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Subject - Power Transmission

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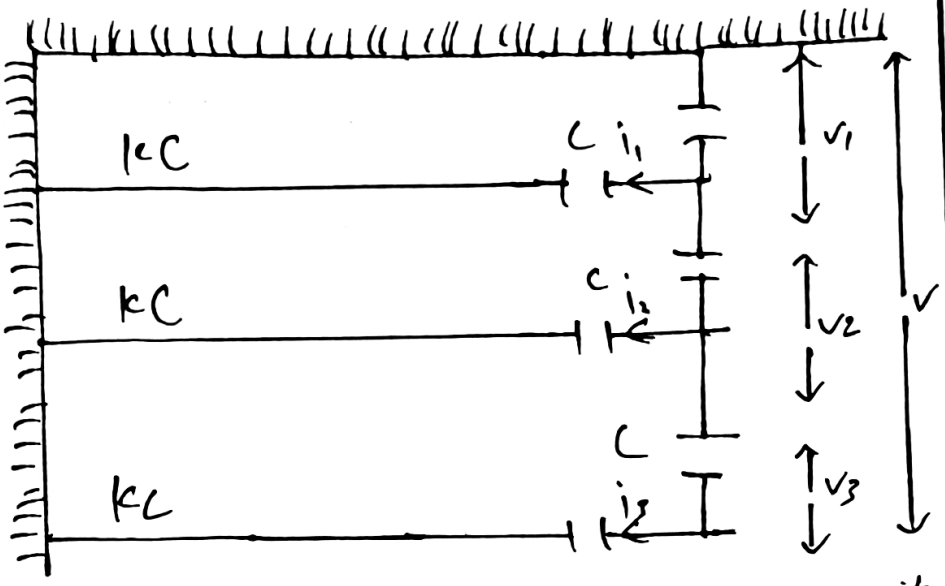
"Question 1 (A)"

1 Diagram :



Solution : The figure show that the equilant circuit of string Insulator Let V_1, V_2 & V_3 be the voltage across top, middle & bottom until respective. if C is the self capacitors of each unit, then kc will be the shunt Capacitance.

$$kc = \frac{\text{Shunt Capacitance}}{\text{Self Capacitence}}$$

$$k = 22\% = 0.22$$

$$\boxed{k = 0.22}$$

Voltage across the String

$$V = 66\ kV/\sqrt{3}$$

$$V = 38.10\ kV$$

At junction A

$$i_2 = I_1 + i_1$$

$$V_2 wc = V_1 wc + V_1 k wc$$

$$V_2 w/c = V_1 w/c\ (1+k)$$

$$V_2 = V_1\ (1+k)$$

$$V_2 = V_1\ (1+0.22)$$

$$V_2 = \boxed{1.22 V_1} \quad \text{—— (i)}$$

At junction B

$$I_3 = I_2 + i_2$$

$$V_3 wc = V_2 wc + (V_1 + V_2)\ kwc$$

$$V_3 = V_2 + (V_1 + V_2)\ k \quad \text{—— (B)}$$

Putting value in (B)

$$V_3 = 1.22 V_1 + (V_1 + 1.22 V_1)\ 0.22$$

$$V_3 = \boxed{1.7084\ VI} \quad \text{—— (ii)}$$

Voltage across the whole string

$$V = V_1 + V_2 + V_3 \quad \text{—— (C)}$$

Put $V_2 = 1.22 V_1$ & $V_3 = 1.7084 V_1$ in Equation (C).

Now $V = V_1 + 1.22V_1 + 1.7084V_1$

$38.10 = 3.9284V_1$

$V_1 = \frac{38.10}{3.9284}$

$V_1 = \boxed{9.698 \text{ kv}}$

So $V_2 = 1.22V_1 \quad V_2 = 1.22 \times 9.698$

$V_2 = \boxed{11.83 \text{ kv}}$

$V_3 = 1.7084\ V_1$

$V_3 = 1.7084 \times 9.698$

$V_3 = \boxed{16.54 \text{ kv}}$

(ii) String Efficiency :

$$\frac{\text{Voltage across string}}{\text{No of Insulator} \times V_3} \times 100$$

$$= \frac{38.10}{3 \times 16.54} \times 100$$

$$= \frac{38.10}{49.62} \times 100$$

$$= \boxed{76.78\ \%}$$

Question # 1 part "B"

Given Data:

Conductor diameter = 4cm

Conductor Spacing = 2m = 0.02cm

Dielectric Strength of air, g = 60 kv/cm

Air density Factor = δ = 1.5

Irregularity Factor η_0 = 0.6

Required Data:

Disruptive Critical Voltage V_c = ?

