Parametric Study on Asymmetric Building with Three- legged Rooftop Telecommunication Tower

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Abstract. The growth of telecommunications over the past few years has increased competition between telecommunications firms. The installation of many towers is necessary for improved network connectivity. Mobile networks primarily varies on the tower's location. The best location for a tower is on level ground, and the primary requirement for better coverage is the height of the mounted antenna. Urbanization has reduced the availability of prime property. However, using roof-top structures is an option in this circumstance. In the current study, the impact of towers on buildings with and without shear walls that are located on plain ground and subject to earthquake effects is being evaluated. The three-legged telecommunication tower is positioned in various places on buildings with plan irregularities in order to find the best site for the tower and reduce building response. Base shear, storey movement, storey drift, drift ratio, and torsion irregularity ratio responses of buildings subjected to RTT. ETABS software is used to perform the analysis of different models. Different structure analysis techniques, including the equivalent static force method (ESFM), reaction spectrum method (RSM), and non-linear static pushover analysis, are used to conduct the analysis. When compared to other shapes of buildings, it has been discovered that C shape structures with rooftop towers perform best when subjected to earthquake loading.

Introduction

General. Radio towers that are mainly constructed for the transportation of telecommunications antennas are known as telecom towers. Such towers frequently need to be identified by an expansive field and must be constructed to prevent them from naturally swinging in the breeze. Masts are also used, but very stable structural kinds like low-rubber towers and iron-concrete towers are most frequently used. Towers for telecommunications are a mix of stainless steel buildings built to hold broadcast antennas and telecom equipment. Cellular networking, TV antennas, and radio transmission all use telecom towers as their primary means of connection for wireless communication. A complete telecommunication tower can be described as a collection of mechanical structures and an electronic signal handling system that can be connected via these towers.The towers may range in height based on their position and various designs. These structures can range in height from 15 to 60 meters. Telecommunications towers are used to enable inter-person contact. Elevated antennas are necessary for networking communications in order to transmit and receive radio signals efficiently. Towers may be used to install antennas if there are no big buildings to which they can be connected. The demand for both rural and off-grid telecommunication towers has increased, in part due to the development of the telephone market.

Vertical Irregular Structures

Definition of vertically irregular structures as per IS 1893:2016 (part-1)

Due to irregularities in their mass, strength, and stiffness distributions, along with the height of the building,irregularities in the structure may be the result. There are two types of irregularities,

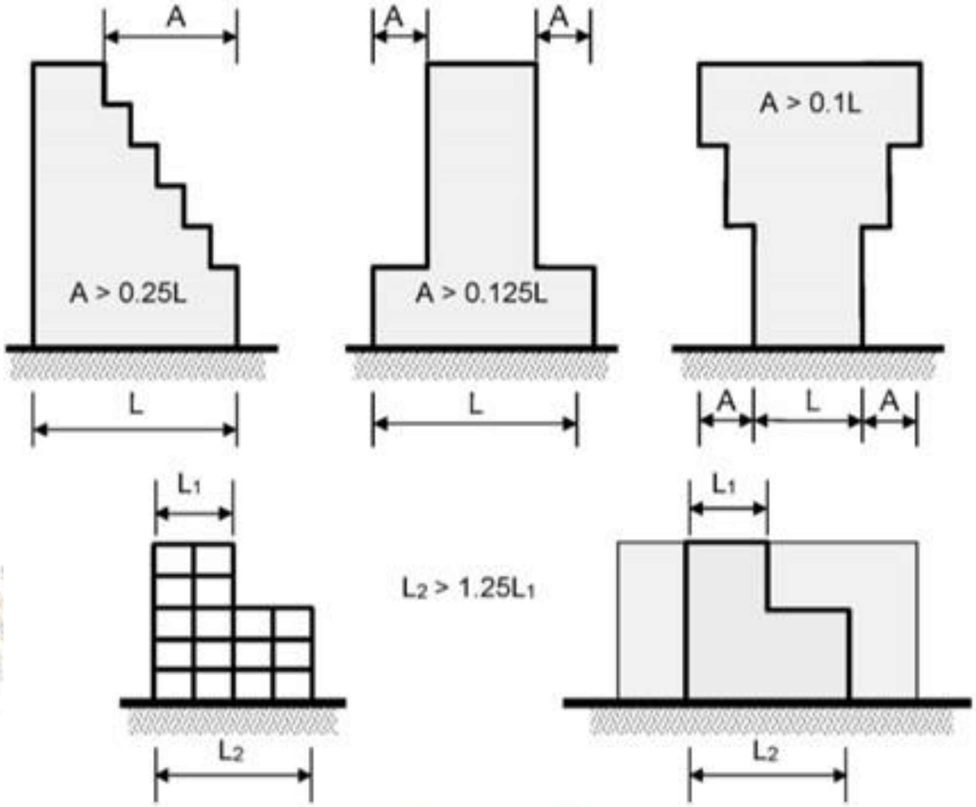
- Plan Irregularities
- Vertical Irregularities.

