TOWERS (Masts)

Tower:- The tall structure with relatively small cross section and with a large ratio b/w the height and max width, are known as tower. A tower is a single cantilever structure freely standing over the (foundation) self supporting structure fixed at its base.

Mast: A mast is a structure pin connected to its foundation and braced with guys or other elements.

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Types of Tower:

1> Power transmission line tower <2> Microwave Tower <3> Water Tower
4> Radio and Television Tower.

Transmission Line Towers: The tower of power transmission line are used to support transmission cables transmitting voltage exceeding 132 kV over longer distances. The tall transmission tower provide necessary clearance where the transmission cables have maxium sag. These towers may be built up of ~~three or~~ four legs, spaced suitably. The four legs of tower maintain stability of the towers. The transmission line tower may be

<i> Self Supporting type <ii> Flexible type <iii> Semi-flexible type
<iv> Self supporting wide base and guyed ~~base~~ type

Self supporting transmission line towers: These are rigid in both the transverse and longitudinal direction.

Flexible Tower: These are not rigid in longitudnal direction i.e. in the direction along the transmission cables.

The straight portion of power line, ~~is changed~~ the line towers are used. When the direction of power line is changed, then angle tower are provided.

IS CODE Recommends Four types of tower

i> Tangent Tower with not more than 2° line deviation.
ii> Small Angle Tower with not more than 10° line deviation with suspension insulator.
iii> Medium Angle Tower up to 30° line deviation
iv> Large angle with 60° deviation
v> Dead End Tower

Specification of transmission line tower:
The height of these tower range from 20 to 40 m. The tower of such height provide 6 to 10 m height from the ground surface to the point of maximum sag of the cables. The type of tower depends on loading condition and type terrain.

se towers are also ...

<ii> Double Circuit Tower

<iii> Multiple Circuit Tower

, phase conductor and shield wires of a transmission line are supported by e transmission tower structure. These tower structure are either lattice type or pole type. Lattice type structure usually consist of steel angle section

Lattice Type Structure :- Lattice type structure usually consist of Steel angle section). These type structure are used for high voltage level (more than 345 kV). Lattice type structure may be of following configuration.

1> Horizontal Configuration <2> Vertical Configuration <3> Delta Type Configuration

Pole Type Structures :- These structure are usually used for voltage of 345 kV or less. Poles used may be wooden, steel or concrete.

Factors Upon which Configuration of a Transmission Line Tower

> Type of structure which supports the electric power transmission Line like wooden poles, R.C.C poles, fabricated steel poles.

> Type of Bracing like tension system bracing, tension compression bracing system and K-braced system (staggered bracing)

> Voltage Rating (60 to 500 kV)

> Web Patterns

> Optimal Angle (40° to 60°) or Deviation.

> Economical Base Width ($B = K\sqrt{M}$)

> Ratio of Base width (B) to height (H)

> A horizontal phase configuration usually results in lowest structure cost.

> In case, right of the way costs are high, or the width of the right of the way is restricted or the line closely parellels other lines, a vertical configuration may be lower in total cost.

> Besides to a wider right of way, horizontal configuration generally need more tree cleaning than vertical configuration.

> Although vertical Configuration are narrower than the horizontal configuration, these are taller, which may be objectionable from an aesthetic point of view.

> Where electric and magnetic field ~~is concerned~~ strength is concerned, the phase configuration is considered as means of reducing these fields.

Types of Main Bracing System used in Tower:

1> Tension System Bracing

2> Tension Compression System.

3> K Braced System.

> Tension Bracing System: In tension bracing the diagonal member have tensile force only. They become dummy when subjected to compression. However, horizontal member are designed for compression and Tension Bracing is economical for light tangent towers.

> ~~Tension Compression System~~:

Tension – Compression System: The tension compression system is suitably only for large tower as it distributes the load equally to tower leg.

Staggered or K Bracing: A staggered bracing system is used on the adjacent faces of a tower for ease of connection and reduce to number of bolt holes at a section. The staggering of main bracing member may produce significant moment in the member specially for heavily loaded towers. The members are connected to the main bracing member on the adjacent faces at a common panel point.

Transmission Poles:

> steel <2> Concrete <3> Wooden Poles may be used as transmission poles in transmission lines at voltage upto 345 kV. For shorter span and lower voltage, the wooden poles may be economically used. Concrete poles are larger strength and are used for higher voltage. Steel poles are most cost effective choice for areas where sever climatic load prevail.

