The real stars of the communication business are the antennas:

They are not much good on the ground.

They have to be elevated and stable if they are to serve their purpose.

For this we need towers.

We have ready made towers all around us.

Trouble is the branches get in the way.

So, we leave them,

For the birds:

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But, we are coming back to them:

Sort of

They call this “STEALTH”

from hidden.

Or stealing?

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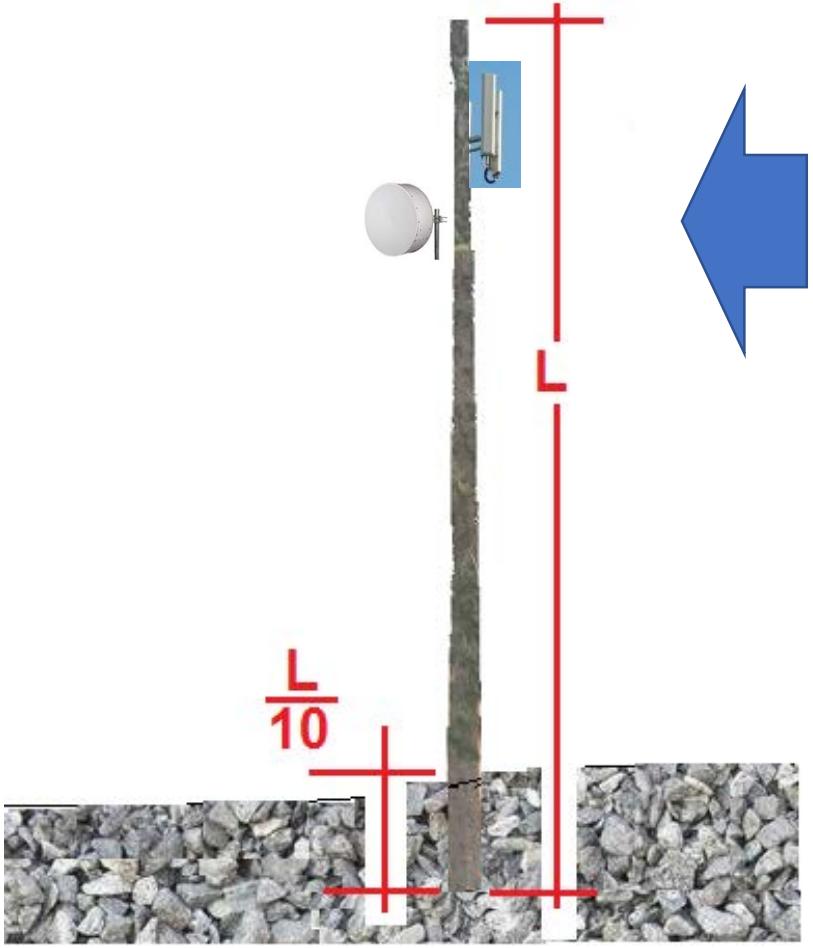
Tower
Attributes



We cut them down,

Strip off the branches, and

Bury them with 10% of their length in the ground.

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And they end up looking more like this:

With a cross section like this:

They started as “Telegraph Poles”, in long lines beside every railway track.

Now serve as “Power Poles” &

“Telephone Poles”

A Self-Supporting (SS) POLE:

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Tower Attributes

This is probably the most common tower in the world.

To control deflection and rotation and add strength,

We add guy stays, and end up with:

A guyed tower.

