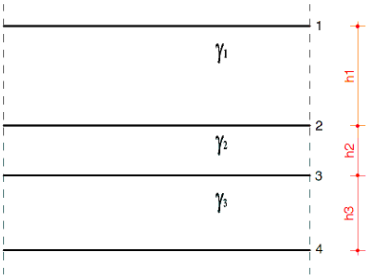
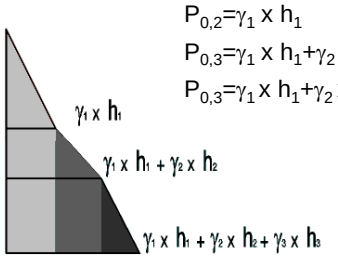
Vertikalni pritisci u tlu

Totalni, efektivni i neutralni napon u tlu

-Totalni napon u tlu P_0

P_0 – napon usled zapreminske težine tla





$P_{0,1}=0$

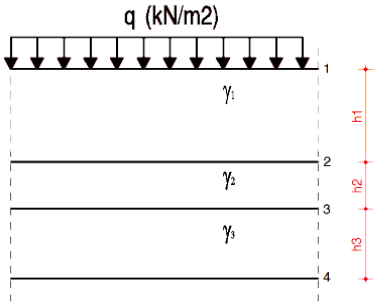
$P_{0,2}=\gamma_1 \times h_1$

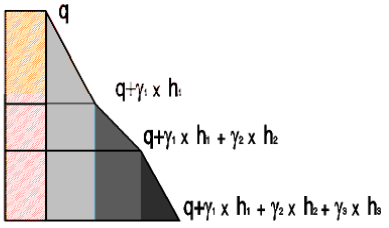
$P_{0,3}=\gamma_1 \times h_1+\gamma_2 \times h_2$

$P_{0,3}=\gamma_1 \times h_1+\gamma_2 \times h_2+\gamma_3 \times h_3$

1

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





$P_{0,1}=q$

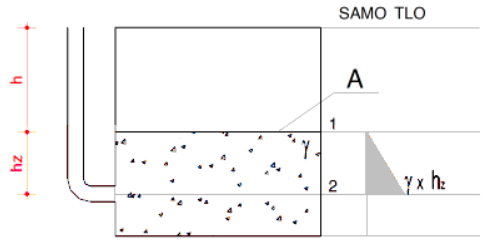
$P_{0,2}=q+\gamma_1 \times h_1$

$P_{0,3}=q+\gamma_1 \times h_1+\gamma_2 \times h_2$

$P_{0,4}=q+\gamma_1 \times h_1+\gamma_2 \times h_2+\gamma_3 \times h_3$

2

Posmatrajmo posudu napunjenu tlom prema slici

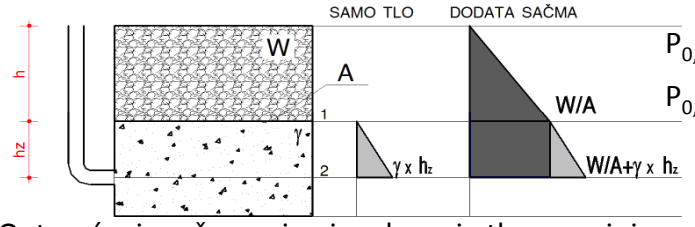


Totalni naponi

$P_{0,1}=0$

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

Ako posudu dopunimo sačmom do vrha totalni naponi su



$P_{0,1}=W/A$

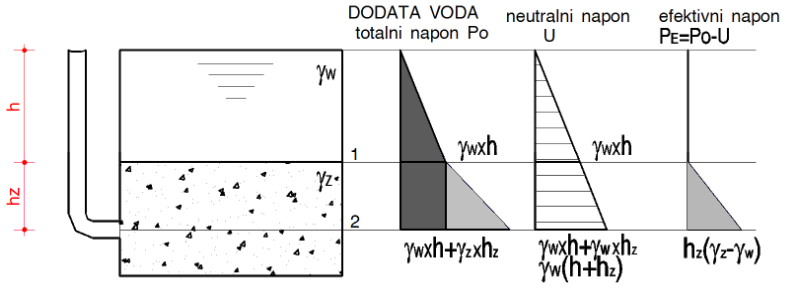
$P_{0,2}=W/A+\gamma \times h_z$

$q=W/A$

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 γ_w***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 γ_z=20 kN/m^3. Odrediti efektivni pritisak u tlu na dubini od 5 m ispod površine tla.

