Force (KN) (parallel to X direction)**	**Beam Shear Force (KN) (parallel to Z direction)**
SHAPE V	303.636	5.021

Table 4.15: Maximum Moment in beams parallel to X and Z direction for SHAPE V

SHAPE	**Beam Bending Moment (KNm) (parallel to X direction)**	**Beam Bending Moment (KNm) (parallel to Z direction)**
SHAPE B	13.056	639.472

Table 4.16: Maximum Torsional Moment in beams parallel to X and Z direction for SHAPE V

SHAPE	**Beam Torsional Moment (KNm) (parallel to X direction)**	**Beam Torsional Moment (KNm) (parallel to Z direction)**
SHAPE B	42.381	41.406

4.2.3 Results for SHAPE X

Table 4.17: Maximum Displacement in X and Z direction for SHAPE X in Zone IV

SHAPE No.	**Maximum Displacement (mm)**	
	For X Direction	**For Z Direction**
X	307.554	315.146

Table 4.18: Storey Drift in X and Z direction for SHAPE X in Zone IV

S. No.	**Height (m)**	**Storey Drift (cm)**	
		For X Direction	**For Z Direction**
1	0	0	0
2	3	0.1223	0.1010
3	4.58	0.4725	0.3308
4	8.24	0.5160	0.3422
5	11.90	0.5824	0.4172
6	15.56	0.9221	0.9226
7	19.22	1.0030	1.1311
8	22.88	1.0965	1.2393
9	26.54	1.1716	1.3265
10	30.20	1.2239	1.3801
11	33.86	1.2565	1.4033
12	37.52	1.2715	1.4015
13	41.18	1.2709	1.3786
14	44.84	1.2568	1.3376
15	48.50	1.2314	1.2815
16	52.16	1.1972	1.2135
17	55.82	1.1574	1.1378
18	59.48	1.1150	1.0601
19	63.14	1.0775	0.980
20	66.80	1.0239	0.8724

Table 4.19: Base Shear in X and Z direction for SHAPE X

SHAPE	**Base Shear (KN)**	
	X direction	**Z direction**
SHAPE X	16242.56	14638.39

Table 4.20: Time Period and Mass Participation Factor for SHAPE X

Mode No.	Time Period (Seconds)	Participation X %	Participation Z %
	SHAPE X		
1	2.659	0	23.710
2	2.602	0	0
3	2.439	45.818	0
4	2.101	0	0
5	1.362	0	0
6	1.340	0	23.179

Table 4.21: Maximum Axial Forces, Shear Force and Bending Moment in Column at ground level for SHAPE X

SHAPE	Column Axial Force (KN)	Column Shear Force (KN)		Column Bending Moment (KNm)	
		Shear along Y	Shear along Z	Moment along Y	Moment along Z
SHAPE X	12166.444	347.659	333.437	723.077	662.120

Table 4.22: Maximum Shear Forces in beams parallel to X and Z direction for SHAPE X

SHAPE	Beam Shear Force (KN) (parallel to X direction)	Beam Shear Force (KN) (parallel to Z direction)
SHAPE X	293.589	4.901

Table 4.23: Maximum Moment in beams parallel to X and Z direction for SHAPE X

SHAPE	Beam Bending Moment (KNm) (parallel to X direction)	Beam Bending Moment (KNm) (parallel to Z direction)
SHAPE X	8.629	537.018

Table 4.24: Maximum Torsional Moment in beams parallel to X and Z direction for SHAPE X

SHAPE	Beam Torsional Moment (KNm) (parallel to X direction)	Beam Torsional Moment (KNm) (parallel to Z direction)
SHAPE X	61.567	57.258

4.2.4 Results for SHAPE Y

Table 4.25: Maximum Displacement in X and Z direction for SHAPE Y in Zone III

SHAPE No.	**Maximum Displacement (mm)**	
	For X Direction	**For Z Direction**
Y	306.318	300.378

Table 4.26: Storey Drift in X and Z direction for SHAPEY in Zone III

S. No.	**Height (m)**	**Storey Drift (cm)**	
		For X Direction	**For Z Direction**
1	0	0	0
2	3	0.1268	0.1053
3	4.58	0.1832	0.3439
4	8.24	0.5320	0.3544
5	11.90	0.5998	0.4301
6	15.56	0.9457	0.9296
7	19.22	1.0220	1.1143
8	22.88	1.1168	1.2181
9	26.54	1.1913	1.2998
10	30.20	1.2427	1.3485
11	33.86	1.2743	1.3687
12	37.52	1.2880	1.3655
13	41.18	1.2860	1.3424
14	44.84	1.2703	1.3022
15	48.50	1.2433	1.2474
16	52.16	1.2074	1.1811
17	55.82	1.1658	1.1069
18	59.48	1.1216	1.0304
19	63.14	1.0823	0.9561
20	66.80	1.0285	0.8499

Table 4.27: Base Shear in X and Z direction for SHAPE Y

SHAPE	**Base Shear (KN)**	
	X direction	**Z direction**
SHAPE D	17133.64	15076.40

Table 4.28: Time Period and Mass Participation Factor for SHAPE Y

Mode No.	Time Period (Seconds)	Participation X %	Participation Z %
	SHAPE Y		
1	2.685	0	25.119
2	2.624	0	0
3	2.518	47.633	0
4	2.168	0	0
5	1.426	0	0
6	1.400	0	23.327

Table 4.29: Maximum Axial Forces, Shear Force and Bending Moment in Column at ground level for SHAPE Y

SHAPE	Column Axial Force (KN)	Column Shear Force (KN)		Column Bending Moment (KNm)	
		Shear along Y	Shear along Z	Moment along Y	Moment along Z
SHAPE Y	12615.482	348.983	327.768	735.521	642.813

Table 4.30: Maximum Shear Forces in beams parallel to X and Z direction for SHAPE Y

SHAPE	Beam Shear Force (KN) (parallel to X direction)	Beam Shear Force (KN) (parallel to Z direction)
SHAPE Y	302.431	4.884

Table 4.31: Maximum Moment in beams parallel to X and Z direction for SHAPE Y

SHAPE	Beam Bending Moment (KNm) (parallel to X direction)	Beam Bending Moment (KNm) (parallel to Z direction)
SHAPE D	44.663	502.668

Table 4.32: Maximum Torsional Moment in beams parallel to X and Z direction for SHAPE Y

SHAPE	Beam Torsional Moment (KNm) (parallel to X direction)	Beam Torsional Moment (KNm) (parallel to Z direction)
SHAPE Y	6.832	42.419

4.2.5 Results for SHAPE Z

Table 4.33: Maximum Displacement in X and Z direction for SHAPE E in Zone III

SHAPE No.	**Maximum Displacement (mm)**	
	For X Direction	**For Z Direction**
Z	284.759	272.813

Table 4.34: Storey Drift in X and Z direction for SHAPE Z in Zone III

S. No.	**Height (m)**	**Storey Drift (cm)**	
		For X Direction	**For Z Direction**
1	0	0	0
2	3	0.1286	0.1074
3	4.58	0.4934	0.3491
4	8.24	0.5357	0.3566
5	11.90	0.6051	0.4252
6	15.56	0.9403	0.8237
7	19.22	1.0158	0.9820
8	22.88	1.1060	1.0714
9	26.54	1.1770	1.1430
10	30.20	1.2253	1.1871
11	33.86	1.2540	1.2073
12	37.52	1.2651	1.2076
13	41.18	1.2608	1.1909
14	44.84	1.2430	1.1595
15	48.50	1.2141	1.1156
16	52.16	1.1766	1.0617
17	55.82	1.1336	1.0008
18	59.48	1.0882	0.9376
19	63.14	1.0479	0.8766
20	66.80	0.9920	0.7875

Table 4.35: Base Shear in X and Z direction for SHAPE Z

SHAPE	**Base Shear (KN)**	
	X direction	**Z direction**
SHAPE Z	17832.21	15508.48

Table 4.36: Time Period and Mass Participation Factor for SHAPE Z

Mode No.	Time Period (Seconds)	Participation X %	Participation Z %
	SHAPE Z		
1	2.644	0	21.023
2	2.591	0	0
3	2.525	48.657	0
4	2.170	0	0
5	1.543	0	0
6	1.519	0	0

Table 4.37: Maximum Axial Forces, Shear Force and Bending Moment in Column at ground level for SHAPE Z

SHAPE	Column Axial Force (KN)	Column Shear Force (KN)		Column Bending Moment (KNm)	
		Shear along Y	Shear along Z	Moment along Y	Moment along Z
SHAPE Z	12851.082	340.143	290.163	644.418	640.112

Table 4.38: Maximum Shear Forces in beams parallel to X and Z direction for SHAPE Z

