VISOKA ŠKOLA ELEKTROTEHNIKE I RAČUNARSTVA
STRUKOVNIH STUDIJA

Seminarski rad iz Elemenata elektroenergetskih sistema

Zadaci za prvi kolokvijum

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Sadržaj

1. Zadatak

Odrediti maksimalan ugib za dalekovod sa sledećim parametrima:

$a = 150m$

$d = 11.7mm$

$S = 81.3mm^2$

$\delta_{nd} = 11\frac{daN}{mm^2}$

$\gamma = 3.5 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$

$E = 7700\frac{daN}{mm^2}$

$\alpha = 1.89 \cdot 10^{-5} \frac{1}{^\circ C}$

$k = 1$

Rešenje:

Normalno dodatno opterećenje je:

$$g_{dod} = 0.18 \cdot \sqrt{d} = 0.18 \cdot \sqrt{11.7} = 0.6157 \frac{daN}{m}$$

Dodatno specifično opterećenje usled leda:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1 \cdot \frac{0.616}{81.3} = 7.57 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$$

Ukupno opterećenje:

$$\gamma_r = \gamma + \gamma_{nd} = (3.5 + 7.57) \cdot 10^{-3} = 11.07 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$$

Kritični raspon:

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 11 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{(11.07^2 - 3.5^2) \cdot 10^{-6}}} = 86.40\ m$$

Kako je $a > a_{kr} \Rightarrow$ maksimalno naprezanje nastupa pri temperaturi od -5°C+led.

Kritična temperatura:

$$t_{kr} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_r}\right) - 5 = \frac{11}{1.89 \cdot 10^{-5} \cdot 7700} \cdot \left(1 - \frac{3.5 \cdot 10^{-3}}{11.07 \cdot 10^{-3}}\right) - 5 = 46.69^\circ C$$

Kako je $t_{kr} > 40$°C maksimalan ugib se javlja na temperaturi od -5°C+led.

Maksimalan ugib na temperaturi od -5°C + led je:

$$f_{\max} = \frac{a^2 \cdot \gamma_r}{8 \cdot \sigma_{nd}} = \frac{150^2 \cdot 11.07 \cdot 10^{-3}}{8 \cdot 11} = 2.83m$$

2. Zadatak

Izračunati max. ugib za dalekovod sa sledećim parametrima:

$a = 350m$

$d = 14mm$

$S = 150mm^2$

$\delta_{nd} = 11\frac{daN}{mm^2}$

$\gamma = 3.5 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$

$E = 7800\frac{daN}{mm^2}$

$\alpha = 1.89 \cdot 10^{-5} \frac{1}{^\circ C}$

Raspon se nalazi na terenu koji je okarakterisan koeficijentom leda $k = 2.5$.

Rešenje:

Normalno dodatno opterećе je:

$$g_{dod} = 0.18 \cdot \sqrt{d} = 0.18 \cdot \sqrt{14} = 0.6735\frac{daN}{m}$$

Dodatno specifično opterećenje usled leda:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 2.5 \cdot \frac{0.6735}{150} = 11.22 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$$

Ukupno opterećenje:

$$\gamma_r = \gamma + \gamma_{nd} = (3.5 + 11.22) \cdot 10^{-3} = 14.72 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$$

Kritični raspon:

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 11 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{(14.72^2 - 3.5^2) \cdot 10^{-6}}} = 63.46\ m$$

Kako je $a > a_{kr} \Rightarrow$ maksimalno naprezanje nastupa pri temperaturi od -5°C+led.

Kritična temperatura:

$$t_{kr} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_r}\right) - 5 = \frac{11}{1.89 \cdot 10^{-5} \cdot 7800} \cdot \left(1 - \frac{3.5 \cdot 10^{-3}}{14.72 \cdot 10^{-3}}\right) - 5 = 51.87\ ^\circ C$$

Kako je $t_{kr} > 40$°C maksimalan ugib se javlja na temperaturi od -5°C+led.

Maksimalan ugib na temperaturi od -5°C + led je:

$$f_{\max} = \frac{a^2 \cdot \gamma_r}{8 \cdot \sigma_{nd}} = \frac{350^2 \cdot 14.72 \cdot 10^{-3}}{8 \cdot 11} = 20.49\ m$$

3. Zadatak

Odrediti maksimalan ugib za dalekovod sa sledećim parametrima

$a = 50m$

$d = 10.5mm$

$S = 65.8mm^2$

$\delta_{nd} = 7\frac{daN}{mm^2}$

$\gamma = 2.8 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$

$E = 5600\frac{daN}{mm^2}$

$\alpha = 2.3 \cdot 10^{-5}\frac{1}{^\circ C}$

$k = 1$

Rešenje:

Normalno dodatno opterećе je:

$$g_{dod} = 0.18 \cdot \sqrt{d} = 0.18 \cdot \sqrt{10.5} = 0.5833\frac{daN}{m}$$

Dodatno specifično opterećenje usled leda:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1 \cdot \frac{0.18 \cdot \sqrt{10.5}}{65.8} = 8.86 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$$

Ukupno opterećenje:

$$\gamma_r = \gamma + \gamma_{nd} = (2.8 + 8.86) \cdot 10^{-3} = 11.66 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$$

Kritični raspon:

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 7 \cdot \sqrt{\frac{360 \cdot 2.3 \cdot 10^{-5}}{(11.66^2 - 2.8^2) \cdot 10^{-6}}} = 56.27m$$

Kako je $a < a_{kr} \Rightarrow$ maksimalno naprezanje nastupa pri temperaturi od -20°C.

Kritična temperatura:

$a < a_{kr} \quad \Rightarrow \quad \sigma_l^3 + A \cdot \sigma_l^2 = B$

$$A = 15 \cdot \alpha \cdot E \cdot \cos\psi + \left[\frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^2\psi}{24 \cdot \sigma_{nd}^2}\right] - \sigma_{nd} = 15 \cdot 2.3 \cdot 10^{-5} \cdot 5600 + \left[\frac{50^2 \cdot 2.8^2 \cdot 10^{-6} \cdot 5600}{24 \cdot 7^2}\right] - 7 = -4.975$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3\psi}{24} = \frac{50^2 \cdot 11.66^2 \cdot 10^{-6} \cdot 5600}{24} = 79.307$$

$$\sigma_l^{(0)} = \sigma_{nd} - 1 = 6\frac{daN}{mm^2}$$

$$\phi\left(\sigma_l^{(0)}\right) = \left(\sigma_l^{(0)}\right)^3 - 4.975 \cdot \left(\sigma_l^{(0)}\right)^2 - 79.307$$