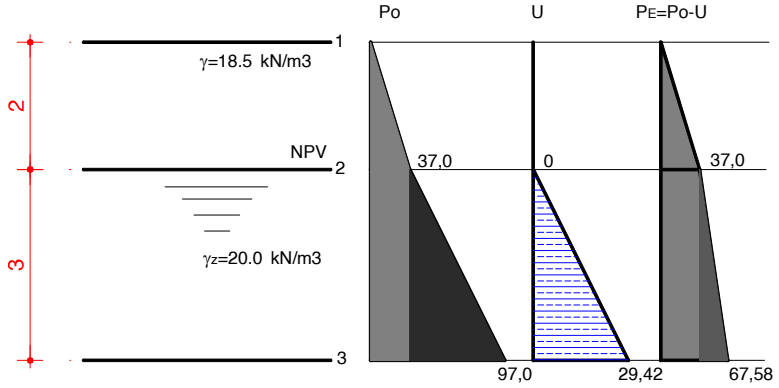
5

Totalni naponi Po

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

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

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



6

Neutralni napon

$U_1 = 0$ kN/m^2

$U_2 = 0$ kN/m^2

$U_3 = 3*9,807=29,42$ kN/m^2

Efektivni napon P_E=Po-U

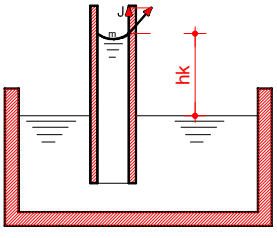
$P_{E,1} = 0$ kN/m^2

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

$P_{E,3} = 97,0-29,42=67,58$ 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 hc=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 Gs=2,70

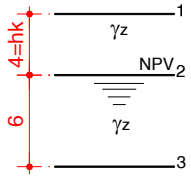


Kapilarnost: Voda se uz usku cev potopljenu u vodu penje uz cev do visine kapilarnog penjanja h_k

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

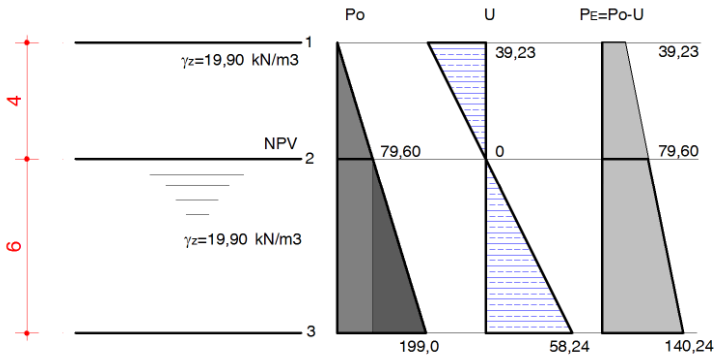
$$G_S = \frac{\gamma_s}{\gamma_w} \rightarrow \gamma_s = G_s \cdot \gamma_w = 2.70 \cdot 9{,}807 = 26{,}48 \text{kN/m}^3$$

