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Response of Multistorey Building with Rooftop Telecommunication Tower in Different Positions: An Approach to Efficient Case

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Abstract - *To overcome the need of connecting peoples, mobile phone creates a vital role among us. For this, the network service provider expands their business by extending the coverage of their network. In urban areas, the scarcity of land is the major issue now days and companies are approaching to the rooftop telecommunication, since it resolves the land use and to extend the coverage by approaching the height. Since it was not acknowledged before that the telecommunication tower will going to install over the roof of the multistorey building. In this work, to overcome this issue that creates a negative effect over the parts of the building after installation, by the help of Staad pro software, a plan is selected and designed not according to tower need and then the tower is applied over the roof in different positions to analyze the parametric values and select a position that creates least negative effects under seismic zone IV.*

***Key Words*: Beam shear, Beam Moments, Efficient Case, Rooftop Telecommunication Tower, Seismic Forces, Square base, Staad pro, Torsional Moments.**

1. INTRODUCTION

The figurative analysis and survey shows that each and every person now have a mobile phone and for this, communication between then is now a major part of the economy. Without mobile, now it is very critical for one to connect his /her family. Due to this, the number of mobile tower is also increasing and the figures shows that it is always increase in number. Since telecommunication towers require a height to transmit the signals, it is now constructed increasing in height. Due to land consumption in urban area, the mobile towers are installed over the roof of the multistorey building to expand its range and to overcome the criteria of scarcity of land.

The telecommunication tower which is installed on the roof is fixed into the columns or a framed structure over the roof. It is normally square in shape or can be inclined from its base, depending upon the design. It does not require guys to support it, it is now self-supported on its legs, preferably, triangular or square in shape.

Due to its size and shape, it is heavy and can create a major disaster during an earthquake. Since seismic intensity is high in terms of horizontal loads, the multistorey building requires a position on which its negative effects are lesser. Since multistorey building is a host structure, its parts are not designed to overcome this problem, since it is not predefined that the tower will come over it in future. The other thing is the worst condition should not extend to other neighbouring structures

2. OBJECTIVES

To show the work with the objective of an approach to find the efficient case, Response Spectrum Method is used on the selected host structure consist of telecommunication tower over roof. The points of comparison on which various objectives are followed up are as follows:-

1. To compare maximum shear in in beam parallel to X direction (with efficient position).
2. To find and compare maximum shear in beam parallel to Z direction (with efficient position).
3. To find and examine maximum bending moments in beam parallel to X direction (with efficient position).
4. To evaluate and compare maximum bending moments in beam parallel to Z direction (with efficient position).
5. To investigate and relate the maximum Torsional moments (with efficient position).
6. To compare Period, Frequency and Participation factor in X (with efficient position).
7. To find and relate Period, Frequency and Participation factor in Z (with efficient position).
8. To show the most efficient position case as per different selected parameters with position.

3. STRUCTURE CONFIGURATION

In this paper, G + 12 storey residential building with 43.26m height having 5 bays of 3 m each in X direction and 7 bays of 3 m each in Z direction for complete 7 cases that are mentioned in table 1 and figure 1 & 2. Depth of foundation taken as 3m and height of each floor is taken as 3.66m. According to several cases mentioned in table, acronym such as S1 to S7 used to represent "Structure" and T1& T2 used to represent as "Type" were made. Indian Standard code 1893 (part 1): 2002 has used for seismic analysis of all cases,

various parameters were taken presumed that the structure has located in seismic zone IV and on rested over hard soil.

Several data used in this study for modeling and loadings are as follows:

- Length and width of building = 15 m and 21 m respectively.
- Thickness of slab and Shear wall = 125 mm and 230 mm.
- Beam, bracings and column size = 600 mm x 300 mm, 230 mm x 230 mm & 500 mm x 500 mm.
- Dead load as floor finish load = 1 KN/m^2 (intermediate floors).
- Wall load = 17.934 KN/m and 4.9 KN/m for intermediate floors with 3.66 m wall height and for terrace periphery with 1 m height (roof).
- Water proofing and terrace finish load = 2KN/m^2 and 1KN/m^2 respectively for roof.
- Live load as per IS 875 part II = 4 KN/m^2 for intermediate floors and 1.5 KN/m^2 for roof.