$$\phi'\left(\sigma_l^{(0)}\right) = 3 \cdot \left(\sigma_l^{(0)}\right)^2 - 2 \cdot 4{,}975 \cdot \left(\sigma_l^{(0)}\right)$$

$$\Delta\left(\sigma_l^{(0)}\right) = -\frac{\phi\left(\sigma_l^{(0)}\right)}{\phi'\left(\sigma_l^{(0)}\right)} = 0.878\,\frac{daN}{mm^2}$$

$$\sigma_l^{(1)} = \sigma_l^{(0)} + \Delta\left(\sigma_l^{(0)}\right) = 6.878\,\frac{daN}{mm^2}$$

$$\Delta\left(\sigma_l^{(1)}\right) = -\frac{\phi\left(\sigma_l^{(1)}\right)}{\phi'\left(\sigma_l^{(1)}\right)} = -0.146\,\frac{daN}{mm^2}$$

$$\sigma_l^{(2)} = \sigma_l^{(1)} + \Delta\left(\sigma_l^{(1)}\right) = 6.732\,\frac{daN}{mm^2}$$

$$\Delta\left(\sigma_l^{(2)}\right) = -\frac{\phi\left(\sigma_l^{(2)}\right)}{\phi'\left(\sigma_l^{(2)}\right)} = -0.005\,\frac{daN}{mm^2}$$

$$\sigma_l^{(3)} = \sigma_l^{(2)} + \Delta\left(\sigma_l^{(2)}\right) = 6.727\,\frac{daN}{mm^2}$$

$$t_{kr} = \frac{\sigma_l}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_r}\right) - 5 = \frac{6.727}{2.3 \cdot 10^{-5} \cdot 5600} \cdot \left(1 - \frac{2.8 \cdot 10^{-3}}{11.6 \cdot 10^{-3}}\right) - 5 = 34.69^{\circ}C$$

Kako je $t_{kr} < 40^{o}$C maksimalan ugib se javlja na temperaturi od 40^{o}C

$$A = E \cdot \cos\psi \left[\alpha \cdot (t + 20) + \frac{a^2 \cdot \gamma^2 \cdot \cos^2\psi}{24 \cdot \delta_{nd}^2}\right] - \delta_{nd} = 5600 \cdot \left[2.3 \cdot 10^{-5} \cdot 60 + \frac{50^2 \cdot 2.8^2 \cdot 10^{-6}}{24 \cdot 7^2}\right] - 7 = 0.821$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3\psi}{24} = \frac{50^2 \cdot 2.8^2 \cdot 10^{-6} \cdot 5600}{24} = 4.573$$

$$\sigma_{40}^3 + 0.821 \cdot \sigma_{40}^2 = 4.573$$

$$\sigma_{40} = 1.536\,\frac{daN}{mm^2}$$

$$f_{\max} = \frac{a^2 \cdot \gamma_r}{8 \cdot \sigma_{40}} = \frac{50^2 \cdot 2.8 \cdot 10^{-3}}{8 \cdot 1.536} = 0.57m$$

4. Zadatak

Odrediti max ugib za dalekovod sa sledećim parametrima:

$a = 80m$

$d = 15mm$

$S = 165mm^2$

$\delta_{nd} = 11\frac{daN}{mm^2}$

$\gamma = 3.5 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$

$E = 7500\frac{daN}{mm^2}$

$\alpha = 1.89 \cdot 10^{-5} \frac{1}{^\circ C}$

$k = 1.6$

Normalno dodatno opterećе je:

$$g_{dod} = 0.18 \cdot \sqrt{d} = 0.18 \cdot \sqrt{15} = 0.6971\frac{daN}{m}$$

Dodatno specifično opterećenje usled leda:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1.6 \cdot \frac{0.6971}{165} = 6.76 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$$

Ukupno opterećenje:

$$\gamma_r = \gamma + \gamma_{nd} = (3.5 + 6.76) \cdot 10^{-3} = 10.26 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$$

Kritični raspon:

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 11 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{(10.26^2 - 3.5^2) \cdot 10^{-6}}} = 94.08m$$

Kako je $a < a_{kr} \Rightarrow$ maksimalno naprezanje nastupa pri temperaturi od -20^{o}C.

Kritična temperatura:

$$\sigma_L^3 + A \cdot \delta_L^2 = B$$

$$A = 15 \cdot \alpha \cdot E \cdot \cos\psi + \left[\frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^2 \psi}{24 \cdot \delta_{nd}^2} \right] - \sigma_{nd} = 15 \cdot 1.89 \cdot 10^{-5} \cdot 7500 + \left[\frac{80^2 \cdot 3.5^2 \cdot 10^{-6} \cdot 7500}{24 \cdot 11^2} \right] - 11 = -8.671$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3 \psi}{24} = \frac{80^2 \cdot 3.5^2 \cdot 10^{-6} \cdot 7500}{24} = 210,535$$

$$\phi\left(\sigma_L^{(0)}\right) = \left(\sigma_L^{(0)}\right)^3 - 8.671 \cdot \left(\sigma_L^{(0)}\right)^2 - 210.535$$

$$\phi'\left(\sigma_L^{(0)}\right) = 3 \cdot \left(\sigma_L^{(0)}\right)^2 - 2 \cdot 8,671 \cdot \sigma_L^{(0)}$$

$$\Delta\left(\sigma_L^{(0)}\right) = -\frac{\phi\left(\sigma_L^{(0)}\right)}{\phi'\left(\sigma_L^{(0)}\right)} = 0.613 \frac{daN}{mm^2}$$

$$\sigma_L^{(1)} = \sigma_L^{(0)} + \Delta\left(\sigma_L^{(0)}\right) = 10.613 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_L^{(1)}\right) = -\frac{\phi\left(\sigma_L^{(1)}\right)}{\phi'\left(\sigma_L^{(1)}\right)} = -0.053 \frac{daN}{mm^2}$$

$$\sigma_L^{(2)} = \sigma_L^{(1)} + \Delta\left(\sigma_L^{(1)}\right) = 10.560 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_L^{(2)}\right) = -\frac{\phi\left(\sigma_L^{(2)}\right)}{\phi'\left(\sigma_L^{(2)}\right)} = 0.001 \frac{daN}{mm^2}$$

$$\sigma_L^{(3)} = \sigma_L^{(2)} + \Delta\left(\sigma_L^{(2)}\right) = 10.559 \frac{daN}{mm^2}$$

$$t_{kr} = \frac{\sigma_L}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_r}\right) - 5 = \frac{10.56}{1.89 \cdot 10^{-5} \cdot 7500} \cdot \left(1 - \frac{3.5 \cdot 10^{-3}}{10.26 \cdot 10^{-3}}\right) - 5 = 44.08^{\circ} C$$

Kako je $t_{kr} > 40^{o}$C maksimalan ugib se javlja na temperaturi od -5^{o}C+led.

