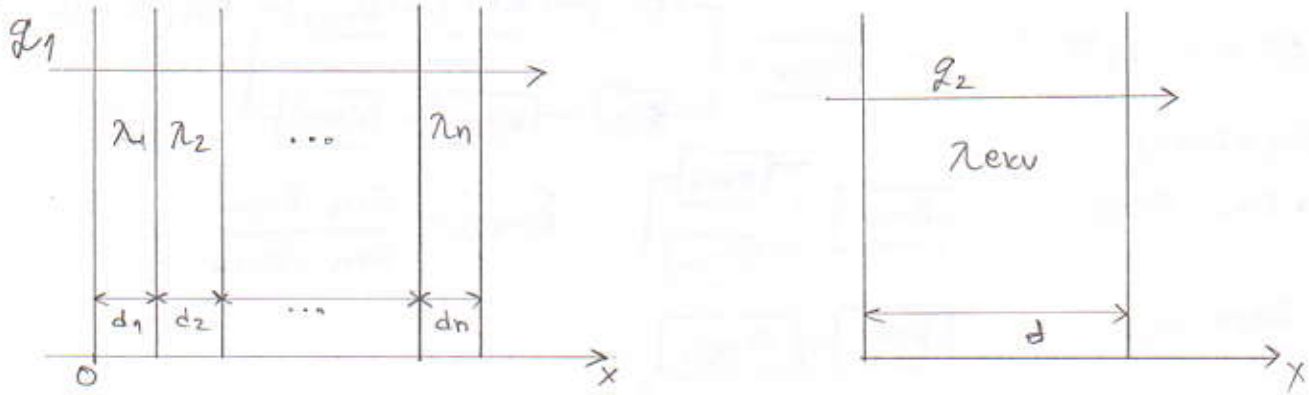
GRAĐEVINSKA FIZIKA - RAČUNSKE VEŽBE - IV NEDELJA

(1) A) Ravan nehomogen zid dimenzija axb se sastoji od n slojeva debljina d_i, $i=1,2...n$. Zid je potrebno zameniti homogenim čija je debljina 1,5 puta manja od nehomogenog. Naći ekvivalentni koeficijent toplotne provodnosti materijala homogenog zida, tako da gustina fluksa toplotnih gubitaka nehomogenog zida bude 2 puta veća od homogenog. Zanemariti prelaze toplote sa vazduha na zid i sa zida na vazduh.

B) Ako se ravan zid sastoji od 3 sloja čije su debljine i koeficijenti toplotne provodnosti dati u tabeli, naći ekvivalentni koeficijent toplotne provodnosti jednoslojnog zida, tako da uslovi pod A) budu zadovoljeni. Spoljašnja temperatura vazduha je 10°C, a unutrašnja 26°C.

Br.	Materijal	Debljina d[cm]	$\lambda \left[\frac{W}{m\cdot K}\right]$
1	Malter	1,5	1,4
2	Opeka	12	0,76
3	Malter	3	1,4

A)



$$q_1 = \frac{t_1 - t_2}{\sum R_i} = \frac{t_1 - t_2}{\frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \ldots + \frac{d_n}{\lambda_n}} \qquad q_2 = \frac{t_1 - t_2}{R_e} = \frac{t_1 - t_2}{\frac{d}{\lambda_e}}$$

$$q_1 = 2q_2$$

$$\frac{t_1 - t_2}{\frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \ldots + \frac{d_n}{\lambda_n}} = 2 \cdot \frac{t_1 - t_2}{\frac{d}{\lambda_e}} \Rightarrow 2\left(\frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \ldots + \frac{d_n}{\lambda_n}\right) = \frac{d}{\lambda_e}$$

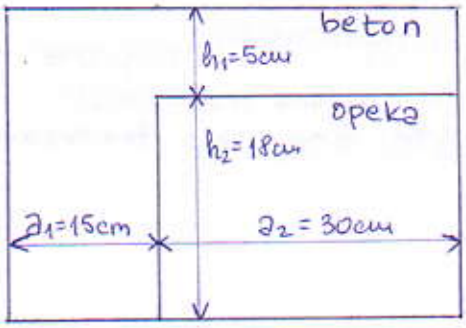
$$2\left(\frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \ldots + \frac{d_n}{\lambda_n}\right) = \frac{d_1 + d_2 + \ldots + d_n}{1{,}5\,\lambda_e} \Rightarrow \boxed{\lambda_e = \frac{d_1 + d_2 + \ldots + d_n}{3\left(\frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \ldots + \frac{d_n}{\lambda_n}\right)}}$$