SHAPE	Beam Shear Force (KN) (parallel to X direction)	Beam Shear Force (KN) (parallel to Z direction)
SHAPE Z	295.564	4.368

Table 4.39: Maximum Moment in beams parallel to X and Z direction for SHAPE Z

SHAPE	Beam Bending Moment (KNm) (parallel to X direction)	Beam Bending Moment (KNm) (parallel to Z direction)
SHAPE Z	6.784	476.253

Table 4.40: Maximum Torsional Moment in beams parallel to X and Z direction for SHAPE Z

SHAPE	Beam Torsional Moment (KNm) (parallel to X direction)	Beam Torsional Moment (KNm) (parallel to Z direction)
SHAPE Z	50.866	48.008

4.3 Discussion

Table 4.41: Maximum Displacement in X direction all 13 SHAPEs in Zone III

SHAPE No.	Maximum Displacement (mm)
	For X Direction
U	333.739
V	308.525
X	307.554
Y	306.318
Z	284.759

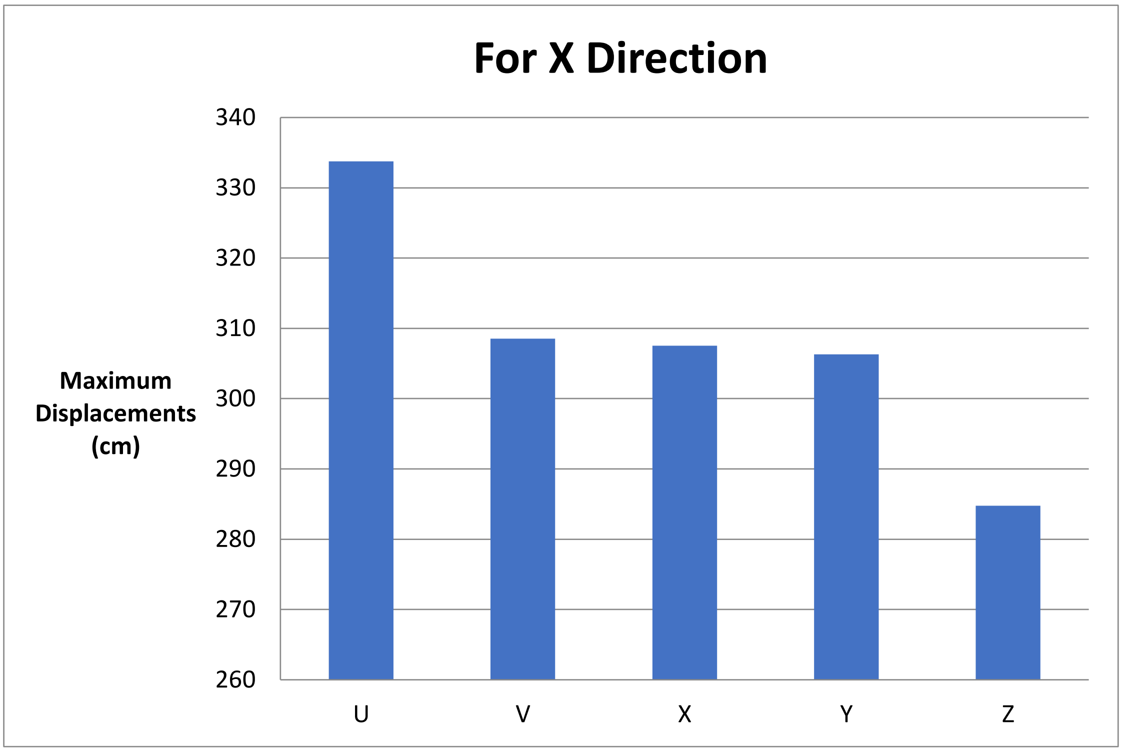


Fig.4.1: Maximum Displacement in X direction for all 5 SHAPEs in Zone III

As the study shows shape Z is perform well among all the cases in the displacement.

Table 4.42: Maximum Displacement in Z direction of R.C.C. for all 13 SHAPEs in Zone IV

SHAPE No.	Maximum Displacement (mm)
	For Z Direction
U	311.785
V	304.022
X	315.146
Y	300.378
Z	272.813

Fig.4.2: Maximum Displacement in Z direction for all 5 SHAPEs in Zone III

Shape Z , displacement is better than other shape in direction Z

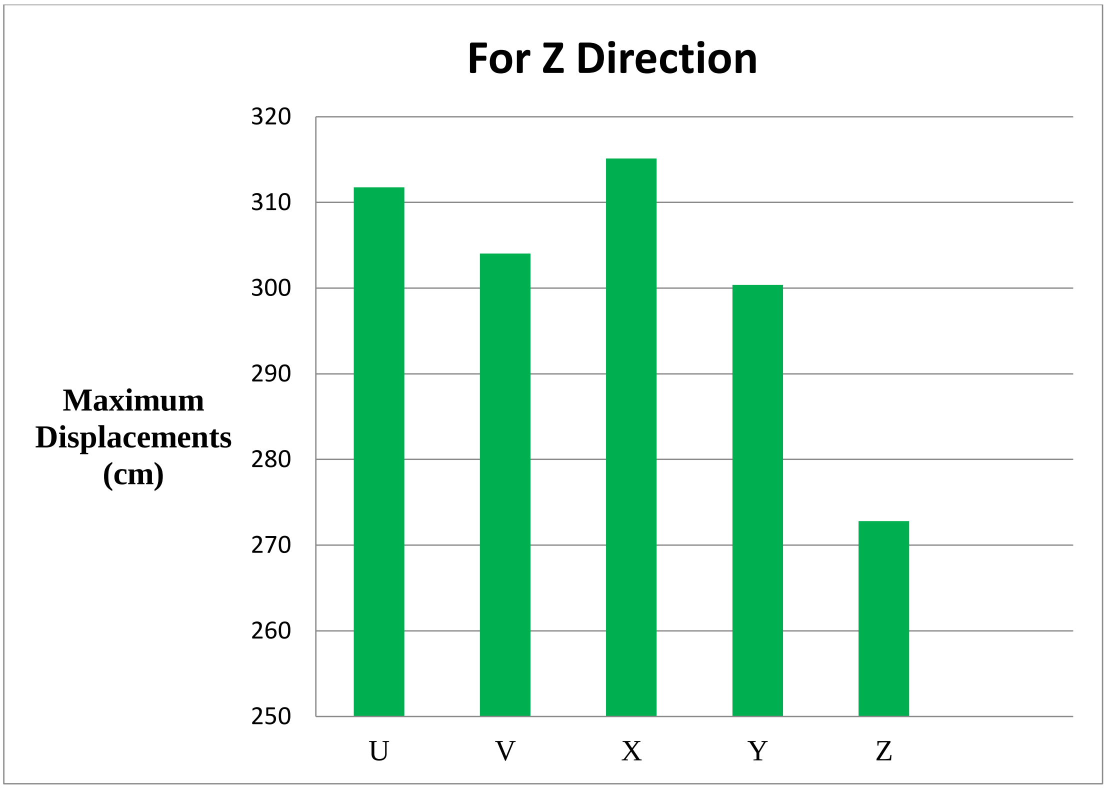


Table 4.43: Storey Drift in X direction for all 5 SHAPEs in Zone III

S. No.	Height (m)	Storey Drift (cm)				
		For X Direction				
		SHAPE U	SHAPE V	SHAPE X	SHAPE Y	SHAPE Z
1	0	0	0	0	0	0
2	3	0.1515	0.0480	0.1223	0.1268	0.1286
3	4.58	0.5762	0.4910	0.4725	0.1832	0.4934
4	8.24	0.6318	0.5326	0.5160	0.5320	0.5357
5	11.90	0.7276	0.6014	0.5824	0.5998	0.6051
6	15.56	1.0686	0.9332	0.9221	0.9457	0.9403
7	19.22	1.1580	1.0123	1.0030	1.0220	1.0158
8	22.88	1.2580	1.1015	1.0965	1.1168	1.1060
9	26.54	1.3347	1.1722	1.1716	1.1913	1.1770
10	30.20	1.1550	1.22	1.2239	1.2427	1.2253
11	33.86	1.4154	1.2480	1.2565	1.2743	1.2540
12	37.52	1.4152	1.2583	1.2715	1.2880	1.2651
13	41.18	1.4176	1.2531	1.2709	1.2860	1.2608
14	44.84	1.1627	1.2344	1.2568	1.2703	1.2430

15	48.50	1.3605	1.2047	1.2314	1.2433	1.2141
16	52.16	1.3164	1.1664	1.1972	1.2074	1.1766
17	55.82	1.2664	1.1227	1.1574	1.1658	1.1336
18	59.48	1.2142	1.0769	1.1150	1.1216	1.0882
19	63.14	1.1678	1.0365	1.0775	1.0823	1.0479
20	66.80	1.1073	0.9781	1.0239	1.0285	0.9920

