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Comparative Study of Microwave Tower as Per I.S Code & ANSI/TIA/EIA/RS222-G

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ABSTRACT: Telecommunication plays an important role in today's era as it improves coverage area and network connectivity. To meet the demand of growing population and urbanization, telecommunication industry is growing enormously by installing large number of towers day by day. Therefore, it is extremely important to consider appropriate parameters for designing of these towers in order to enhance their sustainability. In this study, two self-supporting four legged tower are analysed and designed using IS code (Indian Standard) and ANSI/TIA-222-G code (American Standard) with the help of STAAD.Pro v.8i. For both the towers, basic wind speed is taken as 200kmph and the appurtenances are selected from Andrew catalogue. Wind load is calculated using both the codes and the variations that occur by the use of two different codes are pointed out and discussed for the understanding of appropriate use and benefits of the same.

KEYWORDS: self-supporting, four legged tower, STAAD.pro V8i, basic wind speed, Andrew catalogue.

I. INTRODUCTION

Telecommunication tower are tall structure installed at a specific height usually designed for supporting all type of antennae. Free standing lattice tower are generally used in our country. India's telecommunication network is second largest in the world based on the total number of telephone users. Communication tower or lattice tower are classified into three categories that are Guyed masts, monopole and self-supporting tower. The structural engineers face the challenging job of designing and constructing telecommunication tower to support antennae loads, platform as well as steel ladder loads. The direction and height of tower along with the antennae mounted on it is completely governed by the functional requirements. Most of the communication facilities built today fall into one of the two types of application, the first for use by communication industry (mostly for wireless communications) and the second for broadcast (radio and television) applications.

II. TOWER CONFIGURATION

The report gives the design of two 30 meter high self-supporting tower one as per IS code and another as per ANSI/TIA-222-G. Both the tower is square in plan and can safely withstand a wind velocity of 200kmph. The base width of the tower is 3.65m C/C and a top width 1.80m C/C. The general arrangement drawing is given in the report. The base width of the tower has been arrived after a number of trial design on minimum weight.

III. TECHNICAL SPECIFICATION FOR BOTH THE TOWER

- 1) Towers is designed for highest wind velocity 200km/h.
- 2) Towers is designed for two operator.

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- 4 number of solid antenna 0.6m diameter solid parabolic antennae at 2m below from top.
- 6 number of GSM of size 2.500x0.30x0.15m at 1.5m below from top.
- 3) Tower have one rest platform of 150kg and one service platform of 250kg.
- 4) An internal climbing ladder and a separate cable ladder are to be provided.
- 5) Load calculation for Climbing ladder and cable ladder is same for both the tower.
- 6) Wind load on tower 1, appurtenances and antennae shall be based on IS: 875-1987 (part3) and wind load on tower 2, appurtenances and antennae shall be based on ANSI/TIA-222-G.
- 7) Design of tower member is based on IS: 802 and also by AISC LRFD approach.
- 8) Twist and sway of towers shall not exceed 0.5 degree for wind speed of 200kmph

IV. TOWER ANALYSIS

The tower is idealized as a space truss and the analysis is carried out using STAAD.Pro v8i. Only static analysis has been carried out. The loading considered for the analysis of the tower is as follows:

a) Wind load on climbing ladder and cable ladder

For the computation of the ladder it is assumed that the main legs of the ladder will be made of flat 50mmx5mm, with the runners made from 16mm dia rods welded to the flat legs. The runners are spaced at 300mm c/c. The rods are extended at every 600mm c/c for a width of 150mm on both sides for bringing down the cables. The climbing ladder width is 350mm with protective guides of 50mmx4mm provided horizontally at 900mm c/c and three vertical guides made from 25mmx4mm flats provided vertically. The feeder cable size is taken from standard specification 22mm. A force coefficient of 1.2 is used for rounded members and 2.0 for flat-sided members.

An overall exposed area of 0.2sqm per meter is considered due to ladder (accessories). The details of load computation as explained above are done using a computer program.