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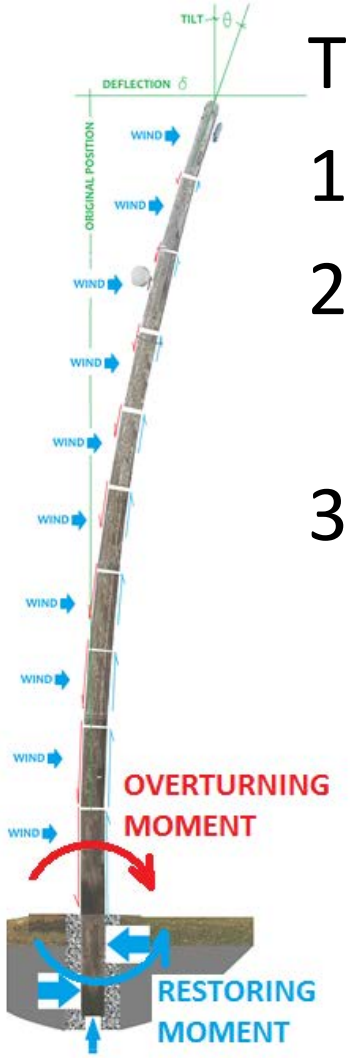

The basics:

1. All loads are eventually resisted by the earth;
2. Loads are only transferred through deformation (deflection & rotation);
3. Deformation and deflection depend on: material stiffness, E (elasticity), and geometric stiffness, L & I (shape).

E ➡ wood: 2,000 KSI, 14 GPa

E steel: 29,000 KSI, 200 GPa

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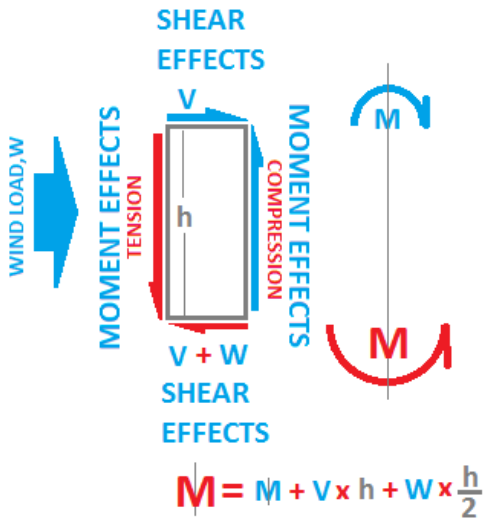
Tower Attributes

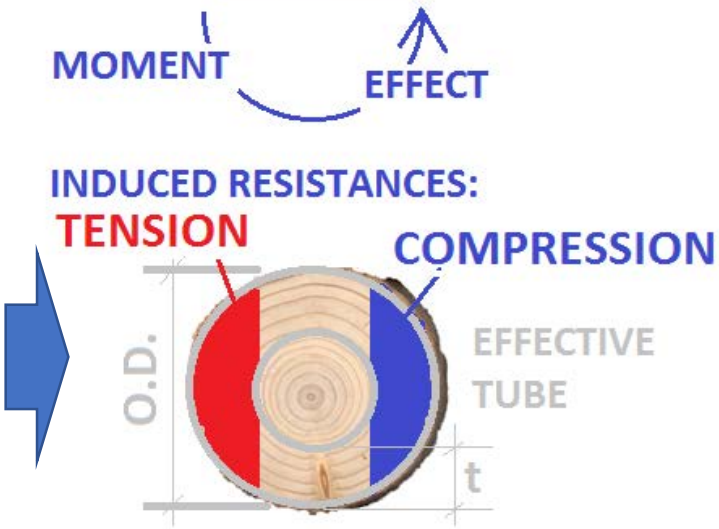
SHEAR EFFECTS: a direct response to the wind load on the segment pluss all the segments above it (arithmetic increase). Shear effect increases down the pole.

MOMENT EFFECTS: a result of the accumulation of shear effects multiplied by their relative lever arms (geometric increase - much faster than the arithmetic increase).



Note that most of the action is towards the outside of the shape (red and blue).

In a lattice tower, we concentrate these fibres into legs.