There are five types of Vertical Irregularities:

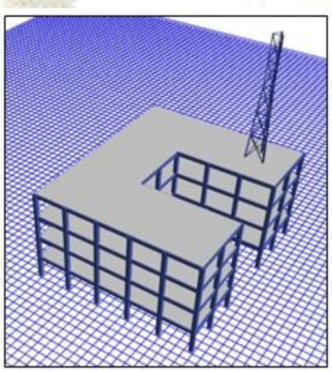
- Irregularity in stiffness (soft storey)
- Irregularity in mass
- Irregularity in vertical geometry
- In-plan discontinuity in vertical elements resisting lateral force
- Irregularity in strength (weak storey)

Vertical geometry irregularity:

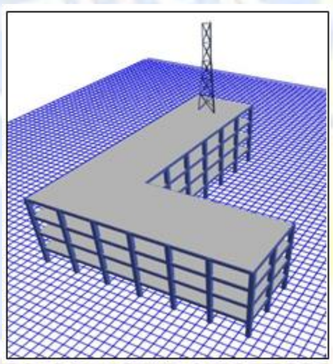
As per IS 1893:2016 following are different types of cases for vertical irregularities



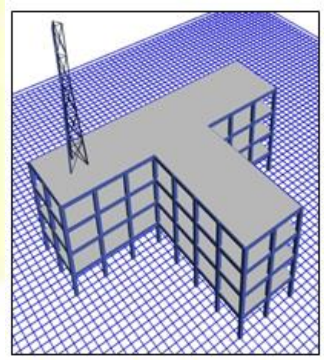
Elevation



C Shape



L Shape

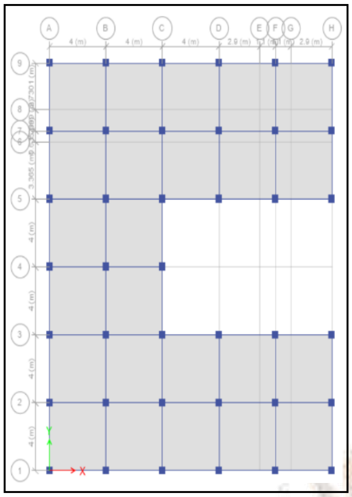


T Shape

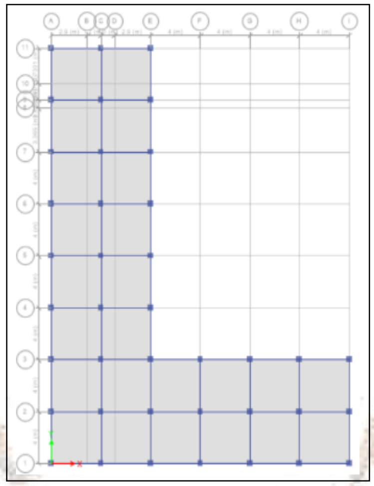
METHODOLOGY

Models have been made such a way that possess plan irregularities as per IS 1893:2016 (Part-I). Three different shape of plan irregular buildings have been chosen in this study. Thus, these buildings have plan irregularity specifically due to re-entrant corners.

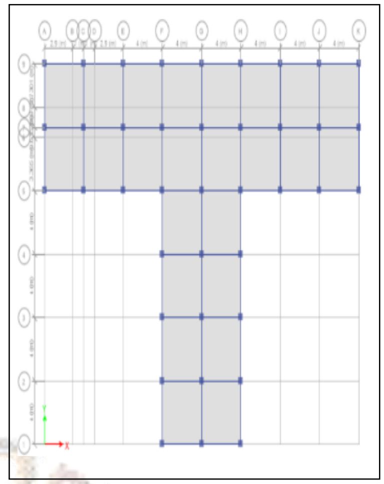
C, L and T shape plan irregular building models with and without shear wall have been made which have a three - legged rooftop tower on different location.



A = 8m, L = 24m
A/L = 8/24 = 0.33 > 0.15
Re-entrant corners. Hence, Plan irregularity Exist.