Maksimalan ugib na temperaturi od -5^{o}C + led je:

$$f_{\max} = \frac{a^2 \cdot \gamma_r}{8 \cdot \delta_L \cos\psi} = \frac{80^2 \cdot 10.26 \cdot 10^{-3}}{8 \cdot 10.559} = 0.78\ m$$

5. Zadatak

Izračunati maksimalan ugib za AlČe užad data u tabeli, raspon je prav a = 250m , račun sprovesti za zonu leda 2 tj. sa faktorom leda k=1.6:

Redni broj	Nazivni presek [mm^2]	Stvarni presek [mm^2]	Prečnik užeta [mm]
1	50/8	56.3	9.6
2	95/15	109.7	13.6
3	210/5	243.2	20.3
4	240/40	282.5	21.9
5	360/55	417.5	26.6

$$\sigma_{nd} = 10\,\frac{daN}{mm^2}$$

$$\gamma = 3.45 \cdot 10^{-3}\,\frac{daN}{m \cdot mm^2}$$

$$E = 7700\,\frac{daN}{mm^2}$$

$$\alpha = 1.89 \cdot 10^{-5}\,\frac{1}{^{\circ}C}$$

Rešenje:

Dodatno specifično opterećenje usled leda:

$$\gamma_{nd1} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 15.85 \cdot 10^{-3}\,\frac{daN}{m \cdot mm^2}$$

$$\gamma_{nd2} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 9.68 \cdot 10^{-3}\,\frac{daN}{m \cdot mm^2}$$

$$\gamma_{nd3} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 5.34 \cdot 10^{-3}\,\frac{daN}{m \cdot mm^2}$$

$$\gamma_{nd4} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 4.77 \cdot 10^{-3}\,\frac{daN}{m \cdot mm^2}$$

$$\gamma_{nd5} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 3.56 \cdot 10^{-3}\,\frac{daN}{m \cdot mm^2}$$

Ukupno opterećenje:

$$\gamma_{r1} = \gamma + \gamma_{nd1} = (3.45 + 15.85) \cdot 10^{-3} = 19.30 \cdot 10^{-3} \ \frac{daN}{m \cdot mm^2}$$

$$\gamma_{r2} = \gamma + \gamma_{nd2} = (3.45 + 9.68) \cdot 10^{-3} = 13.13 \cdot 10^{-3} \ \frac{daN}{m \cdot mm^2}$$

$$\gamma_{r3} = \gamma + \gamma_{nd3} = (3.45 + 5.32) \cdot 10^{-3} = 8.79 \cdot 10^{-3} \ \frac{daN}{m \cdot mm^2}$$

$$\gamma_{r4} = \gamma + \gamma_{nd4} = (3.45 + 4.77) \cdot 10^{-3} = 8.22 \cdot 10^{-3} \ \frac{daN}{m \cdot mm^2}$$

$$\gamma_{r5} = \gamma + \gamma_{nd5} = (3.45 + 3.56) \cdot 10^{-3} = 7.01 \cdot 10^{-3} \ \frac{daN}{m \cdot mm^2}$$

Kritični raspon:

$$a_{kr1} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_{r1}^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{(19.3^2 - 3.45^2) \cdot 10^{-6}}} = 43.44 \ m$$

$$a_{kr2} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_{r2}^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{(13.13^2 - 3.45^2) \cdot 10^{-6}}} = 65.11 \ m$$

$$a_{kr3} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_{r3}^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{(8.79^2 - 3.45^2) \cdot 10^{-6}}} = 102.03 \ m$$

$$a_{kr4} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_{r4}^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{(8.22^2 - 3.45^2) \cdot 10^{-6}}} = 110.56 \ m$$

$$a_{kr5} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_{r5}^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{(7.01^2 - 3.45^2) \cdot 10^{-6}}} = 135.17 \ m$$

Kako je za sve slučajeve $a > a_{kr} \Rightarrow$ maksimalno naprezanje se javlja pri temperaturi od -5^{o}C+led.

Kritična temperatura:

$$t_{kr1} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_{r1}}\right) - 5 = \frac{11}{1.89 \cdot 10^{-5} \cdot 7700} \cdot \left(1 - \frac{3.45 \cdot 10^{-3}}{19.3 \cdot 10^{-3}}\right) - 5 = 51.43 \ ^\circ C$$

$$t_{kr2} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_{r2}}\right) - 5 = \frac{11}{1.89 \cdot 10^{-5} \cdot 7700} \cdot \left(1 - \frac{3.45 \cdot 10^{-3}}{13.13 \cdot 10^{-3}}\right) - 5 = 45.66 \ ^\circ C$$

$$t_{kr3} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_{r3}}\right) - 5 = \frac{11}{1.89 \cdot 10^{-5} \cdot 7700} \cdot \left(1 - \frac{3.45 \cdot 10^{-3}}{8.79 \cdot 10^{-3}}\right) - 5 = 36.74 \ ^\circ C$$

$$t_{kr4} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_{r4}}\right) - 5 = \frac{11}{1.89 \cdot 10^{-5} \cdot 7700} \cdot \left(1 - \frac{3.45 \cdot 10^{-3}}{8.22 \cdot 10^{-3}}\right) - 5 = 34.87 \ ^\circ C$$

$$t_{kr5} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_{r5}}\right) - 5 = \frac{11}{1.89 \cdot 10^{-5} \cdot 7700} \cdot \left(1 - \frac{3.45 \cdot 10^{-3}}{7.01 \cdot 10^{-3}}\right) - 5 = 29.90\,^{\circ}C$$

Kako su t_{kr1} i $t_{kr2} > 40^{o}\text{C} \Rightarrow$ maksimalni ugib je pri temperaturi od -5^{o}C+led.

Kako su t_{kr3}, t_{kr4} i $t_{kr5} < 40^{o}\text{C} \Rightarrow$ maksimalni ugib je pri temperaturi od 40^{o}C.