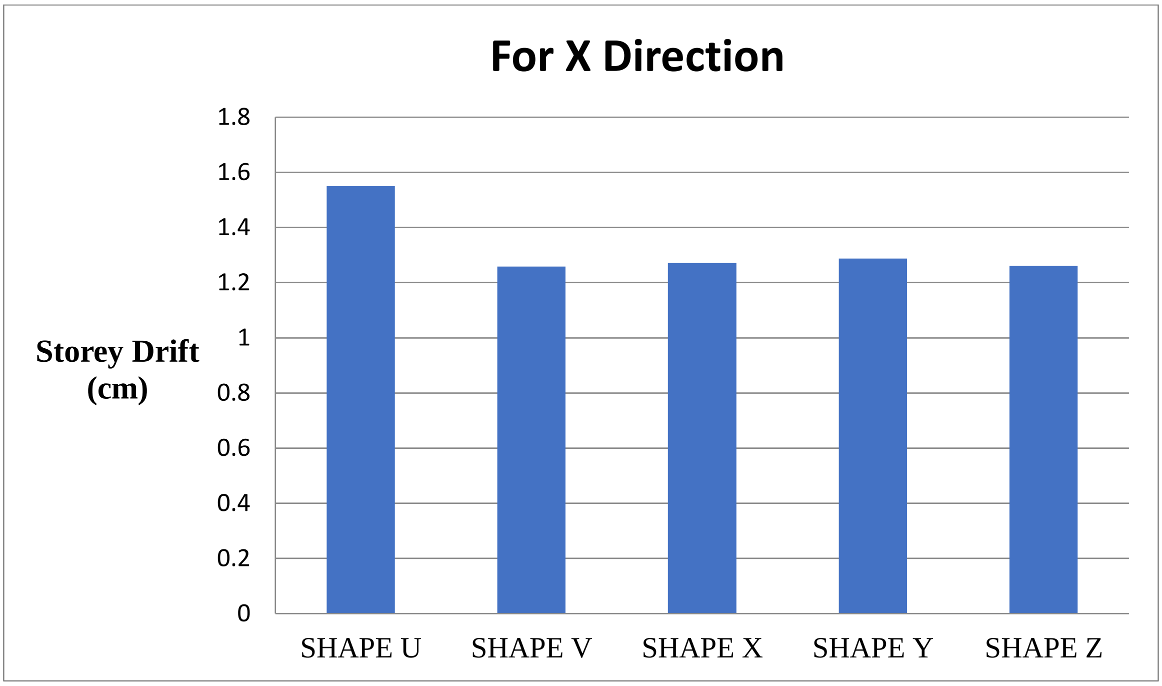


Fig.4.3: Storey Drift in X direction for all 5 SHAPEs in Zone III

Amoung all the cases storey drift of case V perform good in seismic analysis

Table 4.44: Storey Drift in Z direction for all 13 SHAPEs in Zone III

S. No.	Height (m)	Storey Drift (cm)				
		For Z Direction				
		SHAPE U	SHAPE V	SHAPE X	SHAPE Y	SHAPE Z
1	0	0	0	0	0	0
2	3	0.1515	0.1062	0.1010	0.1053	0.1074
3	4.58	0.5762	0.3441	0.3308	0.3439	0.3491
4	8.24	0.6318	0.3533	0.3422	0.3544	0.3566
5	11.90	0.7276	0.4375	0.4172	0.4301	0.4252
6	15.56	1.0686	0.3853	0.9226	0.9296	0.8237
7	19.22	1.1580	1.2095	1.1311	1.1143	0.9820
8	22.88	1.2580	1.3148	1.2393	1.2181	1.0714
9	26.54	1.3347	1.3955	1.3265	1.2998	1.1430

10	30.20	1.1550	1.4421	1.3801	1.3485	1.1871
11	33.86	1.4154	1.4578	1.4033	1.3687	1.2073
12	37.52	1.4152	1.4482	1.4015	1.3655	1.2076
13	41.18	1.4176	1.4171	1.3786	1.3424	1.1909
14	44.84	1.1627	1.3677	1.3376	1.3022	1.1595
15	48.50	1.3605	1.3028	1.2815	1.2474	1.1156
16	52.16	1.3164	1.2253	1.2135	1.1811	1.0617
17	55.82	1.2664	1.1394	1.1378	1.1069	1.0008
18	59.48	1.2142	1.0510	1.0601	1.0304	0.9376
19	63.14	1.1678	0.9621	0.980	0.9561	0.8766
20	66.80	1.1073	0.8372	0.8724	0.8499	0.7875

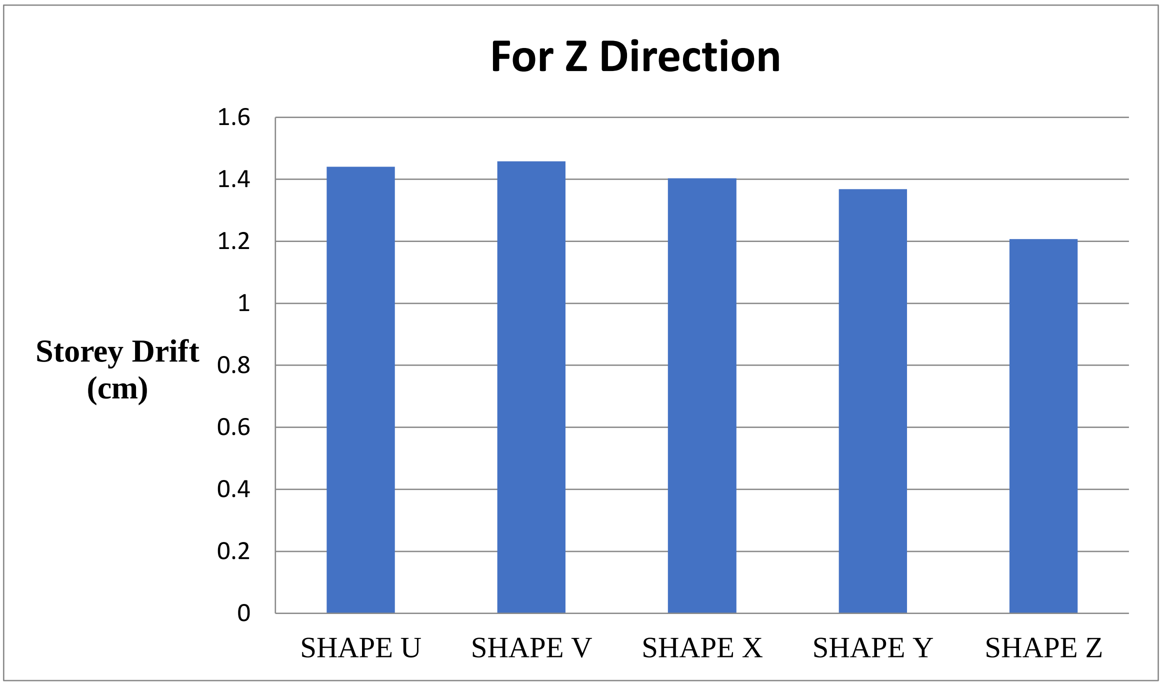
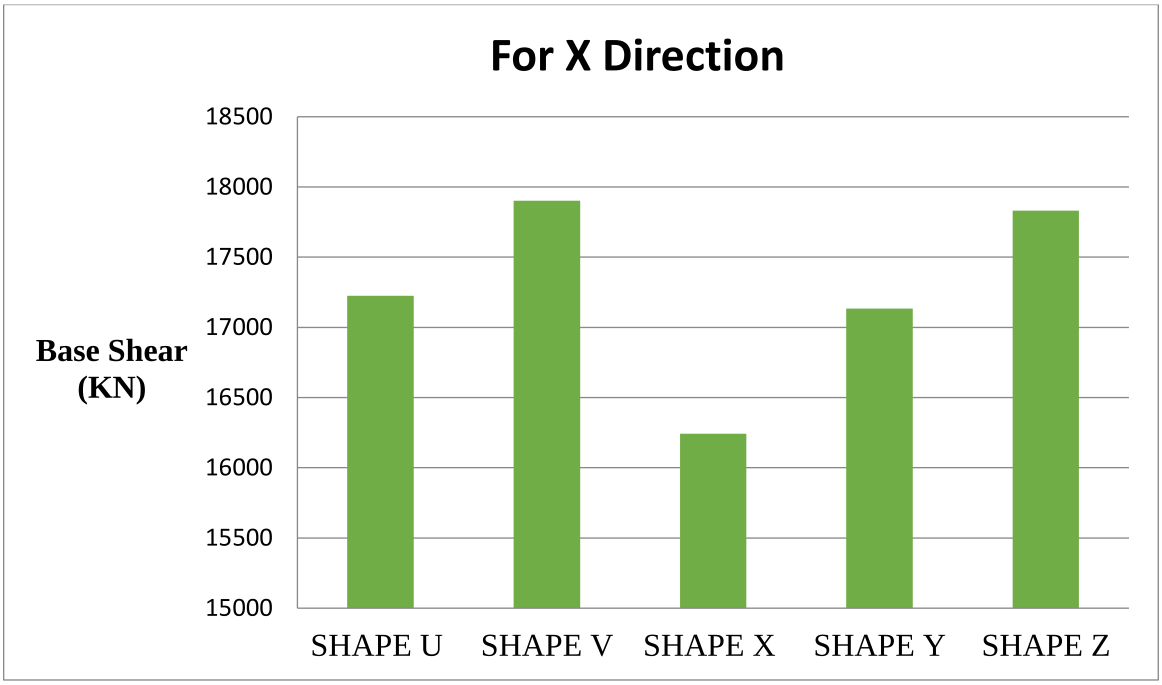