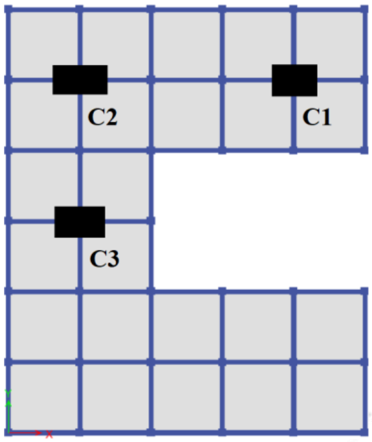
A = 16m, L = 24m
A/L = 16/24 = 0.67 > 0.15
Re-entrant corners. Hence, Plan irregularity Exist.



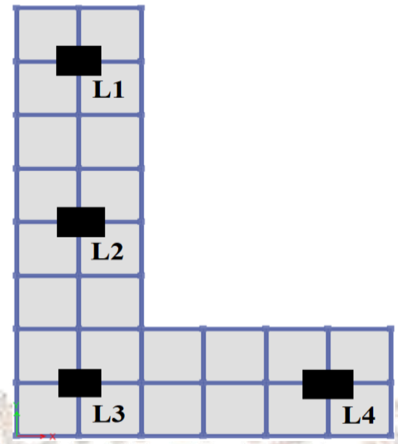
A = 16m, L = 24m
A/L = 16/24 = 0.67 > 0.15
Re-entrant corners. Hence, Plan irregularity Exist.

[Table: Notations of various models]

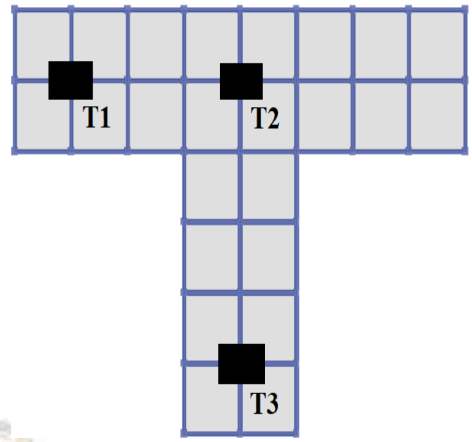
Shape of building	Tower location	Notations	
		Without shear wall	**With shear wall**
C	Short side edge	**C1**	**CS1**
	Re-entrant corner	**C2**	**CS2**
	Long side middle	**C3**	**CS3**
L	Long side edge	**L1**	**LS1**
	Long side middle	**L2**	**LS2**
	Re-entrant corner	**L3**	**LS3**
	Short side edge	**L4**	**LS4**
T	Long side edge	**T1**	**TS1**
	Long side middle	**T2**	**TS2**
	Short side edge	**T3**	**TS3**



C Shape



L Shape



T Shape

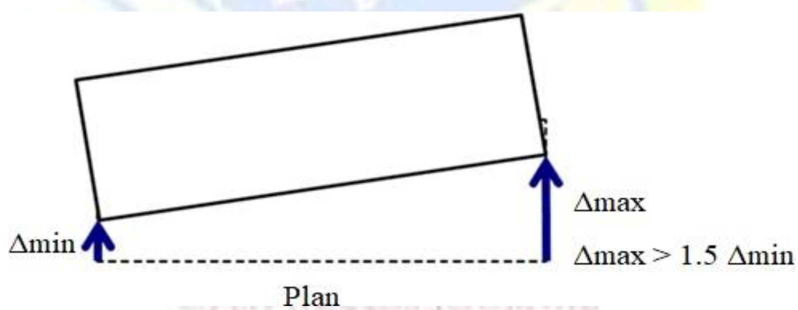
Results and Discussions

In this study C, L & T shape plan irregular buildings with and without shear wall having a three-legged rooftop telecommunication tower on different location resting on plain groundwere analysed by three methods such as linear static, linear dynamic and nonlinear static. Total twenty numbers of models are analysed and studied various parameters like torsional irregularity ratio, base shear, storey displacement, storey drift and drift ratio.

Torsional irregularity ratio

Torsional irregularity is that the ratio of the utmost displacement drift of a floor corner to the typical displacement drift of the considered fringe of the ground.