Total load of ladder is coming 37.2 kg, approximately we have taken 40 kg load at each node.

b) Wind load on 2 Operator

Each operator stands for 2 MW antennae and 3 GSM. Wind load calculation for 4 antennae and 6 GSM.

a) For tower 1 (as per IS code)

a) Load due to 6 no of GSM antennae

Size of 1 GSM is 2.500x0.30x0.15 in 6 no of GSM 3 no of GSM are fully exposed and 3 no of GSM are shielded.

Load due to 1 antenna = area exposed x cf x wind pressure at 1.5m below from top = 2.017 KN

Hence total load = load due to 1 antenna x no of antenna exposed + (no of antenna shielded x 0.5x load due to one antenna)

$$= 9.075 \text{ KN}$$

b) Load due to 4 no of antenna

Solid parabolic antenna of 0.6m diameter placed at 2m below from top

Wind load exerted by 0.6m microwave antenna 490N for 55.55 m/s from Andrew catalogue.

Wind load exerted by 0.6m microwave antenna 593N

Total load due to 4no of microwave antennae = wind load due to 1 MW antenna x 4 = 2.37KN

Total load = 11.44KN

b) For tower 2 (as per ANSI/TIA-222-G)

a) Load due to 6 no of GSM antennae

6no of GSM at 1.5m below from top, size of GSM is 2.500x0.30x0.15

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The design wind force on appurtenances $F_A = q_z \times G_h \text{ (EPA)A}$
 Effective projected area of appurtenance (EPA)A = $K_a [(EPA)N \cos^2(\theta) + (EPA)T \sin^2(\theta)]$
 $: K_a = 1$
 Effective projected area in wind ward face (EPA)N = $\Sigma(C_a AA)N$
 Effective projected area in wind ward side face (EPA)T = $\Sigma(C_a AA)T$
 Effective projected area in wind word face, (EPA)N is 1.083 for 1 GSM
 Effective projected area in wind ward side face, (EPA)T is 0.646 for 1 GSM
 Effective projected area of appurtenance (EPA)A = 5.366
 The design wind force on appurtenances FA is 9.25 KN

- b) Load due to 4 no of antenna
 Solid parabolic antenna of 0.6m diameter placed at 2m below from top
 Force on microwave antenna, $F_{AM} = q_z \times G_h \times C_A \times A$
 Wind force co-efficient, $C_A = 1.2617$ for 0° and 1.056 for 180°
 2 no of antennae at 0° and 2 no of antennae at 180°
 Total force on solid antennae is 2.189 KN

Total load 11.43 KN

c) Body wind computation

Panel No.	Height of panels (m)	Members (AF) (sq.m)	Accessories (AA) (sq.m)	Kz	Velocity (Vz) (mps)	$0.6 \times V_z^2$ (kg/sq.m)	Solidity ratio (ϕ)	Force coeff (Cf)	Normal Wind load (kN)
1	3	1.642	0.60	0.98	54.44	177.8	0.16	3.52	11
2	3	1.595	0.60	0.98	54.44	177.8	0.16	3.48	10.94
3	3	1.494	0.60	0.98	54.44	177.8	0.17	3.46	10.25
4	3	1.599	0.60	0.99	55.33	183.7	0.19	3.31	10.81
5	3	1.259	0.60	1.02	56.67	192.6	0.17	3.43	9.47
6	3	1.065	0.60	1.04	57.67	199.5	0.17	3.46	8.56
7	2	0.784	0.40	1.05	58.33	204.1	0.21	3.26	6.04
8	2	0.818	0.40	1.06	58.89	208.07	0.23	3.16	6.22
9	2	0.683	0.40	1.07	59.44	212.01	0.19	3.35	5.70
10	2	0.623	0.40	1.08	60.00	216.0	0.17	3.43	5.49
11	2	0.713	0.40	1.09	60.56	220.0	0.19	3.31	6.07
12	2	0.848	0.40	1.10	61.11	224.0	0.23	3.12	6.83

Table.1. Body wind computation for tower 1 – 200 kmph (Normal wind load as per IS code)