Maksimalan ugib:

$$f_{\max 1} = \frac{a^2 \cdot \gamma_{r1}}{8 \cdot \sigma_{nd}} = \frac{250^2 \cdot 19.3 \cdot 10^{-3}}{8 \cdot 10} = 15.08m$$

$$f_{\max 2} = \frac{a^2 \cdot \gamma_r}{8 \cdot \delta_{nd}} = \frac{250^2 \cdot 13.13 \cdot 10^{-3}}{8 \cdot 10} = 10.26m$$

$$A = E \cdot \cos\psi \left[\alpha \cdot (t+5) + \frac{a^2 \cdot {\gamma_r}^2 \cdot \cos^2\psi}{24 \cdot \sigma_{nd}^2}\right] - \delta_{nd} = 12.042$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3\psi}{24} = 238.670$$

$$\sigma_{3(40)} = 3.873 \frac{daN}{mm^2}$$

$$f_{\max 3} = \frac{a^2 \cdot \gamma}{8 \cdot \sigma_{3(40)}} = \frac{250^2 \cdot 3.45 \cdot 10^{-3}}{8 \cdot 3.87} = 6.96m$$

$$A = E \cdot \cos\psi \left[\alpha \cdot (t+5) + \frac{a^2 \cdot {\gamma_r}^2 \cdot \cos^2\psi}{24 \cdot \sigma_{nd}^2}\right] - \sigma_{nd} = 10.098$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3\psi}{24} = 238.670$$

$$\sigma_{4(40)} = 4.100 \frac{daN}{mm^2}$$

$$f_{\max 4} = \frac{a^2 \cdot \gamma}{8 \cdot \sigma_{4(40)}} = \frac{250^2 \cdot 3.45 \cdot 10^{-3}}{8 \cdot 4.1} = 6.57m$$

$$A = E \cdot \cos\psi \left[\alpha \cdot (t+5) + \frac{a^2 \cdot {\gamma_r}^2 \cdot \cos^2\psi}{24 \cdot \sigma_{nd}^2}\right] - \sigma_{nd} = 6.402$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3\psi}{24} = 238.670$$

$$\sigma_{5(40)} = 4.648 \frac{daN}{mm^2}$$

$$f_{\max 5} = \frac{a^2 \cdot \gamma}{8 \cdot \sigma_{5(40)}} = \frac{250^2 \cdot 3.45 \cdot 10^{-3}}{8 \cdot 4.648} = 5.80m$$

6. Zadatak

Odrediti masimalan ugib za Al/Če uže sa sledećim parametrima:

$a = 200m$

$d = 21mm$

$S = 330mm^2$

$\delta_{nd} = 10\frac{daN}{mm^2}$

$\gamma = 3.75 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$

$E = 7800\frac{daN}{mm^2}$

$\alpha = 1.9 \cdot 10^{-5}\frac{1}{^\circ C}$

$k = 1.6$

Rešenje:

Normalno dodatno opterećeće je:

$$g_{dod} = 0.18 \cdot \sqrt{d} = 0.18 \cdot \sqrt{21} = 0.8249\frac{daN}{m}$$

Dodatno specifično opterećenje usled leda:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1.6 \cdot \frac{0.8249}{330} = 4 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$$

Ukupno opterećenje:

$$\gamma_r = \gamma + \gamma_{nd} = (3.75 + 4.00) \cdot 10^{-3} = 7.75 \cdot 10^{-3}$$

Kritični raspon:

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.9 \cdot 10^{-5}}{(7.75^2 - 3.75^2) \cdot 10^{-6}}} = 121.94\ m$$

Kako je $a > a_{kr} \Rightarrow$ maksimalno naprezanje nastupa pri temperaturi od -5^{o}C+led.

Kritična temperatura:

$$t_{kr} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_r}\right) - 5 = \frac{10}{1.9 \cdot 10^{-5} \cdot 7800} \cdot \left(1 - \frac{3.75 \cdot 10^{-3}}{7.75 \cdot 10^{-3}}\right) - 5 = 29.83^\circ C$$

Kako je $t_{kr} < 40^o$C maksimalan ugib se javlja na temperaturi od 40^{o}C

$$\sigma_{40}^3 + A \cdot \sigma_{40}^2 = B$$

$$A = E \cdot \cos\psi \left[\alpha \cdot (t+5) + \frac{a^2 \cdot \gamma_r^2 \cdot \cos^2\psi}{24 \cdot \delta_{nd}^2} \right] - \delta_{nd} = 7800 \cdot \left[1.9 \cdot 10^{-5} \cdot 45 + \frac{200^2 \cdot 7.75^2 \cdot 10^{-6}}{24 \cdot 10^2} \right] - 10 = 4.477$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3\psi}{24} = \frac{40000 \cdot 3.75^2 \cdot 10^{-6} \cdot 7800}{24} = 182.813$$

$$\sigma_{40}^{(0)} = \sigma_{nd} - 1 = 9 \frac{daN}{mm^2}$$

$$\phi\left(\sigma_{40}^{(0)}\right) = \left(\sigma_{40}^{(0)}\right)^3 + 4.477 \cdot \left(\sigma_{40}^{(0)}\right)^2 - 282.813$$

$$\phi'\left(\sigma_{40}^{(0)}\right) = 3 \cdot \left(\sigma_{40}^{(0)}\right)^2 + 2 \cdot 4.477 \cdot \left(\sigma_{40}^{(0)}\right)$$

$$\Delta\left(\delta_{40}^{(0)}\right) = -\frac{\phi\left(\sigma_{40}^{(0)}\right)}{\phi'\left(\sigma_{40}^{(0)}\right)} = \frac{9^3 + 4.477 \cdot 9^2 - 182.8}{3 \cdot 9^2 + 2 \cdot 4.477 \cdot 9} = -2.809 \frac{daN}{mm^2}$$

$$\sigma_{40}^{(1)} = \sigma_{40}^{(0)} + \Delta\left(\sigma_{40}^{(0)}\right) = 6.191 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_{40}^{(1)}\right) = -\frac{\phi\left(\sigma_{40}^{(1)}\right)}{\phi'\left(\sigma_{40}^{(1)}\right)} = -1.327 \frac{daN}{mm^2}$$

$$\sigma_{40}^{(2)} = \sigma_{40}^{(1)} + \Delta\left(\sigma_{40}^{(1)}\right) = 4.864 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_{40}^{(2)}\right) = -\frac{\phi\left(\sigma_{40}^{(2)}\right)}{\phi'\left(\sigma_{40}^{(2)}\right)} = -0.333 \frac{daN}{mm^2}$$

$$\sigma_{40}^{(3)} = \sigma_{40}^{(2)} + \Delta\left(\sigma_{40}^{(2)}\right) = 4.531 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_{40}^{(3)}\right) = -\frac{\phi\left(\sigma_{40}^{(3)}\right)}{\phi'\left(\sigma_{40}^{(3)}\right)} = -0.021 \frac{daN}{mm^2}$$

$$\sigma_{40}^{(4)} = \sigma_{40}^{(3)} + \Delta\left(\sigma_{40}^{(3)}\right) = 4.510 \frac{daN}{mm^2}$$