Design factors for Zone IV are as follows:

- Zone factor Z=0.24 (ZONE IV)
- Response reduction factor R = 5
- Importance factor I = 1
- The fundamental natural period (Ta) for X and Z direction has taken as 1.2978 & 0.8496 seconds

3D models constructed in Staad pro, a complete software tool for analysis has used for total seven Cases and work has evaluated.

4. STRUCTURE MODELING

The different rooftop telecommunication tower placing is used to compare the response of the host multistorey building that how it will behave under various position load along with horizontal seismic loads. The stiffness of the parts of the member can easily be compared with other parts. Size of the plinth area is 369 m^2 and the configuration of the building is selected as 13 storey (G + 12) residential apartment. The floor to floor height is selected as 3.66m with 3m depth of foundation below the ground level. The height above the ground level is 47.58 m. In the Staad pro, the support is assumed to be fixed. Size of column is taken as 0.50 m x 0.45 m and the size of beam is selected as 0.60 m x 0.35 m. The thickness of slab is selected as 0.20m. Coming towards the steel section, the platform thickness is selected as 0.025m, square section tower is used. For main horizontal and vertical member, ISA section 130 mm x 130 mm x 10 mm has used. For X bracings, ISA section 100 mm x 100 mm x 10 mm has used. Top cross section of tower is selected as 1 m and 3m width is selected as bottom member. Since each bay width is selected as 3m, the tower is supposed to be rested over four corners of the room. The grade of the concrete is selected as M25 along with Fe 415 grade is used. Weight of CDMA antenna is taken as 20 KG and microwave antenna is taken as 45 kg. This weight is applied over the tower.

5. LOADING DETAILS

The self-weight is the first criteria to be applied over the frame structure. After then 0.42 KN/m^2 load is calculated and selected as 10 mm mortar load on above and below the slab. Clay floor tiles are selected for the flooring for intermediate floors. It has 12.5 mm thickness and having a load of 0.10 KN/m^2. The roof parapet load is taken as 3.9 KN/m, the external wall load is taken as 13.65 KN/m and for internal wall load and the value of load is selected as 7.66 KN/m. The extra load generated by tower accessories are calculated and selected as 2.4375 KN in the form of point load transferred by four tower legs. Weight of tower platform is selected as 2.25 KN/m^2. Live load is also calculated and its value selected as 3 KN/m^2 for intermediate floors and 1.5 KN/m^2 is selected for roof. Live load over the tower platform is selected as 1.9613 KN/m^2.

For seismic Zone IV in India, as per IS 1893, response spectrum method is selected with Zone factor 0.24is selected. For this, response reduction factor 5 along with 5% damping ratio and importance factor 1 is selected. Soil profile for this building is assumed as medium soil.

The load combinations as per IS codes are:-

1) 1.5 (DL+LL)
2) 1.2 (DL+LL+- EQ)
3) 1.5 (DL+-EQ)
4) 0.9 DL +- 1.5 EQ

The above combinations are as per IS 1893, since in the work the earthquake forces are taken to be applied in both X and Z direction. Hence the above loads are taken for both X and Z directions and the further load bifurcations of total 13 combinations are:-

1) 1.5 (DL + LL)
2) 1.2 (DL + LL + EQx)
3) 1.2 (DL + LL - EQx)
4) 1.2 (DL + LL + EQz)
5) 1.2 (DL + LL - EQz)
6) 1.5 (DL + EQx)
7) 1.5 (DL - EQx)
8) 1.5 (DL + EQz)
9) 1.5 (DL - EQz)
10) 0.9 DL + 1.5 EQx
11) 0.9 DL - 1.5 EQx
12) 0.9 DL + 1.5 EQz
13) 0.9 DL - 1.5 EQz

6. TOWER PLACING CASES USED

The plan is selected in such a way that each and every case is sufficient to compare on different location. Each case shows the parametric values in corner, side and middle portion, since the approach is to fins the efficient position case. The details of such cases are as follows:-

1) CASE A – When tower is located at P1
2) CASE B – When tower is located at P2
3) CASE C – When tower is located at P3
4) CASE D – When tower is located at P4
5) CASE E – When tower is located at P5

The complete structure designed in Staad Pro software consists both multistorey building and telecommunication tower. Fig -1 drawn below shows the typical floor plan with different cases used and denoted as position P1, P2 and so on up to P5. Fig -2 describes Case A of Telecommunication Tower over Roof and subsequent figures shows the different locations up to Fig -6. The 3D view of Telecommunication Tower over roof of Multistorey Building is shown in Fig -7. The details of Telecommunication tower with its dimensions of different parts is shown in Fig -8. Total 5 different location cases are used in this research work.