Fig. 4.4: Storey Drift in Z direction for all 13 SHAPEs in Zone III

As the study shows story drift in direction Z ,shape Z result are better than other cases

Table 4.45: Base Shear in X and Z direction for all Building SHAPEs

SHAPES	**Base Shear (KN)**	
	X direction	**Z direction**
SHAPE A	17224.46	14850.59
SHAPE B	17901.00	15519.22
SHAPE C	16242.56	14638.39
SHAPE D	17133.64	15076.40
SHAPE E	17832.21	15508.48



On comparing base shear for X direction Shape X is performing very well than other cases

Fig. 4.5: Base Shear in X direction for all Building SHAPEs

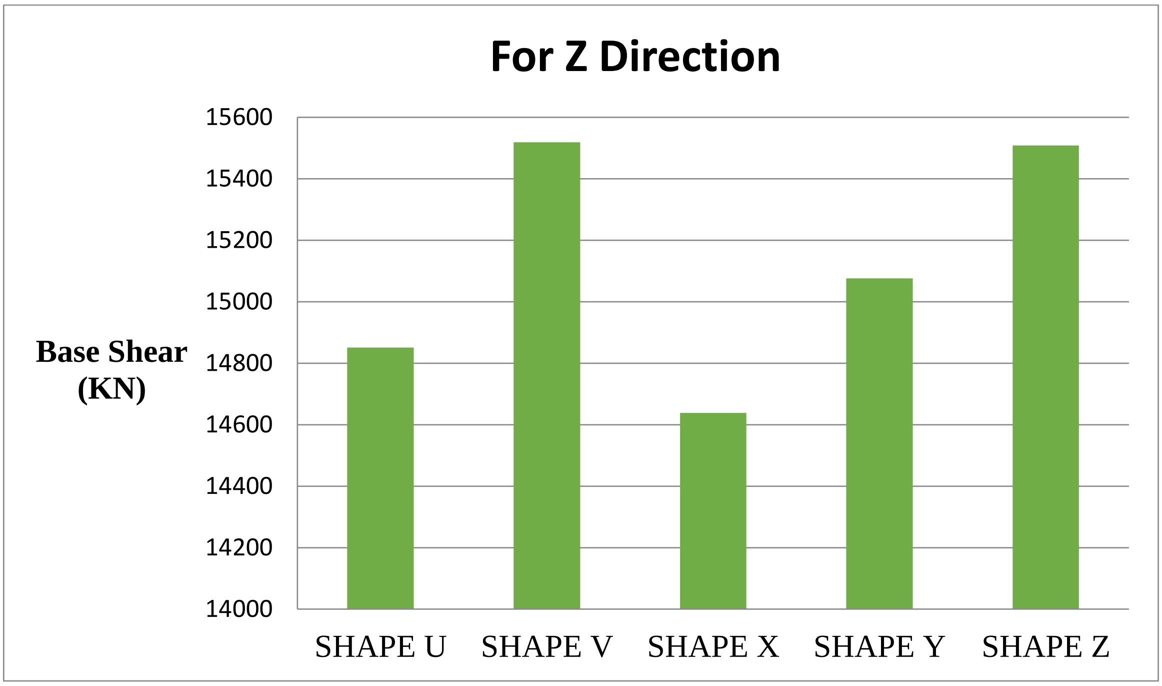


Fig. 4.46: Base Shear in Z direction for all Building SHAPEs

On comparing base shear for Z direction Shape X is performing very well than other cases

Table 4.46: Time Period and Mass Participation Factor for all Building SHAPEs

SHAPES	Time Period (Seconds)	Participation X %	Time Period (Seconds)	Participation Z %
SHAPE U	2.764	50.919	1.614	28.278
SHAPE V	2.517	48.699	2.788	26.480
SHAPE X	2.439	45.818	2.659	23.710
SHAPE Y	2.518	47.657	2.644	25.119
SHAPE Z	2.525	48.657	2.644	21.023