B)

$$\lambda_e = \frac{d_1 + d_2 + d_3}{3\left(\frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \frac{d_3}{\lambda_3}\right)}$$

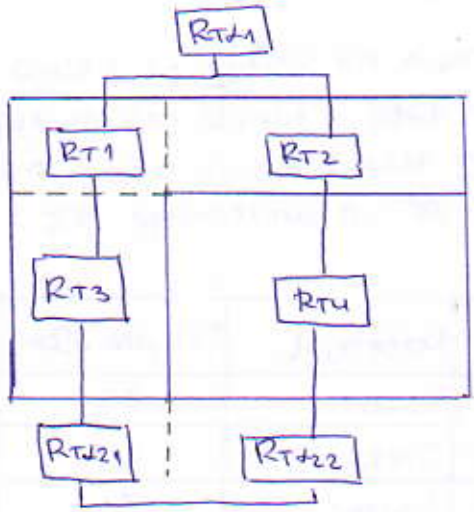
$$\boxed{\lambda_e = 0{,}2899 \frac{W}{m\cdot K}}$$

(2.) Izračunati ekvivalentnu termalnu otpornost za prolaz toplote i ekvivalentn koeficijent prolaza toplote horizontalne međuspratne konstrukcije, dužine 2,5m, čiji je vertikalni presek prikazan na slici. Koeficijenti prelaza toplote sa unutrašnje i spoljašnje strane su jednaki i iznose $7{,}69\ \frac{W}{m^2 K}$. Posmatrana struktura se sastoji od betona i opeke čiji su koeficijenti toplotne provodnosti $0{,}9\ \frac{W}{m\cdot K}$ i $0{,}61\ \frac{W}{m\cdot K}$ respektivno.



$\lambda_b = 9{,}9\ \frac{W}{m\cdot K}$

$\lambda_o = 0{,}61\ \frac{W}{m\cdot K}$



$L = 2{,}5\,m$

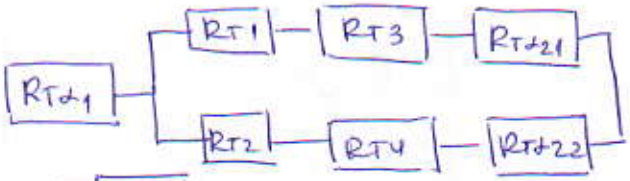
$S = (a_1 + a_2)\cdot L = 0{,}45 \cdot 2{,}5 = 1{,}125\,m^2$

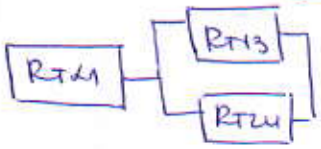
$S_1 = a_1 \cdot L = 0{,}15 \cdot 2{,}5 = 0{,}375\,m^2$

$S_2 = a_2 \cdot L = 0{,}3 \cdot 2{,}5 = 0{,}75\,m^2$

$R_{T13} = R_{T1} + R_{T3} + R_{T\alpha 21}$

$R_{T24} = R_{T2} + R_{T4} + R_{T\alpha 22}$





$R_{T1324} = \frac{R_{T13}\cdot R_{T24}}{R_{T13} + R_{T24}}$

$R_T = R_{T\alpha 1} + R_{T1324}$

$R_{T\alpha 1} = \frac{1}{\alpha_1 \cdot S} = 0{,}1156\ \frac{K}{W}$

$R_{T\alpha 21} = \frac{1}{\alpha_2 \cdot S_1} = 0{,}34677\ \frac{K}{W}$

$R_{T\alpha 22} = \frac{1}{\alpha_2 S_2} = 0{,}173385\ \frac{K}{W}$

$R_{T1} = \frac{h_1}{\lambda_b \cdot S_1} = \frac{0{,}05}{0{,}9 \cdot 0{,}375} = 0{,}148\ \frac{K}{W}$

$R_{T2} = \frac{h_1}{\lambda_b \cdot S_2} = \frac{0{,}05}{0{,}9 \cdot 0{,}75} = 0{,}074\ \frac{K}{W}$