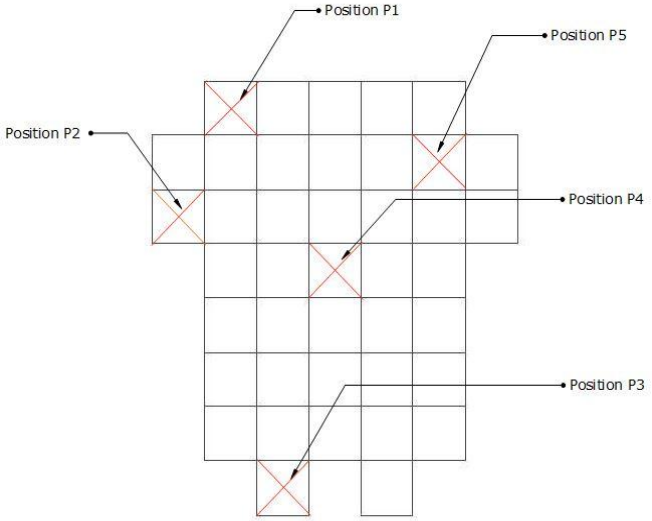

Fig -1: Different Cases of Telecommunication Tower over Roof

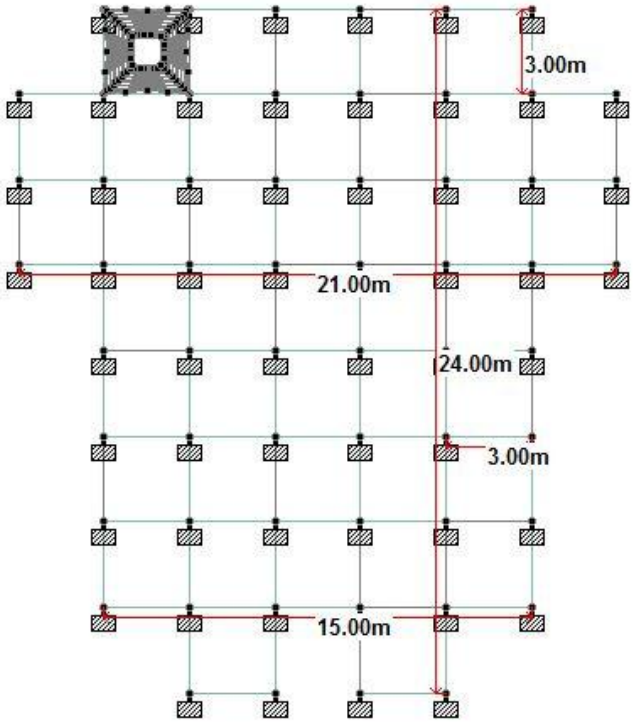

Fig -2: Case A of Telecommunication Tower over Roof (Plan-Position P1)

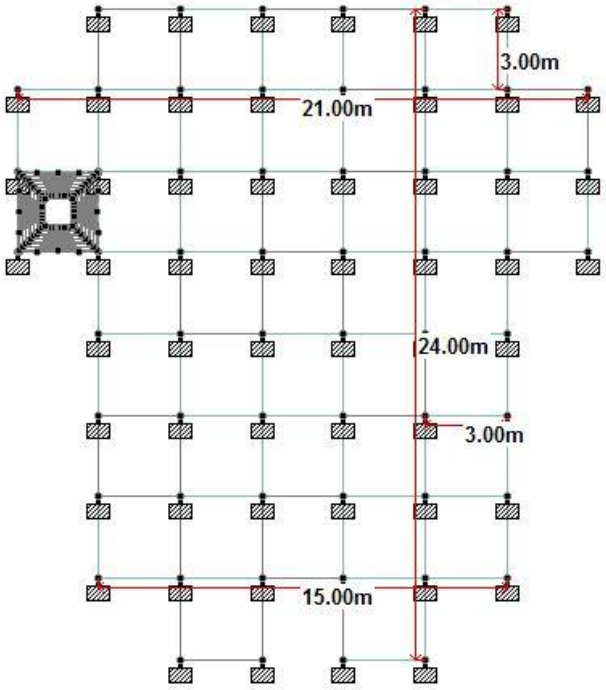

Fig -3: Case B of Telecommunication Tower over Roof (Plan-Position P2)