Panel No.	Ht of panels (m)	Area of Members (sq.m)	Area of Accessories (sq.m)	Kz	Wind Pressure (kN/m ²) -qz	Solidity ratio (ϕ)	Force coeff	Normal Wind load (kN)	Diagonal Wind load (kN)
1	3	1.64	0.60	0.85	1.37	0.16	3.18	6.76	7.55
2	3	1.60	0.60	0.90	1.45	0.16	3.14	6.89	7.74
3	3	1.49	0.60	0.98	1.57	0.17	3.12	7.04	7.93
4	3	1.60	0.60	1.04	1.67	0.20	2.98	7.64	8.78

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5	3	1.26	0.60	1.09	1.75	0.17	3.09	6.70	7.58
6	3	1.07	0.60	1.13	1.82	0.17	3.13	6.09	6.85
7	2	0.72	0.40	1.16	1.86	0.19	3.02	4.09	4.68
8	2	0.76	0.40	1.18	1.90	0.21	2.93	4.24	4.91
9	2	0.62	0.40	1.20	1.94	0.17	3.10	3.84	4.33
10	2	0.62	0.40	1.21	1.97	0.17	3.10	3.90	4.41
11	2	0.71	0.40	1.24	2.00	0.20	2.99	4.30	4.94
12	2	0.85	0.40	1.26	2.03	0.24	2.83	4.83	5.69

Table.2. Body wind computation for tower 2– 200 kmph wind load as per ANSI/TIA-222-G