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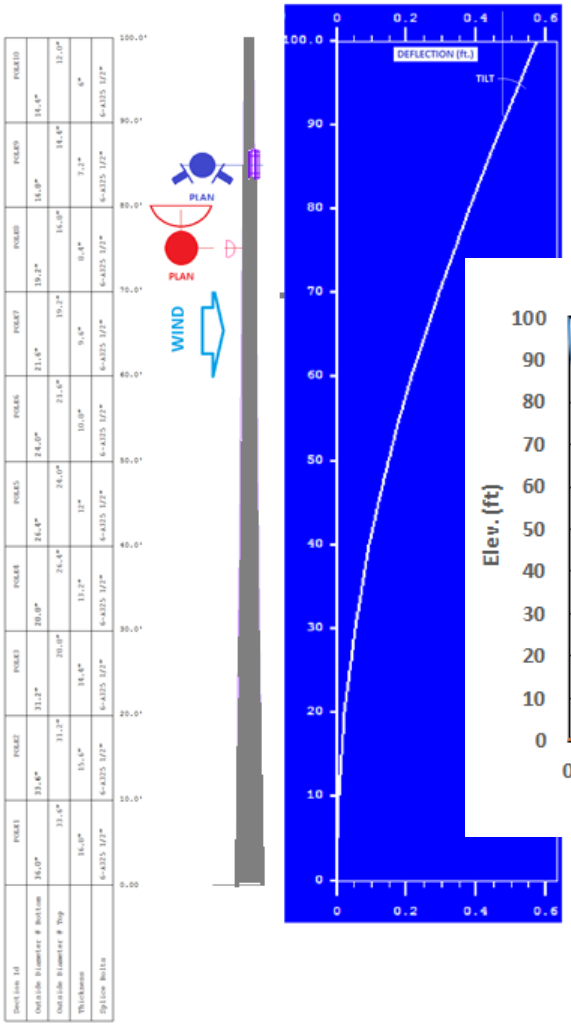
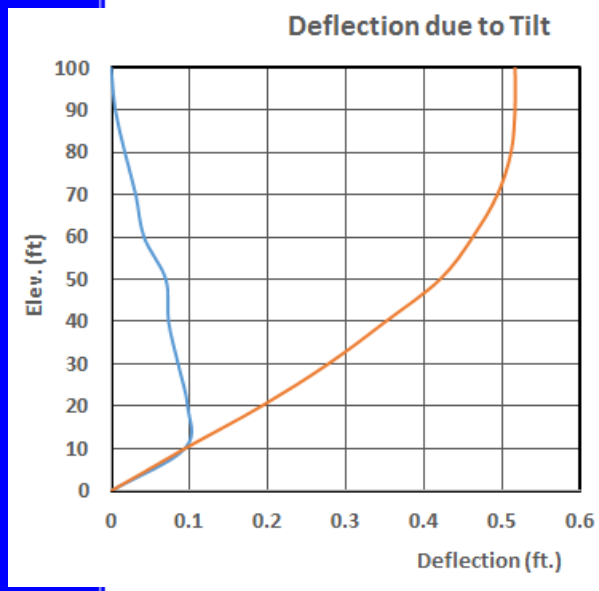
Tower Attributes





DUE TO TILT (deg) @	DEFLECT @ 100 ft due to Tilt at Elev. (ft)	CUMULATIVE DEFLECTION at Elev. (ft)	% of Total	Cummul %
100	0	0.5165	0	100
90	0.0052	0.5165	1.01	100
80	0.0175	0.5113	3.39	98.99
70	0.0314	0.4938	6.08	95.6
60	0.0419	0.4624	8.11	89.52
50	0.0698	0.4205	13.51	81.41
40	0.0733	0.3507	14.19	67.9
30	0.0855	0.2774	16.55	53.71
20	0.0977	0.1919	18.92	37.16
10	0.0942	0.0942	18.24	18.24
0	0	0	0	0

Because the lower part of the tower has such a big influence on deflection at the top, towers tend to be built wider at the base and narrower at the top.

