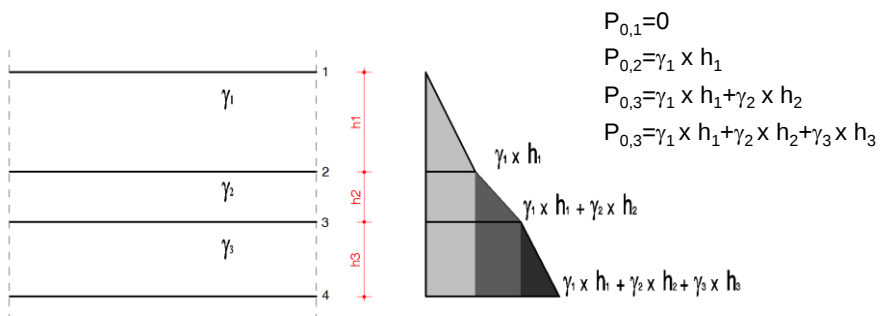


Vertikalni pritisci u tlu

Totalni, efektivni i neutralni napon u tlu

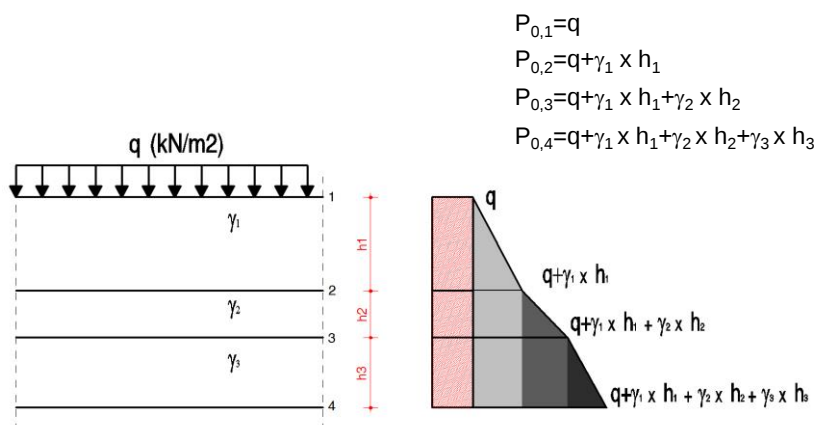
-Totalni napon u tlu P_0

P_0 – napon usled zapreminske težine tla



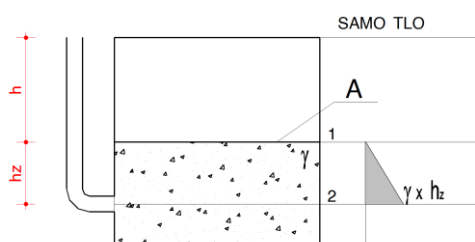
1

U slučaju opterećenja na tlo, totalni napon se povećava za veličinu pritiska na tlo



2

Posmatrajmo posudu napunjenu tlom prema slici

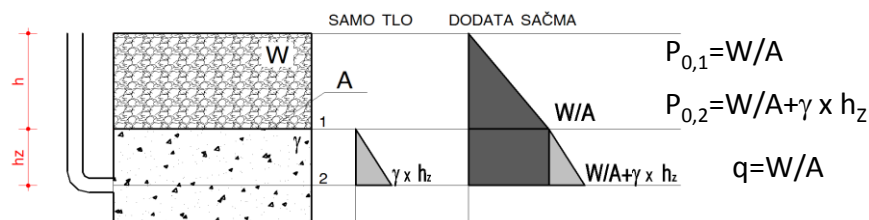


Totalni naponi

$$P_{0,1}=0$$

$$P_{0,2}=\gamma \times h_z$$

Ako posudu dopunimo sačmom do vrha totalni naponi su

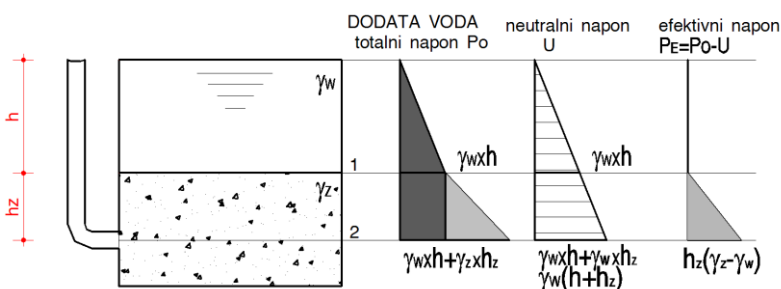


Opterećenje sačmom izaziva sleganje tla, smanjuje poroznost i povećava smičuću otpornost tla

3

Ako posudu napunimo vodom umesto sačmom, a da pri tom voda ispuni sve pore uzorka tla.

Tada je tlo ima težinu u zasićenom stanju γ_z



Napon $\gamma_w \times h$ naziva se neutralni napon (**U**) i on ne izaziva sleganje niti povećanje smičuće čvrstoće tla. Prenosi se porama tla u svim pravcima.

PE=Po-U naziva se efektivni napon u tlu. Prenosi se dodirnim površinama čvrstih čestica.

4

$$P_{E,1} = \gamma_w \cdot h - \gamma_w \cdot h = 0$$

$$P_{E,2} = \gamma_w \cdot h + \gamma_z \cdot h_z - \gamma_w \cdot h - \gamma_w \cdot h_z = h_z (\gamma_z - \gamma_w) = h_z \cdot \gamma'$$

Gde je γ' - zapreminska težina tla u potopljenom stanju

Zadaci

1. U propustljivom tlu nivo podzemne vode je na 2 m ispod površine terena. γ tla iznad nivoa podzemne vode je 18.5 kN/m^3 a ispod je $\gamma_z = 20 \text{ kN/m}^3$. Odrediti efektivni pritisak u tlu na dubini od 5 m ispod površine tla.

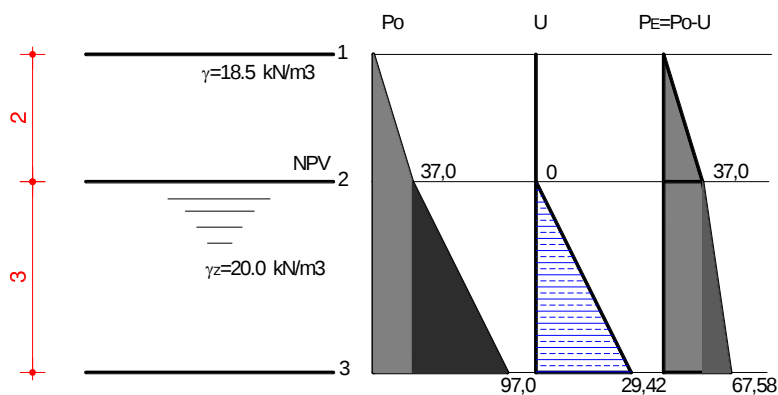
5

Totalni naponi P_o

$$P_{o,1} = 0 \text{ kN/m}^2$$

$$P_{o,2} = 18,5 \cdot 2 = 37,0 \text{ kN/m}^2$$

$$P_{o,3} = 18 \cdot 2 + 20 \cdot 3 = 37,0 + 60 = 97,0 \text{ kN/m}^2$$



6

Neutralni napon

$$U_1 = 0 \text{ kN/m}^2$$

$$U_2 = 0 \text{ kN/m}^2$$

$$U_3 = 3 \cdot 9,807 = 29,42 \text{ kN/m}^2$$

Efektivni napon $P_E = P_o - U$

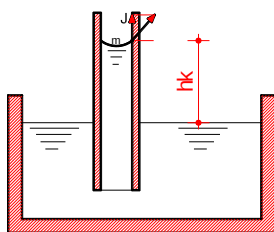
$$P_{E,1} = 0 \text{ kN/m}^2$$

$$P_{E,2} = 0 \text{ kN/m}^2$$

$$P_{E,3} = 97,0 - 29,42 = 67,58 \text{ kN/m}^2$$

7

2. Profil tla se sastoji od sloja nisko plastične gline (CL) debljine 10 m, koja leži na zbijenom pesku (SW). Podzemna voda se nalazi na dubini 4 m. Do visine kapilarnog penjanja $h_c = 4,0$ m glina je u zasićenom stanju. Sračunati i nacrtati dijagram vertikalnih totalnih i efektivnih napona u sloju ako je koeficijent poroznosti gline $e = 0,65$ i $G_s = 2,70$