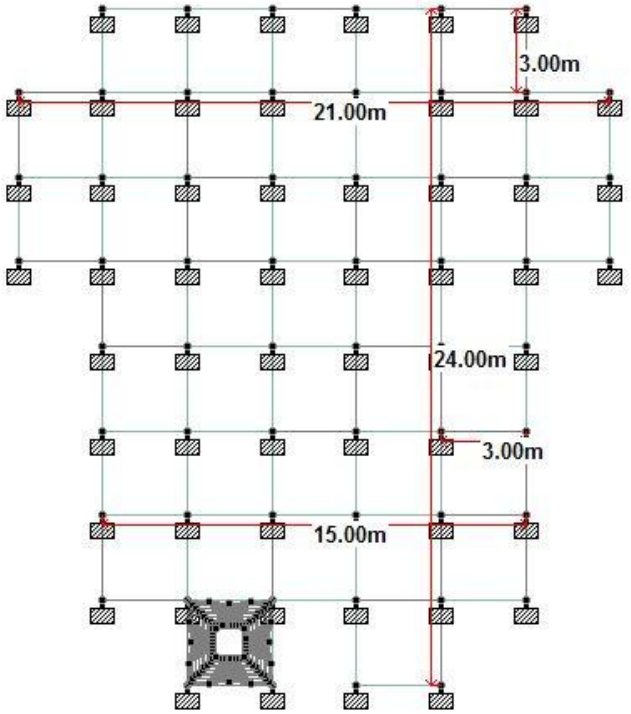

Fig -4: Case C of Telecommunication Tower over Roof (Plan-Position P3)

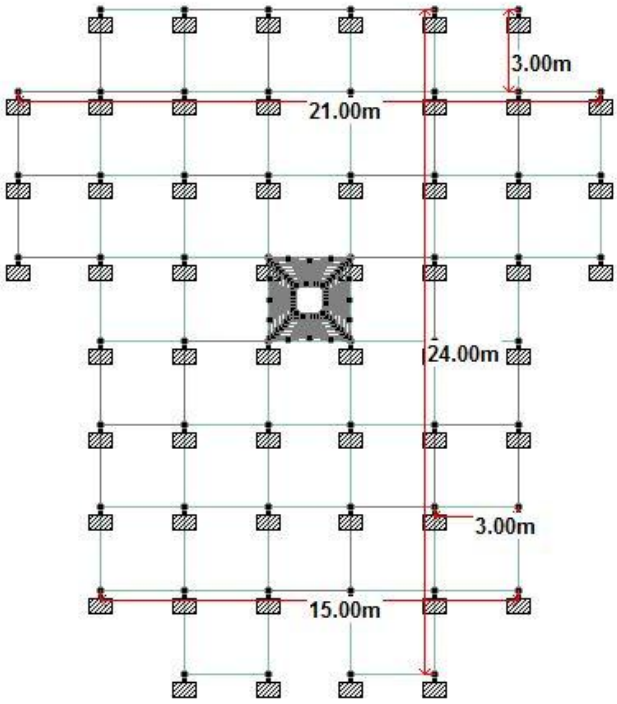

Fig -5: Case D of Telecommunication Tower over Roof (Plan-Position P4)

