# Contents

# Introduction

This report is to explore the parameters involved in the design of a transmission line. We need to know some formula and parameters. Such as sag, design tension,tower span etc.

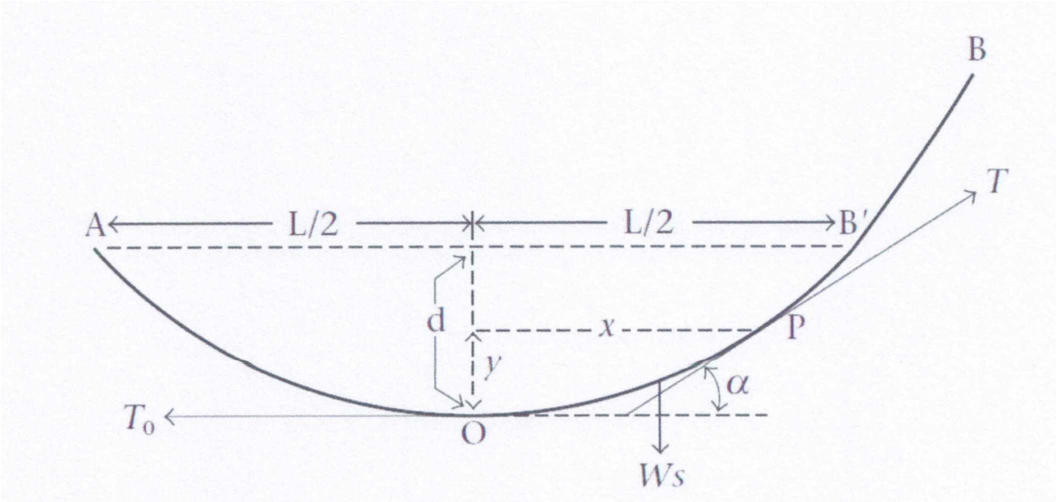



*Figure1- Overhead line sag*

The basic formula as follows:

$$T = \frac{x^2 w}{2y}$$

Equation 1

Where:

L is the length of the span

d is the sag

w is the weight per meter length of the conductor

T is the tension in the conductor

We have chosen any point on the conductor, say point P

The distance of point P from the lowest point O is x

y is the height from point O to point P

Electrical4U. (2020) mentioned in a transmission line, sag is defined as the vertical difference in level between points of support (most commonly transmission towers) and the lowest point of the conductor. The calculation of sag and tension in a transmission line depends on the span of the overhead conductor.

Then S (remember distance along the curve from the origin) approximates to:

$$S = x + \frac{x^3 w^2}{6 * T^2}$$

Equation 2

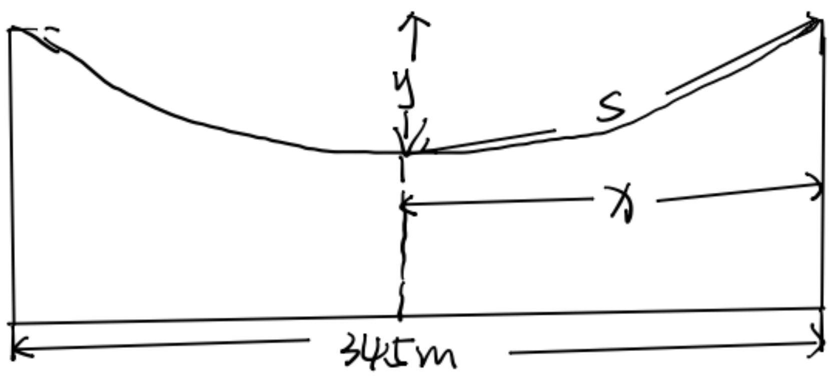
Tips:

Density of ice = 917 kg/m$^3$

1 kg = 9.81N (Admin, 2023)

# PART1

1) Calculate the Design Tension for your line on a horizontal installation (both towers of similar height at the same ground level). (6 marks)




Minimum Tower Height 36m

Tower span 345m

Minimum Ground clearance 12m

Maximum Sag (y) 10m

Gradient 9 %

Calculator Weight Calculation. (no date) gave a example:

The conductor is ACSR weighing 689 kg/km (463 lbs. Per 1000ft.)