Stress Analysis for Transmission Poles:

Transmission Poles are flexible structure. These structure undergo large lateral deflection under design loads. A secondary moment develop in the poles due to lateral deflection at the load points. This secondary moment may be a significant percent of total amount.

Family of Structure: A family structure include

> Tangent Structure <2> Angle Tower <3> Dead End Structure

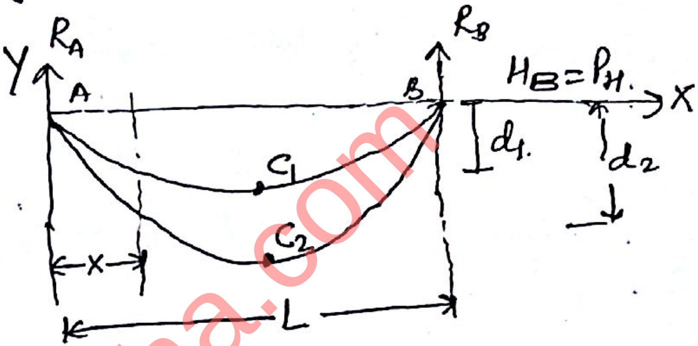
> Tangent Structure: When transmission line is straight or when there is a small line angle (less than 3°), then tangent structure are used.

Line Angle towers: The line angle is defined as the deflection angle of line in to adjacent span. When the line changes its direction, then angle towers are used. The point at which direction change occurs is generally referred as point of Intersection [P.I]. When angle exceeds 30°, the usual practice is to use a dead end type design.

Dead End Structure: Dead end structure are designed to resist wire pulls on one side. In addition to their use for large angles, the dead end structure are used as Terminal structure.

Sag: Distance measured vertically from a conductor to the straight line joining its end of support.

$$d = \frac{wL^2}{8P_H}$$



Various Loads on Transmission Line Tower:

<1> Vertical Loads <2> Horizontal Loads <3> Longitudinal Load
<4> Torsional Load.

1> Vertical Load: May dead or live

<i> Weight of tower $(W) = kH(M)^{0.5}$
<ii> Self wt of insulator and fitting <iii> Self wt of ice coating
<iv> Wt. of lineman with tools <v> Weight of power conductor
<vi> Wt. of ground wire.

> Horizontal Load (T):

<i> Wind (or Seismic) load on conductor <ii> Wind (or seismic) load on ground wire <iii> Wind or seismic load on insulator and fitting <iv> Wind load on tower structure.
<v> Transverse Component of line tension at angles.

Wind load on Wire (W_h)

$W_h = p.d$ (horizontal span) x Overload capacity Factor.

p = wind pressure d = diameter of wire.

Horizontal Span = Distance b/w midpoint of adjacent span.

Transverse load due to line angle: Where a line changes direction, the total transverse load on structure is the sum of transverse wind load and transverse component of wire tension.

Transverse Component of Wire tension on structure.

$H = 2T \sin(\theta/2)$

H = Transverse Load due to wire tension
T = Wire tension

θ = Line Angle.

3

Longitudnal Load (P):

<i> Unbalanced pull due to broken conductor
<ii> Unbalanced pull due broken insulator, broken ground wire.
<iii> Seismic load on wire
<iv> Seismic load on tower.
<v> Load due to temprature variation

Torsional Loads (M_t):

<i> Due to Ground wire Broken.
<ii> Due to Conductor Broken.

Condition of Design of Transmission Line Towers:

(1) Normal Condition

<2> Broken Wire Condition: A broken wire condition occurs when a wire breaks from one line, giving rise to an unbalanced longitudnal force.

Normal Condition	Broken Wire Condition
Single Circuit Tower a> Tangent tower (2°) b> Small angle tower (10°)) Medium Angle Tower (30°) Large Angle Tower up to (60°) and dead end tower	For single circuit tower of all four categorie any one power conductor of one ground wire is considered as broken, which ever is more serious for a particular member.
Double Circuit Tower Tangent Tower (2°) Small angle Tower (10°) Medium Angle Tower (30°) large angle and dead end tower (60°)	(a) For doubled circuit tower of first two categories, any one power conductor of one ground wire is considered as broken.

power conductor are considered as broken on the same circuit, and on the same span or any one of the power conductor and one ground wire considered as broken on the same span.