$R_{T3} = \frac{h_2}{\lambda_b S_1} = \frac{0{,}18}{0{,}9 \cdot 0{,}375} = 0{,}53\dot{3}\ \frac{K}{W}$

$R_{T4} = \frac{h_2}{\lambda_o \cdot S_2} = \frac{0{,}18}{0{,}61 \cdot 0{,}75} = 0{,}39344\ \frac{K}{W}$

$R_{T13} = R_{T1} + R_{T3} + R_{T\alpha 21} = 1{,}0278\ \frac{K}{W}$

$R_{T24} = R_{T2} + R_{T4} + R_{T\alpha 22} = 0{,}640385\ \frac{K}{W}$

$R_{T1324} = \frac{R_{T13}\cdot R_{T24}}{R_{T13} + R_{T24}} = 0{,}39455\ \frac{K}{W}$

$R_T = R_{T\alpha 1} + R_{T1324} = 0{,}51015\ \frac{K}{W}$

$$U = \frac{1}{\sum R_{Ti} \cdot S_i}$$

$$R_{13} = R_{T13} \cdot S_1 = 0{,}385425 \ \frac{k \cdot w^2}{w}$$

$$R_{24} = R_{T24} \cdot S_2 = 0{,}480289 \ \frac{k \cdot w^2}{w}$$

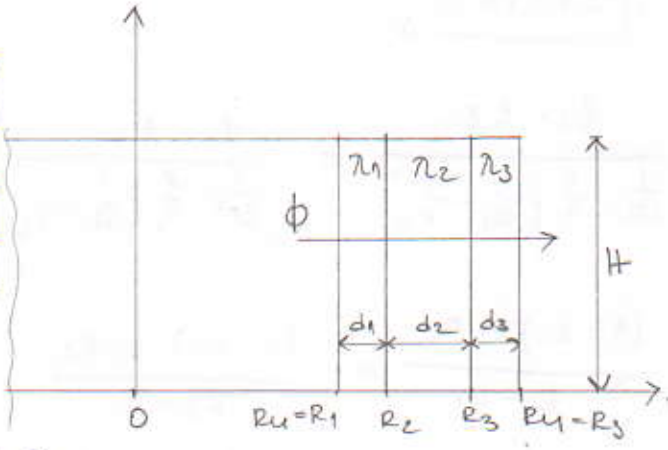
$$R_{1324} = \frac{R_{13} \cdot R_{24}}{R_{13} + R_{24}} = 0{,}2138297 \ \frac{k \cdot w^2}{w}$$

$$\sum R_{Ti} \cdot S_i = R_{T4} \cdot S + R_{1324} = 0{,}30053 \ \frac{k \cdot w^2}{w}$$

$$U = \frac{1}{0{,}30053} = 3{,}3275 \ \frac{w}{m^2 k}$$

(3) Cilindrični zid visine 10m i unutrašnjeg prečnika 7m je izrađen od tri sloja. Debljine slojeva i koeficijenti toplotnih provodnosti su dati u tabeli. Prvi sloj u tabeli se nalazi sa unutrašnje strane zida, a poslednji sa spoljašnje. Razlika temperatura vazduha sa unutrašnje i spoljašnje strane zida je konstantna i iznosi 20°C. Koeficijenti prelaza toplote sa unutrašnje i spoljašnje strane zida su $7{,}69 \ \frac{w}{m^2 k}$ i $25 \ \frac{w}{m^2 \cdot k}$ redom. Izračunati toplotni fluks kroz zid, podužnu gustinu fluksa, k20 i gustine toplotnih fluksova na unutrašnjoj i spoljašnjoj površini zida.