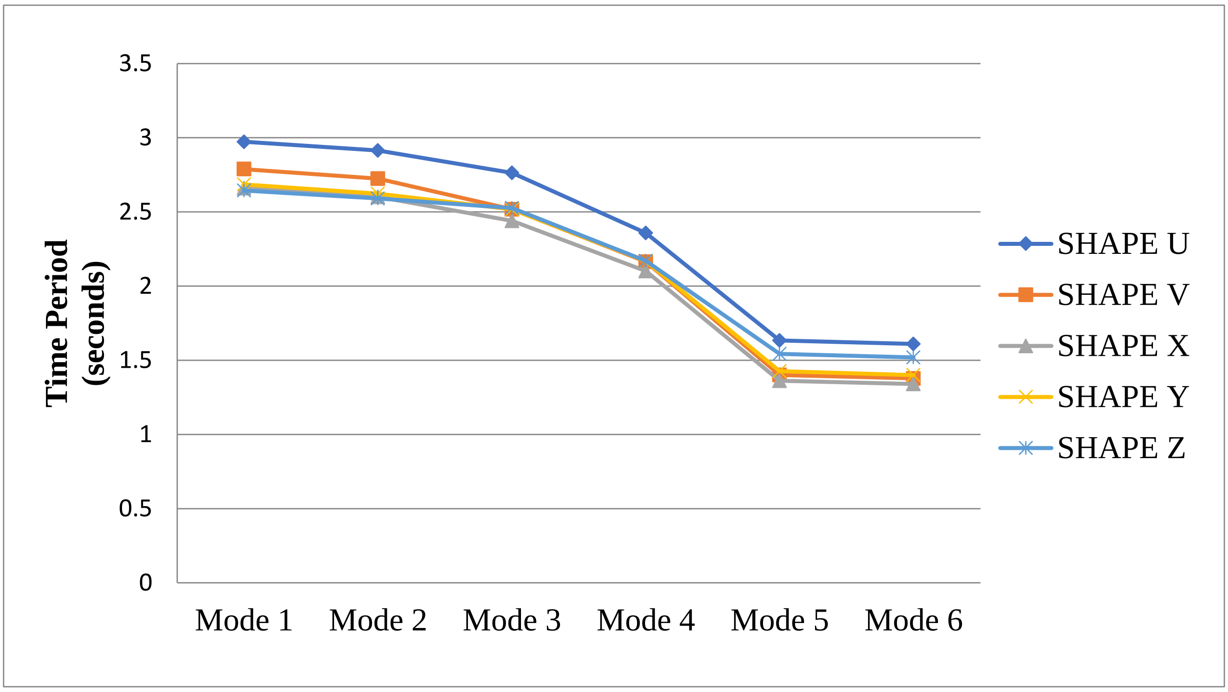


Fig. 4.7: Time Period for all Building SHAPEs

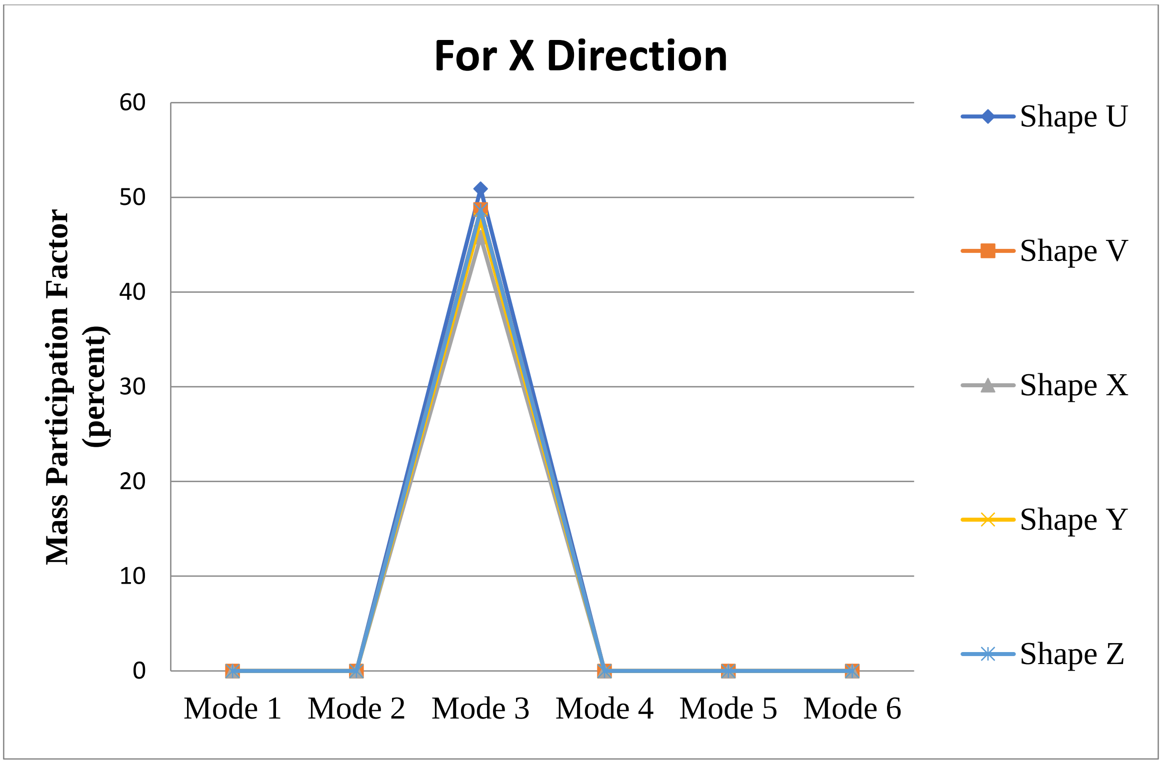


Fig. 4.8: Mass Participation Factor in X direction for all Building SHAPEs

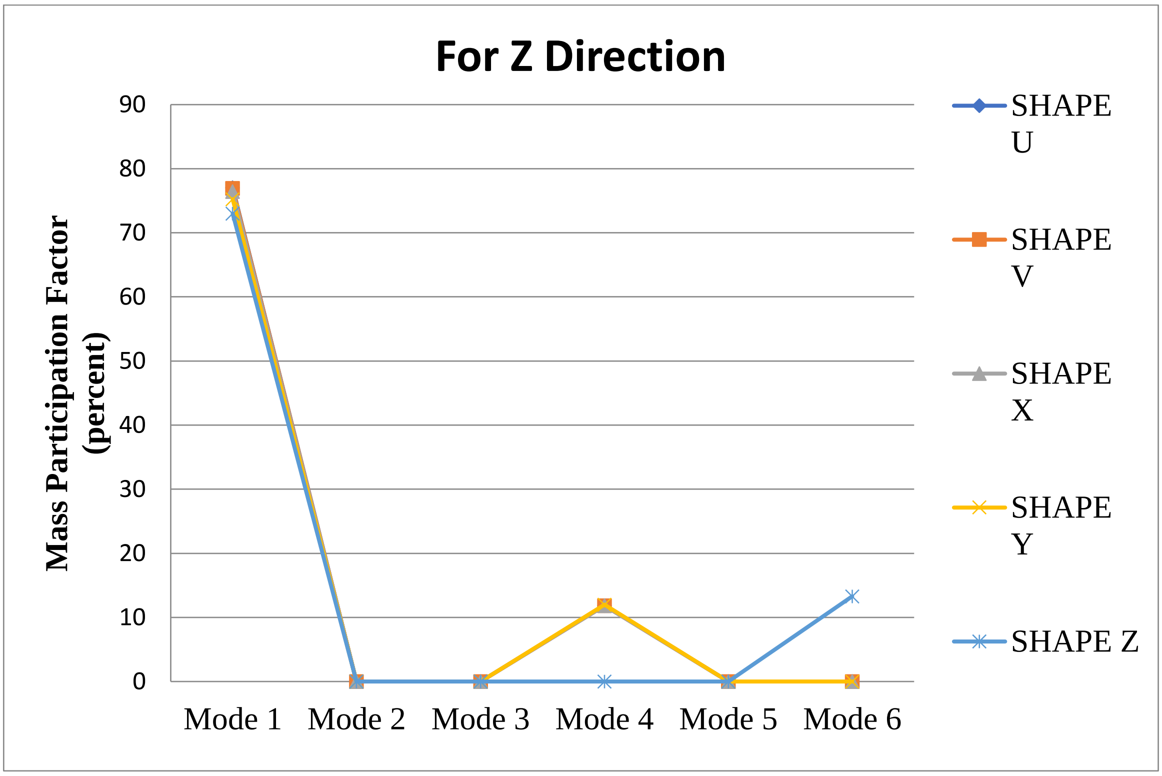


Fig. 4.9: Mass Participation Factor in Z direction for all Building SHAPEs

Table 4.47: Maximum Axial Forces in Column at ground level for all Building SHAPEs

SHAPE No.	Column Axial Force (KN)
U	11713.396
V	12447.030
X	12166.444
Y	12615.482
Z	12851.082

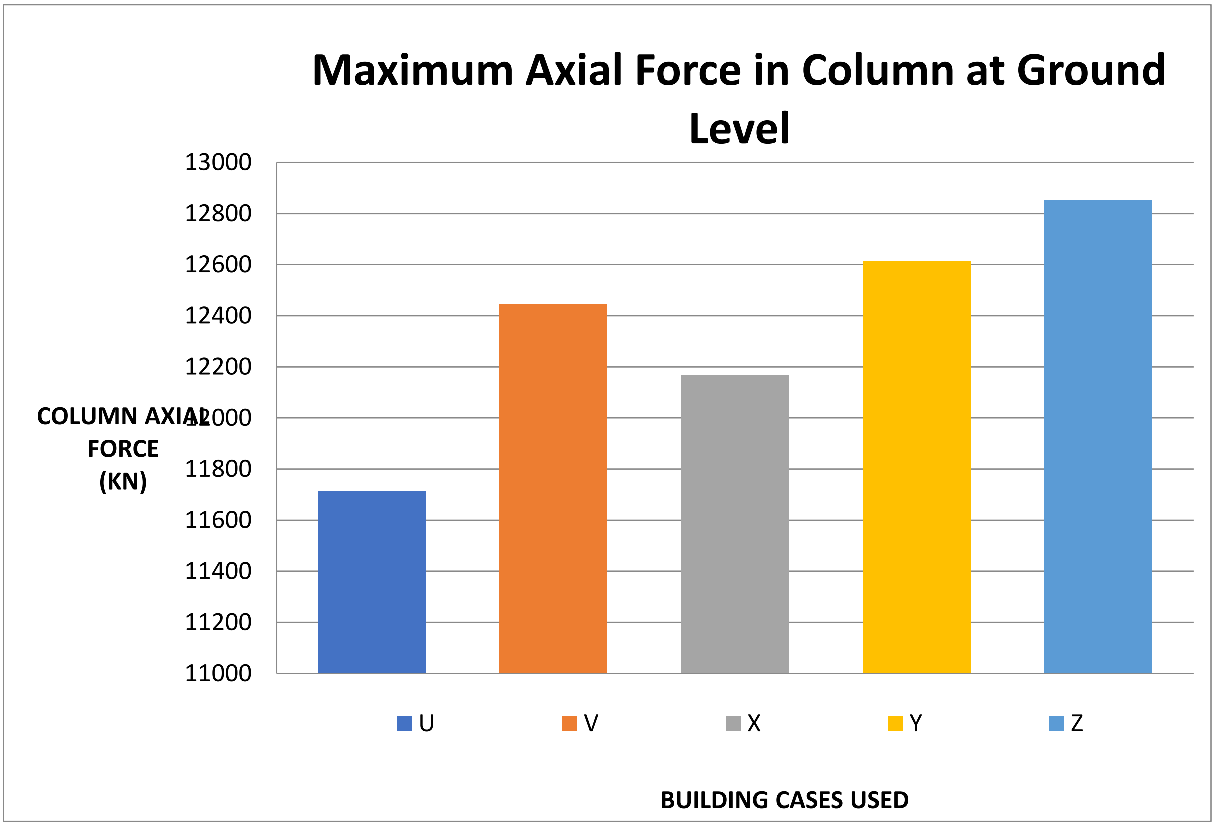


Fig. 4.10: Maximum Axial Forces in Column at ground level for all Building SHAPEs

In the study of mass participation factor shape Z is performing well than other

Table 4.48: Maximum Shear Forces in Columns for all Building SHAPEs

SHAPE No.	Column Shear Force (KN)	
	Shear along Y	**Shear along Z**
U	341.434	297.931
V	362.629	359.766
X	347.659	333.437
Y	348.983	327.768
Z	340.143	290.163