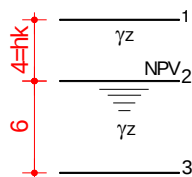


Kapilarnost: Voda se uz usku cev potopljenu u vodu penje uz cev do visine kapilarnog penjanja h_k

Penjanje vode izaziva intermolekularna sila privlačenja između zidova uske cevi i vode

Visina penjanja zavisi od prečnika cevi i temperature

8



Tlo je do visine kapilarnog penjanja u zasićenom stanju, pa je potrebno odrediti

γ_z

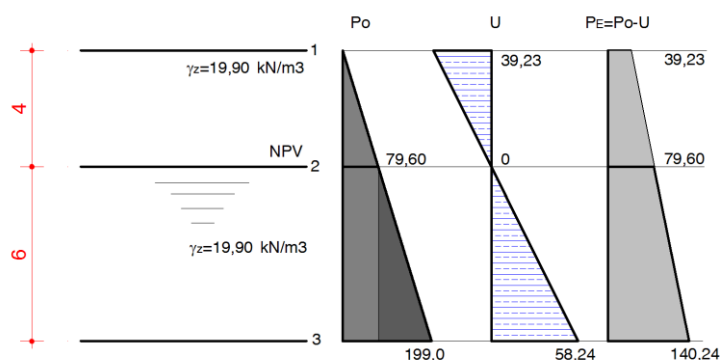
$$G_s = \frac{\gamma_s}{\gamma_w} \rightarrow \gamma_s = G_s \cdot \gamma_w = 2,70 \cdot 9,807 = 26,48 \text{ kN/m}^3$$

$$e = \frac{\gamma_s}{\gamma_d} - 1 \rightarrow \gamma_d = \frac{\gamma_s}{e+1} = \frac{26,48}{0,65+1} = 16,0 \text{ kN/m}^3$$

$$w_z = \left(\frac{1}{\gamma_d} - \frac{1}{\gamma_s} \right) \cdot \gamma_w = \left(\frac{1}{16} - \frac{1}{26,48} \right) \cdot 9,807 = 0,2458$$

$$\gamma_z = (1 + w_z) \cdot \gamma_d = (1 + 0,2458) \cdot 16,0 = 19,90 \text{ kN/m}^3$$

9



Totalni naponi Po

$$P_{o,1} = 0 \text{ kN/m}^2$$

$$P_{o,2} = 19,90 \cdot 4 = 79,6 \text{ kN/m}^2$$

$$P_{o,3} = 19,9 \cdot 10 = 199,0 \text{ kN/m}^2$$

Neutralni napon

$$U_1 = -9,807 \cdot 4 = -39,23 \text{ kN/m}^2$$

$$U_2 = 0 \text{ kN/m}^2$$

$$U_3 = 9,807 \cdot 6 = 58,84 \text{ kN/m}^2$$

10

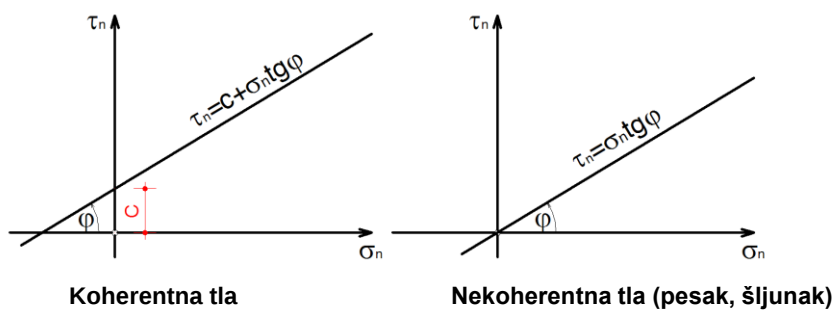
Efektivni napon $P_E = P_0 - U$

$$P_{E,1} = 0 - (-39,23) = 39,23 \text{ kN/m}^2$$

$$P_{E,2} = 79,6 - 0 = 79,6 \text{ kN/m}^2$$

$$P_{E,3} = 199,0 - 58,84 = 140,24 \text{ kN/m}^2$$

11

SMIČUĆA OTPORNOST TLA**Coulombov (Kulonov) zakon loma**

$$\tau_n = c + \sigma_n \operatorname{tg} \varphi$$

Gde su τ_n -smičuća čvrstoća tla

c-kohezija

 σ_n -normalni napon na ravni loma (smicanja) φ -ugao trenja tla

12

Merenje smičuće otpornosti tla

1. Opit direktnog smicanja
2. Opit jednoaksijalne kompresije
3. Opit triaksijalne kompresije

13

ZEMLJANI PRITISAK NA POTPORNE KONSTRUKCIJE

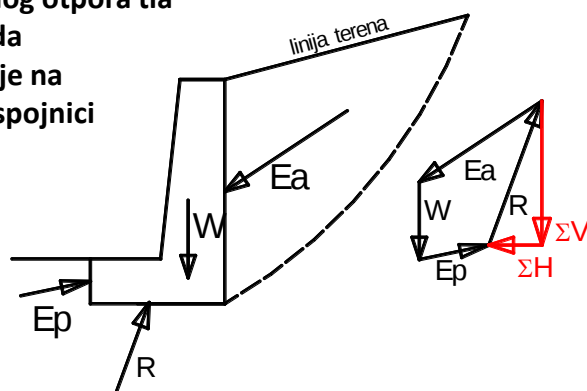
Gravitacione potporne konstrukcije – masivni potporni zidovi

E_a -sila aktivnog pritiska

E_p -sila pasivnog otpora tla

W – težina zida

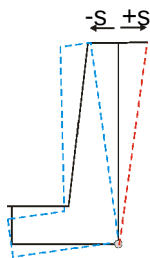
R – opterećenje na temeljnoj spojnici



Sile koje deluju na masivnu potpornu konstrukciju

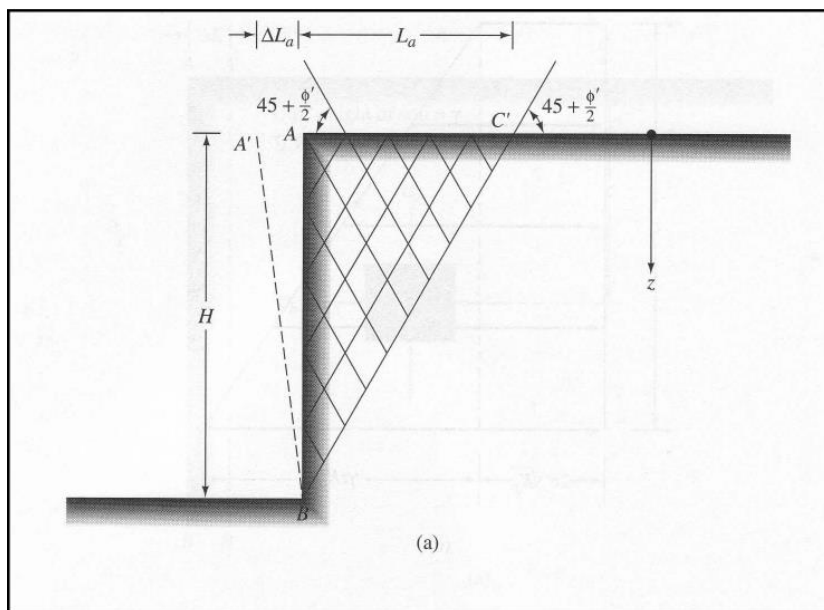
14

Aktivni pritisak i pasivni otpor tla



- Aktivni pritisak nastaje kada se zid pomera napred ili obrće oko nožice, što se uglavnom dešava u stišljivom tlu, zemljana masa se širi i klizi naniže stvarajući aktivni pritisak tla.
- Dijagram aktivnih pritisaka tla se dobija množeći vertikalni efektivni napon sa koeficijentom aktivnog pritiska tla k_a .
- Sila aktivnog pritiska tla je jednaka površini dijagrama aktivnog pritiska tla i deluje u težištu te površine.