As per IS: 1893 (Part 1) - 2016 in torsionally irregular buildings, when the ratio of maximum horizontal displacement at one end and therefore the minimum horizontal displacement at the opposite end is,



[Table: Torsional irregularity ratio (EQx)]

Model	C1	CS1	C2	CS2	C3	CS3	L1	LS1	L2	LS2
Ratio	1.175	1.097	1.174	1.094	1.188	1.095	1.239	1.102	1.233	1.222
Model	L3	LS3	L4	LS4	T1	TS1	T2	TS2	T3	TS3
Ratio	1.220	1.209	1.220	1.211	1.162	1.143	1.162	1.066	1.177	1.142

Model	C1	CS1	C2	CS2	C3	CS3	L1	LS1	L2	LS2
Ratio	1.118	1.037	1.133	1.115	1.133	1.097	1.123	1.095	1.125	1.080
Model	**L3**	**LS3**	**L4**	**LS4**	**T1**	**TS1**	**T2**	**TS2**	**T3**	**TS3**
Ratio	1.125	1.118	1.155	1.142	1.233	1.089	1.194	1.067	1.194	1.085

[Table: Torsional irregularity ratio (EQy)]

Model	Base shear (kN)	
	EQx	**EQy**
C1	1080.21	1060.89
CS1	1718.76	1718.76
C2	1081.20	1058.40
CS2	1718.95	1718.95
C3	1079.71	1057.92
CS3	1805.79	1805.79
L1	1133.00	1170.05
LS1	1840.39	1840.39
L2	1136.83	1169.85
LS2	1905.58	1905.58
L3	1139.22	1169.29
LS3	1883.85	1883.85
L4	1137.41	1165.92
LS4	1840.39	1840.39
T1	1165.72	1147.77
TS1	1883.85	1883.85
T2	1166.41	1148.44
TS2	1927.30	1927.30
T3	1161.28	1148.43
TS3	1883.85	1883.85

[Table : Storey displacement of C shape building (EQx)]

Storey	C1	CS1	C2	CS2	C3	CS3
4	19.216	0.455	19.222	1.118	19.469	0.479
3	15.497	0.343	15.500	0.791	15.678	0.360
2	9.842	0.212	9.844	0.454	9.947	0.222
1	3.612	0.089	3.613	0.166	3.648	0.093
Base	0	0	0	0	0	0

[Table: Storey displacement of L shape building (EQx)]

Storey	L1	LS1	L2	LS2	L3	LS3	L4	LS4
4	23.299	0.844	23.066	0.748	22.760	0.955	22.722	2.165
3	18.680	0.629	18.451	0.557	18.185	0.711	18.156	1.531
2	11.741	0.384	11.597	0.340	11.435	0.433	11.416	0.875
1	4.229	0.156	4.178	0.138	4.121	0.175	4.114	0.315
Base	0	0	0	0	0	0	0	0

[Table: Storey displacement of T shape building (EQx)]

Storey	T1	TS1	T2	TS2	T3	TS3
4	21.126	1.093	21.143	0.754	21.514	1.341
3	16.968	0.782	16.978	0.541	17.313	0.975
2	10.720	0.453	10.726	0.315	10.931	0.578
1	3.893	0.168	3.895	0.119	3.967	0.225
Base	0	0	0	0	0	0

[Table: Storey displacement of C shape building (EQy)]

Storey	C1	CS1	C2	CS2	C3	CS3
4	18.405	1.493	18.606	0.772	18.606	0.743
3	14.837	1.064	15.000	0.564	14.995	0.535
2	9.416	0.614	9.514	0.336	9.510	0.314
1	3.454	0.226	3.489	0.130	3.487	0.120
Base	0	0	0	0	0	0

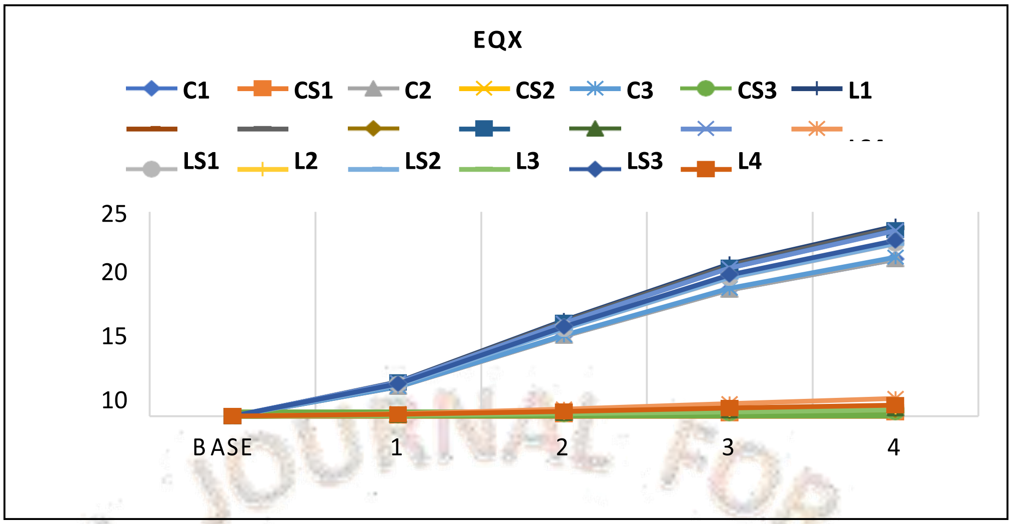
[Table: Storey displacement of L shape building (EQy)]