689 kg divided by 1000m = 0.689 kg/m (463 lbs divided by 1000ft = 0.463 lbs/ft)

So, according to the data sheet, we can calculate the w as follows:

Conductor weight $= 2423.5 \ kg/km$

$w = 2423.5 \times 9.81 \times 10^{-3} = 23.77 \ Nm^{-1}$ $(1kg = 9.81N)$

The maximum permissible tension is 199.96 KN

$$x = \frac{345}{2} = 172.5 \ m$$

Design Tension : $T = \frac{x^2 w}{2y}$

$$T = \frac{172.5^2 \times 23.77}{2 \times 10} = 35.37 \ KN < 199.96 KN$$

central conductor

$$13 + 13 - 3.65 = 22.35 \ m$$

$$36 - 32.25 + 22.35 = 26.1 \ m$$

2) Verify the conductor remains within the design parameters. (2 marks)

A span of line s is distance along the line from origin

$$S = x + \frac{x^3 w^2}{6T^2}$$

$$S = 172.5 + \frac{172.5^3 \times 23.77^2}{6 \times (35 \times 10^3)^2}$$

$$S = 172.5 \ m$$

The length of line $= 2S = 345 \ m$

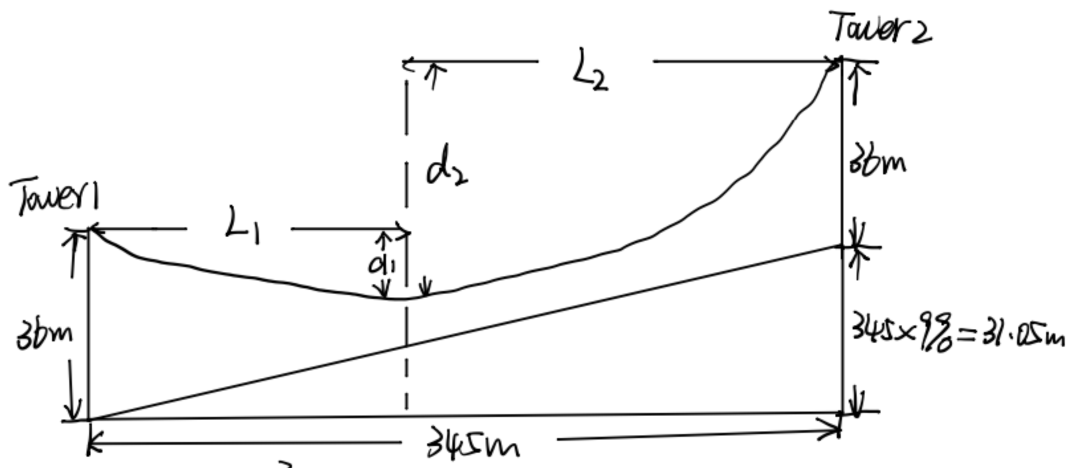
3) Calculate length of conductor required to span the distance of 10 transmission towers. (2 marks)

Span the distance of 10 transmission towers

345 × 9 = 3105m

# PART2

1) Now repeat the calculations from part 1 for two towers installed at the gradient specified. Break the calculations down to sub blocks of the main challenge. (8 marks)