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

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

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

9



Totalni naponi Po

$P_{o,1}$ = 0 kN/m²

$P_{o,2}$ = 19,90*4=79,6 kN/m²

$P_{o,3}$= 19,9*10=199,0 kN/m²

Neutralni napon

U_1 =-9.807*4=-39,23 kN/m²

U_2 = 0 kN/m²

U_3= 9,807*6=58,84 kN/m²

10

Efektivni napon P_E=Po-U

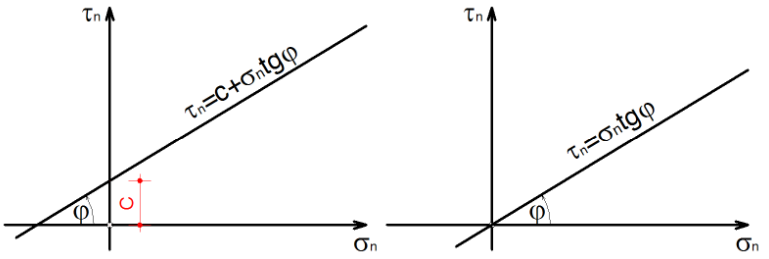
$P_{E,1}$ = 0-(-39,23)=39,23 kN/m^2

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

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

11

SMIČUĆA OTPORNOST TLA



Koherentna tla **Nekoherentna tla (pesak, šljunak)**

Coulombov (Kulonov) zakon loma

$\tau_n = c + \sigma_n tg\varphi$

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

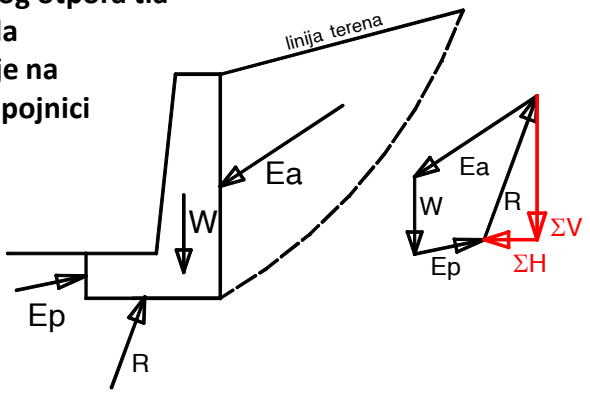
1. **Opit direktnog smicanja**
2. **Opit jednoaksijalne kompresije**
3. **Opit triaksijalne kompresije**

13

ZEMLJANI PRITISAK NA POTPORNE KONSTRUKCIJE

Gravitacione potporne konstrukcije – masivni potporni zidovi

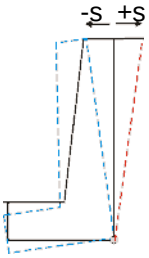
Ea-sila aktivnog pritiska
Ep-sila pasivnog otpora tla
W – težina zida
R –opterećenje na temeljnoj spojnici



Sile koje deluju na masivnu potpornu konstrukciju

14

Aktivni pritisak i pasivni otpor tla

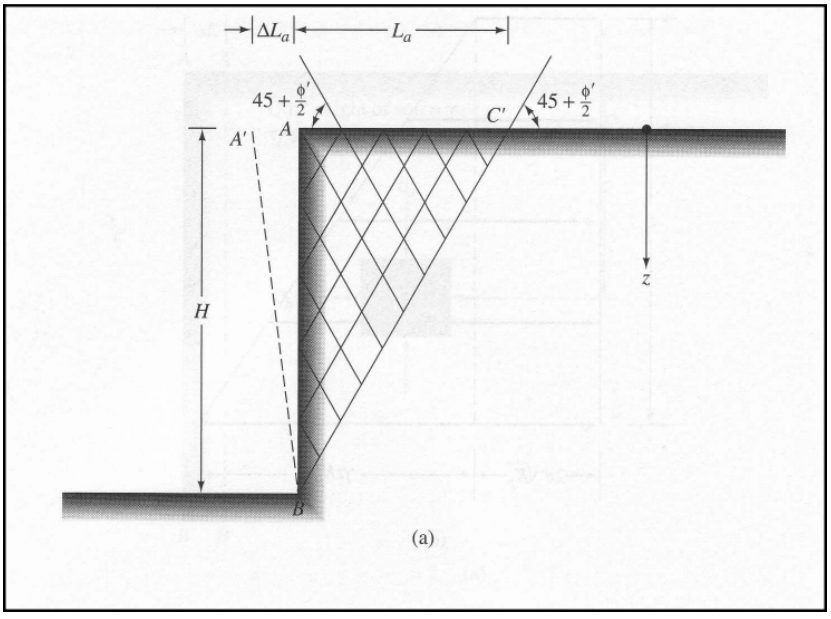


-Aktivni pritisak nastaje kada kada se zid pomera napred ili obrće oko nožice, što se uglavnom dešava u stišljivom tlu, zemljana masa se širi i klizi naniže stvarajući aktivni pritisak tla.