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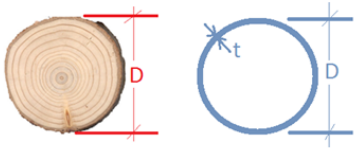
Tower Attributes



	Wood	Steel
E =	2000 ksi 14 GPa	29000 Ksi 200 GPa
Unit Wt. =	50 pcf 795 kg/m³	500 pcf 7850 kg/m³

There is a practical limit to the size of a wooden pole.

This limits: 1. how high we can put the antenna;

2. control on rotations of the antennas.

So, steel poles work better for taller and stiffer towers.

Steel is 14.5 times as stiff (E) and 10 times as heavy as wood.

An efficiency factor of 1.45;

To achieve the same moment strength for D = 24” requires t = 0.0125”

In the steel pipe. If we use t=.1875 (the smallest practical),

X-Area of steel = 14 in^2 ; X-Area of wood = 452 in^2

So, efficiency becomes 1.45 x 452/14 = **46.8**

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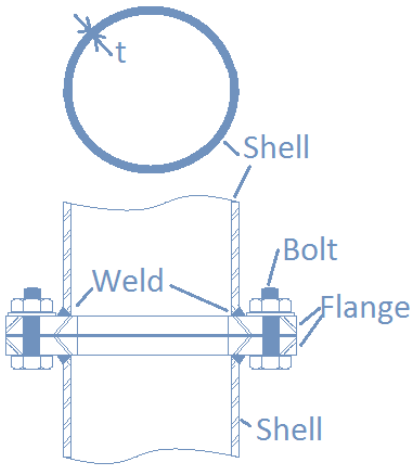
Tower Attributes

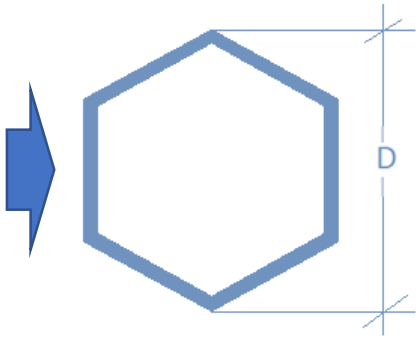
With steel we can build any size pole.

We can shape steel, weld it, and assemble it in any size, adding more to its advantages.

Most of the resistance is developed near the outer layers of the cross section, so we can use pipe.

This can also reach a limit, so we can use polygonal poles made out of bent plates.





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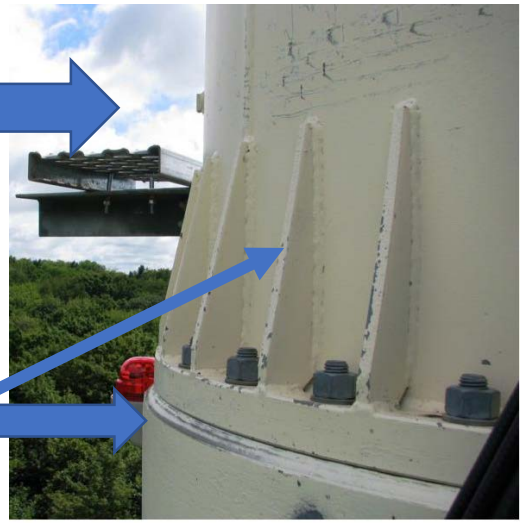
Tower Attributes

Here is a typical tubular tower far right.

This one has flanges on the outside on the bottom of the section(photos to the right) and flanges on the inside at the top of the section in the upper photo to the right below the splice line.

The vertical gussets between bolts are to increase weld area and ease the transfer of load from the shell to the splice bolts.



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Forming the Polygonal Tube:

A flat plate is bent as shown here:

When the two outside edges meet, the seam is welded to produce the many sided tube.

This way one can easily produce a tapered pole.

Tapered sections can be stacked to form a tall pole without the use of flanges and bolts, except at the base.

This makes for a more economical pole than the use of pipes.

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Tower Attributes

A tapered polygonal monopole large enough to have the climbing ladder and the tx-lines on the inside.

