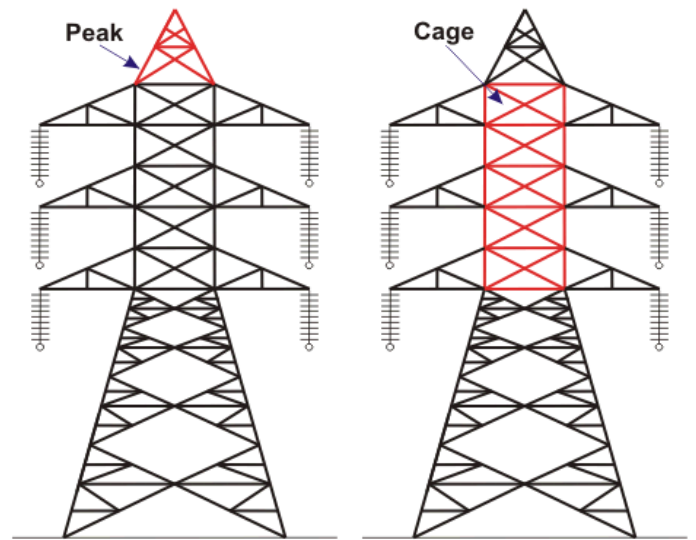# TOPIC: Power system design – 06


NIMRA IDRIS SIDDIQUI

17 EEB 409

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TOWER DESIGN

A **transmission tower** or **power tower** is a tall structure, usually a steel lattice tower, used to support an overhead power line.

In electrical grids, they are generally used to carry high-voltage transmission lines that transport bulk electric power from generating stations to electrical substations
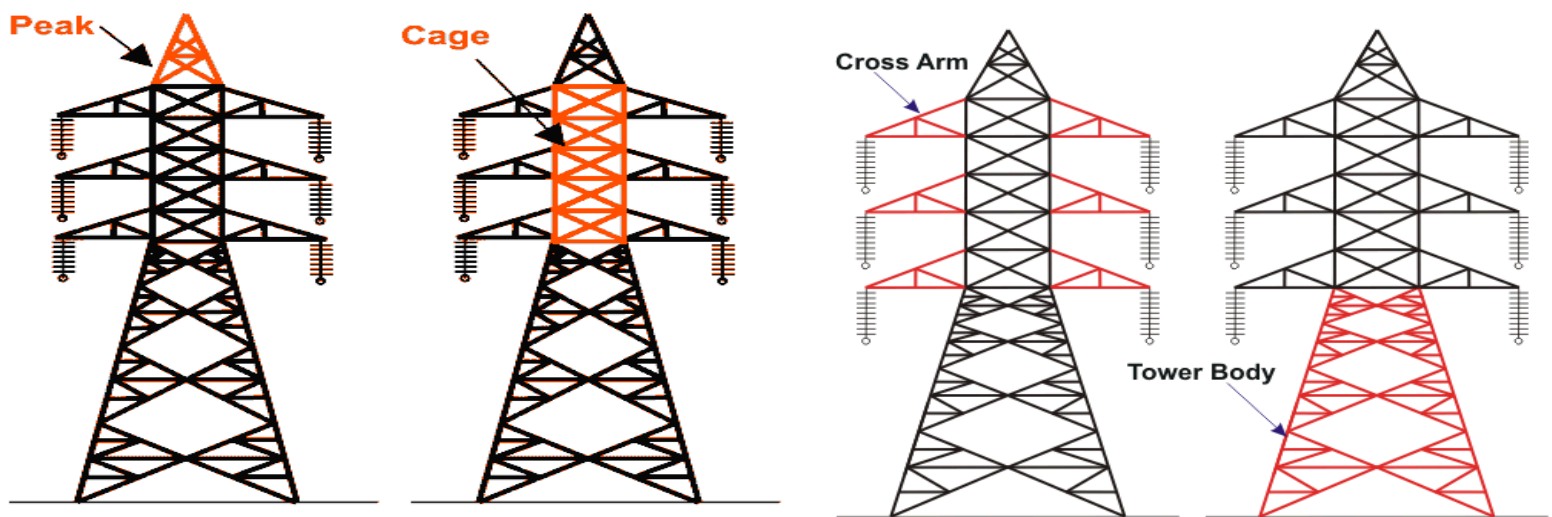
Different parts of transmission tower

Types of Transmission Tower

In total length of a long transmission line there may be several deviation points. According to the angle of deviation there are four types of transmission tower-

1. A – type tower – maximum deviation is **2**°C
2. B – type tower – maximum deviation is **30**°C
3. C – type tower – maximum deviation is **60**°C
4. D – type tower – maximum deviation is **90**°C

As per the force applied by the conductor on the cross arms, the transmission towers can be categorized in another way-

1. Tangent suspension tower and it is generally A - type tower.
2. Angle tower or tension tower or sometime it is called section tower. All B, C and D types of transmission towers come under this category.