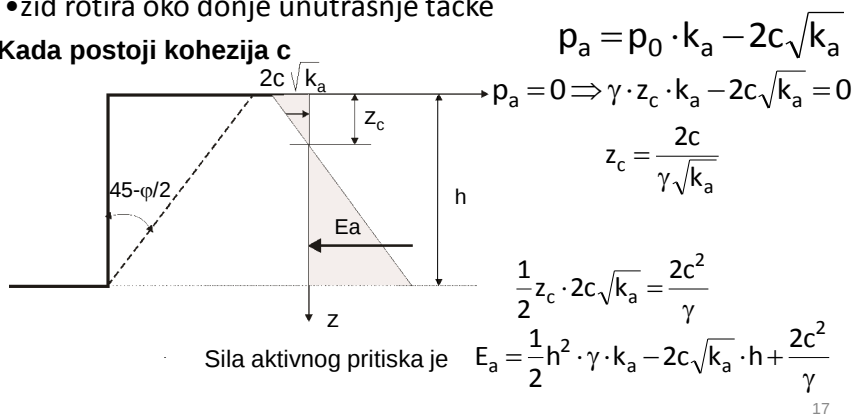
15



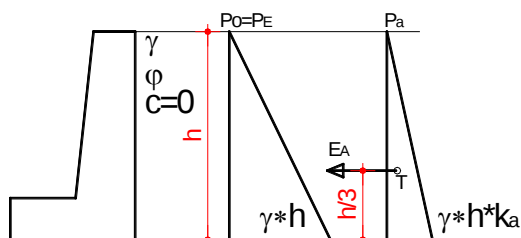
16

RANKINE-ova teorija. Uslovi:

- teren iza zida je horizontalan i proteže se dovoljno daleko
- Dodirna površina zida sa tlom je vertikalna
- Dodirna površina zida sa tlom je glatka
(nema trenja između tla i zida)
- zid rotira oko donje unutrašnje tačke

Kada postoji kohezija c

17

Kada je kohezija c=0

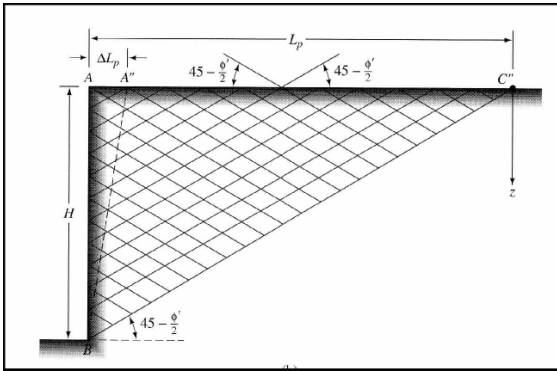
$$E_a = \gamma \cdot h \cdot \frac{h}{2} \cdot k_a = \gamma \frac{h^2}{2} \cdot k_a \quad \text{Površina dijagrama } P_a$$

Koeficijent aktivnog pritiska tla

$$k_a = \tan^2 \left(45 - \frac{\phi}{2} \right)$$

18

Pasivni otpor tla



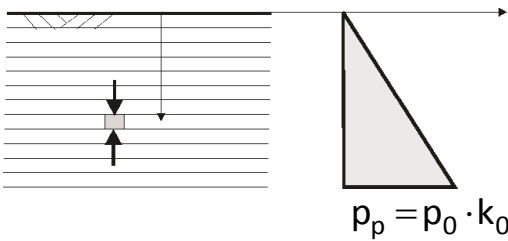
$$p_p = p_0 \cdot k_p + 2c\sqrt{k_p}$$

$$k_p = \tan^2(45 + \varphi/2)$$

Sila pasivnog otpora je
$$E_p = \frac{1}{2}h^2 \cdot \gamma \cdot k_p + 2c\sqrt{k_p} \cdot h$$

19

Tlo u stanju mirovanja



$$p_p = p_0 \cdot k_0$$

$$k_0 = 1 - \sin \varphi$$

$$p_p = p_0 \cdot k_0$$

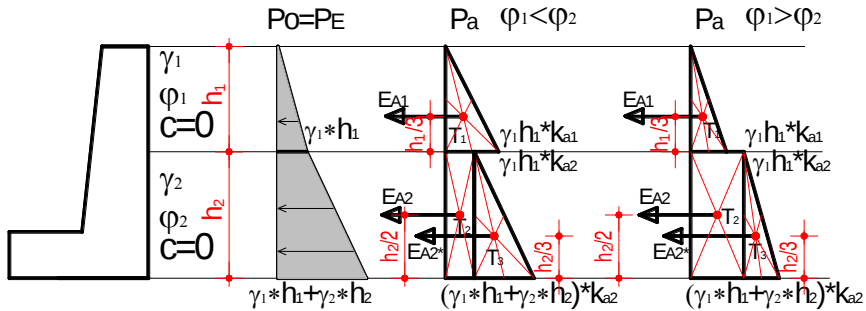
Redak slučaj

Uglavnom potporne konstrukcije proračunavamo na aktivno dejstvo tla

20

Posebni slučajevi aktivnog pritiska tla

*Dva sloja različitih karakteristika $\varphi_1 \neq \varphi_2 \Rightarrow k_{a1} \neq k_{a2} \quad c=0$



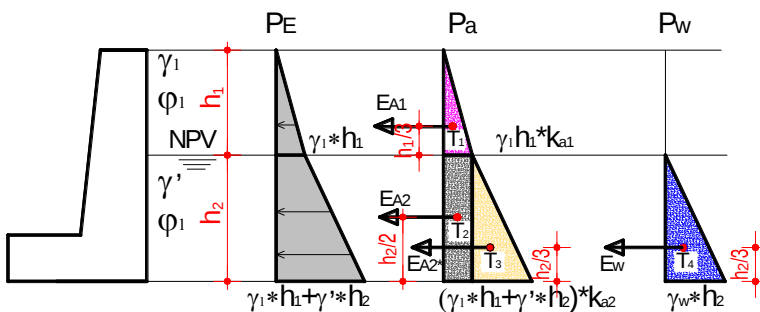
$$E_{a1} = \gamma_1 \cdot h_1 \cdot k_{a1} \cdot \frac{h_1}{2} = \gamma_1 \cdot k_{a1} \cdot \frac{h_1^2}{2} \quad E_{a2} = \gamma_1 \cdot h_1 \cdot k_{a2} \cdot h_2$$

$$E_{a2*} = (\gamma_1 \cdot h_1 + \gamma_2 \cdot h_2) \cdot k_{a2} - \gamma_1 \cdot h_1 \cdot k_{a2} = \gamma_2 \cdot h_2 \cdot k_{a2}$$