This is a slip fit pole.

Note the access door.

Note the only flanges are at the base.

Guymast

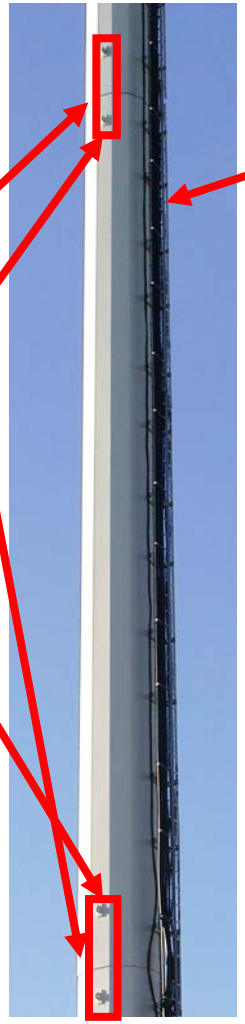
Tower Attributes

A smaller polygonal tapered monopole.

The splices are near the top and bottom in the picture.

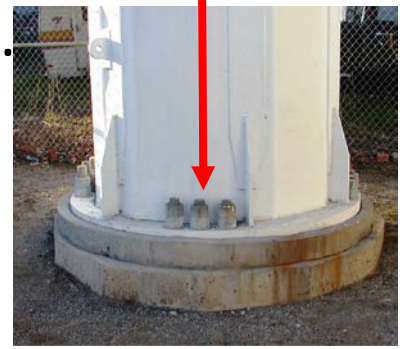
There are pairs of jacking lugs on the outside.

During installation, the nesting sections can be forced to properly seat themselves to maintain the straight line.



Note, here the ladder and Tx-lines are on the outside.

Unusual location of anchor bolts.



Guymast

Tower Attributes

When: 1. single pole gets impractical; or

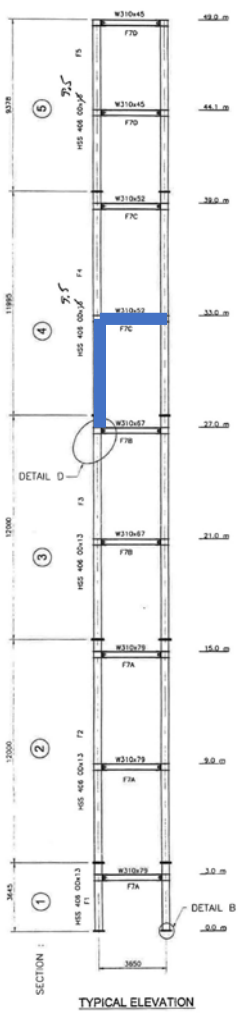
2. much greater stiffness is required,

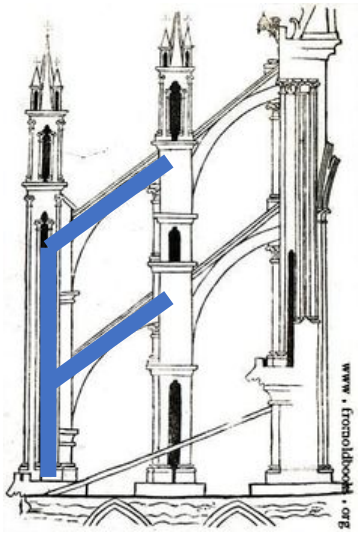
A good option is the TRIPOLE

(a Vierendeel truss).

The TRIPOLE - three tubular poles at a distance from each other.

Each vertical tube acts both as a mast on its own and, together with the horizontal beams, as a buttress for its neighbours.