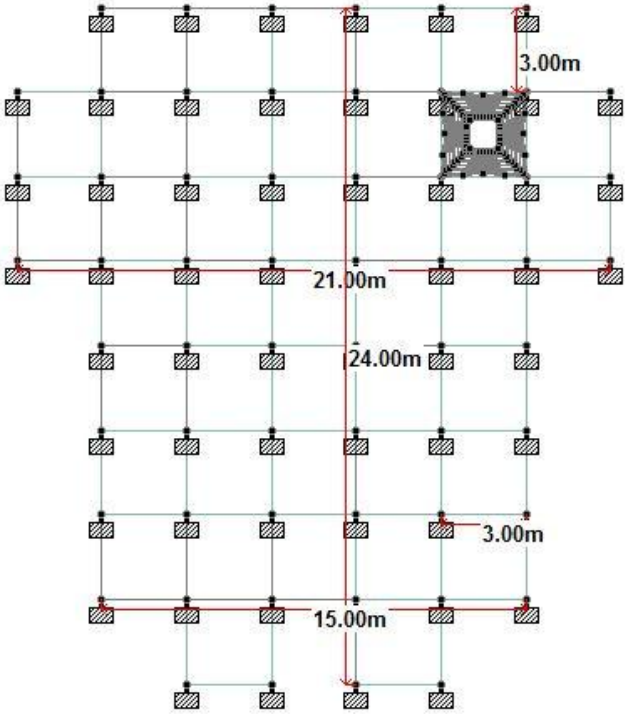

Fig -6: Case E of Telecommunication Tower over Roof (Plan-Position P5)

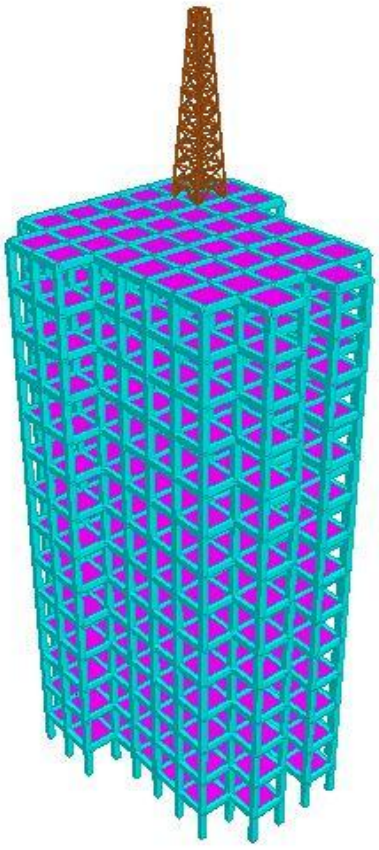

Fig -7: 3D view of Telecommunication Tower over Roof of Multistorey Building

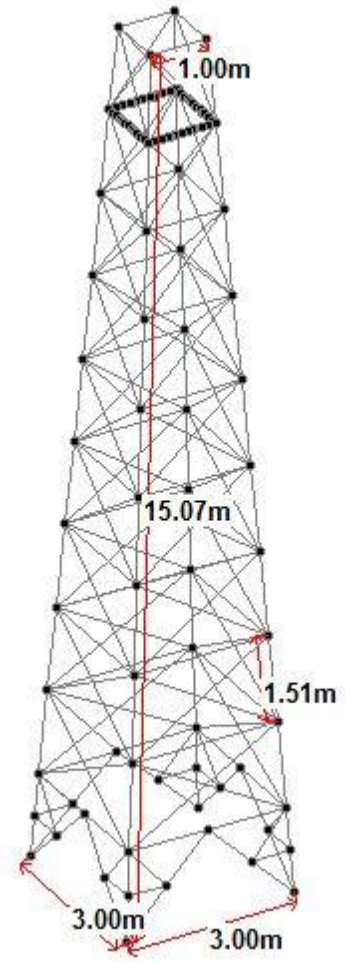

Fig -8: 3D view of Telecommunication Tower

7. RESULTS AND DISCUSSION

Seismic forces are considered to be applied on X and Z directions on the selected building with total five different cases. As per objectives, results are shown both in tabular form as well as graphical form for various parameters are as follows:-

Table -1: Shear force comparison in beam long X direction

Tower Location Cases	Shear Forces in beam along X direction (KN)	Efficient Position
Case A	123.846	Whenever telecommunication tower used in multistorey building, the efficient position case for shear forces in beam in X direction will be Case A
Case B	124.252	
Case C	126.558	
Case D	124.499	
Case E	124.288	