-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



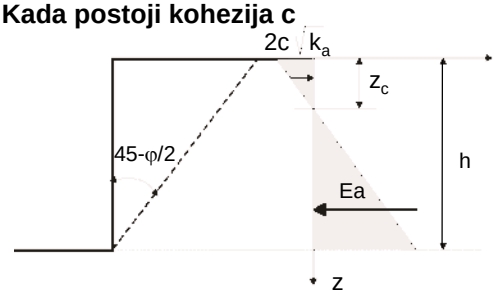
16

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

$$p_a = p_0 \cdot k_a - 2c\sqrt{k_a}$$



$$p_a = 0 \Rightarrow \gamma \cdot z_c \cdot k_a - 2c\sqrt{k_a} = 0$$

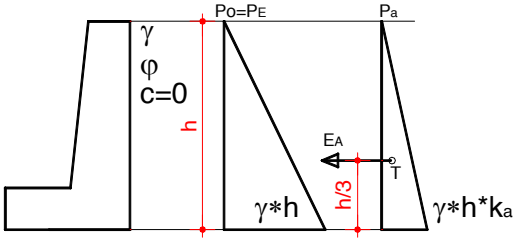
$$z_c = \frac{2c}{\gamma\sqrt{k_a}}$$

$$\frac{1}{2} z_c \cdot 2c\sqrt{k_a} = \frac{2c^2}{\gamma}$$

Sila aktivnog pritiska je $E_a = \frac{1}{2}h^2 \cdot \gamma \cdot k_a - 2c\sqrt{k_a} \cdot h + \frac{2c^2}{\gamma}$

17

Kada je kohezija c=0



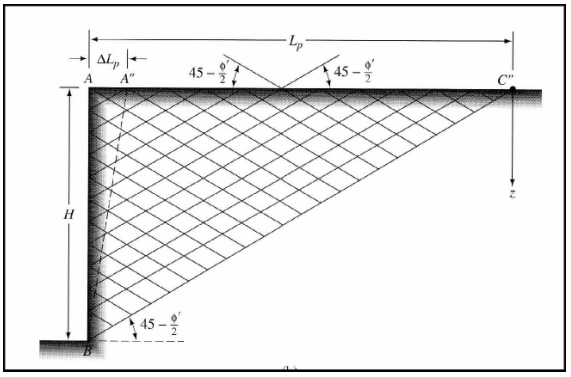
$$E_a = \gamma \cdot h \cdot \frac{h}{2} \cdot k_a = \gamma \frac{h^2}{2} \cdot k_a$$ **Površina dijagrama P_a**