Maksimalan ugib na temperaturi od 40^{o}C je:

$$f_{\max} = \frac{a^2 \cdot \gamma}{8 \cdot \sigma_{40} \cos\psi} = \frac{40000 \cdot 3.75 \cdot 10^{-3}}{8 \cdot 4.510} = 4.16\ m$$

7. Zadatak

Odrediti maksimalni ugib za uže sa sledećim parametrima:

$a = 200m$

$d = 26mm$

$S = 422mm^2$

$\sigma_{nd} = 9.8\frac{daN}{mm^2}$

$\gamma = 3.5 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$

$E = 7700\frac{daN}{mm^2}$

$\alpha = 1.9 \cdot 10^{-5}\frac{1}{^\circ C}$

$k = 2.5$

Rešenje:

Normalno dodatno opterećе je:

$$g_{dod} = 0.18 \cdot \sqrt{d} = 0.18 \cdot \sqrt{26} = 0.9178\frac{daN}{m}$$

Dodatno specifično opterećenje usled leda:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 2.5 \cdot \frac{0.918}{422} = 5.44 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$$

Ukupno opterećenje:

$$\gamma_r = \gamma + \gamma_{nd} = (3.5 + 5.44) \cdot 10^{-3} = 8.94 \cdot 10^{-3}$$

Kritični raspon:

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.9 \cdot 10^{-5}}{(8.94^2 - 3.5^2) \cdot 10^{-6}}} = 98.52\ m$$

Kako je $a > a_{kr} \Rightarrow$ maksimalno naprezanje nastupa pri temperaturi od -5°C+led.

Kritična temperatura:

$$t_{kr} = \frac{\sigma_{nd}}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_r}\right) - 5 = \frac{9.8}{1.9 \cdot 10^{-5} \cdot 7700} \cdot \left(1 - \frac{3.5 \cdot 10^{-3}}{8.94 \cdot 10^{-3}}\right) - 5 = 35.76\,^\circ C$$

Kako je $t_{kr} < 40^oC$ maksimalan ugib se javlja na temperaturi od 40°C.

$$\sigma_{40}^3 + A \cdot \sigma_{40}^2 = B$$

$$A = E \cdot \cos\psi \left[\alpha \cdot (t+5) + \frac{a^2 \cdot \gamma_r^2 \cdot \cos^2\psi}{24 \cdot \sigma_{nd}^2} \right] - \sigma_{nd} = 7700 \cdot \left[1.9 \cdot 10^{-5} \cdot 45 + \frac{200^2 \cdot 8.94^2 \cdot 10^{-6}}{24 \cdot 9.8^2} \right] - 9.8 = 7.463$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3\psi}{24} = \frac{200^2 \cdot 3.5^2 \cdot 10^{-6} \cdot 7700 \cdot 1}{24} = 157.208$$

$$\sigma_{40}^{(0)} = \sigma_{nd} - 1 = 8.8 \frac{daN}{mm^2}$$

$$\phi\left(\sigma_{40}^{(0)}\right) = \left(\sigma_{40}^{(0)}\right)^3 + 7.463 \cdot \left(\sigma_{40}^{(0)}\right)^2 - 157.2$$

$$\phi'\left(\sigma_{40}^{(0)}\right) = 3 \cdot \left(\sigma_{40}^{(0)}\right)^2 + 2 \cdot 7.463 \cdot \left(\sigma_{40}^{(0)}\right)$$

$$\Delta\left(\sigma_{40}^{(0)}\right) = -\frac{\phi\left(\sigma_{40}^{(0)}\right)}{\phi'\left(\sigma_{40}^{(0)}\right)} = \frac{8.8^3 + 7.463 \cdot 8.8^2 - 157.208}{3 \cdot 8.8^2 + 2 \cdot 7.463 \cdot 8.8} = -3.031 \frac{daN}{mm^2}$$

$$\sigma_{40}^{(1)} = \sigma_{40}^{(0)} + \Delta\left(\sigma_{40}^{(0)}\right) = 5.769 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_{40}^{(1)}\right) = -\frac{\phi\left(\sigma_{40}^{(1)}\right)}{\phi'\left(\sigma_{40}^{(1)}\right)} = -1.523 \frac{daN}{mm^2}$$

$$\sigma_{40}^{(2)} = \sigma_{40}^{(1)} + \Delta\left(\sigma_{40}^{(1)}\right) = 4.246 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_{40}^{(2)}\right) = -\frac{\phi\left(\sigma_{40}^{(2)}\right)}{\phi'\left(\sigma_{40}^{(2)}\right)} = -0.459 \frac{daN}{mm^2}$$

$$\sigma_{40}^{(3)} = \sigma_{40}^{(2)} + \Delta\left(\sigma_{40}^{(2)}\right) = 3.787 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_{40}^{(3)}\right) = -\frac{\phi\left(\sigma_{40}^{(3)}\right)}{\phi'\left(\sigma_{40}^{(3)}\right)} = -0.042 \frac{daN}{mm^2}$$

$$\sigma_{40}^{(4)} = \sigma_{40}^{(3)} + \Delta\left(\sigma_{40}^{(3)}\right) = 3.745 \frac{daN}{mm^2}$$

Maksimalan ugib na temperaturi od 40^{o}C je:

$$f_{\max} = \frac{a^2 \cdot \gamma}{8 \cdot \sigma_{40} \cdot \cos\psi} = \frac{200^2 \cdot 3.5 \cdot 10^{-3}}{8 \cdot 3.745 \cdot 1} = 4.67\,m$$

8. Zadatak

Izračunati maksimalni ugib za dalekovod sa sledećim parametrima:

$a = 100m$

$d = 20mm$

$S = 240mm^2$

$\sigma_{nd} = 11\frac{daN}{mm^2}$

$\gamma = 3.75 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$

$E = 7500\frac{daN}{mm^2}$

$\alpha = 1.8 \cdot 10^{-5} \frac{1}{^\circ C}$

$k = 1.6$

Rešenje:

Normalno dodatno opterećе je:

$$g_{dod} = 0.18 \cdot \sqrt{d} = 0.18 \cdot \sqrt{20} = 0.8050 \frac{daN}{m}$$

Dodatno specifično opterećenje usled leda:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1.6 \cdot \frac{0.805}{240} = 5.37 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$$