21

Posebni slučajevi aktivnog pritiska tla

*Voda u drugom sloju $\varphi_1 = \varphi_2 \Rightarrow k_{a1} = k_{a2} \quad c=0$



$$E_{a1} = \gamma_1 \cdot h_1 \cdot k_{a1} \cdot \frac{h_1}{2} = \gamma_1 \cdot k_{a1} \cdot \frac{h_1^2}{2} \quad E_{a2} = \gamma_1 \cdot h_1 \cdot k_{a2} \cdot h_2$$

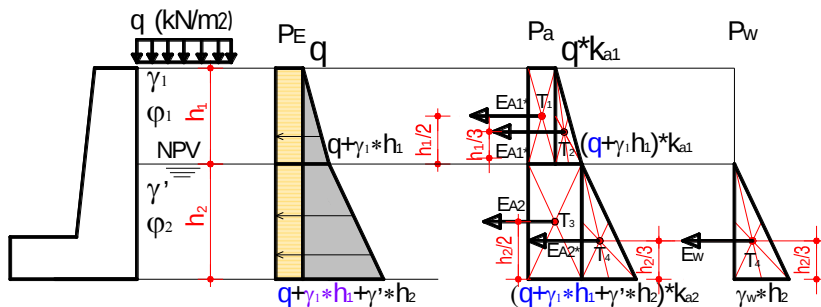
$$E_{a2*} = (\gamma_1 \cdot h_1 + \gamma' \cdot h_2) \cdot k_{a2} - \gamma_1 \cdot h_1 \cdot k_{a2} = \gamma' \cdot h_2 \cdot k_{a2}$$

$$E_w = \gamma_w \cdot h_2 \cdot \frac{h_2}{2} = \gamma_w \cdot \frac{h_2^2}{2}$$

22

Posebni slučajevi aktivnog pritiska tla

*Voda u drugom sloju +površinsko opterećenje



$$E_{a1} = q \cdot k_{a1} \cdot h_1$$

$$E_{a1}^* = \gamma_1 \cdot h_1 \cdot k_{a1} \cdot \frac{h_1}{2} = \gamma_1 \cdot k_{a1} \cdot \frac{h_1^2}{2}$$

$$E_{a2} = (q + \gamma_1 \cdot h_1) \cdot k_{a2} \cdot h_2$$

$$E_{a2}^* = \gamma' \cdot h_2 \cdot k_{a2} \cdot \frac{h_2}{2} = \gamma' \cdot k_{a2} \cdot \frac{h_2^2}{2}$$

$$E_w = \gamma_w \cdot h_2 \cdot \frac{h_2}{2} = \gamma_w \cdot \frac{h_2^2}{2}$$

23

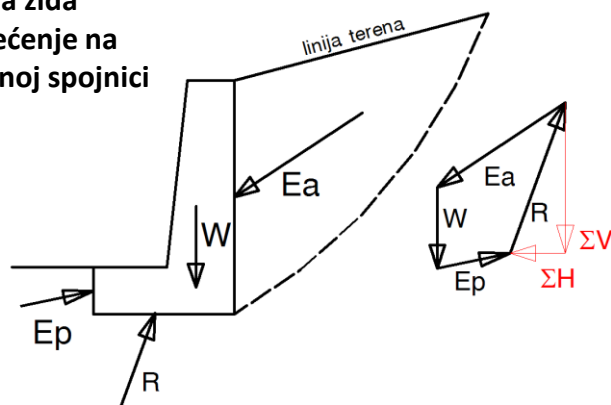
STABILNOST GRAVITACIONIH POTPORNIH ZIDOVA

Ea-sila aktivnog pritiska

Ep-sila pasivnog otpora tla

W – težina zida

R –opterećenje na temeljnoj spojnici



Sile koje deluju na masivnu potpornu konstrukciju

24

SIGURNOST NA KLIZANJE $F_S < 1$ – nestabilan

$$F_S = \frac{\Sigma V \cdot \operatorname{tg} \varphi}{\Sigma H} \geq 1.5$$

 $1 \leq F_S \leq 1.5(2)$ – uslovno stabilan $F_S > 1.5(2)$ – stabilan

$$F_S = \frac{\Sigma V \cdot \operatorname{tg} \varphi + E_p}{\Sigma H} \geq 2 \quad \text{-sa uzimanjem u obzir pasivnog otpora tla}$$

gde je

ΣV suma svih vertikalnih komponenti sila koje deluju na potporni zid (vertikalne projekcije aktivnih sila + težina zida)

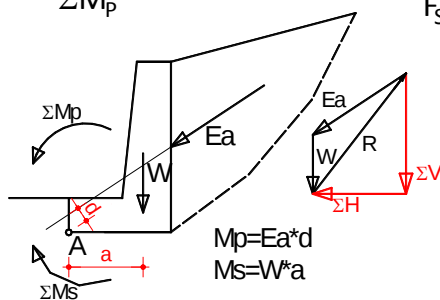
ΣH suma svih horizontalnih komponenti sila koje deluju na potporni zid (horizontalne projekcije aktivnih sila + sila od vode)

$\operatorname{tg} \varphi$ tangens ugla unutrašnjeg trenja tla sloja po kome kliza zid (za dvoslojno tlo to je drugi sloj)

25

SIGURNOST NA PRETURANJE $F_S < 1$ – nestabilan

$$F_S = \frac{\Sigma M_s}{\Sigma M_p} \geq 1.5$$

 $1 \leq F_S \leq 1.5$ – uslovno stabilan $F_S > 1.5$ – stabilan

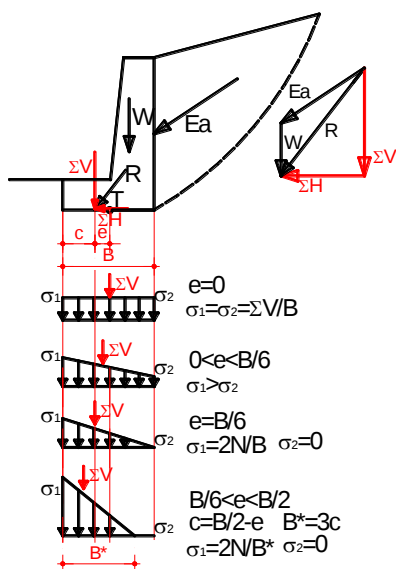
gde je

ΣM_s suma momenata oko tačke A svih stabilizujućih sila, a to sile čiji pravci prolaze desno od tačke A (tačka rotacije)

ΣM_p suma momenata oko tačke A svih sila koje preturaju zid, a to su sile čiji pravci prolaze levo od tačke A

26

KONTROLA IVIČNIH NAPONA



Osnova temelja je pravougaona sa težištem u tački T (sredina osnove stope širine B)

Rezultanta svih sila koje deluju na zid može

- da prolazi kroz težište (tačka T)
- da bude u jezgru preseka
- da bude izvan jezgra preseka
- da bude van osnove temelja

e-ekscentricitet rezultante sila

$$e = \frac{\sum M_T}{\sum V} \quad \text{Gde je}$$

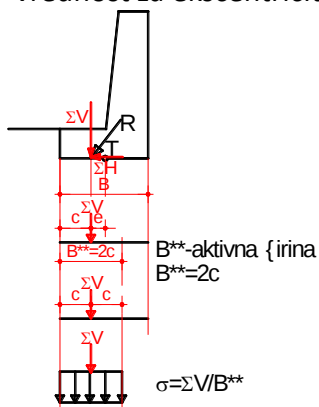
$\sum M_T$ -suma momenata svih sila u odnosu na težište preseka

