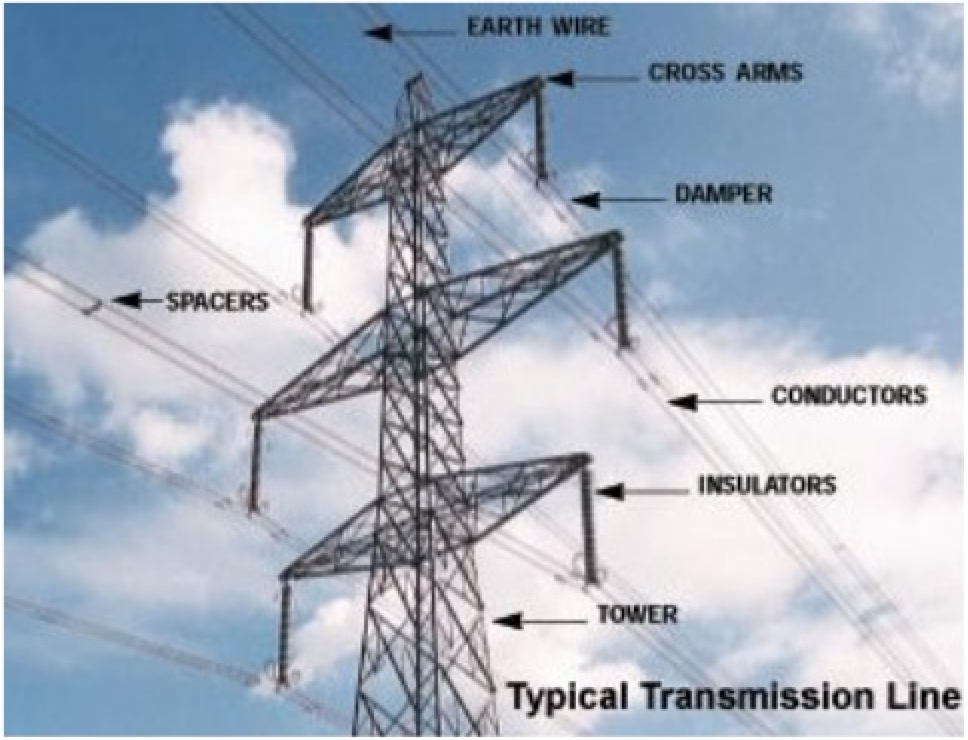
TRANSMISSION LINE

RAVI SHANKAR SINGH
(E6S304)

Component of Transmission Line

- Conductor
- Earth wire
- Insulator
- Transmission Tower
- Wave trap and other hardware(Clamp, Spacer, Vibration dampers, connectors etc.



Typical Transmission Line

Design Methodology

- Gather preliminary line design data and available climatic data
- Select reliability level in terms of return period of design
- Calculate climatic loading on components
- Calculate loads corresponding to security requirements (failure containment)
- Calculate loads related to safety during construction and maintenance
- Select appropriate correction factors, if applicable, to the design components such as use factor, strength factors related to numbers of components, strength coordination, quality control, and the characteristic strength.
- Design the components for the above loads and strength.

Reliability Levels

- Reliability Level ≥1(One)
- Higher the reliability level means higher safety factor and ultimately more cost.

Reliability Levels	**1**	**2**	**3**
T, Return period of climatic design loads, in years	50	150	300

Selection of Transmission Voltage

- **Standard Voltage - 66,110,132, 220, 400 KV**
  - **Tolerances** - ±10% up to 220 KV & ±5% for 400 KV

- **Selection Criterion of Economic Voltage –**
  - Quantum of power to be evacuated
  - Length of line
  - Voltage regulation
  - Power loss in Transmission
  - Initial and operating cost
  - Present and future voltage in neighborhood

Economic Voltage of Transmission of Power

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$$E = 5.5\sqrt{\frac{L}{1.6} + \frac{KVA}{150}}$$

E = Transmission voltage (KV) (L-L).
L = Distance of transmission line in KM

Table-1 shows the economic voltage level for efficient transmission.