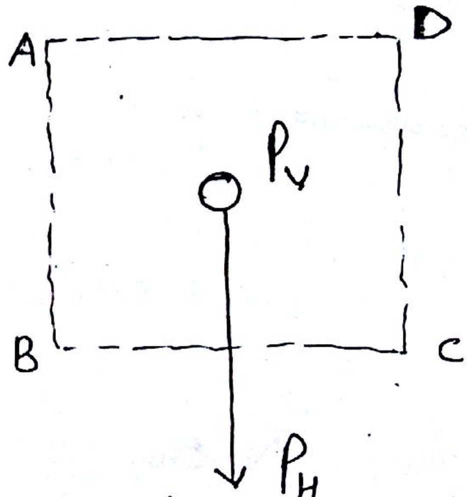
(c) For large angle tower and dead end tower, three power conductors are considered as broken or any two of the power conductor and any one of ground wires are considered as broken.

> Cross Arms

In all tower design, the power conductor supports and earth wire supports shall be designed for the broken wire supports shall be designed for the broken wire condition also.

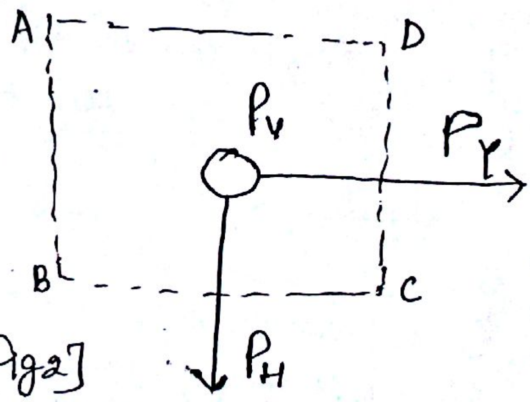
Analysis of Tower and Masts :

1) Figure 1 shows the rectangular base of a tower. In case the pull in the transmission cable is parellel to AB and CD truss, then P_V and P_H are vertical and the horizontal components of pull in the cable. The vertical component P_V is distributed equally in four legs of the tower, because of symmetry. The horizontal component P_H is distributed equally in two trusses AB and CD.



(Fig 1)

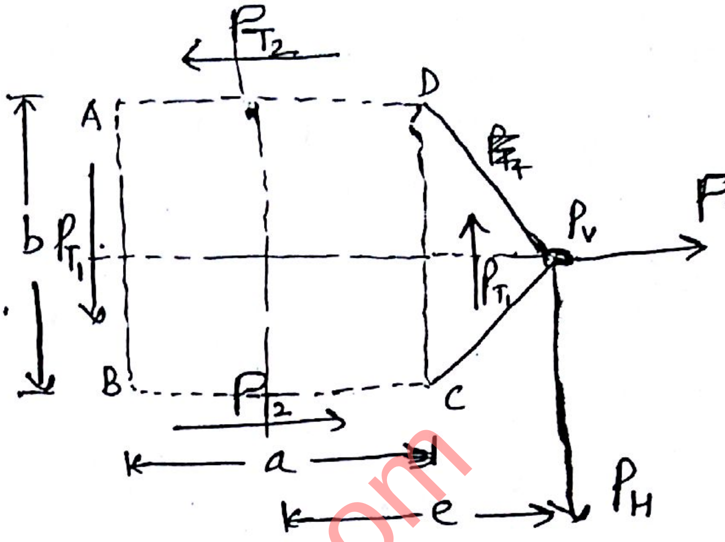
> Fig 2 shows the rectangular base of a tower. The pull in the cable 'P', is included with the plane AB and CD trusses. The pull in the cable is resolved in to three components P_V, P_H, and P_Y. P_H is the horizontal component parellel to AB and CD truss. The component P_Y is parellel to AD and BC trusses. The horizontal component P_H is distributed equally in AB and CD truss.



[Fig 2]

component 'P_Y' is distributed equally in AD and BC truss. The vertical component 'P_V' is distributed equally in the four legs of the tower.

<3> Fig 3 shows the rectangular base of a tower. In case some transmission cables are snapped, then the pull in the wire acts eccentrically, at a distance 'e' from center. The pull in the wire 'P_1' resolved in to its three components, P_V, P_H & P_Y. The component 'P_V' causes bending moment ($M = P_V \cdot e$) because eccentricity. It is assumed that moment 'M' is resisted by 'AD' and 'BC' truss. The vertical component also produces equal axial loads in the four legs of the tower. The horizontal force 'P_H' is distributed equally in AB and CD.



The twisting couple 'M_t' is resisted equally by force in the trusses 'AB' and 'CD' and 'P_{T_2}' be the force in the trusses AD & BC due to the twisting couple 'M_t'.

$$P_{T_1} = \frac{M_t}{2a}, \quad P_{T_2} = \frac{M}{2b}$$

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SHAPE OF SAG AND TENSION in Uniformly Loaded Conductor