27

Izraz za napon u opštem slučaju (ekscentrični pritisak) je:

$$\sigma_{1,2} = \frac{\sum V}{B} \left(1 \pm \frac{6 \cdot e}{B} \right)$$

iz koga su izvedene sve vrednosti napona ubacujući u jednačinu vrednost za ekscentricitet e



Granično opterećenje tla

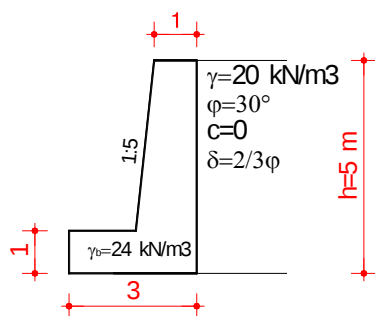
$\sigma = \sum V / B^{**}$ gde je $B^{**} = 2c$

Granično opterećenje upoređujemo sa graničnom nosivošću tla

28

ZADACI

1. Za zadati potporni zid odrediti
 - Sigurnost na klizanje
 - Sigurnost na preturanje
 - Izvršiti kontrolu ivičnih napona

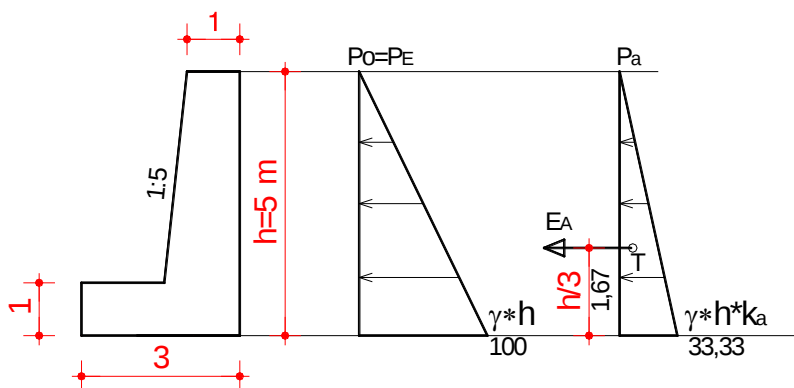


29

Rešenje

1. Efektivni pritisci u tlu $P_E = P_0$ ($p_0 = \gamma \cdot h$) –nema neutralnih napona
 $p_{0,0} = 0 \text{ kN/m}^2$
 $p_{0,1} = 20 \cdot 5,0 = 100,0 \text{ kN/m}^2$
2. Koeficijent aktivnog pritiska tla
 $k_a = \tan^2(45 - \varphi/2) = \tan^2(45 - 30/2) = 0.33$
3. Aktivni pritisci tla $P_A = P_E \cdot k_a$
 $p_{A,0} = 0 \text{ kN/m}^2$
 $p_{A,1} = 100,0 \cdot 0.33 = 33,3 \text{ kN/m}^2$

30



4. Aktivna sila pritiska

$$E_A = \gamma \cdot h \cdot k_a \cdot h / 2 = 33,33 \cdot 5 / 2 = 83,25 \text{ kN/m}$$

31

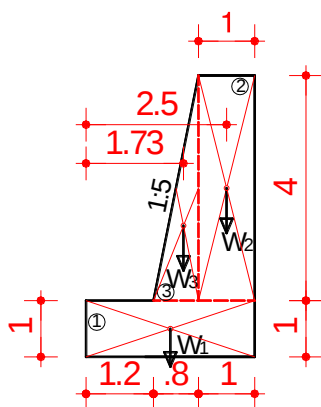
5. Težina zida

$$W_1 = 3 \cdot 1 \cdot 24 = 72,0 \text{ kN/m}$$

$$W_2 = 1 \cdot 4 \cdot 24 = 96,0 \text{ kN/m}$$

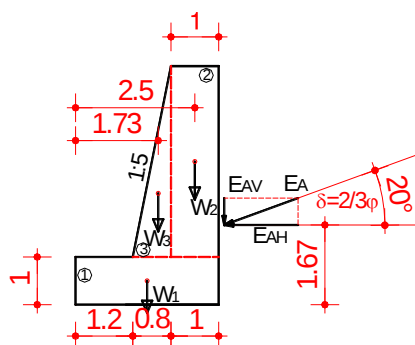
$$W_3 = 0,8 \cdot 4 / 2 \cdot 24 = 38,40 \text{ kN/m}$$

$$\Sigma W = 206,40 \text{ kN/m}$$

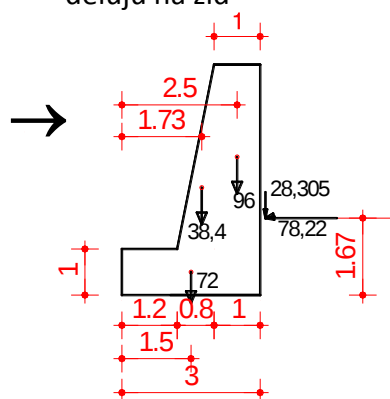


32

Dejstvo sila na zid



Vrednosti i položaj sila koje deluju na zid



6. Dejstvo aktivnih sila na zid

$$E_{AV} = E_A \cdot \sin \delta = E_A \cdot \sin(2/3\varphi) = 83.25 \cdot \sin 20^\circ = 28,305 \text{ kN/m}$$

$$E_{AH} = E_A \cdot \cos \delta = E_A \cdot \cos(2/3\varphi) = 83.25 \cdot \cos 20^\circ = 78,22 \text{ kN/m}$$

33

7. Sigurnost na klizanje

$$F_s = \frac{\Sigma V \cdot \operatorname{tg} \varphi}{\Sigma H} \geq 1.5$$

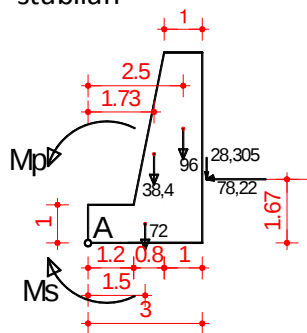
$$\Sigma V = \Sigma W + E_{AV} = 206,4 + 28,3 = 234,7 \text{ kN/m}$$

$$\Sigma H = E_{AH} = 78,22 \text{ kN/m}$$

$$F_s = \frac{234,7 \cdot \operatorname{tg} 30^\circ}{78,22} = 1.73 > 1.5 - \text{stabilan}$$

8. Sigurnost na preturanje

$$F_s = \frac{\Sigma M_s}{\Sigma M_p} \geq 1.5$$



34

$$\begin{aligned}\Sigma M_S &= W_1 \cdot 1,5 + W_2 \cdot 2,5 + W_3 \cdot 1,73 + E_{AV} \cdot 3,0 = \\ &= 72 \cdot 1,5 + 96 \cdot 2,5 + 38,4 \cdot 1,73 + 28,3 \cdot 3,0 = \\ \Sigma M_S &= 499,3 \text{ kNm/m}\end{aligned}$$

$$\Sigma M_p = E_{AH} \cdot 1,67 = 78,22 \cdot 1,67 = 130,36 \text{ kNm/m}$$

$$F_s = \frac{\Sigma M_s}{\Sigma M_p} = \frac{499,33}{130,36} = 3,83 > 1.5 - \text{stabilan}$$