Minimum ground Clearance

- It is the height of the lowest conductor with respect to the ground.

- According to the Indian standard, the minimum ground clearance (G_{min}) between the lowest conductor and ground is given by :

$$G_{min} = \left(17 + \frac{V_{kV} - 33}{33}\right) \text{ft}$$

Height of Tower

- For Double Circuit Line:

$$\text{I} \qquad H_1 = (G_{min} + \delta_{max}) \, m$$

$$H_2 = (H_1 + y) \, m$$

$$H_3 = (H_2 + y) \, m$$

$$H_t = (H_3 + d') \, m$$

Bending Moment acting on Tower

- Bending moment is given by :

$$M = \frac{2.5}{1000}\left[N_c(L_{pc} + F_c)(H_1 + H_2 + H_3) + N_e H_t(L_{pe} + F_e)\right]$$

where,
M = bending moment
N_c = number of circuits
N_e = number of earth wires (= 1).
H_1 = height of lowest conductor from ground
H_2 = height of middle conductor from ground
H_3 = height of top conductor from ground
H_t = height of tower

L_{pc} = Transverse force acting on the line conductor due to wind pressure in kg

L_{pe} = Transverse force acting on the earth wire to wind pressure in kg

F_c = Transverse force acting on the conductor due to change in direction in kg

F_e = Transverse force acting on the earth wire due to change in direction in kg

$$L_{pe} = \frac{2}{3} \times D_e \times P \times l$$

where,
P = wind pressure = 100 kg/m²
l   = span length (m)
D_e = diameter of earth wire (m) = 1.828 x 10⁻² m

$$F_e = 2\,T_e\sin(\alpha/2)$$

where,
T_e = UTS/FOS
Here, UTS = 18870 and FOS = 2
α = turning angle (2°) .

- Now, Bending moment is given by :

$$M = \frac{2.5}{1000}\left[N_c(L_{pc} + F_c)(H_1 + H_2 + H_3) + N_E H_t(L_{pe} + F_e)\right] \; k - kgm$$

- Weight of tower, $W_t = KH_t\sqrt{M}$

Where K = Rayleigh constant = 0.008

For different span lengths, calculate the values of M, L_{pe}, L_{pc} and W_t and write them in tabulated form

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For different span lengths, calculate the values of M, L_{pe}, L_{pc} and W_t and write them in tabulated form

LEOPARD

y	d'	Vkv	Gminf	Gminm	L	d2	h1	h2	h3	ht
3.57989	6.466	132	20	6.096	250	5.1614	11.2574	14.83729	18.41718	24.88318
3.57989	6.466	132	20	6.096	275	6.1182	12.2142	15.79409	19.37398	25.83998
3.57989	6.466	132	20	6.096	300	7.1583	13.2543	16.83419	20.41408	26.88008
3.57989	6.466	132	20	6.096	325	8.2825	14.3785	17.95839	21.53828	28.00428
3.57989	6.466	132	20	6.096	350	9.4913	15.5873	19.16719	22.74708	29.21308
3.57989	6.466	132	20	6.096	375	10.7854	16.8814	20.46129	24.04118	30.50718
3.57989	6.466	132	20	6.096	400	12.1651	18.2611	21.84099	25.42088	31.88688
3.57989	6.466	132	20	6.096	425	13.631	19.727	23.30689	26.88678	33.35278

K	Lpc	Lpe	Nc	Ne	Te	De	α	T1	p	D
0.008	264	304.6667	2	1	9435	1.83E-02	2	2068.5	100	1.58E-02
0.008	290.4	335.1333	2	1	9435	1.83E-02	2	2068.5	100	1.58E-02
0.008	316.8	365.6	2	1	9435	1.83E-02	2	2068.5	100	1.58E-02
0.008	343.2	396.0667	2	1	9435	1.83E-02	2	2068.5	100	1.58E-02
0.008	369.6	426.5333	2	1	9435	1.83E-02	2	2068.5	100	1.58E-02
0.008	396	457	2	1	9435	1.83E-02	2	2068.5	100	1.58E-02
0.008	422.4	487.4667	2	1	9435	1.83E-02	2	2068.5	100	1.58E-02
0.008	448.8	517.9333	2	1	9435	1.83E-02	2	2068.5	100	1.58E-02