Solution:

We know that

$$V_c = m_0 g_0 \delta r \log_e (d/r) \text{ kv/phase (r.m.s)}$$

Radius of Conductor is

$$r = \frac{4cm}{2} = \boxed{2\,cm}$$

Question 2

Given data :

Length $l = 300m$

hight $h = 25m$

Weight $\omega = 3.789$ kg/m

X-section area of conducter $= 6.2\ cm^2$

Ultimate String $= 950.665\ kg/cm^2$

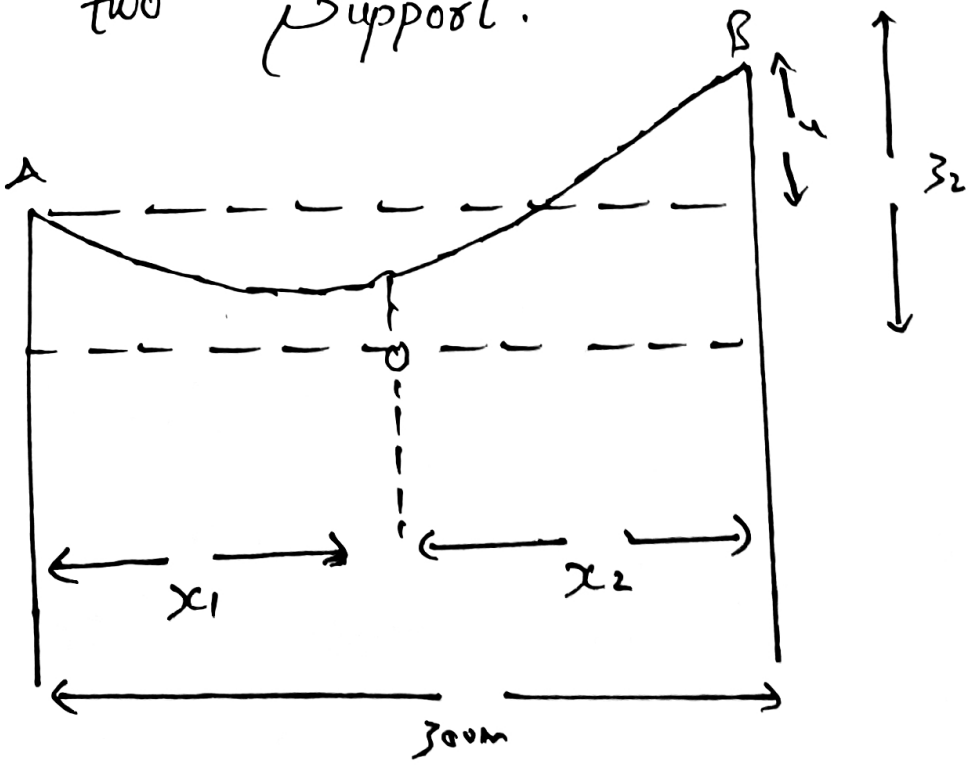
$\omega_i = 2$ kg/m

Safety factor $= 2$

Required data :

Calculate Sag from the taller of two Support.

Diagram :



Solution : The above figure show Conducter Suspended between two Support A & B at different level with O is the lowest, on the conducter.

Here working tension $T = \frac{\text{ultimate Strength} \times C.F}{\text{Safty factor}}$

$$T = \frac{950.665 \times 6.2}{2}$$

$$T = \frac{5894.123}{2}$$

$$T = \boxed{2947.06} \text{ kg}$$

Now total weight of length of Conductor is

$$wt = w + wi$$

$$= 3.789 + 2$$

$$wt = \boxed{5.789} \text{ kg}$$

Let the Lower ~~Power~~ point O of the Conducter be at distance x_1 from the Support at lower level, &..

at a distance x_2 from the Support at higher level.

$$x_1 + x_2 = 300\,m \longrightarrow (1)$$

Now $h = S_2 - S_1$

$$h = \frac{w_1 \cdot x_2}{2T} - \frac{wt\, x_1^2}{2T}$$

$$h = \frac{wt}{2T}\left(x_2^2 - x_1^2\right)$$

$$\frac{2T \times h}{wt\,(x_2 + x_1)} = x_2 \cdot x_1$$

Now putting Value

$$x_2 - x_1 = \frac{2xT \times h}{w7 \times (x_2 + x_1)}$$

$$x_2 - x_2 = \frac{2 \times 2947.06 \times 25}{5.789 \times 300}$$

$$x_2 - x_1 = \frac{147353}{1736.7}$$

$$x_2 - x_1 = \boxed{84.84}\,m \text{ —— (ii)}$$

Compare equation i) & ii) to get the value of x_1 & x_2

So

$$x_1 + x_2 = 300\,m$$

$$-x_1 + x_2 = 84.84\,m$$

$$\frac{2x_2}{2} = \frac{384.84}{2}$$

$$x_2 = \boxed{192.42\,m}$$

Now put the value of x_2 in equation (i) to get x_1.