Buttresses in an old cathedral

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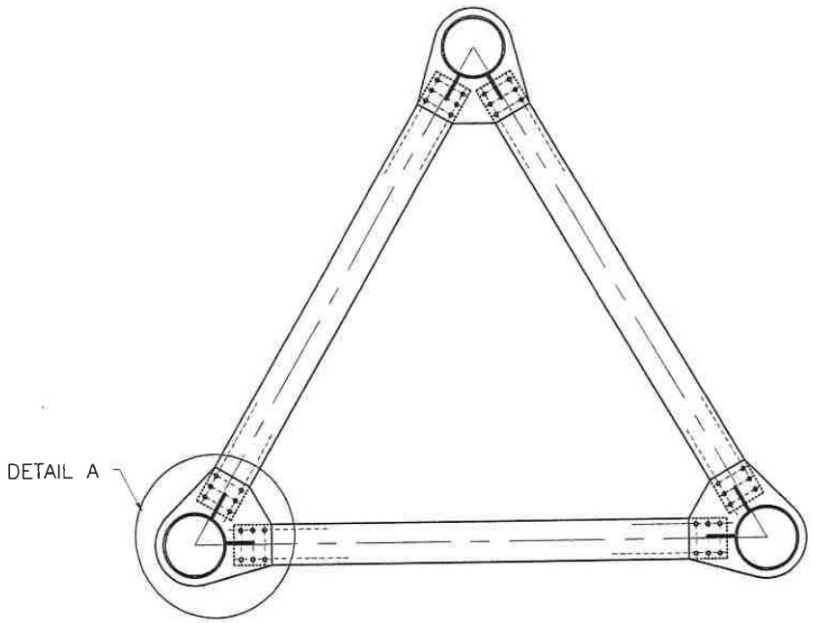
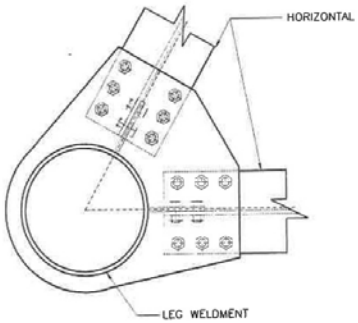
Tower Attributes

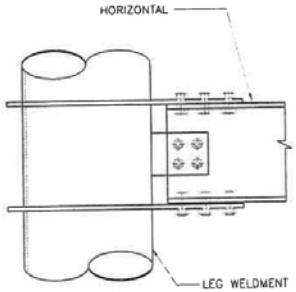
Typical details for the Tripole:



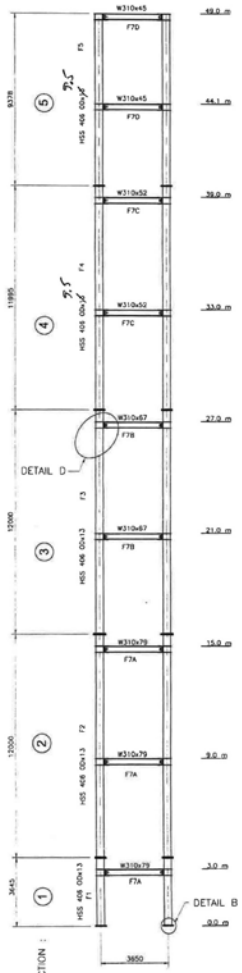
TYPICAL PLAN AT HORIZONTALS



DETAIL A (TYPICAL)



DETAIL D (TYPICAL)



TYPICAL ELEVATION

Because there will be significant moments in the connections, these have to be executed with care.

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Tower Attributes

This is sometimes called a "TRIPOLE" but,

it is a lattice Self-Supporting tower with lattice legs.

It is a truss not a frame. A TRIPOLE has to be a frame.

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Tower Attributes

For much larger towers, we have to move up to lattice construction in which we concentrate the major vertical loads in the legs and the shear effects in the lattice bracing.

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Tower Attributes

The early steel towers were self -supporting lattice towers built up of standard structural steel shapes of angle, channel, and plate sections. This was because they were built by bridge companies, like the famous 300 m Eiffel Tower in Paris, France to the left.

You can actually see the bridge like structure in the bottom part.

It is a beauty, but not very cheap.