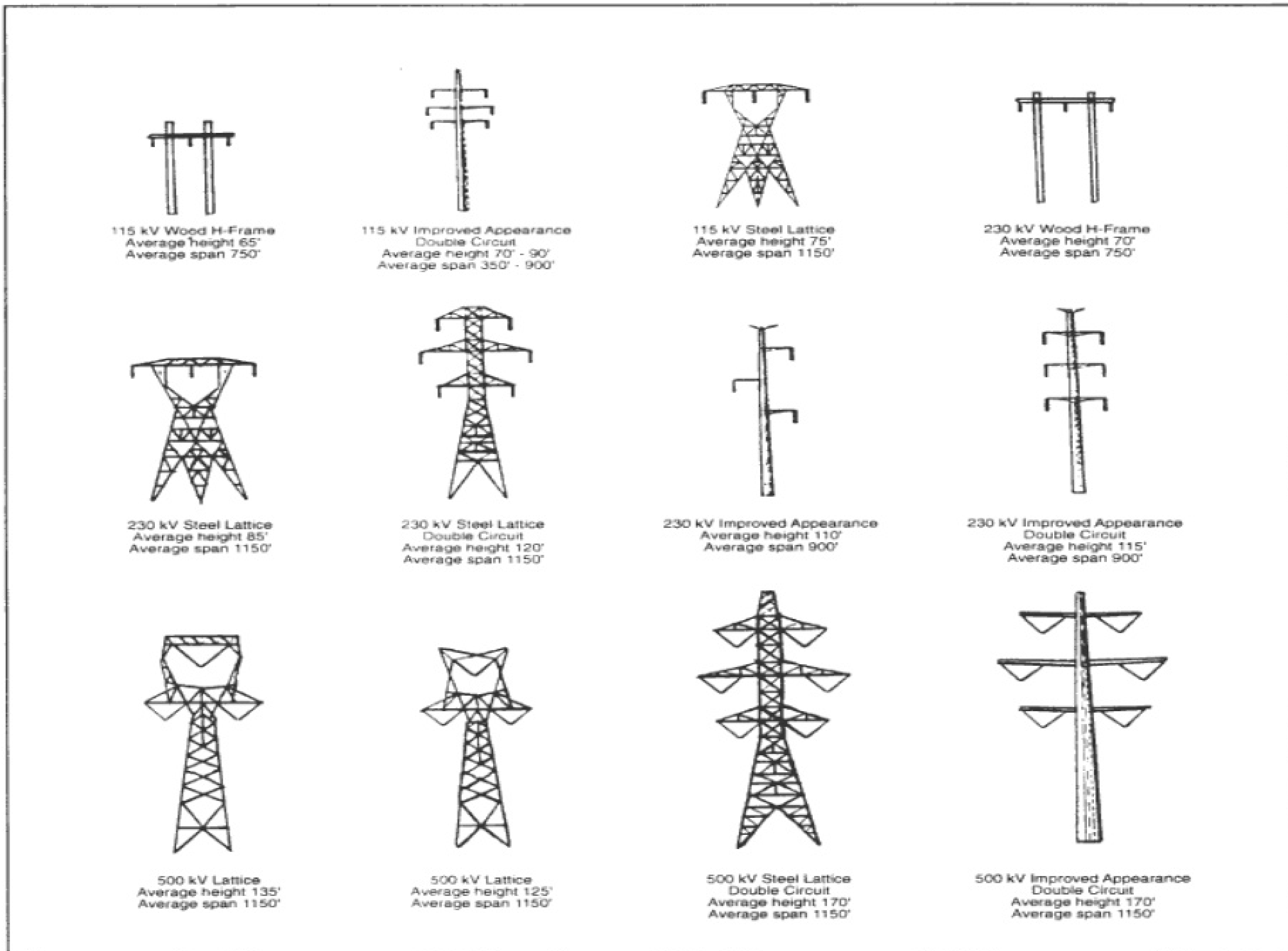
Power Transfer Requirement (MW)	Distance (km)	Economic Voltage Level (KV)
3500	500	765
500	400	400
120	150	220
80	50	132