Storey	L1	LS1	L2	LS2	L3	LS3	L4	LS4
4	20.504	2.396	20.521	1.820	20.509	0.902	20.970	1.959
3	16.477	1.686	16.480	1.287	16.472	0.661	16.794	1.378
2	10.420	0.957	10.42	0.736	10.415	0.396	10.598	0.782
1	3.792	0.342	3.791	0.265	3.790	0.156	3.852	0.279
Base	0	0	0	0	0	0	0	0

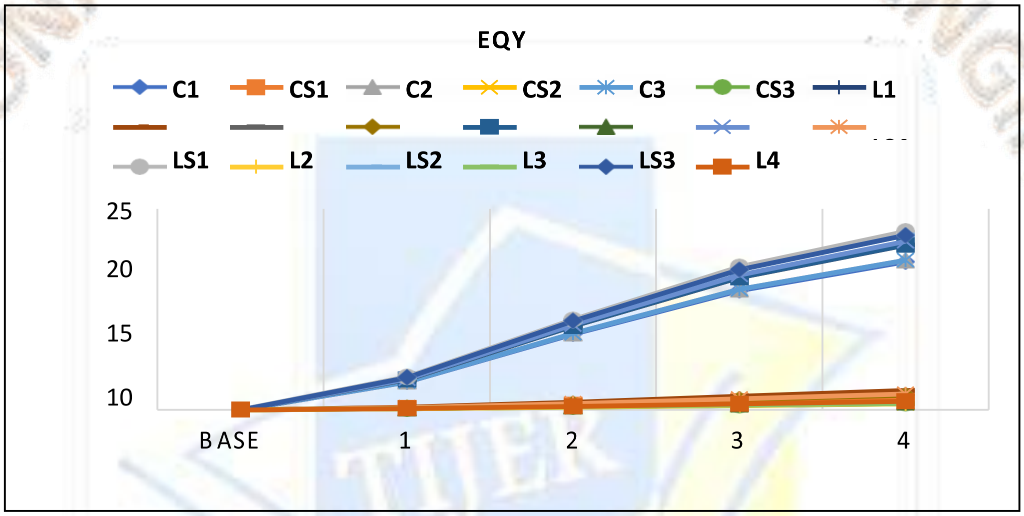
[Table: Storey displacement of T shape building (EQy)]

Storey	T1	TS1	T2	TS2	T3	TS3
4	22.198	0.739	21.737	0.762	21.724	1.047
3	17.787	0.576	17.460	0.597	17.455	0.749
2	11.232	0.369	11.044	0.384	11.043	0.435
1	4.089	0.160	4.024	0.169	4.024	0.164
Base	0	0	0	0	0	0

Storey displacement (EQx)]



Storey displacement (EQy)]



Conclusion

In the current research, static and dynamic analyses of variously shaped buildings with three-legged rooftop communication towers positioned on flat ground were conducted.

The following finding has been made:

1. In a C-shaped structure, a shear wall model exhibits a 69% increase in base shear and a 5% decrease in the torsion irregularity ratio.

2. Buildings with shear walls demonstrate a 92–95% reduction in storey displacement and drift values.

3. According to pushover analysis, buildings with shear walls experience an 85% increase in base shear and an 86% reduction in displacement.

4. The tower positions C1 and CS3 are the safest for placement on a building's top, according to the findings and observations

5. The shear wall model for an L-shaped structure attracts 40% more base shear and displays a 3% decrease in the torsion irregularity ratio.

6. Storey displacement and drift values for buildings with shear walls indicate a reduction of 88–92%.

7. According to pushover analysis, buildings with shear walls experience an increase in base shear of 77% and a reduction in displacement of 76%.

8. Based on the findings and observations, it is determined that L3 and LS3 are the safest tower positions for installation on a building's top.

9. In a T-shaped structure, the shear wall model exhibits a 40% increase in base shear and a 7% decrease in the torsion irregularity ratio.

10. Storey displacement and drift values for buildings with shear walls indicate a reduction of 92–96%.

11. According to pushover analysis, buildings with shear walls have a base shear increase of 55% and a reduction in displacement of 76%.

12. It can be deduced from the findings and observations that tower positions T2 and TS2 are the safest for the tower location on a building roof.

13. The outcomes of C shape buildings with RTT are better than those of L and T shape buildings, according to the aforementioned observation

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