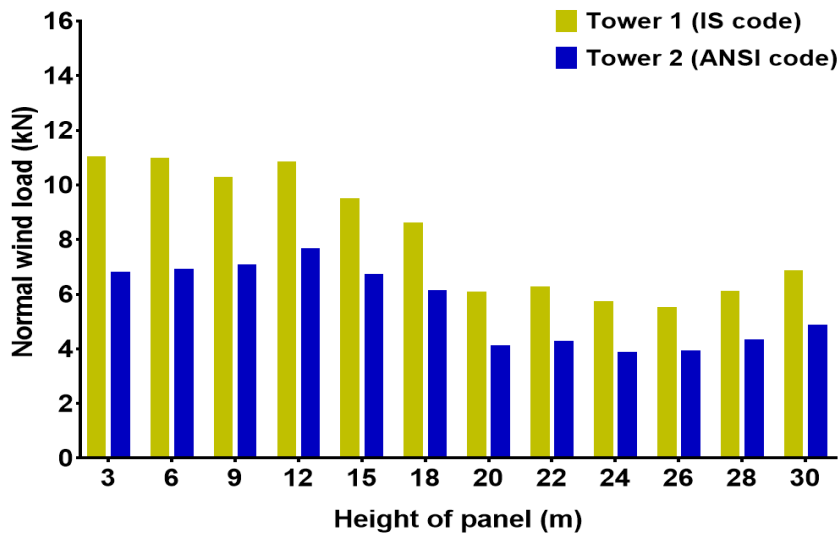


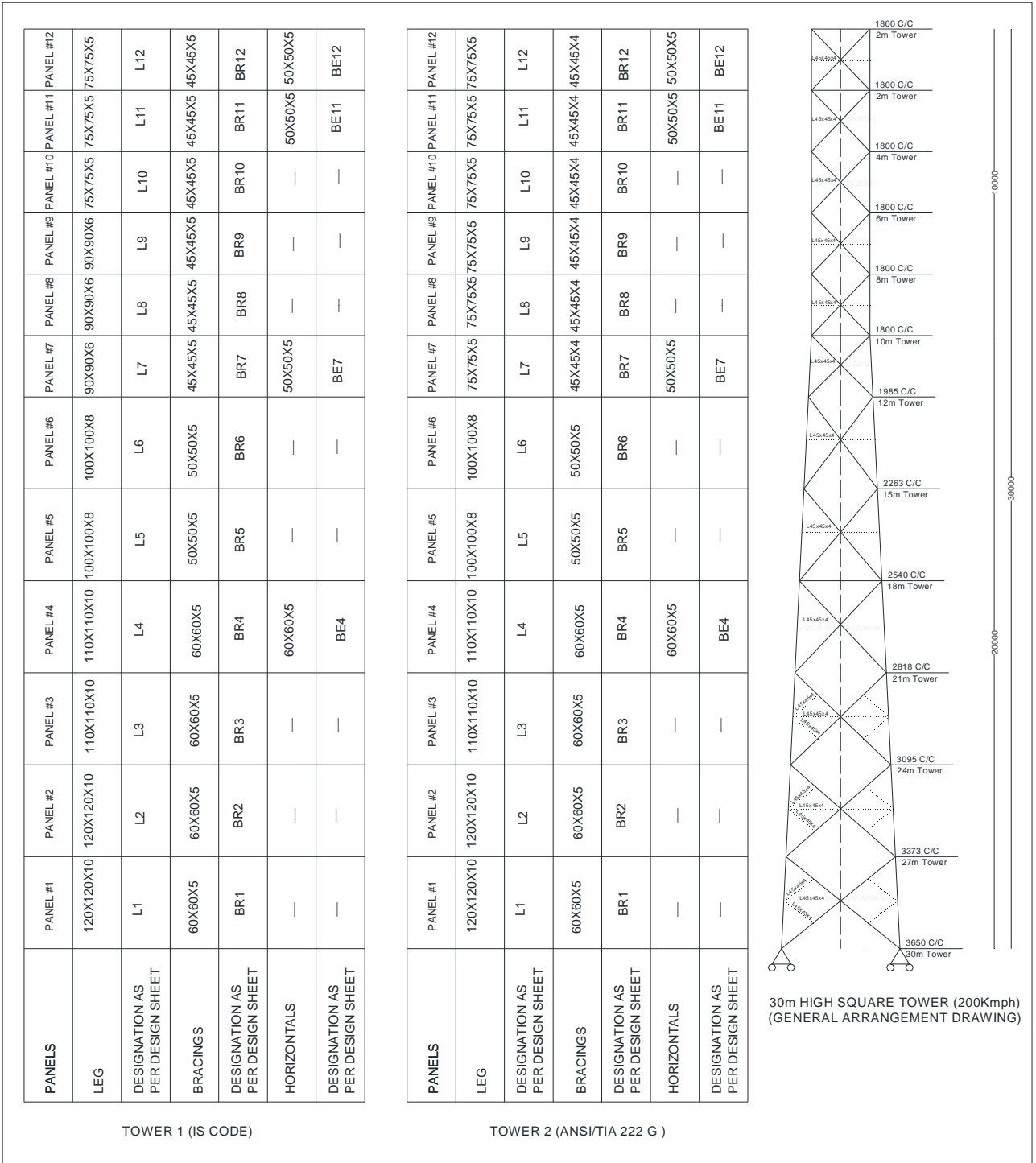
Fig.1.comparison of normal wind load by panel height

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V. RESULT OF ANALYSIS

Twist /sway of the tower

The deflection from output is reproduced below:

a) Tower 1 (IS code)

JOINT DISPLACEMENT (CM RADIANS) STRUCTURE TYPE = TRUSS							
JOINT	LOAD	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
49	1	18.5779	0.8365	-0.0002	0.0000	0.0000	0.0000
	2	15.0540	-0.0884	15.0549	0.0000	0.0000	0.0000
	3	18.5781	0.8718	-0.0003	0.0000	0.0000	0.0000
	4	15.0541	-0.0530	15.0548	0.0000	0.0000	0.0000
50	1	18.5785	-1.0132	0.0007	0.0000	0.0000	0.0000
	2	15.0553	-1.5769	15.0556	0.0000	0.0000	0.0000
	3	18.5784	-0.9778	0.0006	0.0000	0.0000	0.0000
	4	15.0551	-1.5415	15.0555	0.0000	0.0000	0.0000
51	1	18.5785	-1.0132	-0.0007	0.0000	0.0000	0.0000
	2	15.0546	-0.0883	15.0544	0.0000	0.0000	0.0000
	3	18.5784	-0.9778	-0.0006	0.0000	0.0000	0.0000
	4	15.0545	-0.0530	15.0545	0.0000	0.0000	0.0000
52	1	18.5779	0.8365	0.0002	0.0000	0.0000	0.0000
	2	15.0547	1.4002	15.0551	0.0000	0.0000	0.0000
	3	18.5781	0.8718	0.0003	0.0000	0.0000	0.0000
	4	15.0548	1.4355	15.0552	0.0000	0.0000	0.0000