Ukupno opterećenje:

$$\gamma_r = \gamma + \gamma_{nd} = (3.75 + 5.367) \cdot 10^{-3} = 9.12 \cdot 10^{-3} \frac{daN}{m \cdot mm^2}$$

Kritični raspon:

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.8 \cdot 10^{-5}}{(9.12^2 - 3.75^2) \cdot 10^{-6}}} = 106.51\, m$$

Kako je $a < a_{kr}$ maksimalno naprezanje se javlja pri -20^{o}C

$$\sigma_l^3 + A \cdot \sigma_l^2 = B$$

$$A = 15 \cdot \alpha \cdot E \cdot \cos\psi \left[\frac{a^2 \cdot \gamma^2 \cdot \cos^2\psi}{24 \cdot \sigma_{nd}^2} \right] - \sigma_{nd} = 15 \cdot 1.8 \cdot 10^{-5} \cdot 7500 \cdot \left[\frac{100^2 \cdot 3.75^2 \cdot 10^{-6}}{24 \cdot 11^2} \right] - 11 = -8.612$$

$$B = \frac{a^2 \cdot \gamma^2 \cdot E \cdot \cos^3\psi}{24} = \frac{100^2 \cdot 3.75^2 \cdot 10^{-6} \cdot 7500 \cdot 1}{24} = 259.920$$

$$\sigma_{40}^{(0)} = \sigma_{nd} - 1 = 10 \frac{daN}{mm^2}$$

$$\phi\left(\sigma_l^{(0)}\right) = \left(\sigma_l^{(0)}\right)^3 - 8.612 \cdot \left(\sigma_{40}^{(0)}\right)^2 - 259.920$$

$$\phi'\left(\sigma_l^{(0)}\right) = 3 \cdot \left(\sigma_l^{(0)}\right)^2 - 2 \cdot 8.612 \cdot \left(\sigma_l^{(0)}\right)$$

$$\Delta\left(\sigma_l^{(0)}\right) = -\frac{\phi\left(\sigma_l^{(0)}\right)}{\phi'\left(\sigma_l^{(0)}\right)} = \frac{10^3 - 8.612 \cdot 10^2 - 259.920}{3 \cdot 10^2 - 2 \cdot 8.612 \cdot 10} = 0.948 \frac{daN}{mm^2}$$

$$\sigma_l^{(1)} = \sigma_l^{(0)} + \Delta\left(\sigma_l^{(0)}\right) = 10.948 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_l^{(1)}\right) = -\frac{\phi\left(\sigma_l^{(1)}\right)}{\phi'\left(\sigma_l^{(1)}\right)} = -0.117 \frac{daN}{mm^2}$$

$$\sigma_l^{(2)} = \sigma_l^{(1)} + \Delta\left(\sigma_l^{(1)}\right) = 10{,}831 \frac{daN}{mm^2}$$

$$\Delta\left(\sigma_l^{(2)}\right) = -\frac{\phi\left(\sigma_l^{(2)}\right)}{\phi'\left(\sigma_l^{(2)}\right)} = -0.002 \frac{daN}{mm^2}$$

$$\sigma_l^{(3)} = \sigma_l^{(2)} + \Delta\left(\sigma_l^{(2)}\right) = 10{,}829 \frac{daN}{mm^2}$$

Kritična temperatura:

$$t_{kr} = \frac{\sigma_l}{\alpha \cdot E \cdot \cos\psi} \cdot \left(1 - \frac{\gamma}{\gamma_r}\right) - 5 = \frac{10.829}{1.8 \cdot 10^{-5} \cdot 7500} \cdot \left(1 - \frac{3.75 \cdot 10^{-3}}{9.117 \cdot 10^{-3}}\right) - 5 = 42.23\,^{\circ}C$$

Pošto je $t_{kr} > 40^oC$ maksimalni ugib se javlja pri -5^oC + led

$$f_{\max} = \frac{a^2 \cdot \gamma_r}{8 \cdot \sigma_l \cos\psi} = \frac{100^2 \cdot 9.117 \cdot 10^{-3}}{8 \cdot 10.83} = 1.05\ m$$

9. Zadatak

Za čelično uže 350/80 obrazovati montažnu tablicu i nacrtati montažnu krivu za raspon

$a = 270m$

$h = 80m$

$S = 428.2mm^2$

$E = 8000\dfrac{daN}{mm^2}$

Tačke vešanja užeta su sa visinskom razlikom, ostali podaci su:

$d = 26.9mm$

$\sigma_{nd} = 11\dfrac{daN}{mm^2}$

$\gamma = 3.64 \cdot 10^{-3}\dfrac{daN}{m \cdot mm^2}$

$\alpha = 1.8 \cdot 10^{-5}\dfrac{1}{^\circ C}$

$k = 1.6$

Rešenje:

$$\cos\varphi = \frac{a}{\sqrt{a^2 + h^2}} = 0.96$$

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1.6 \cdot \frac{0.18\sqrt{26.9}}{330} = 3.49 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$$

$$\gamma_r = \gamma + \gamma_{nd} = (3.64 + 3.46) \cdot 10^{-3} = 7.13 \cdot 10^{-3}$$

$$a_{kr} = \frac{\sigma_{nd}}{\cos\psi} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 150.5m$$

$$a > a_{kr} \Rightarrow \delta_{nd}$$

Jednačina stanja za $a > a_{kr}$

$$\frac{a^2\cos^2\psi}{24} \cdot \left(\frac{\gamma^2}{\sigma^2} - \frac{\gamma_r^2}{\sigma_{nd}^2}\right) = (t + 5) \cdot \alpha + \frac{\sigma - \sigma_{nd}}{E \cdot \cos\psi}$$

$$Z = \frac{1}{\alpha}\left[\frac{a^2 \cdot \cos^2\psi}{24}\left(\frac{\gamma^2}{\sigma^2} - \frac{\gamma_r^2}{\sigma_{nd}^2}\right) - \frac{\sigma - \sigma_{nd}}{E \cdot \cos\psi}\right] - 5$$