Types of Towers

- **Type A Tower** (Tangent Tower with suspension string)
  - Used on straight runs and up to 2° line diversion
- **Type B Tower** (Small Angle Tower with tension string)
  - Used for line deviation from 2° to 15°
- **Type C Tower** (Medium Angle Tower with tension string).
  - Used for line deviation from 15° to 30°.
- **Type D Tower** (Large angle tower with tension string)
  - Used for line deviation from 30° to 60°
- **Type E Tower** (Dead End Tower with tension string)
  - Used for line termination & starting
- **Special tower-**
  - **Suspension Tower** (Span ≈ 1000 m)
    - Used for River crossing, Mountain crossing etc.
  - **Transposition Tower**
    - Used for transposition of tower

Different Types of Towers

ORNL DWG95-7685



Selection of Tower Structure

- Single circuit Tower/ double circuit Tower
- Length of the insulator assembly
- Minimum clearances to be maintained between ground conductors, and between conductors and tower
- Location of ground wire/wires with respect to the outermost conductor
- Mid-span clearance required from considerations of the dynamic behavior of conductors and lightning protection of the line
- Minimum clearance of the lowest conductor above ground level

Tower Design

- Tower height
- Base width
- Top damper widt
- Cross arms lengt

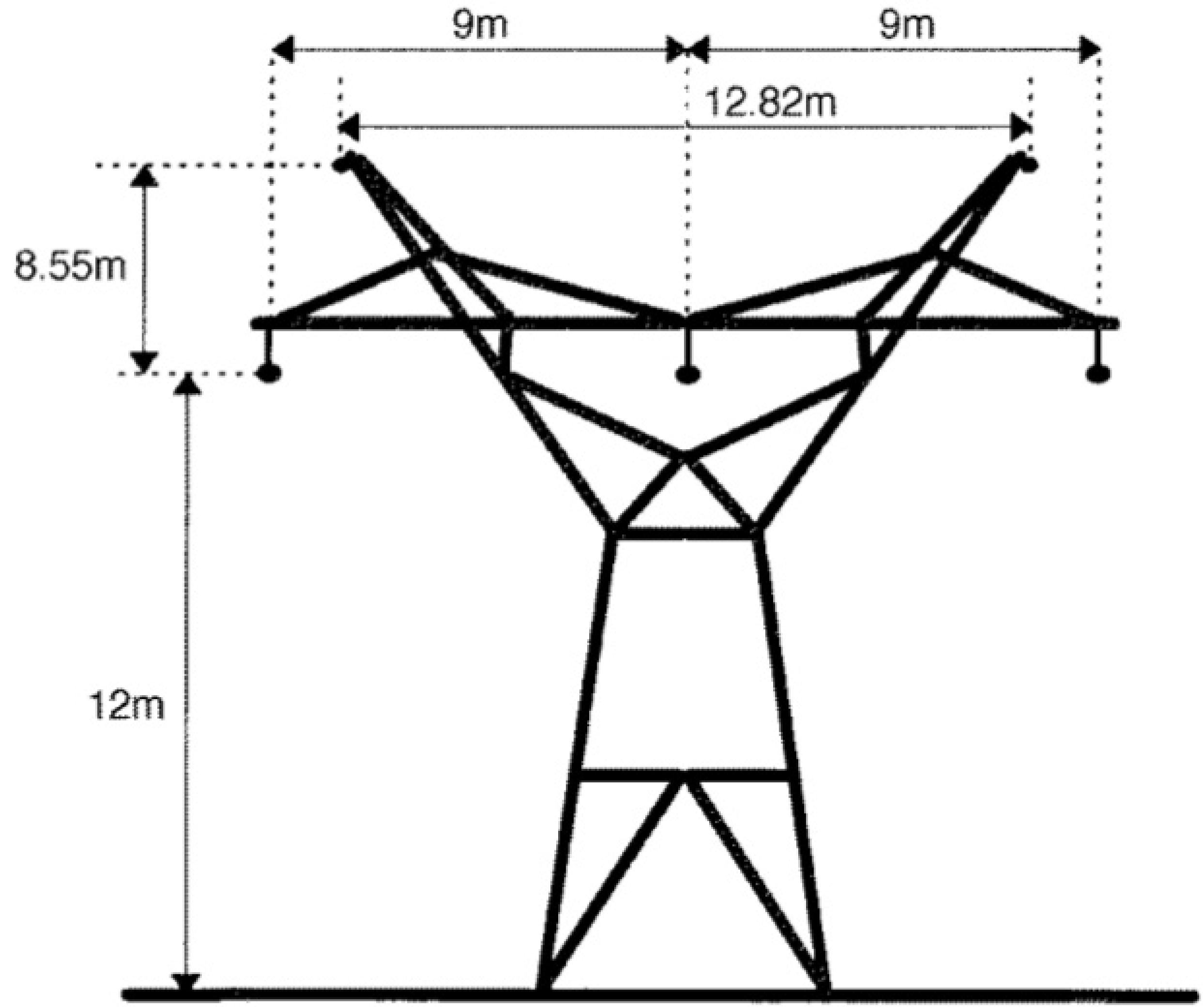
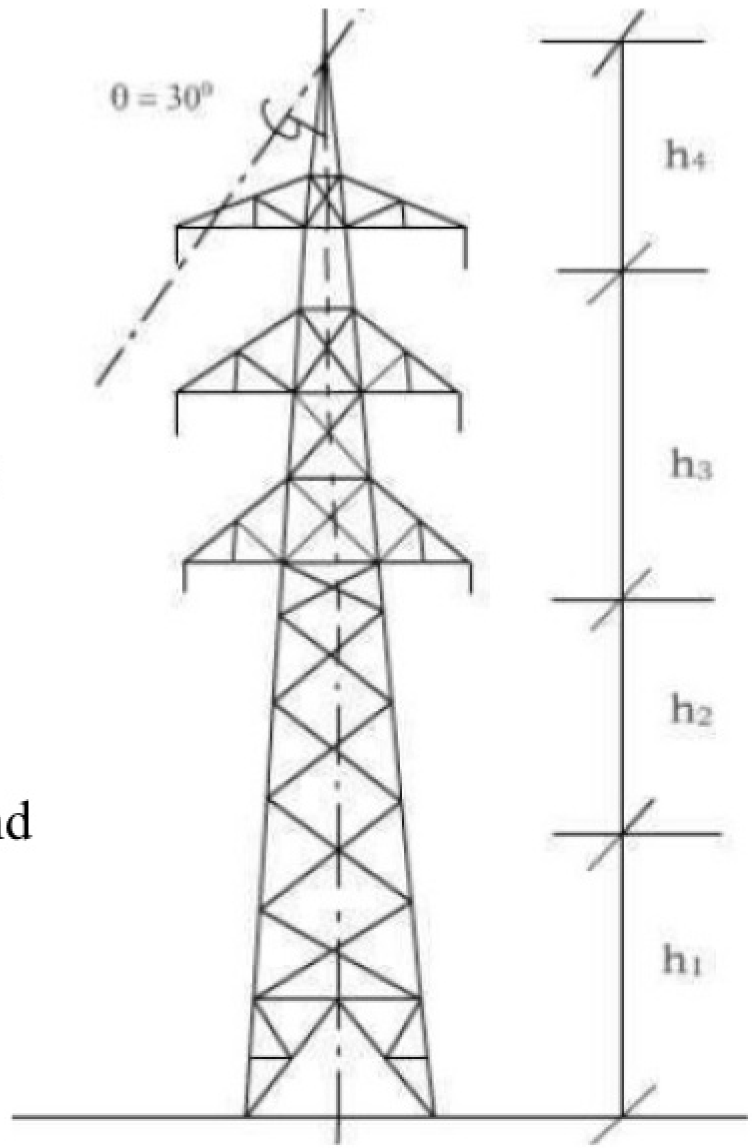


Fig. Typical 765 KV Tower Structure

Height of Tower Structure

Height of tower is determine by-

$$H = h_1 + h_2 + h_3 + h_4$$



h₁=Minimum permissible ground clearance

h₂=Maximum sag

h₃=Vertical spacing between conductors

h₄=Vertical clearance between earthwire and top conductor

Determination of Base Width

The base width(at the concrete level) **is the distance between the centre of gravity at one corner leg and the centre of gravity of the adjacent corner leg.**

- A particular base width which gives the minimum total cost of the tower and

foun

$$B = 0.42\sqrt{M} \text{ or } 0.013\sqrt{m}$$

Ryle Formula

Where
B = Base width in meters,
M = Overturning moment about the ground level in tonne-meters, and
m= Overturning moment about the ground level in kg.meters.