This tower is a good example of a profile that is meant to optimize the design.

The biggest impact on moment is the load at a distance from the support, so the tower is narrow towards the top, to minimize the wind load up there.

At the same time a bigger distance between legs results in a smaller leg load due to moment.

Since the highest moment is at the base, this is where the distance between legs is greatest.

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An American version of a self-supporting lattice tower (for broadcasting).

This is the 318 m tower for KCTV.

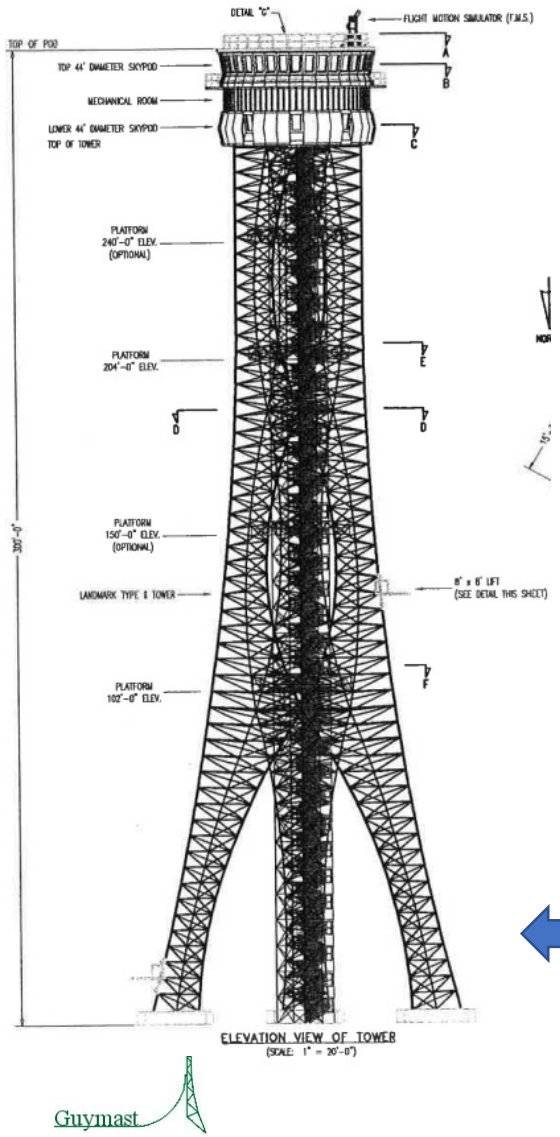
See how much lighter it looks than the Eiffel Tower.

At the base of the KCTV tower: KCPT's studio

Note that the old towers were of square cross section, because that is how steel was assembled using structural shapes and bolted or riveted construction.

Guymast

Tower Attributes



Modern self-supporting towers will be more like this.

Looking up the inside of the self-supporting tower. Compare this simplicity with the complexity of the Eiffel Tower.

A reasonably modern attempt to duplicate the Eiffel Tower

Tower Attributes

Starting in the late 1940's TV stations were installing tall towers to support the UHV antennas (like the one in the second picture at bottom right).

These towers went beyond 450 m in height, but only supported the one antenna and its transmission line.

The most economical structure was a guyed tower with a constant triangular cross section of about 3 m, supported on a pin at the base and guys at 60 m intervals up the mast.

Round legs, structural angles for horizontals and tension only solid rods for diagonal bracing.

These would have been "knock-down" towers (bolted connections).

All designed to keep wind loads as low as possible and to minimize the number of components.

The one in the photo to the right is a more recent all-weld tower made of solid round steel welded together in 6 m sections.