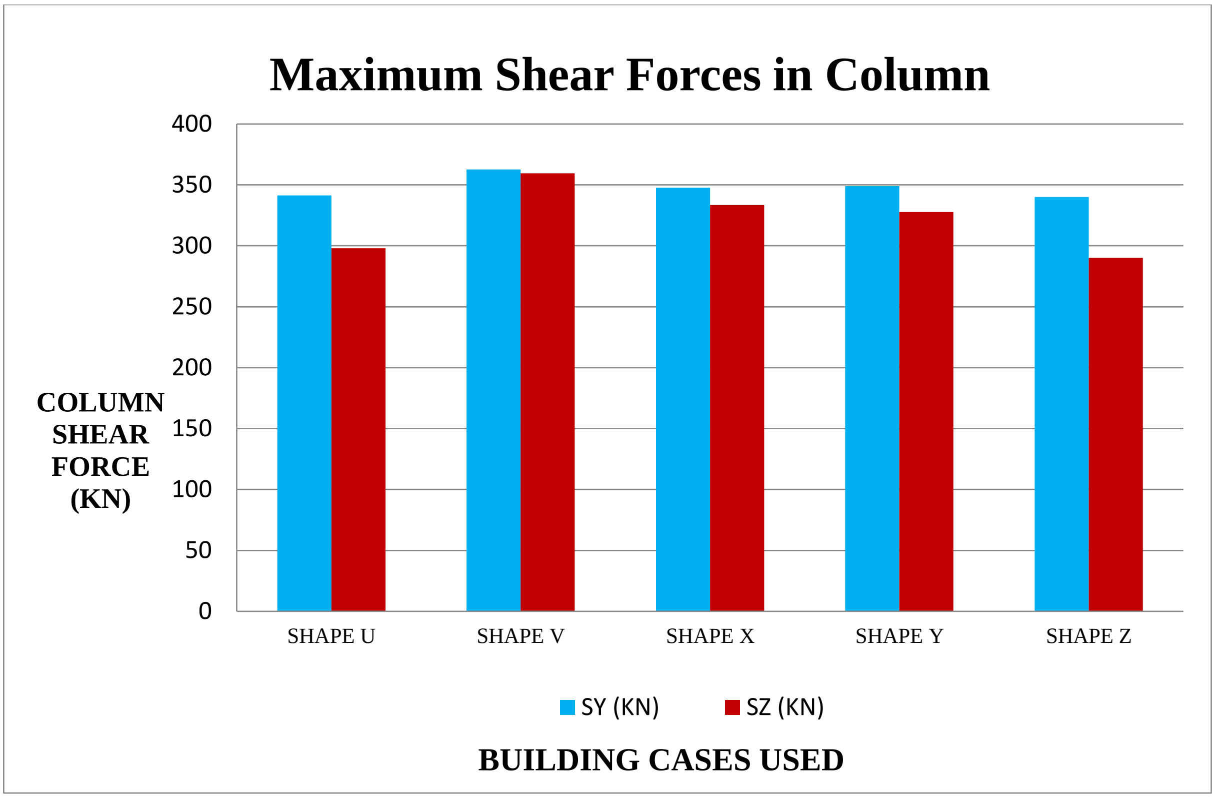


Fig. 4.11: Maximum Shear Forces in Columns for all Building SHAPEs

Above study of shear force in both direction shape z perform well

Table 4.49: Maximum Bending Moment in Columns for all Building SHAPEs

SHAPE No.	**Column Bending Moment (KNm)**	
	Moment along Y	**Moment along Z**
U	587.355	624.836
V	733.600	663.914
X	547.659	633.437
Y	548.983	527.768
Z	540.141	510.153

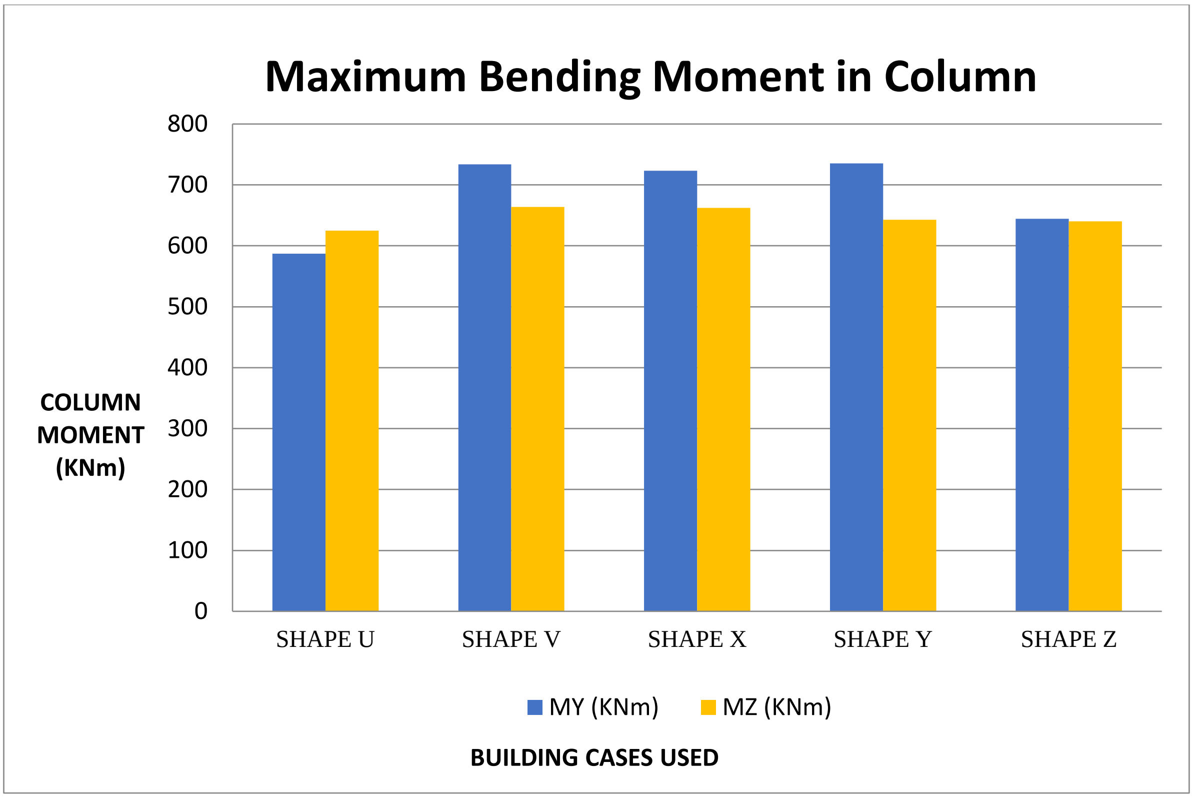


Fig. 4.12: Maximum Bending Moment in Columns for all Building SHAPEs

Above study of bending moment in both direction shape z perform well

Table 4.50: Maximum Shear Forces in beams parallel to X direction for all Building SHAPEs

SHAPE No.	**Beam Shear Force (parallel to X direction) (KN)**
U	276.949
V	303.636
X	293.589
Y	302.431
Z	295.564