$$y = d \qquad y = \frac{x^2 w}{2T}$$

$$d_1 = \frac{L_1^2 w}{2T} \qquad d_2 = \frac{L_2^2 w}{2T}$$

$$d_2 - d_1 = (36 + 345 \times 9\%) - 36 = 31.05\,m$$

$$L_1 + L_2 = 345\,m$$

$$L_1 = 345 - L_2$$

$$L_1 = 345 - L_2$$

$$\frac{L_2^2 W}{2T} - \frac{L_1^2 W}{2T} = 31.05$$

$$\frac{L_2^2 w - (345 - L_2)^2 w}{2T} = 31.05$$

$$\frac{L_2^2 w - [(345^2 - 2 \times 345 \times L_2 + L_2^2)]w}{2T} = 31.05$$

$$\frac{L_2^2 w - 119025w + 690L_2w - L_2^2 w}{2T} = 31.05$$

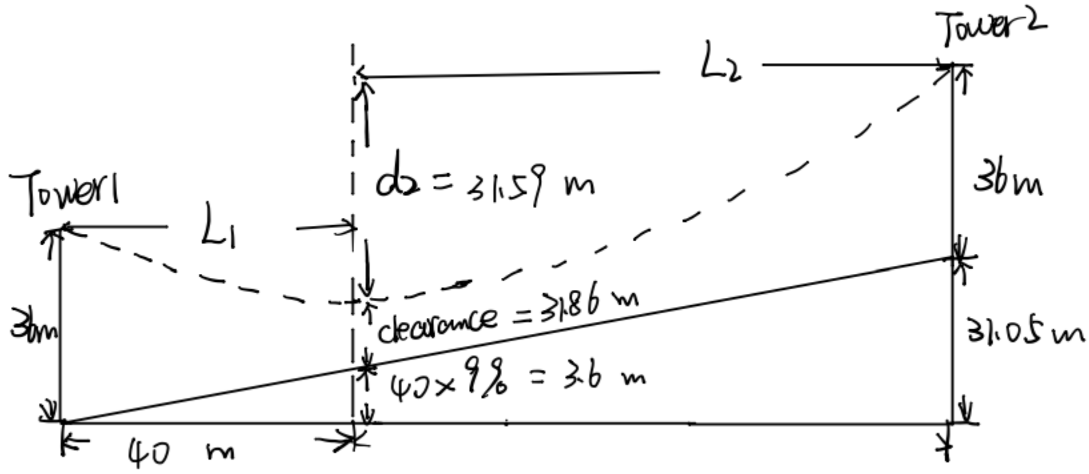
$$690 L_2 w = 31.05 \times 2T + 119025w$$

$$L_2 = \frac{0.09T}{w} + 172.5$$

We known $w = 23.77\ Nm^{-1}$ $T = 35KN$

$$L_2 = \frac{0.09 \times 35 \times 10^3}{23.77} + 172.5 = 305m$$

$$L_1 = 345 - 305 = 40m$$




$$d_1 = \frac{L_1^2 w}{2T} = \frac{40^2 \times 23.77}{2 \times 35 \times 10^3} = 0.54m$$

$$d_2 = \frac{L_2^2 w}{2T} = \frac{305^2 \times 23.77}{2 \times 35 \times 10^3} = 31.59m$$

length of line

$$S_1 = L_1 + \frac{L_1^3 W^2}{6T^2}$$

$$S_1 = 40 + \frac{40^3 \times 23.77^2}{6 \times (35 \times 10^3)^2}$$

$$S_1 = 40 \text{ m}$$

$$S_2 = L_2 + \frac{L_2^3 W^2}{6T^2}$$

$$S_2 = 305 + \frac{305^3 \times 23.77^2}{6 \times (35 \times 10^3)^2}$$

$$S_2 = 307.2 \text{ m}$$

length of line $S = S_1 + S_2 = 347.2 \text{m}$

span the distance of 10 transmission tower

$9 \times 347.2 = 3124.8$ m

Ground clearance $= 31.86 + 3.6 = 35.46$ m

## PART 3 – Ice and Wind

1) Discuss, in your own words, how overhead line design may be influenced by the presence of ice and/or wind.

The design of overhead lines must take into account the potential for ice and wind loads:

Ice: The accumulation of ice on conductors adds weight, causing increased sag and tension. Design considerations must include stronger materials or reduced span lengths to manage the extra load.

Wind: Wind can exert lateral forces, leading to galloping or swaying of conductors and towers. Overhead line design may incorporate aerodynamic conductor profiles, sturdier towers, and damping devices to mitigate these effects.