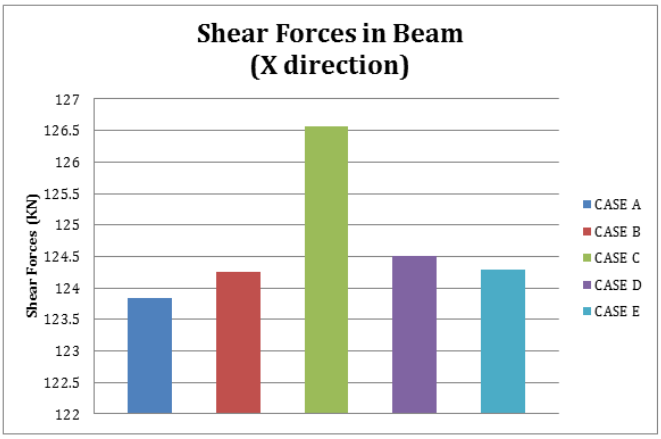

Chart -1: Shear forces comparison in beam long X direction

Table -2: Shear force comparison in beam long Z direction

Tower Location Cases	Shear Forces in beam along Z direction (KN)	Efficient Position
Case A	91.716	Whenever telecommunication tower used in multistorey building, the efficient position case for shear forces in beam in Z direction will be Case D
Case B	91.680	
Case C	91.644	
Case D	91.553	
Case E	91.688	

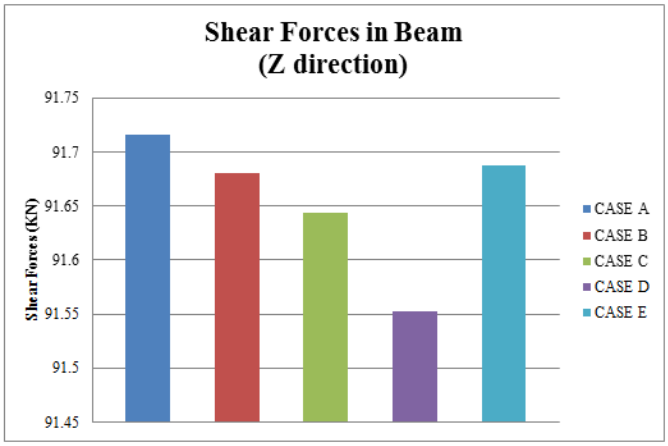

Chart -2: Shear forces comparison in beam long Z direction

Table -3: Torsional moment comparison in beam

Tower Location Cases	Torsional Moment (KNm)	Efficient Position
Case A	11.759	Whenever telecommunication tower used in multistorey building, the efficient position case for Torsional moment will be Case E
Case B	11.817	
Case C	12.026	
Case D	11.839	
Case E	11.751	

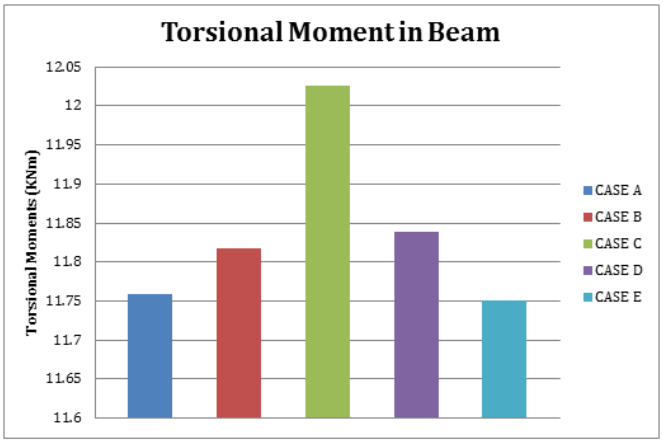

Chart -3: Torsional moment comparison in beam

Table -4: Time period with participation factor in X and Z direction for Case A in Zone IV

Mode No.	Frequency (Hz)	Time Period (Seconds)	Participation X (%)	Participation Z (%)
	CASE A			
1	0.489	2.045	0	79.011
2	0.499	2.003	72.471	0
3	0.542	1.846	5.510	0
4	1.489	0.672	0	10.902
5	1.539	0.650	11.054	0
6	1.641	0.609	0.663	0

Table -5: Time period with participation factor in X and Z direction for Case B in Zone IV

Mode No.	Frequency (Hz)	Time Period (Seconds)	Participation X (%)	Participation Z (%)
	CASE B			
1	0.489	2.045	0	79.012
2	0.499	2.003	72.342	0
3	0.542	1.845	5.636	0
4	1.489	0.672	0	10.901
5	1.539	0.650	11.039	0
6	1.641	0.609	0.679	0

Table -6: Time period with participation factor in X and Z direction for Case C in Zone IV