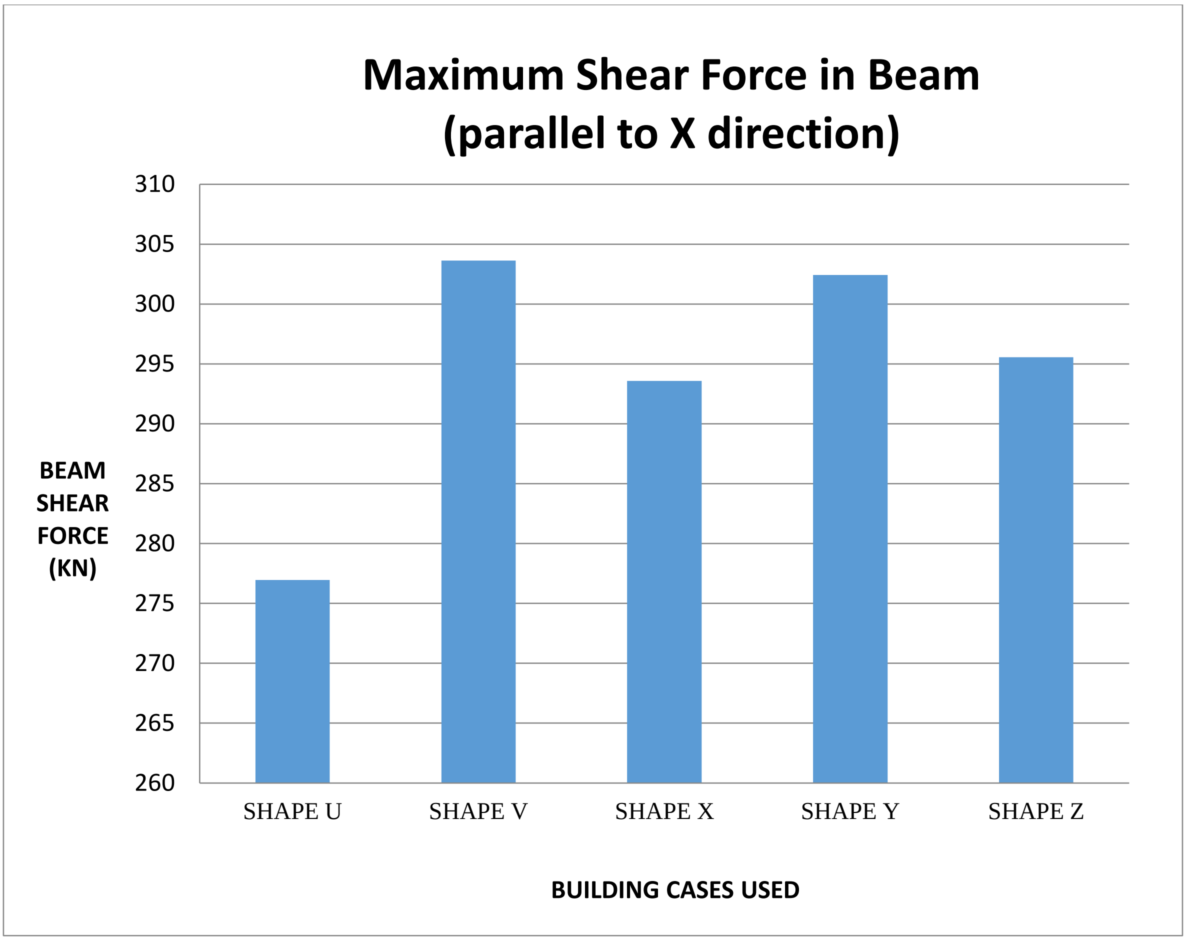


Fig. 4.13: Maximum Shear Forces in beams parallel to X direction for all Building SHAPEs

Above study of Beam shear force in X direction shape U perform well

Table 4.51: Maximum Shear Forces in beams parallel to Z direction for all Building SHAPEs

SHAPE No.	**Beam Shear Force (parallel to Z direction) (KN)**
U	2.584
V	5.021
X	4.901
Y	4.884
Z	4.368

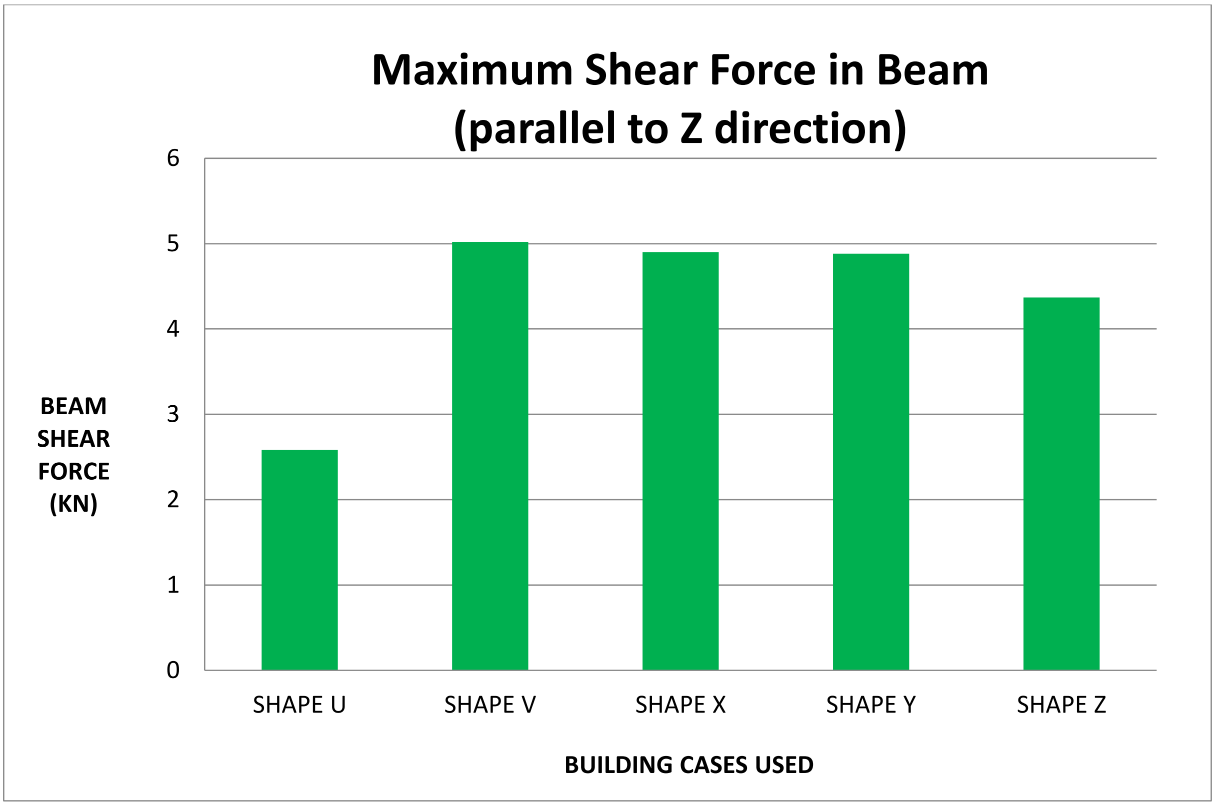


Fig. 4.14: Maximum Shear Forces in beams parallel to Z direction for all Building SHAPEs

Above study of Beam shear force in Z direction shape U perform well

Table 4.52: Maximum Bending Moment in beams parallel to X direction for all Building SHAPEs

SHAPE No.	**Beam** **Bending Moment** **(along X direction)** **(KNm)**
U	12.650
V	13.056
X	8.629
Y	6.832
Z	6.784

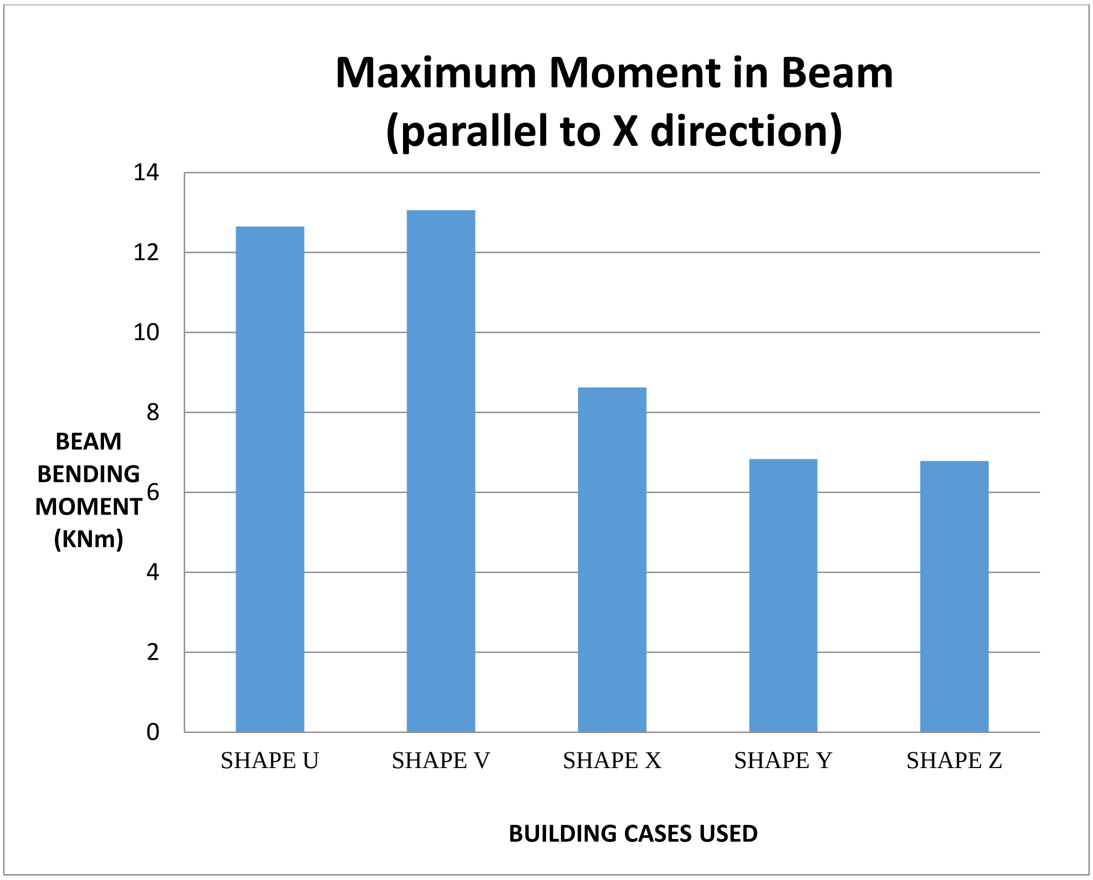


Fig. 4.15: Maximum Bending Moment in beams parallel to X direction for all Building SHAPEs