2) Calculate the increase in sag for the line design in part 1, if the line experiences a buildup of a 3 mm surface coating of ice. (4 marks)

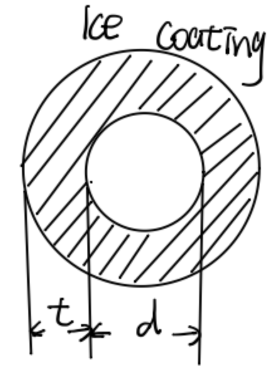
Let's assume, $w$ is the weight of the conductor per unit length.

$w_i$ is the weight of ice per unit length

$w_i$ = desity of ice x volume of ice per unit length

$$W_i = \text{density of ice} \times \frac{\pi}{4}[(d+2t)^2 - d^2] \times 1$$

$$= \text{density of ice} \times \pi t(d+t)$$

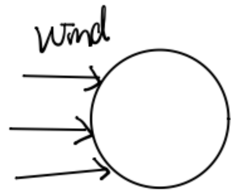



$t = 3mm$

$W_w$ is the force of wind per unit length

$W_w$ = wind pressure per unit area × projected area per unit length

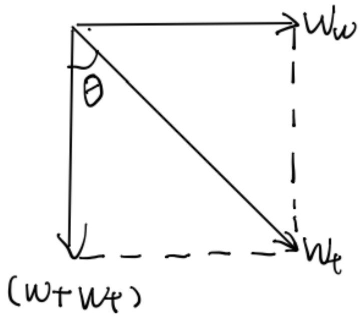
$$W_w = \text{wind pressure} \times [(d+2t) \times 1]$$

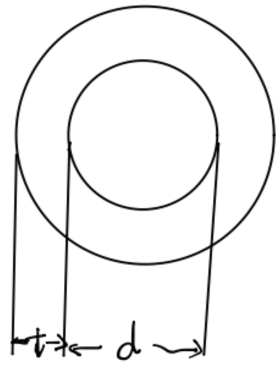



So the total weight of the conductor per unit length is

$$W_t = \sqrt{(w+W_i)^2 + (W_w)^2}$$

$$\tan\theta = \frac{W_w}{w+W_i}$$




$t = 3mm$

Area of ice = (Area of ice + cable) − (Area of cable)

$$= \pi\left(\frac{d}{2}+t\right)^2 - \pi\left(\frac{d}{2}\right)^2$$

$d = 35.1\,mm$ (from data sheet)

$$\text{Area of Ice} = \pi \times \left[\left(\frac{35.1}{2}+3\right)\times 10^{-3}\right]^2 - \pi \times \left[\frac{35.1}{2}\times 10^{-3}\right]^2$$

$$= 3.591 \times 10^{-4}\,m^3$$

1m ice Volume $= 3.591 \times 10^{-4} m^3 \times 1m = 3.591 \times 10^{-4} m^3$

density of ice $= 917 kg/m^3$

weight of ice $= 3.591 \times 10^{-4} \times 917 = 329.28 g/m$

$= 329.28 g/m \times 9.81 \times 10^{-3} = 3.23 Nm^{-1}$

cable weight $= 23.77 Nm^{-1}$ Total $w = 23.77 + 3.23 = 27 Nm^{-1}$

Increase in sag $= d = \dfrac{(\frac{L}{2})^2 w}{2T} = \dfrac{(\frac{365}{2})^2 \times 27}{2 \times 35 \times 10^3} \approx 11.48 m$

$11.48 - 10 = 1.48 m$ increase in sag

3) Calculate an appropriate line tension in order to accommodate the additional ice loading and remain within clearance values. State also the % increase in tension. (4 marks)

$$T = \frac{l^2 w}{2y} = \frac{(\frac{365}{2})^2 \times 27}{2 \times 10}$$

$$T = 40.2 kN$$

$$\% \text{ increase in tension} = \frac{40.2 - 35}{35} \times 100\% = 14.86\%$$

# PART 4 – Thermal Effects

1)Discuss the influence of thermal changes on the transmission line sag. (2 marks)

Thermal changes affect transmission line sag as temperatures rise, conductors expand, increasing sag, and potentially reducing clearance. Conversely, in colder temperatures, conductors contract, reducing sag but increasing tension, which could stress the infrastructure. Design must accommodate these thermal effects to ensure safety and reliability.