Table.3.The deflection from output for tower 1

The deflection at the top of tower from analysis for diagonal wind = 15.0549x1.414 =21.29cm
Sway = tan-1(21.29/3000) = 0.41deg< 0.5 deg...Hence the tower is adequate.

b) Tower 2 (ANSI TIA 222 G)

JOINT DISPLACEMENT (CM RADIANS) STRUCTURE TYPE = TRUSS							
JOINT	LOAD	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
49	1	15.9973	0.7543	-0.0002	0.0000	0.0000	0.0000
	2	12.4169	1.2056	-12.4172	0.0000	0.0000	0.0000
	3	15.9973	0.7728	-0.0002	0.0000	0.0000	0.0000
	4	12.4169	1.2240	-12.4172	0.0000	0.0000	0.0000
50	1	15.9977	-0.9022	0.0006	0.0000	0.0000	0.0000
	2	12.4167	-0.0740	-12.4166	0.0000	0.0000	0.0000
	3	15.9977	-0.8837	0.0006	0.0000	0.0000	0.0000
	4	12.4167	-0.0555	-12.4166	0.0000	0.0000	0.0000
51	1	15.9977	-0.9022	-0.0006	0.0000	0.0000	0.0000
	2	12.4173	-1.3535	-12.4176	0.0000	0.0000	0.0000
	3	15.9977	-0.8837	-0.0006	0.0000	0.0000	0.0000
	4	12.4173	-1.3350	-12.4176	0.0000	0.0000	0.0000
52	1	15.9973	0.7543	0.0002	0.0000	0.0000	0.0000
	2	12.4163	-0.0740	-12.4170	0.0000	0.0000	0.0000
	3	15.9974	0.7728	0.0002	0.0000	0.0000	0.0000
	4	12.4163	-0.0555	-12.4170	0.0000	0.0000	0.0000

Table.4.The deflection from output for tower 2

The deflection at the top of tower from analysis for diagonal wind = 12.4176x1.414 =17.56
Sway = tan-1(17.56/3000) = 0.34 deg< 0.5deg...Hence the tower is adequat

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VI. CONCLUSION

1. The steel section for the tower designed as per the IS was on the higher side as compared to the tower designed as per ANSI/TIA RS-222G.
2. The normal wind load calculated was found to be higher for the tower designed as per IS as compared to the tower designed as per ANSI/TIA RS-222G.
3. The probability factors for IS is denoted as K_1 and the probability factors for ANSI is denoted as K_D , where K_1 depend upon different classes of structure and life of structure according to zone which makes it give more precise value as compared to K_D which is broadly categorized into 2 categories based on structure type. The terrain, height and structure size factor in IS is denoted by K_2 and topography factor is denoted as K_3 whereas the topography factor in ANSI is denoted as K_{ZT} which is combination of K_2 and K_3 . Another factor in ANSI known as Important factor, I depends upon 3 classes of structures which correspond to the K_2 of IS code.
4. The load calculation of appurtenances for the tower1 designed as per Indian standard as well as the tower2 designed as per American standard was found to be almost similar. The most probable reason for this could be the use of shielding parameter for tower1. Shielding is a parameter that is used in American standard for analysis and design. Full shielding is considered when distance between the element in the direction under consideration for determining effective projected areas is less than or equal to twice the length of the element.
5. Load on the 6 GSM was subdued in which 3GSM is fully exposed and 3GSM is shielded.
6. Effective Projected Area (EPA) is discussed in detail in the ANSI. While calculating EPA for appurtenances, two types of action of the wind can be calculated i.e. the windward face and the windward side face which gives more accurate value.
7. The American Standard code has mentioned various factors as discussed above that can be adopted by Indian Standard code in order to get an effective tower designing code.

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