$$x_1 + x_2 = 300$$

$$x_1 + 192.42 = 300$$

$$x_1 = 300 - 192.42$$

$$x_1 = \boxed{107.58\,m}$$

Now Sag from the taller of two tower is

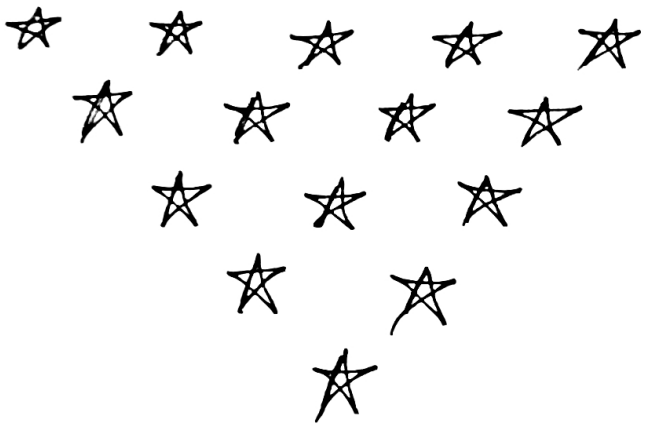
$$S = \frac{w x_2^2}{2T} \quad \text{---} \quad (1)$$

$$S = \frac{5.789 \times (192.42)^2}{2 \times 2947.06}$$

$$S = \frac{5.789 \times 37025.45}{5894.12}$$

$$S = \frac{214340.36}{5894.12}$$

$$S = \boxed{36.36}\ m$$



"Question 3(a)"

Given Data :

Length of Span = 400m

Cross-Sectional area of Conductor = $2.34\ cm^2$

Weight = 70 kg/km = 0.07 kg

Breaking Stress = $42\ kg/cm^2$

Safty Factor = 6

Wind pressure = $5.22\ kg/m^2$

Required data :

Vertical Sag = ?

Solution: We find T = ?

So $T = \frac{\text{Breaking stress} \times \text{cross Sectional area Condu}}{\text{Safty Factor}}$

$T = \frac{42\ kg/cm^2 \times 2.34\ cm^2}{6}$

$T = \frac{98.28}{6}$

$T = \boxed{16.38}\ kg$

Diameter of Conductor

$$d = \sqrt{\frac{4 \times \text{area}}{\pi}}$$

$$d = \sqrt{\frac{4 \times 2.34}{3.14}}$$

$$d = \sqrt{2.98}$$

$$d = \boxed{1.726\ cm}$$

Wind force per m length = pressure x projected area to m^2

$$w_w = 522\ kg/m^2 \times (1.726 \times 10^{-2} \times 1)$$

$$w_w = \boxed{9\ kg}$$

Total weight of Conducter per meter length.