- The ratio of base width to total tower height for most towers is generally about one-fifth to one-tenth.

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Spacing and Clearances

Ground Clearances

$$CL = 5.182 + 0.305 * K$$

Where- $K = \left(\frac{V - 33}{33} \right)$

Minimum permissible ground clearance as per IE Rules, 1956,Rule 77(4)

S.No.	Voltage level	Ground clearance(m)
1.	≤33 KV	5.20
2.	66 KV	5.49
3.	132KV	6.10
4.	220 KV	7.01
5.	400 KV	8.84

Clearance for Power Line Crossings

- **Crossing over rivers:**
  - 3.05m above maximum flood level.

- **Crossing over telecommunication lines**

  Minimum clearances between the conductors of a power line and telecommunication wires are-

Voltage Level	Minimum Clearance(mm)
≤33 KV	2440
66KV	2440
132 KV	2740
220 KV	3050
400 KV	4880

❑ Power line Crossing over railway tracks

under maximum sag condition minimum clearance over rail level stipulated in the regulations for Electrical Crossings of Railway Tracks, 1963

Table. For un-electrified tracks or tracks electrified on 1,500 volts D.C. system

System Voltage Level	Broad Gauge		Meter & Narrow Gauge	
	Inside station limits(m)	Out side station limits(m)	Inside station limits(m)	Out side station limits(m)
≤66 KV	10.3	7.9	9.1	6.7
132 KV	10.9	8.5	9.8	7.3
220 KV	11.2	8.8	10.0	7.6
400 KV	13.6	11.2	12.4	10.0

Table. Tracks electrified on 25 kV A.C. system

System Voltage Level	Broad Gauge	
	Inside station limits(m)	Out side station limits(m)
≤ 66 KV	10.3	7.9
132 KV	10.9	8.5
220 KV	11.2	8.8
400 KV	13.6	11.2

- **Power line Crossing another Power line**

System Voltage Level	Clearance(m)
≤ 66 KV	2.40
132 KV	2.75
220KV	4.55
400 KV	6.00

❑ Spacing Between Conductor(Phases)

- Mecomb's formula

$$Spacing(cm) = 0.3048 * V + 4.010\frac{D}{W}\sqrt{S}$$

Where-

V= Voltage of system in KV

D= Diameter of Conductor in cm

S= Sag in cm

W= weight of conductor in Kg/m

- VDE formula

$$Spacing(cm) = 7.5\sqrt{S} + \frac{V^2}{2000}$$

Where-

V= Voltage of system in KV

S= Sag in cm

Still's formula

$$Spacing(cm) = 5.08 + 1.814 * V + \left[\frac{l}{27.8}\right]^2$$

Where-

l = Average span length(m)

NESC formula

$$Spacing(cm) = 0.762 * V + 3.681\sqrt{S} + \frac{L}{\sqrt{2}}$$

Where-

V= Voltage of system in KV

S= Sag in cm

L= Length of insulator string in cm

- Swedish formula

$$Spacing(cm) = 6.5\sqrt{S} + 0.7 * E$$

Where-

E= Line Voltage in KV

S= Sag in cm

- French formula

$$Spacing(cm) = 8.0\sqrt{S + L} + \frac{E}{1.5}$$

Where-

E= Line Voltage in KV

S= Sag in cm

L= length of insulating string(cm)

- Offset of conductors (under ice-loading conditions)

  Sleet Jump:

  The jump of the conductor, resulting from ice dropping off one span of an ice-covered line, has been the cause of many serious outages on long-span lines where conductors are arranged in the same vertical plane.

  Offset in cm = 60 + Span in cm / 400