2) Optional Exercise: Assuming the calculation of line sag in part 1 was carried out for an ambient temperature of 5 degrees C, recalculate the sag should the ambient temperature rise to 15 degrees C. (0 marks)

# PART 5 – Appendix and Referencing

Provide sources for design criteria using appropriate referencing. (1 mark)

*Electrical4U, 2020 SAG in a transmission line: What is it? (and how to calculate it)*

*Available at: https://www.electrical4u.com/sag-in-overhead-conductor/ (Accessed: 15 February 2024).*

*Admin, 2023 What is the relation between KG and Newton? - detailed explanation, BYJUS.*

*Available at: https://byjus.com/physics/relation-between-kg-and-newton/ (Accessed: 15 February 2024).*

*Calculator Weight Calculation, no date Utility line design calculations.*

*Available at: http://www.utilitylinedesign.com/Calculations.aspx (Accessed: 15 February 2024).*

*ACSR - ASTM - B aluminium conductor steel reinforced, no date.*

*Available at: https://www.elandcables.com/media/38193/acsr-astm-b-aluminium-conductor-steel-reinforced.pdf (Accessed: 14 February 2024).*

*Tower Types - Eirgrid. no date.*

*Available at: https://www.eirgridgroup.com/site-files/library/EirGrid/Tower%20Types.pdf (Accessed: 14 February 2024).*

Provide in an appendix information on your assigned tower type (layout drawing) and cable specification, showing the information used in the assignment. (2 marks)

Tower Types- Eirgrid. (no date) mentioned the tower (NL401) stands 32.5m tall and has a base 7.61m square. The side elevation forms a tapering profile from the base width of 7.6m to a narrow 700mm point. In front elevation the tower tapers from the base until its narrowest point, 13m high where it divides into two sections. These angled sections extend back outwards to form a rough V-shape, until they reach the cross arm from which the phasing arrangement is hung. The 21m long cross arm is at a height of 26m. The cross arm extends beyond the V-shape forming 4.6m long wings symmetrically arranged on either side of the structure. From each wing, the insulators are arranged in vertical formation. From the centre section of the cross arm a further pair of insulators form a V-shape, the point of the V being in the centre of the tower structure. From the cross arm, on either side of the structure, two large earth wire peaks extend. In both front and side elevation the tower forms a symmetrical structure comprised of a typical steel lattice structure composed of a large number of smaller members.