L	Fc	Fe	M	Wt
250	72.18961	329.277	114.2585	2.127845
275	72.18961	329.277	128.8225	2.34627
300	72.18961	329.277	144.9207	2.588724
325	72.18961	329.277	162.6777	2.857449
350	72.18961	329.277	182.2169	3.154726
375	72.18961	329.277	203.6642	3.482967
400	72.18961	329.277	227.1434	3.844608
425	72.18961	329.277	252.7818	4.242237

COYOTE

y	d'	Vkv	Gminf	Gminm	L	d2	h1	h2	h3	ht
3.57989	6.466	132	20	6.096	250	4.4381	10.5341	14.11399	17.69388	24.15988
3.57989	6.466	132	20	6.096	275	5.2988	11.3948	14.97469	18.55458	25.02058
3.57989	6.466	132	20	6.096	300	6.2354	12.3314	15.91129	19.49118	25.95718
3.57989	6.466	132	20	6.096	325	7.2485	13.3445	16.92439	20.50428	26.97028
3.57989	6.466	132	20	6.096	350	8.3387	14.4347	18.01459	21.59448	28.06048
3.57989	6.466	132	20	6.096	375	9.5062	15.6022	19.18209	22.76198	29.22798
3.57989	6.466	132	20	6.096	400	10.7514	16.8474	20.42729	24.00718	30.47318
3.57989	6.466	132	20	6.096	425	12.074	18.17	21.74989	25.32978	31.79578

K	Lpc	Lpe	Nc	Ne	Te	De	α	T1	p	D
0.008	2.65E+02	3.05E+02	2	1	9435	1.83E-02	2	2319	100	1.59E-02
0.008	2.91E+02	3.35E+02	2	1	9435	1.83E-02	2	2319	100	1.59E-02
0.008	3.18E+02	3.66E+02	2	1	9435	1.83E-02	2	2319	100	1.59E-02
0.008	3.44E+02	3.96E+02	2	1	9435	1.83E-02	2	2319	100	1.59E-02
0.008	3.71E+02	4.26E+02	2	1	9435	1.83E-02	2	2319	100	1.59E-02
0.008	3.97E+02	4.57E+02	2	1	9435	1.83E-02	2	2319	100	1.59E-02
0.008	4.24E+02	4.87E+02	2	1	9435	1.83E-02	2	2319	100	1.59E-02
0.008	4.50E+02	5.18E+02	2	1	9435	1.83E-02	2	2319	100	1.59E-02

L	Fc	Fe	M	Wt
250	80.8395	329.3269	1.11E+02	2.04E+00
275	80.8395	329.3269	1.25E+02	2.24E+00
300	80.8395	329.3269	1.40E+02	2.46E+00
325	80.8395	329.3269	1.57E+02	2.70E+00
350	80.8395	329.3269	1.75E+02	2.97E+00
375	80.8395	329.3269	1.95E+02	3.27E+00
400	80.8395	329.3269	2.17E+02	3.59E+00
425	80.8395	329.3269	2.41E+02	3.95E+00

TIGER

y	d'	Vkv	Gminf	Gminm	L	d2	h1	h2	h3	ht
3.57989	6.466	132	20	6.096	250	3.8094	9.9054	13.48529	17.06518	23.53118
3.57989	6.466	132	20	6.096	275	4.5597	10.6557	14.23559	17.81548	24.28148
3.57989	6.466	132	20	6.096	300	5.3755	11.4715	15.05139	18.63128	25.09728
3.57989	6.466	132	20	6.096	325	6.2571	12.3531	15.93299	19.51288	25.97888
3.57989	6.466	132	20	6.096	350	7.2048	13.3008	16.88069	20.46058	26.92658
3.57989	6.466	132	20	6.096	375	8.2189	14.3149	17.89479	21.47468	27.94068
3.57989	6.466	132	20	6.096	400	9.2997	15.3957	18.97559	22.55548	29.02148
3.57989	6.466	132	20	6.096	425	10.4474	16.5434	20.12329	23.70318	30.16918