Mode No.	Frequency (Hz)	Time Period (Seconds)	Participation X (%)	Participation Z (%)
	CASE C			
1	0.489	2.045	0	79.015
2	0.499	2.003	71.822	0
3	0.542	1.845	6.161	0
4	1.489	0.672	0	10.903
5	1.539	0.650	10.912	0
6	1.641	0.609	0.804	0

Table -7: Time period with participation factor in X and Z direction for Case D in Zone IV

Mode No.	Frequency (Hz)	Time Period (Seconds)	Participation X (%)	Participation Z (%)
	CASE D			
1	0.489	2.045	0	79.021
2	0.499	2.004	72.321	0
3	0.542	1.844	5.663	0
4	1.489	0.672	0	10.902
5	1.539	0.650	11.018	0
6	1.641	0.609	0.698	0

Table -8: Time period with participation factor in X and Z direction for Case E in Zone IV

Mode No.	Frequency (Hz)	Time Period (Seconds)	Participation X (%)	Participation Z (%)
	CASE E			
1	0.489	2.045	0	79.015
2	0.499	2.003	72.426	0
3	0.542	1.845	5.553	0
4	1.489	0.672	0	10.904
5	1.539	0.650	11.045	0
6	1.641	0.609	0.674	0

Efficient Position Case: Since if the tower is placed over the roof under different locations, the mass participation will increase. But the main criterion is to show the most efficient case shown by each mode. Hence after comparing, efficient position case for this parameter will be Case B.

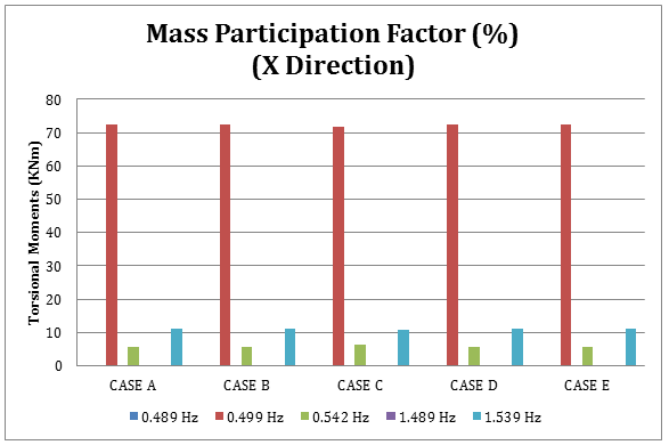

Chart -4: Comparison of mass participation factor in X direction for all five cases in Zone IV

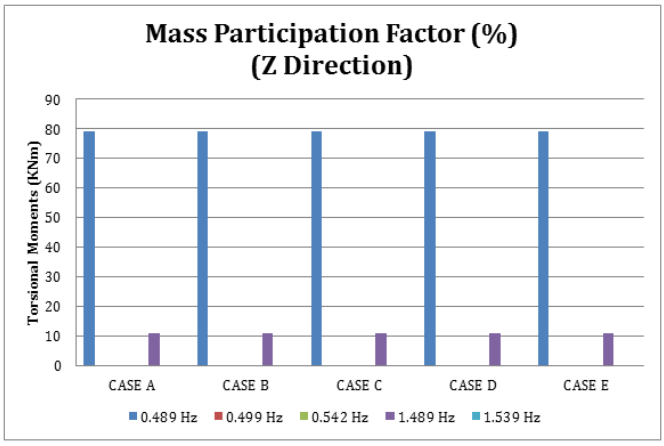

Chart -5: Comparison of mass participation factor in Z direction for all five cases in Zone IV

8. CONCLUSIONS

It has been clinched from the above study that the location of the telecommunication tower will affect the entire host structure under the influence of seismic forces. The location of the tower will affect the different parameters of the building components and as per result, the following results have been drawn:-

1. After deep observation, the result showing most efficient case under various parametric values.
2. On comparing shear forces in beam parallel to X direction, the least value observed in Case A i.e. 123.846 KN.
3. For Shear Forces in Beam parallel to Z direction, Case D shows efficient position having least values among all the cases.
4. When observing the torsional moments in beams in host building, the minimum value and efficient case observed as Case E with a value of 11.751 KNm.
5. Case B shows efficient position case when comparing dynamics of the structure. The least mass participation factor observed in both X and Z direction. This proves that least mass is moving when using this case.
6. When comparing all parametric values for the selected structure, Case C will not be use due to high parametric values.

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