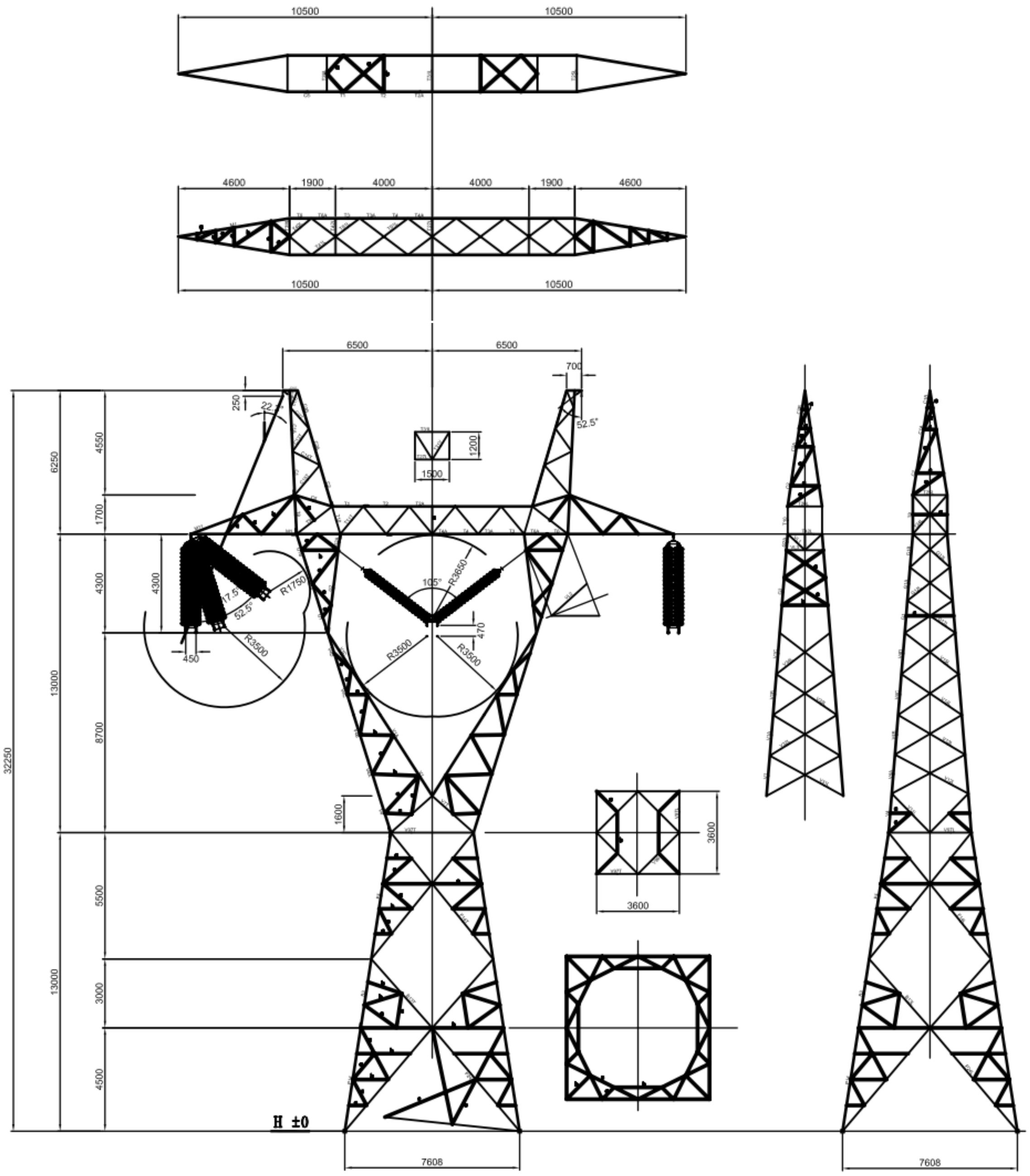



*Figure2- NL401*

| CODE | SIZE KCM | STRANDING No. x mm | | SECTION mm² | | OVERALL DIAMETER mm | | CONDUCTOR WEIGHT kg/km | | | RATED STRENGTH kN | ELECTRICAL RESISTANCE | | | CURRENT CARRYING CAPACITY Amps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Al. | Steel | total | Al | Total | Core | Total | Al. | Steel | | 20°C DC | 25°C AC | 75°C AC | |
| PHEASANT | 1272 | 54 x 3.90 | 19 x 2.34 | 726.8 | 645.1 | 35.1 | 11.7 | 2423.5 | 1783.8 | 639.7 | 199.96 | 0.04429 | 0.04659 | 0.05545 | 1310 |

*Table1-PHEASANT Cable Specification (ACSR, no date )*

## Conclusions

This report mainly design transmission line. Through the calculations, we can get relevantly parameters. If we want to design transmission line ,we need to take account for some aspects. Such as :

Electrical Requirements: Choosing the right voltage level and conductor material to handle the expected load while minimizing losses.

Mechanical Stability: Ensuring towers and conductors can withstand environmental loads, factoring in conductor sag, tension, and the spacing between towers.

Environmental Impact: Designing for resistance to wind, ice, and temperature variations, and selecting materials for durability against corrosion.

Compliance and Safety: Adhering to regulatory standards for safety and reliability, ensuring clearances are maintained for public safety.

Cost and Efficiency: Balancing initial construction costs against long-term operational and maintenance expenses, aiming for a cost-effective, reliable supply.

Future Growth: Allowing for potential expansions or upgrades in response to increasing demand or technological advancements.