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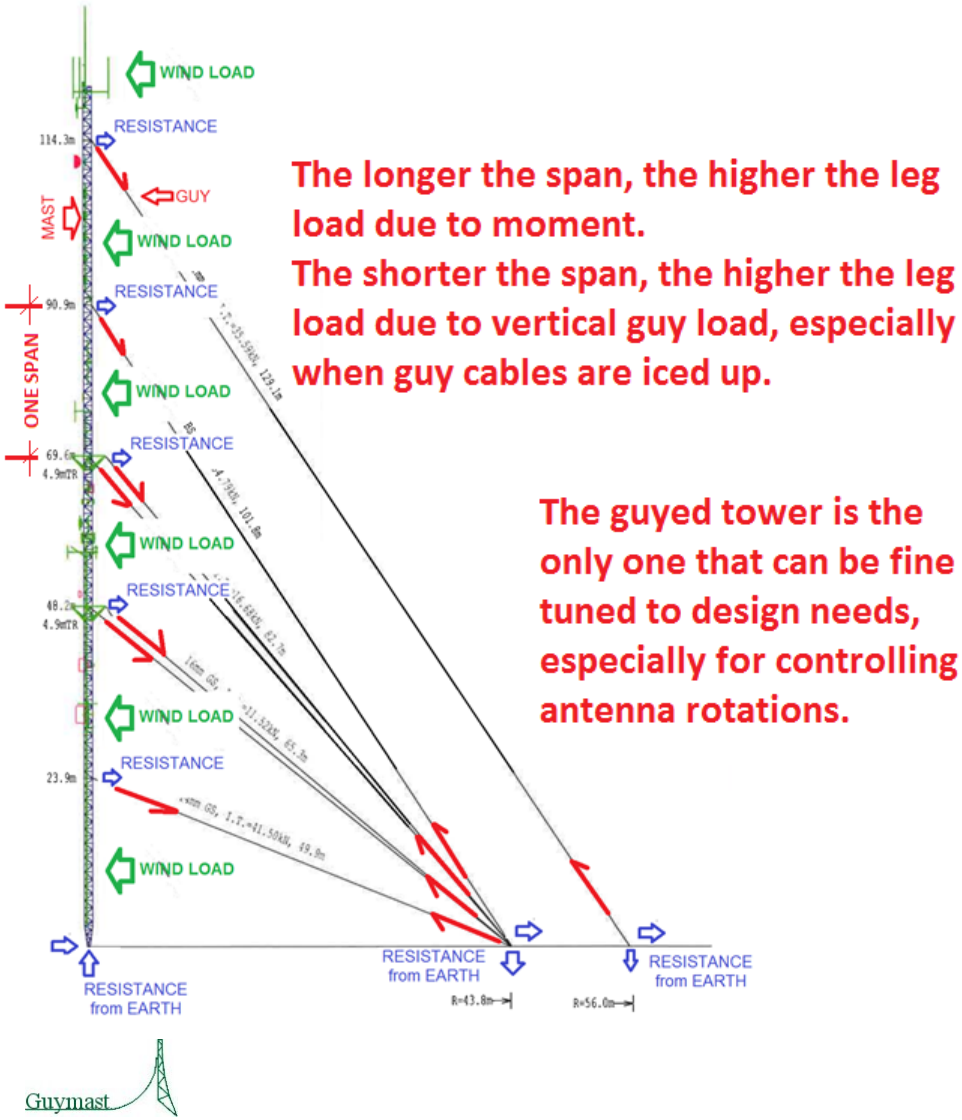
Tower Attributes



The longer the span, the higher the leg load due to moment.
The shorter the span, the higher the leg load due to vertical guy load, especially when guy cables are iced up.

The guyed tower is the only one that can be fine tuned to design needs, especially for controlling antenna rotations.

Stability is always the balance of LOAD and RESISTANCE.

The guyed tower makes the most economical use of steel.

The mast is of small cross section. Uses small short elements that can develop the needed resistance cheaply.

Horizontal resistance to wind load, is provided by the guys, which carry the load to the ground in tension.

The small mast components are quickly and cheaply assembled, as, too, are the guy cables.

The major drawback of guyed towers is:

1. need for significant guy radius, and
2. Overloading of guys under heavy ice.