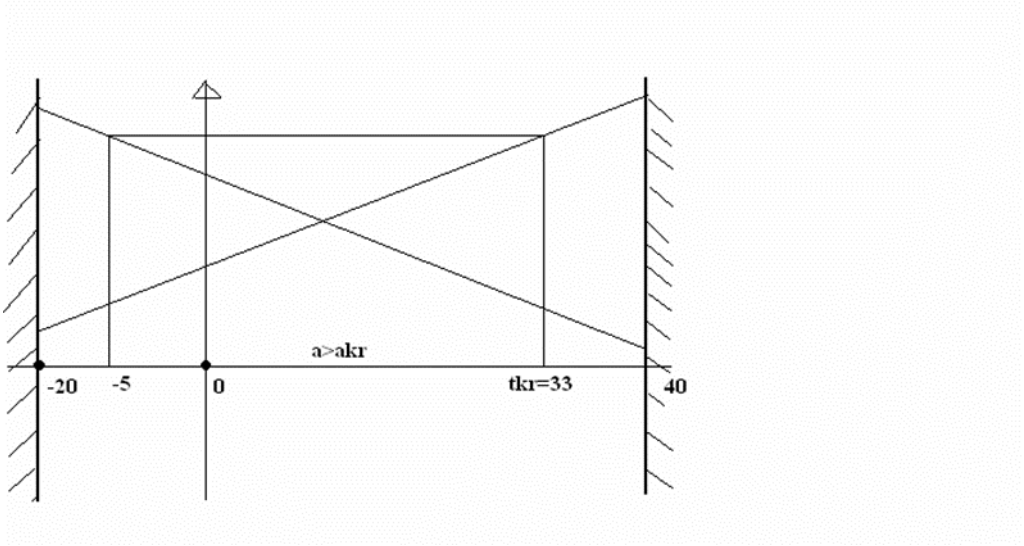
$$t = \frac{2060}{\delta^2} - 7.24 \cdot \delta + 11$$

$$f = \frac{a^2 \cdot \gamma}{8 \cdot \delta \cdot \cos\psi} = \frac{34.56}{\sigma}$$

$\sigma\left[\frac{daN}{mm^2}\right]$	5	6	7	8	9
$t\left[^oC\right]$	57.2	24.8	2.4	-14.7	-28.7
$f\left[m\right]$	6.91	5.75	4.93	4.32	3.84

$$f_5 = \frac{a^2 \cdot \gamma}{8 \cdot \sigma_{nd} \cos\psi} = 6.15\, m$$

$$t_{kr} = 33.9^o C$$



10. Zadatak

Za zatezno polje nominalnog napona 35kV, koje ima 6 pravih raspona 170m, 180m, 160m, 180m, 180m, 280m, treba formirati montažnu tablicu i nacrtati montažne krive. Podaci za proračun su:

$d = 19mm$

$E = 8100\frac{daN}{mm^2}$

$\sigma_{nd} = 7.5\frac{daN}{mm^2}$

$S = 213.6mm^2$

$\gamma = 3.5 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$

$\alpha = 1.91 \cdot 10^{-5}\frac{1}{^\circ C}$

$k = 1.6$

Rešenje:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1.6 \cdot \frac{0.18\sqrt{19}}{213.6} = 5.88 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$$

$$\gamma_r = \gamma + \gamma_{nd} = (3.5 + 5.88) \cdot 10^{-3} = 9.38 \cdot 10^{-3}$$

Idealan raspon:

$$a_i = \sqrt{\frac{\sum_{i-1}^{6} a_j^3}{\sum_{j-1}^{6} a_j}} = \sqrt{\frac{170^3 + 160^3 + 3 \cdot 180^3 + 280^3}{170 + 160 + 3 \cdot 180 + 280}} = 205.3m$$

$$a_{kr} = \sigma_{nd}\sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 7.5\sqrt{\frac{360 \cdot 1.91 \cdot 10^{-5}}{(9.38^2 - 3.5^2) \cdot 10^{-6}}} = 71.46m$$

$a_i > a_{kr}$

Kako je $a_i > a_{kr}$, σ_{nd} nastupa pri -5°C

σ (t) i f(t) $\Rightarrow$ montažne krive

$$\frac{a^2}{24}\left(\frac{\gamma^2}{\sigma^2}-\frac{\gamma_0^2}{\sigma_0^2}\right)=\left(t-t_o\right)\cdot\alpha+\frac{\sigma-\sigma_o}{E}$$

$t_o=-5^oC$

$\sigma_o=\sigma_{nd}$

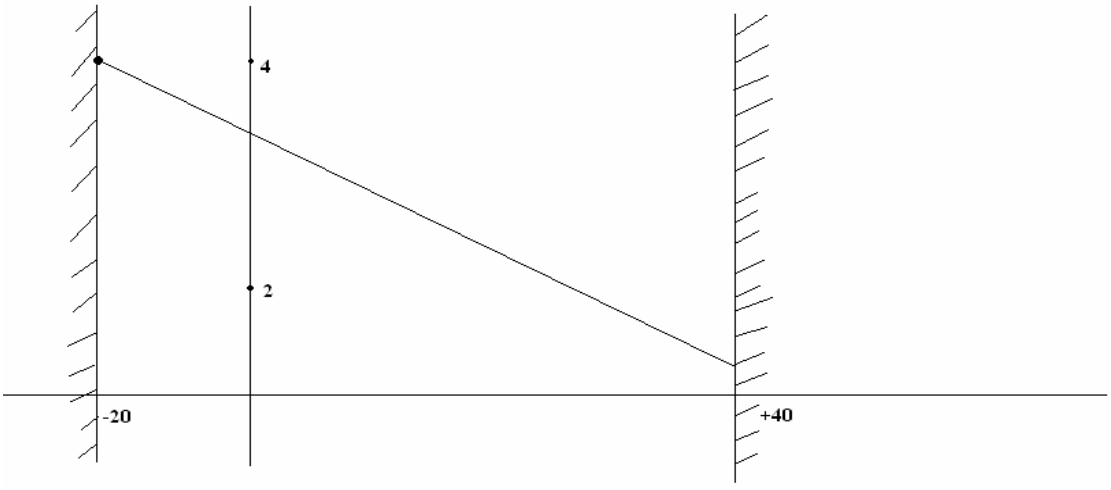
$\gamma_o=\gamma_r$

$$t=\frac{1}{\alpha}\left[\frac{a^2\cdot\cos^2\psi}{24}\left(\frac{\gamma^2}{\sigma^2}-\frac{\gamma_r^2}{\sigma_{nd}^2}\right)-\frac{\sigma-\sigma_{nd}}{E\cdot\cos\psi}\right]-5$$