Br.	Materijal	Debljina d[cm]	$\lambda \left[\frac{w}{m \cdot k}\right]$
1	Malter	1,5	1,4
2	Armirani beton	40	2,33
3	Malter	3	1,4



$H = 10m \quad \Delta t = 20°C \quad \alpha_1 = 7{,}69 \ \frac{w}{m^2 k} \quad \alpha_2 = 25 \ \frac{w}{m^2 k}$

$R_1 = \frac{7m}{2} = 3{,}5m = R_u$

$R_2 = R_1 + d_1 = 3{,}515m$

$R_3 = R_2 + d_2 = 3{,}915m$

$R_4 = R_3 + d_3 = 3{,}945m = R_s$

$S_u = 2R_u \Pi \cdot H = 219{,}91m^2$

$S_s = 2R_s \Pi \cdot H = 247{,}87m^2$

$$\Phi = \frac{\Delta t}{\frac{1}{2\pi H}\left(\frac{1}{\alpha_1 R_1} + \sum_{i=1}^{3} \frac{1}{\lambda_i} \ln\left(\frac{R_{i+1}}{R_i}\right) + \frac{1}{\alpha_2 R_4}\right)} = \frac{20 \cdot 2\Pi \cdot 10}{\frac{1}{7{,}69 \cdot 3{,}5} + \frac{1}{1{,}4} \ln\left(\frac{3{,}515}{3{,}5}\right) + \frac{1}{2{,}33}\left(\frac{3{,}915}{3{,}515}\right) + \frac{1}{1{,}4}\left(\frac{3{,}945}{3{,}915}\right) + \frac{1}{25 \cdot 3{,}945}}$$

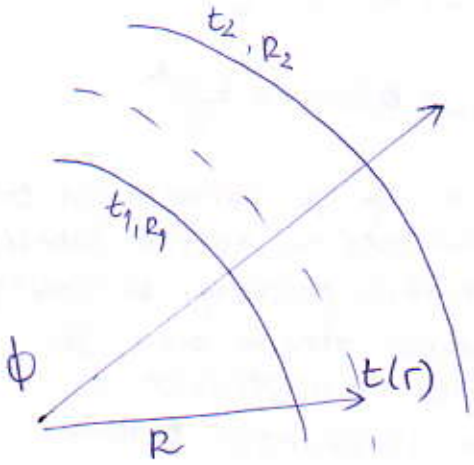
$$\Phi = 12313{,}16 \ W$$

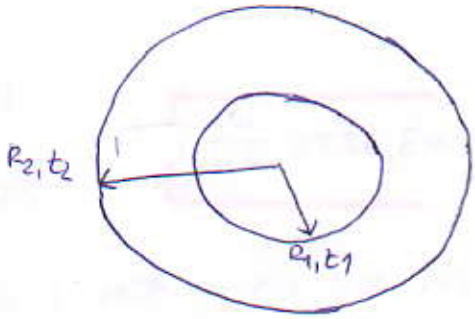
$$q_k = \frac{\Phi}{H} = 1231{,}316 \ \frac{W}{m}$$

$$q_u = \frac{\Phi}{S_u} = 55{,}99 \ \frac{W}{m^2}$$

$$q_s = \frac{\Phi}{S_s} = 49{,}68 \ \frac{W}{m^2}$$

(4.) Odrediti temperaturski raspodelu kroz sfernu ljusku čiji je unutrašnji poluprečnik R_1, a spoljašnji R_2. Temperature površina ljuske su: unutrašnja t_1 i spoljašnja t_2.





$$\phi = \frac{t_1 - t_2}{\frac{1}{2\pi} \cdot \frac{1}{\lambda}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

$$\phi(R) = \frac{t - t_2}{\frac{1}{2\pi} \cdot \frac{1}{\lambda}\left(\frac{1}{R} - \frac{1}{R_2}\right)}$$

$$\boxed{\phi(R) = \phi}$$

$$\frac{t_1 - t_2}{\frac{1}{2\pi} \cdot \frac{1}{\lambda}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)} = \frac{t - t_2}{\frac{1}{2\pi} \frac{1}{\lambda}\left(\frac{1}{R} - \frac{1}{R_2}\right)}$$

$$\frac{(t_1 - t_2) R_1 \cdot R_2}{R_2 - R_1} = \frac{(t - t_2) \cdot R \cdot R_2}{R_2 - R}$$

$$t - t_2 = \frac{(t_1 - t_2) \cdot R_1 \cdot R_2 (R_2 - R)}{(R_2 - R_1) \cdot R \cdot R_2}$$

$$t = t_2 + \frac{(t_1 - t_2) \cdot R_1 (R_2 - R)}{R(R_2 - R_1)}$$

$$\boxed{t(R) = t_2 + \frac{(t_1 - t_2) \cdot R_1 (R_2 - R)}{R(R_2 - R_1)}}$$

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