Above study of Beam shows shear force in X direction shape Z perform well

Table 4.53: Maximum Bending Moment in beams parallel to Z direction for all Building SHAPEs

SHAPE No.	**Beam Bending Moment (along Z direction) (KNm)**
U	435.701
V	639.472
X	537.018
Y	502.668
Z	476.253

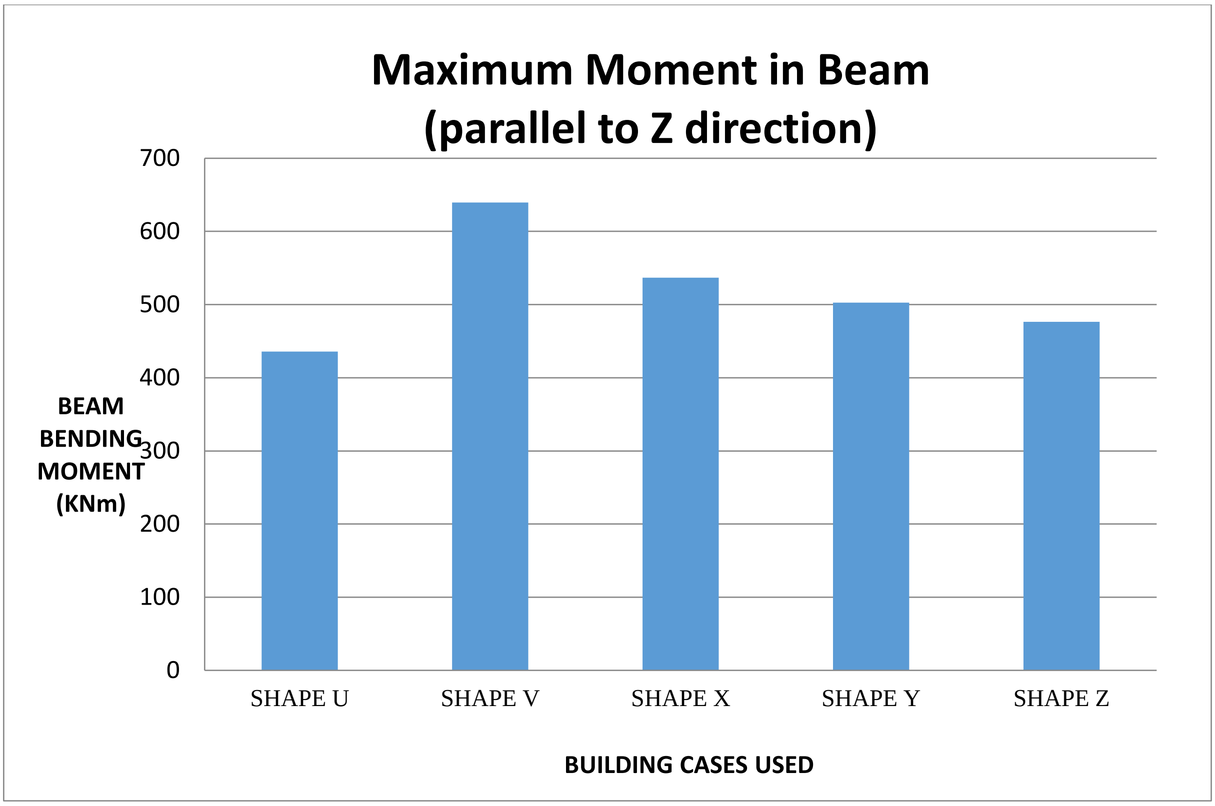


Fig. 4.16: Maximum Bending Moment in beams parallel to Z direction for all Building SHAPEs

Above study of Beam shear force in Z direction shape Z perform well

Table 4.54: Maximum Torsional Moment in beams along X and Z direction for all Building SHAPEs

SHAPE No.	**Beam Torsional Moment (along X direction) (KNm)**	**Beam Torsional Moment (along Z direction) (KNm)**
U	61.761	32.315
V	42.381	41.406
X	61.567	57.258
Y	50.866	42.419
Z	50.866	48.008

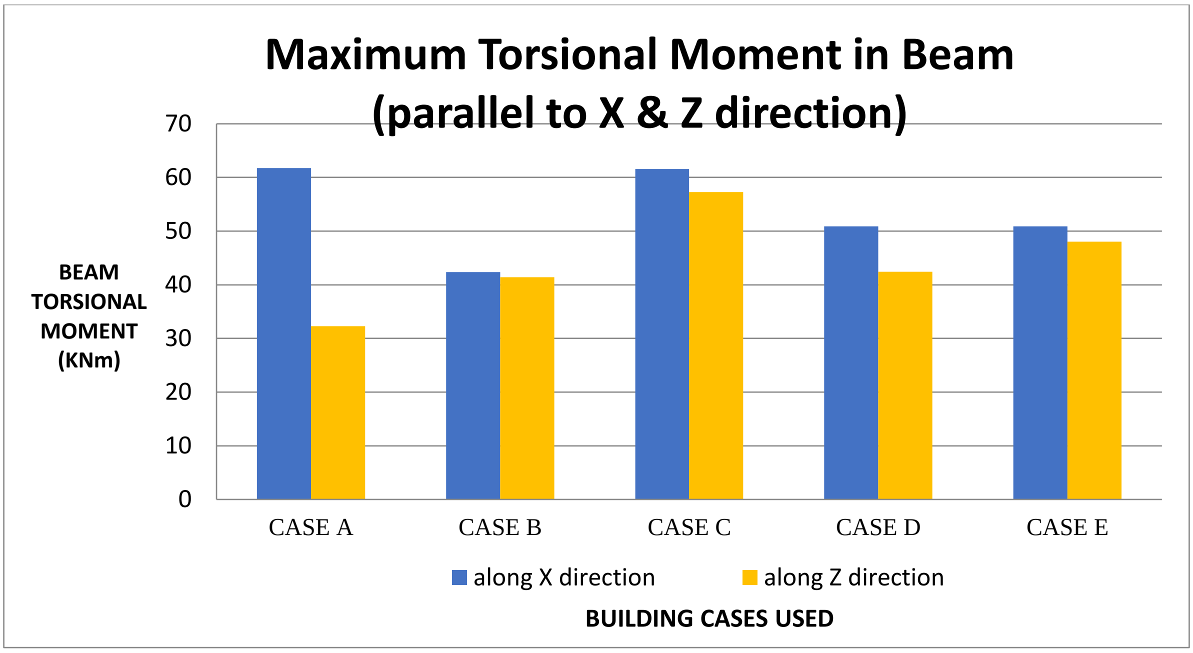


Fig. 4.17: Maximum Torsional Moment in beams parallel to X &Z direction for all Building SHAPE

CONCLUSION

We studied about five different shapes and there are such case which gives the various result about each and every shape of building. On the basis of above parameters following results are obtained from this comparative study.

1. On comparing it has been concluded that the maximum displacement in X direction obtained for shape Z & Y with a minimum value respectively.
2. On comparing it has been concluded that the maximum displacement in Z direction obtained for shape Z & Y with a minimum value respectively again as well as X direction.
3. Comparing the Story drift for all shapes in X direction, shape V is observed as most efficient.
4. Comparing the Story drift for all cases in Z direction, shape Z is observed as most efficient.
5. As per comparative results, Case X for base shear forces in X direction values are efficient among all cases.
6. As per comparative results, Case X for base shear forces in Z direction values are efficient among all cases..
7. On analysing the mass participation factor for both direction for X direction in mass participation shape X is very efficient and direction for Z direction in mass participation shape Z is very efficient
8. As per comparative results in axial force, Case U is very effective than other cases.
9. Comparing the column shear force for all cases shape Z is the optimum than other cases.
10. As per comparative results in column bending moment, Case Z is very effective than other cases.
11. Comparing the beam shear force in X direction for all cases shape U is the optimum than other cases.
12. Comparing the beam shear force in Z direction for all cases shape U is the optimum than other cases.
13. As per comparative results in beam in X direction bending moment, Case Z is very effective than other cases.
14. As per comparative results in beam in Z direction bending moment, Case Z is very effective than other cases.
15. On analyzing the Torsional Moment in beams along X direction shape V is very efficient and direction for Z direction in Torsional Moment in beams shape U is very efficient

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