$$t=\frac{1126}{\sigma^2}-6.46$$

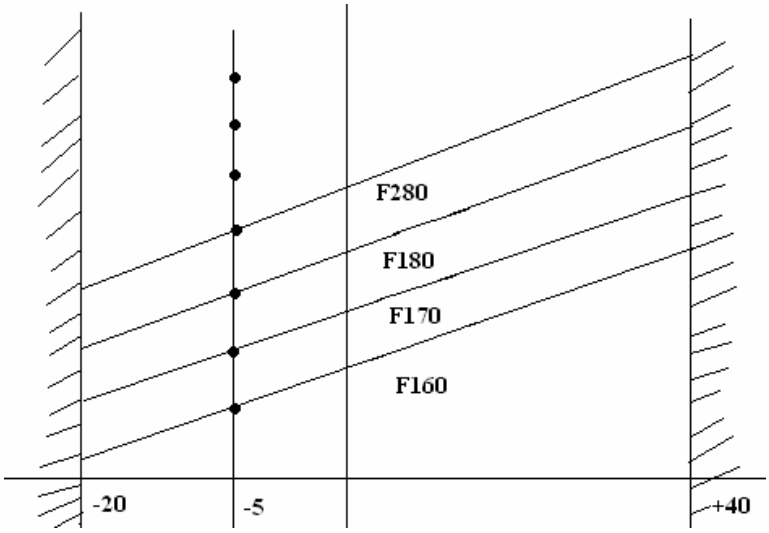
$\sigma\left[\frac{daN}{mm^2}\right]$	2.6	2.7	2.8	2.9	3	3.2	3.4	3.5
$t\left[^oC\right]$	49.1	36.4	34.9	14.5	5.1	-11.4	-25.2	-31.3

$$t_{kr}=\frac{\sigma_L}{\alpha\cdot E}\left(1-\frac{\gamma}{\gamma_r}\right)-5=\frac{7.5}{1.91\cdot10^{-5}\cdot8100}\left(1-\frac{3.5}{9.38}\right)-5=25.4^oC$$



Kako je $t_{kr}<40^oC\Rightarrow$ maksimalni ugib nastupa pri temperaturi od 40°C

$\sigma\left[\frac{daN}{mm^2}\right]$	2.6	2.8	2.9	3	3.2	3.4	3.5	2.67
$t\left[^oC\right]$	49.1	24.9	14.5	5.1	-11.4	-25.2	-31.3	+40
$f_{140}[m]$	4.3	4	3.86	3.73	3.5	3.29	3.2	4.24
$f_{170}[m]$	4.86	4.52	4.36	4.21	3.95	3.72	3.64	4.79
$f_{180}[m]$	5.45	5.06	4.89	4.73	4.43	4.17	4.05	5.37
$f_{280}[m]$	13.19	12.25	11.83	11.43	10.72	10.09	9.08	12.99



11. Zadatak

Utvrditi da li je moguće premostiti dolinu između dva brda koristeći uže Al/Če 240/40 sa sledećim parametrima:

$a = 600m$

$d = 20mm$

$S = 280mm^2$

$\sigma_{nd} = 11\frac{daN}{mm^2}$

$\sigma_{id} = 18\frac{daN}{mm^2}$

$\gamma = 3.5 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$

$E = 7700\frac{daN}{mm^2}$

$\alpha = 1.89 \cdot 10^{-5}\frac{1}{^\circ C}$

$k = 1.6$

Dolinom prolazi železnička pruga.

Rešenje:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1.6 \cdot \frac{0.18 \cdot \sqrt{20}}{280} = 4.6 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$$

$$\gamma_r = \gamma + \gamma_{nd} = (3.5 + 4.6) \cdot 10^{-3} = 8.11 \cdot 10^{-3}$$

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 1.8 \cdot 10^{-5}}{(8.11^2 - 3.5^2) \cdot 10^{-6}}} = 124.2m$$

Kako je $a > a_{kr} \Rightarrow$ maksimalno naprezanje nastupa pri temperaturi od -5^{o}C+led

$$m = \frac{\sigma_{nd}}{\gamma} \cdot \sqrt{\frac{24}{a^2 \cdot E \cdot \cos^2\psi} \cdot (\sigma_{id} - \sigma_{nd}) + \left(\frac{\gamma + \gamma_{nd}}{\sigma_{nd}}\right)^2} - \frac{\gamma}{\gamma_{nd}}$$

$$m = \frac{18}{4.6 \cdot 10^{-3}} \cdot \sqrt{\frac{24}{600^2 \cdot 7700} \cdot (18 - 11) + \left(\frac{8.1 \cdot 10^{-3}}{11}\right)^2} - \frac{3.5}{4.6} = 2.277 \le 4$$

Ne može se premostiti dolina kojom prolazi železnička pruga.

12. Zadatak

Proveriti da li se provodnik od Al sa podacima:

$a = 80m$

$d = 9mm$

$S = 49.5mm^2$

$\sigma_{nd} = 7\dfrac{daN}{mm^2}$

$\sigma_{id} = 12\dfrac{daN}{mm^2}$

$\gamma = 2.7 \cdot 10^{-3}\dfrac{daN}{m \cdot mm^2}$

$E = 5600\dfrac{daN}{mm^2}$

$\alpha = 2.3 \cdot 10^{-5}\dfrac{1}{^\circ C}$

Može ukrstiti u prvom rasponu sa telekomunikacionim vodom.

Rešenje:

$$\gamma_{nd} = k \cdot \frac{0.18 \cdot \sqrt{d}}{S} = 1.6 \cdot \frac{0.18 \cdot \sqrt{9}}{49.5} = 10.91 \cdot 10^{-3}\frac{daN}{m \cdot mm^2}$$

$$\gamma_r = \gamma + \gamma_{nd} = (2.7 + 10.91) \cdot 10^{-3} = 13.61 \cdot 10^{-3}$$

$$a_{kr} = \sigma_{nd} \cdot \sqrt{\frac{360 \cdot \alpha}{\gamma_r^2 - \gamma^2}} = 10 \cdot \sqrt{\frac{360 \cdot 2.3 \cdot 10^{-5}}{(13.61^2 - 2.7^2) \cdot 10^{-6}}} = 47.25m$$

Kako je $a > a_{kr} \Rightarrow$ maksimalno naprezanje nastupa pri temperaturi od -5°C+led

$$m = \frac{\sigma_{nd}}{\gamma_{nd}} \cdot \sqrt{\frac{24}{a^2 \cdot E \cdot \cos^2\psi} \cdot (\sigma_{id} - \sigma_{nd}) + \left(\frac{\gamma + \gamma_{nd}}{\delta_{nd}}\right)^2} - \frac{\gamma}{\gamma_{nd}}$$

$$m = \frac{12}{10.91 \cdot 10^{-3}} \cdot \sqrt{\frac{24}{80^2 \cdot 5600} \cdot (12 - 7) + \left(\frac{13.61 \cdot 10^{-3}}{7}\right)^2} - \frac{2.7}{10.91} = 2.67 \le 3$$

Ne sme se ukrštati sa telekomunikacionim vodom.