$$w_t = \sqrt{w_2 + w_w^2}$$

$$w_t = \sqrt{(0.07)^2 + (9)^2}$$

$$wt = \sqrt{0.0049 + 81}$$

$$wt = \boxed{9kg}$$

Now

$$S = \frac{wt\ \ell^2}{8t}$$

$$S = \frac{9 \times (400)^2}{8 \times 16.38}$$

$$S = \frac{9 \times 160{,}000}{131.04}$$

$$S = \frac{1440{,}000}{131.04}$$

$$S = \boxed{10989.01\,m}$$

The Slant Say makes an angle with the verticle where value of ① is given by

$$\theta = \tan^{-1}\left(\frac{ww}{w}\right)$$

$$= \tan^{-1}\left(9/0.07\right)$$

$$= \tan^{-1}\left(128.5\right)$$

$$\theta = \boxed{89.5541}$$

Now

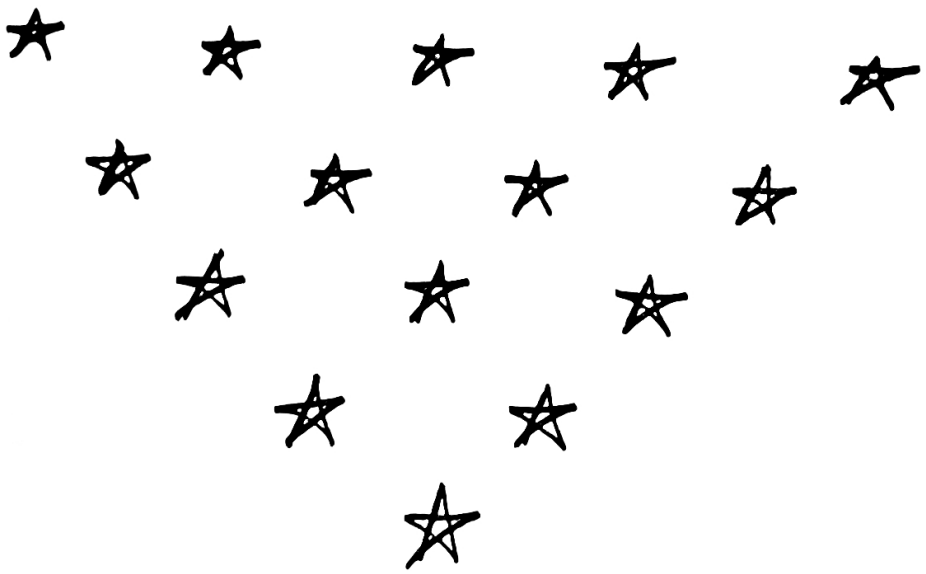
Verticle Sag = S cos θ

= S Cos (89.5541)

= 10989.01 Cos (89.5541)

= 10989.01 x 0.00785

= **86.2966 m**



"Question 3(b)"

Given Data :

Length ; l = 800m

Weight of conductor w = 3.5 kg/m

height ; h = 120m - 60m = 60m

Tension ; T = 400kg

Required Data :

minimum clearness of the Conductor & water & clearence mid-way between the Support = ?

Solution :

The figure show that the conductor suspended between two Support A & B at different level with "O" as the lowest point an the conductor let lowest point "O" of the Conductor be at lower level & w distance x_2 from the Support at

higher level.

So,

$$x_1 + x_2 = 800\text{m} \quad \text{—— ①}$$

$$h = S_2 - S_1$$

$$h = \frac{w x_2^2}{2T} - \frac{w x_1^2}{2T}$$

$$h = \frac{w}{2T}\left(x_2^2 - x_1^2\right)$$

$$h = \frac{w}{2T}\left((x_2 - x_1)(x_2 + x_1)\right)$$

$$\frac{2Th}{w(x_2 + x_1)} = x_2 - x_1$$

$$x_2 - x_1 = \frac{2 \times T \times h}{w \times (x_2 + x_1)} \quad \text{—— ②}$$

Now put Value in ①

$$x_2 - x_1 = \frac{2 \times 400 \times 60}{3.5 \times 800}$$

$$x^2 - x_1 = \frac{48000}{2800}$$

$$x_2 - x_1 = 17.14\text{m} \longrightarrow ②$$

Now Compare equation 1) & 2) So we get the value of V_1 & V_2.

i.e $x_1 + x_2 = 800\,m$

$-x_1 + x_2 = 17.14$

$2x^2 = 817.14$

Divided both Side by 2.

$$\frac{2x^2}{2} = \frac{817.14}{2}$$

$$x^2 = 408.57\,m$$

Put value of x^2 in eq 1) to get x_1

$$x_1 + x_2 = 800$$

$$x_1 + 408.57 = 800$$

$$x_1 = 800 - 408.57$$

$$x_1 = 391.43\,m$$

So

$$S_1 = \frac{W x_1^2}{2T} \longrightarrow x$$

$$S_1 = \frac{3.5 \times (391.43)^2}{2 \times 400}$$

$$S_1 = \frac{3.5 \times 153217.44}{800}$$

$$S_1 = 670.32\ m$$

Now clearence of the lowest point 'O' from water level.

$$= 60 - 670.32$$

$$= \boxed{-610.32\ m}$$

Let the mid point "P" be at a distance x from the lowest point O.

$$x = 400 - x_1$$

$$x = 400 - 391.43$$

$$x = 8.57\ m$$

Sag at mid point P.

$$S_{mid\ P} = \frac{Wx^2}{2T} \longrightarrow A)$$

$$= \frac{3.5 \times (8.57)^2}{2 \times 400}$$

$$= \frac{3.5 \times 73.44}{800}$$

$$S_{mid} = 0.3213\ m$$

Clearence of mid point (P) water level

$$= -610.32 + 0.3213\ m$$

$$= \boxed{-609.9m}$$