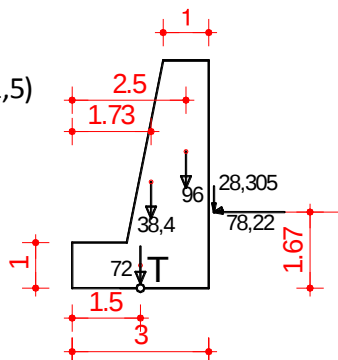
9. Kontrola ivičnih napona

$$\Sigma M_T = W_1 \cdot 0 + W_2 \cdot (2,5 - 1,5) + W_3 \cdot (1,73 - 1,5) + E_{AV} \cdot 1,5 - \Sigma M_p =$$

$$96 \cdot 1,0 + 38,4 \cdot 0,23 + 28,3 \cdot 1,5 - 130,36 =$$

$$\Sigma M_T = 147,28 - 130,36 = 16,92 \text{ kNm/m}$$

$$e = \frac{\Sigma M_T}{\Sigma V} = \frac{16,92}{234,7} = 0,07m = 7cm$$



35

$$e < \frac{B}{6} = \frac{300}{6} = 50\text{cm} \quad \text{Rezultanta u jezgru preseka}$$

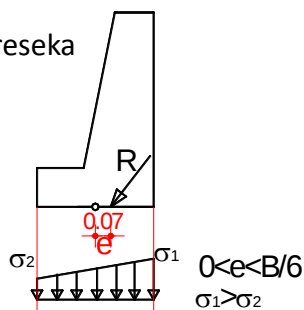
Određivanje napona

$$\sigma_{1,2} = \frac{\Sigma V}{B} \left(1 \pm \frac{6 \cdot e}{B} \right)$$

$$\sigma_{1,2} = \frac{234,7}{3,0} \left(1 \pm \frac{6 \cdot 0,07}{3,0} \right) = 78,23(1 \pm 0,14)$$

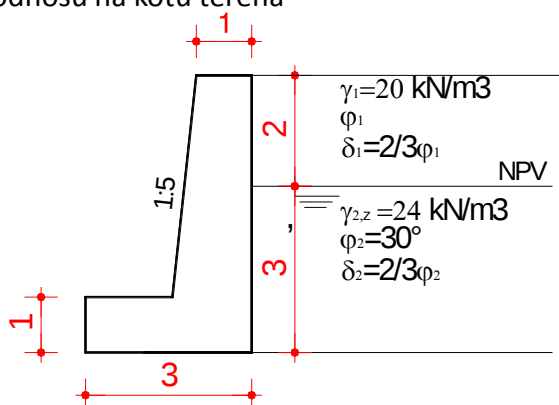
$$\sigma_1 = 78,23 \cdot 1,14 = 89,18 \text{ kN/m}^2$$

$$\sigma_2 = 78,23 \cdot 0,86 = 67,27 \text{ kN/m}^2$$



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2. Za potporni zid iz prethodnog zadatka odrediti
- Sigurnost na klizanje
 - Sigurnost na preturanje
 - Izvršiti kontrolu ivičnih napona
- u slučaju da se nivo podzemne vode nalazi na dubini od 2 m u odnosu na kotu terena



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1. Efektivni napon u tlu

Totalni naponi P_o

$$P_{o,1} = 0 \text{ kN/m}^2$$

$$P_{o,2} = 20 \cdot 2 = 40,0 \text{ kN/m}^2$$

$$P_{o,3} = 20 \cdot 2 + 24 \cdot 3 = 112,0 \text{ kN/m}^2$$

Neutralni napon U

$$U_1 = 0 \text{ kN/m}^2$$

$$U_2 = 0 \text{ kN/m}^2$$

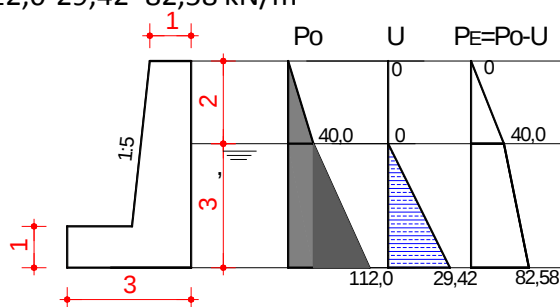
$$U_3 = 9,807 \cdot 3 = 29,42 \text{ kN/m}^2$$

Efektivni napon $P_E = P_o - U$

$$P_{E,1} = 0 \text{ kN/m}^2$$

$$P_{E,2} = 40,0 - 0 = 40,0 \text{ kN/m}^2$$

$$P_{E,3} = 112,0 - 29,42 = 82,58 \text{ kN/m}^2$$



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2. Koeficijent aktivnog pritiska tla

$$k_{a1} = \operatorname{tg}^2(45 - \varphi_1/2) = \operatorname{tg}^2(45 - 30/2) = 0.33$$

$$k_{a2} = \operatorname{tg}^2(45 - \varphi_2/2) = \operatorname{tg}^2(45 - 30/2) = 0.33$$

3. Dijagram aktivnih pritisaka tla $P_A = P_E \cdot k_a$

$$p_{A,0} = 0 \text{ kN/m}^2$$

$$p_{A,1} = 40,0 \cdot 0.33 = 13,20 \text{ kN/m}^2$$

$$p_{A,2} = 82,58 \cdot 0.33 = 27,25 \text{ kN/m}^2$$

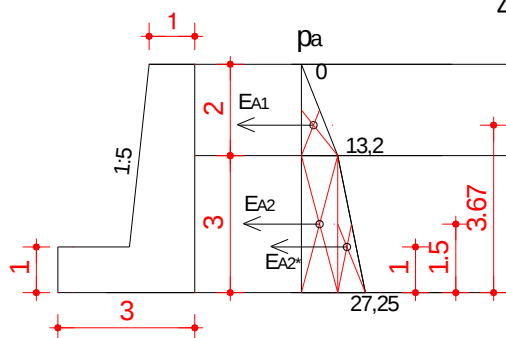
4. Aktivne sila pritiska od tla

$$E_{A1} = 13,2 \cdot 2/2 = 13,2 \text{ kN/m}$$

$$E_{A2} = 13,2 \cdot 3 = 39,6 \text{ kN/m}$$

$$E_{A2*} = (27,25 - 13,2) \cdot 3/2 =$$

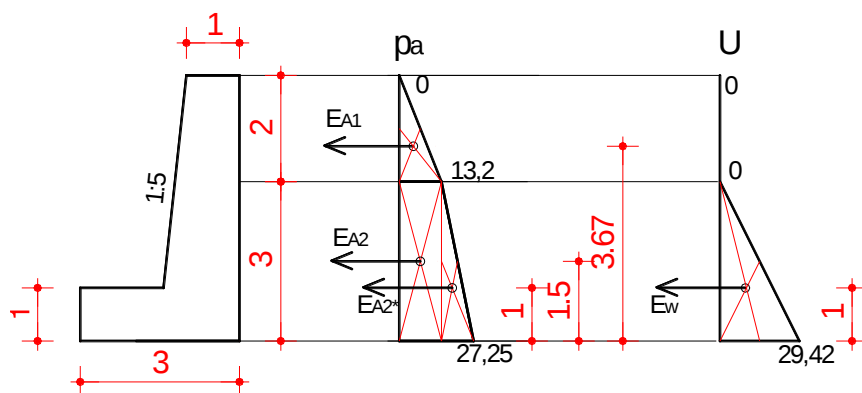
$$E_{A2*} = 21,08 \text{ kN/m}$$



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5. Sila pritiska od vode

$$E_w = 29,42 \cdot 3/2 = 44,13 \text{ kN/m}$$



40

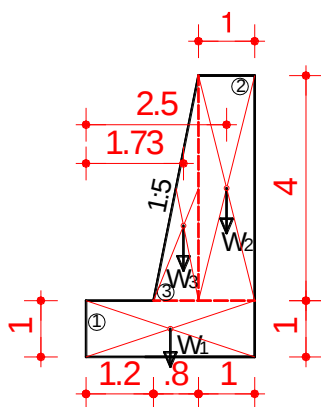
6. Težina zida

$$W_1 = 3 \cdot 1 \cdot 24 = 72,0 \text{ kN/m}$$

$$W_2 = 1 \cdot 4 \cdot 24 = 96,0 \text{ kN/m}$$

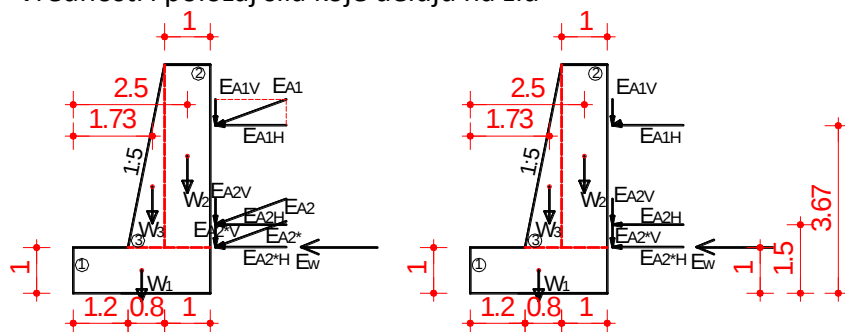
$$W_3 = 0,8 \cdot 4 / 2 \cdot 24 = 38,40 \text{ kN/m}$$