K	Lpc	Lpe	Nc	Ne	Te	De	α	T1	p	D
0.008	2.75E+02	3.05E+02	2	1	9435	1.83E-02	2	2879	100	1.65E-02
0.008	3.03E+02	3.35E+02	2	1	9435	1.83E-02	2	2879	100	1.65E-02
0.008	3.30E+02	3.66E+02	2	1	9435	1.83E-02	2	2879	100	1.65E-02
0.008	3.58E+02	3.96E+02	2	1	9435	1.83E-02	2	2879	100	1.65E-02
0.008	3.85E+02	4.26E+02	2	1	9435	1.83E-02	2	2879	100	1.65E-02
0.008	4.13E+02	4.57E+02	2	1	9435	1.83E-02	2	2879	100	1.65E-02
0.008	4.41E+02	4.87E+02	2	1	9435	1.83E-02	2	2879	100	1.65E-02
0.008	4.68E+02	5.18E+02	2	1	9435	1.83E-02	2	2879	100	1.65E-02

L	Fc	Fe	M	Wt
250	100.476	329.2767	1.13E+02	2.00E+00
275	100.476	329.2767	1.26E+02	2.18E+00
300	100.476	329.2767	1.41E+02	2.38E+00
325	100.476	329.2767	1.57E+02	2.60E+00
350	100.476	329.2767	1.74E+02	2.84E+00
375	100.476	329.2767	1.93E+02	3.10E+00
400	100.476	329.2767	2.13E+02	3.39E+00
425	100.476	329.2767	2.36E+02	3.70E+00

WOLF

y	d'	Vkv	Gminf	Gminm	L	d2	h1	h2	h3	ht
3.57989	6.466	132	20	6.096	250	3.6613	9.7573	13.33719	16.91708	23.38308
3.57989	6.466	132	20	6.096	275	4.3721	10.4681	14.04799	17.62788	24.09388
3.57989	6.466	132	20	6.096	300	5.1432	11.2392	14.81909	18.39898	24.86498
3.57989	6.466	132	20	6.096	325	5.9748	12.0708	15.65069	19.23058	25.69658
3.57989	6.466	132	20	6.096	350	6.8673	12.9633	16.54319	20.12308	26.58908
3.57989	6.466	132	20	6.096	375	7.821	13.917	17.49689	21.07678	27.54278
3.57989	6.466	132	20	6.096	400	8.8362	14.9322	18.51209	22.09198	28.55798
3.57989	6.466	132	20	6.096	425	9.9133	16.0093	19.58919	23.16908	29.63508

K	Lpc	Lpe	Nc	Ne	Te	De	α	T1	p	D
0.008	3.02E+02	3.05E+02	2	1	9435	1.83E-02	2	3440	100	1.81E-02
0.008	3.32E+02	3.35E+02	2	1	9435	1.83E-02	2	3440	100	1.81E-02
0.008	3.63E+02	3.66E+02	2	1	9435	1.83E-02	2	3440	100	1.81E-02
0.008	3.93E+02	3.96E+02	2	1	9435	1.83E-02	2	3440	100	1.81E-02
0.008	4.23E+02	4.26E+02	2	1	9435	1.83E-02	2	3440	100	1.81E-02
0.008	4.53E+02	4.57E+02	2	1	9435	1.83E-02	2	3440	100	1.81E-02
0.008	4.83E+02	4.87E+02	2	1	9435	1.83E-02	2	3440	100	1.81E-02
0.008	5.14E+02	5.18E+02	2	1	9435	1.83E-02	2	3440	100	1.81E-02

L	Fc	Fe	M	Wt	Lpc	Lpe
250	120.055	329.2767	121.5198	2.06E+00	0.00E+00	0.00E+00
275	120.055	329.2767	135.3493	2.24E+00	0.00E+00	0.00E+00
300	120.055	329.2767	150.4725	2.44E+00	0.00E+00	0.00E+00
325	120.055	329.2767	166.9873	2.66E+00	0.00E+00	0.00E+00
350	120.055	329.2767	184.9936	2.89E+00	0.00E+00	0.00E+00
375	120.055	329.2767	204.5914	3.15E+00	0.00E+00	0.00E+00
400	120.055	329.2767	225.8812	3.43E+00	0.00E+00	0.00E+00
425	120.055	329.2767	224.5699	3.55E+00	0.00E+00	0.00E+00