$$\Sigma W = 206,40 \text{ kN/m}$$



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Vrednosti i položaj sila koje deluju na zid



7. Dejstvo aktivnih sila na zid od tla

$$E_{A1V} = E_{A1} \cdot \sin \delta = 13,2 \cdot \sin 20^\circ = 4,51 \text{ kN/m}$$

$$E_{A1H} = E_{A1} \cdot \cos \delta = 13,2 \cdot \cos 20^\circ = 12,40 \text{ kN/m}$$

$$E_{A2V} = E_{A2} \cdot \sin \delta = 39,6 \cdot \sin 20^\circ = 13,54 \text{ kN/m}$$

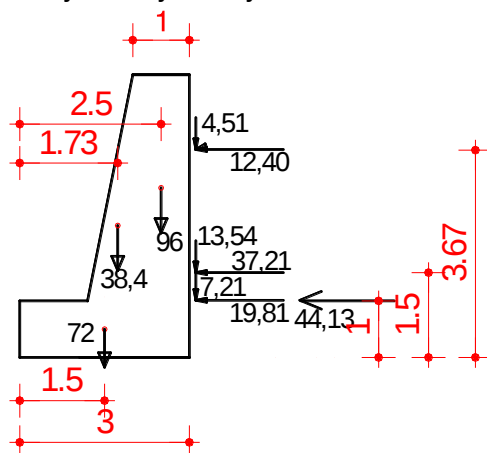
$$E_{A2H} = E_{A2} \cdot \cos \delta = 39,6 \cdot \cos 20^\circ = 37,21 \text{ kN/m}$$

$$E_{A2*V} = E_{A2*} \cdot \sin \delta = 21,08 \cdot \sin 20^\circ = 7,21 \text{ kN/m}$$

$$E_{A2*H} = E_{A2*} \cdot \cos \delta = 21,08 \cdot \cos 20^\circ = 19,81 \text{ kN/m}$$

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Vrednosti i položaj sila koje deluju na zid



$$\Sigma E_{AV} = 4,51 + 13,54 + 7,21 = 25,26 \text{ kN/m}$$

$$\Sigma V = 25,26 + 96 + 38,4 + 72 = 231,66 \text{ kN/m}$$

$$\Sigma H = 12,40 + 37,21 + 19,81 + 44,13 = 113,55 \text{ kN/m}$$

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8. Sigurnost na klizanje

$$F_s = \frac{\Sigma V \cdot \tan \phi}{\Sigma H} \geq 1.5$$

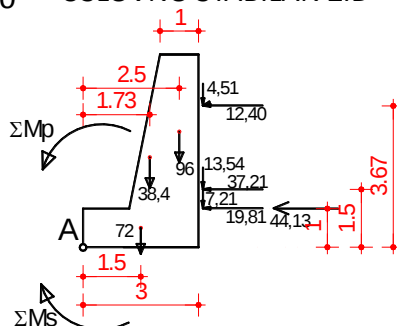
$$\Sigma V = \Sigma W + \Sigma E_{AV} = 231,66 \text{ kN/m}$$

$$\Sigma H = \Sigma E_{AH} = 113,55 \text{ kN/m}$$

$$F_s = \frac{231,66 \cdot \tan 30^\circ}{113,55} = 1.18 > 1.0 \quad \text{USLOVNO STABILAN ZID}$$

9. Sigurnost na preturanje

$$F_s = \frac{\Sigma M_s}{\Sigma M_p} \geq 1.5$$



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$$\Sigma M_S = 72 \cdot 1,5 + 96 \cdot 2,5 + 38,4 \cdot 1,73 + 25,26 \cdot 3,0 =$$

$$\Sigma M_S = 490,2 \text{ kNm/m}$$

$$\Sigma M_P = (19,81 + 44,13) \cdot 1,0 + 37,21 \cdot 1,5 + 12,40 \cdot 3,67 =$$

$$\Sigma M_P = 165,26 \text{ kNm/m}$$

$$F_S = \frac{\Sigma M_S}{\Sigma M_P} = \frac{490,20}{165,26} = 2,96 > 1,5 - \text{stabilan}$$

10. Kontrola ivičnih napona

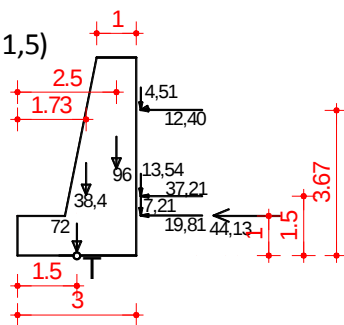
$$\Sigma M_T = W_1 \cdot 0 + W_2 \cdot (2,5 - 1,5) + W_3 \cdot (1,73 - 1,5)$$

$$+ E_{AV} \cdot 1,5 - \Sigma M_P =$$

$$96 \cdot 1,0 + 38,4 \cdot 0,23 + 25,26 \cdot 1,5 - 165,26 =$$

$$\Sigma M_T = 142,72 - 165,26 = 22,54 \text{ kNm/m}$$

$$e = \frac{\Sigma M_T}{\Sigma V} = \frac{-22,54}{231,66} = -0,097 \text{ m} = 9,7 \text{ cm}$$



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$$e < \frac{B}{6} = \frac{300}{6} = 50 \text{ cm} \quad \text{Rezultanta u jezgru preseka}$$

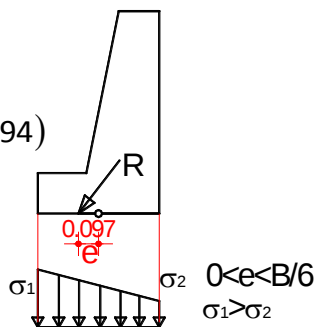
Određivanje napona

$$\sigma_{1,2} = \frac{\Sigma V}{B} \left(1 \pm \frac{6 \cdot e}{B} \right)$$

$$\sigma_{1,2} = \frac{231,66}{3,0} \left(1 \pm \frac{6 \cdot 0,097}{3,0} \right) = 77,22 (1 \pm 0,194)$$

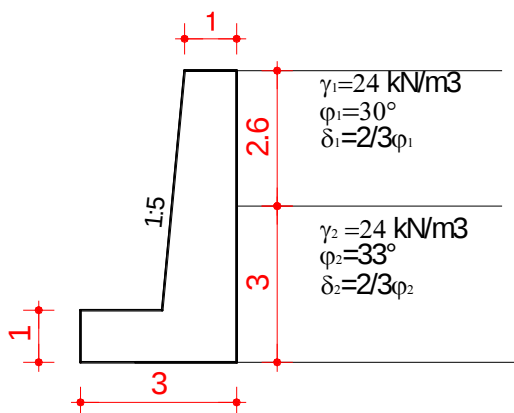
$$\sigma_1 = 77,22 \cdot 1,194 = 92,20 \text{ kN/m}^2$$

$$\sigma_2 = 77,22 \cdot 0,806 = 62,24 \text{ kN/m}^2$$



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3. Za potporni zid prema skici odrediti
- Sigurnost na klizanje
 - Sigurnost na preturanje
 - Izvršiti kontrolu ivičnih napona



47

1. Efektivni napon u tlu $P_E = P_0$

Totalni naponi P_0

$$P_{0,1} = 0 \text{ kN/m}^2$$

$$P_{0,2} = 24 \cdot 2,4 = 62,4 \text{ kN/m}^2$$

$$P_{0,3} = 62,4 + 20 \cdot 3 = 122,4 \text{ kN/m}^2$$

2. Koeficijent aktivnog pritiska tla

$$k_{a1} = \tan^2(45 - \varphi_1/2) = \tan^2(45 - 30/2) = 0.333$$

$$k_{a2} = \tan^2(45 - \varphi_2/2) = \tan^2(45 - 33/2) = 0.294$$

3. Dijagram aktivnih pritisaka tla $P_A = P_E \cdot k_a$

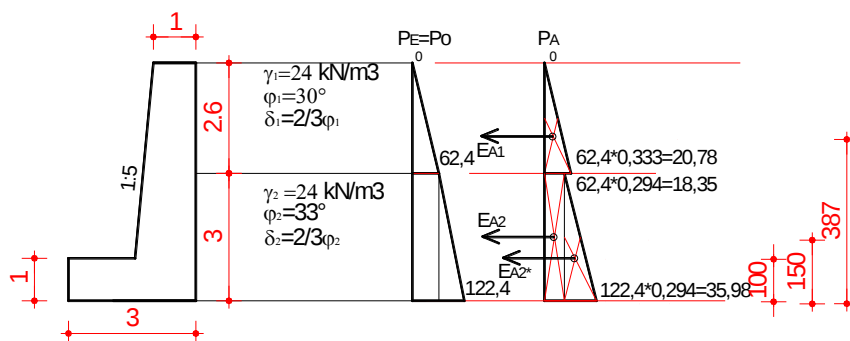
$$p_{A,1} = 0 \text{ kN/m}^2$$

$$p_{A,2}^g = 62,4 \cdot 0,333 = 20,78 \text{ kN/m}^2$$

$$p_{A,2}^d = 62,4 \cdot 0,294 = 18,35 \text{ kN/m}^2$$

$$p_{A,3} = 122,4 \cdot 0,294 = 35,98 \text{ kN/m}^2$$

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4. Aktivne sila pritiska od tla

$$E_{A1} = 20,78 \cdot 2,6 / 2 = 27,01 \text{ kN/m}$$

$$E_{A2} = 18,35 \cdot 3 = 55,05 \text{ kN/m}$$

$$E_{A2*} = (35,98 - 18,35) \cdot 3 / 2 = 26,44 \text{ kN/m}$$

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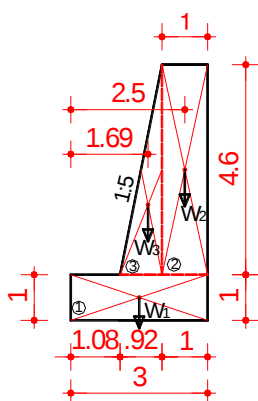
6. Težina zida

$$W_1 = 3 \cdot 1 \cdot 24 = 72,00 \text{ kN/m}$$

$$W_2 = 1 \cdot 4,6 \cdot 24 = 110,40 \text{ kN/m}$$

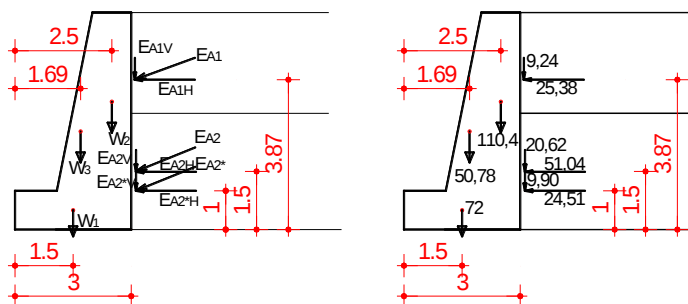
$$W_3 = 0,92 \cdot 4,6 / 2 \cdot 24 = 50,78 \text{ kN/m}$$

$$\Sigma W = 233,18 \text{ kN/m}$$



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Vrednosti i položaj sila koje deluju na zid



7. Dejstvo aktivnih sila na zid od tla

$$E_{A1V} = E_{A1} \cdot \sin \delta_1 = 27,01 \cdot \sin 20^\circ = 9,24 \text{ kN/m}$$

$$E_{A1H} = E_{A1} \cdot \cos \delta_1 = 27,01 \cdot \cos 20^\circ = 25,38 \text{ kN/m}$$

$$E_{A2V} = E_{A2} \cdot \sin \delta_2 = 55,05 \cdot \sin 22^\circ = 20,62 \text{ kN/m}$$

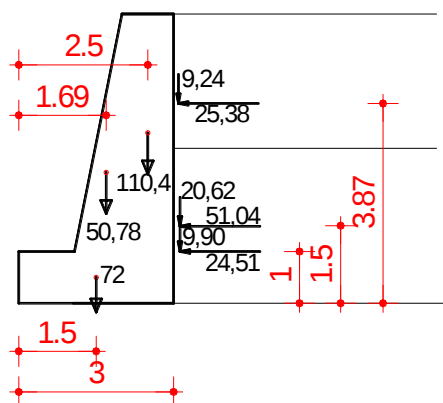
$$E_{A2H} = E_{A2} \cdot \cos \delta_2 = 55,05 \cdot \cos 22^\circ = 51,04 \text{ kN/m}$$

$$E_{A2*V} = E_{A2*} \cdot \sin \delta_2 = 26,44 \cdot \sin 22^\circ = 9,90 \text{ kN/m}$$

$$E_{A2*H} = E_{A2*} \cdot \cos \delta_2 = 26,44 \cdot \cos 22^\circ = 24,51 \text{ kN/m}$$

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Vrednosti i položaj sila koje deluju na zid



$$\Sigma E_{AV} = 9,24 + 20,62 + 9,90 = 39,76 \text{ kN/m}$$

$$\Sigma V = \Sigma E_{AV} + \Sigma W = 39,76 + 233,18 = 272,94 \text{ kN/m}$$

$$\Sigma H = 25,38 + 51,04 + 24,51 = 100,93 \text{ kN/m}$$

52

$$e < \frac{B}{6} = \frac{300}{6} = 50\text{cm} \quad \text{Rezultanta u jezgru preseka}$$

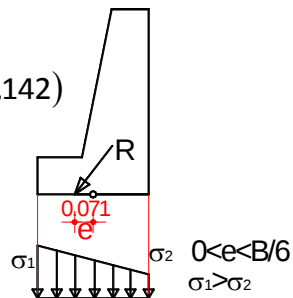
Određivanje napona

$$\sigma_{1,2} = \frac{\Sigma V}{B} \left(1 \pm \frac{6 \cdot e}{B} \right)$$

$$\sigma_{1,2} = \frac{272,94}{3,0} \left(1 \pm \frac{6 \cdot 0,071}{3,0} \right) = 90,98 (1 \pm 0,142)$$

$$\sigma_1 = 90,98 \cdot 1,142 = 103,90 \text{ kN/m}^2$$

$$\sigma_2 = 90,98 \cdot 0,858 = 78,06 \text{ kN/m}^2$$



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