Koeficijent aktivnog pritiska tla

$$k_a = tg^2\left(45 - \varphi/2\right)$$

18

Pasivni otpor tla



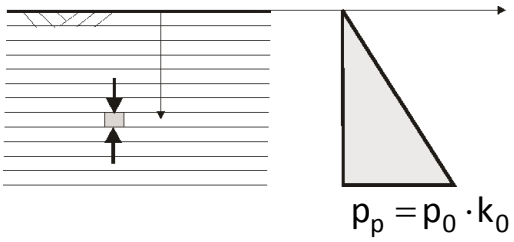
$$p_p = p_0 \cdot k_p + 2c\sqrt{k_p}$$

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

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



$$p_p = p_0 \cdot k_0$$

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

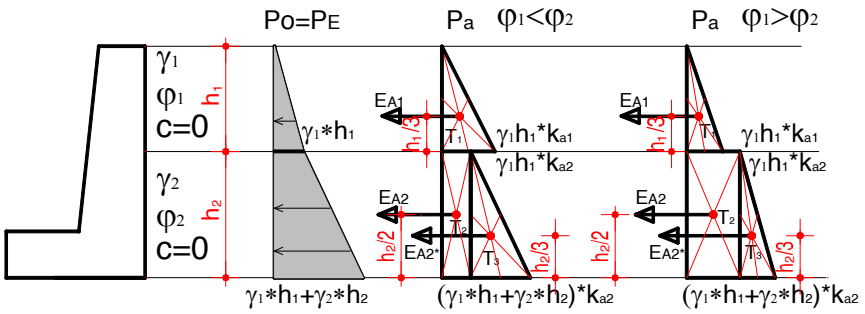
$p_p = p_0 \cdot k_0$

Redak slučaj
Uglavnom potporne konstrukcije proračunavamo na aktivno dejstvo tla

20

Posebni slučajevi aktivnog pritiska tla

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



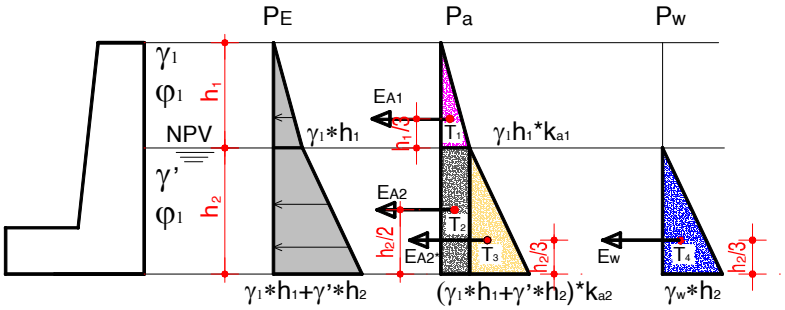
$$E_{a1} = \gamma_1 \cdot h_1 \cdot k_{a1} \cdot \frac{h_1}{2} = \gamma_1 \cdot k_{a1} \cdot \frac{h_1^2}{2} \qquad E_{a2} = \gamma_1 \cdot h_1 \cdot k_{a2} \cdot h_2$$

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

21

Posebni slučajevi aktivnog pritiska tla

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



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

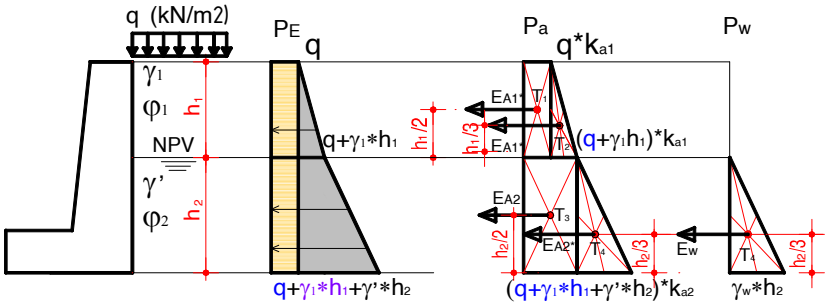
$$E_{a2*} = (\gamma_1 \cdot h_1 + \gamma' \cdot h_2) \cdot k_{a2} - \gamma_1 \cdot h_1 \cdot k_{a2} = \gamma' \cdot h_2 \cdot k_{a2}$$

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

22

Posebni slučajevi aktivnog pritiska tla

***Voda u drugom sloju +površinsko opterećenje**



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

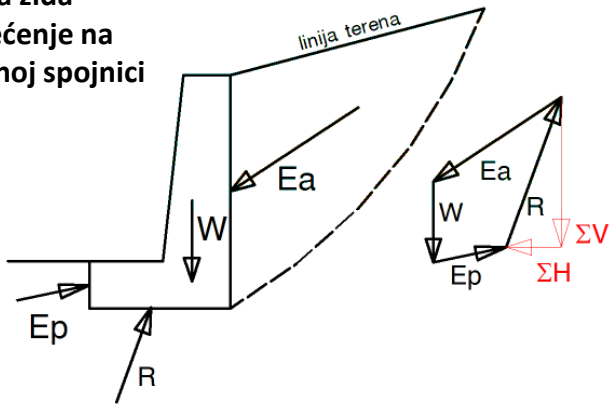
$$E_{a2} = (q + \gamma_1 \cdot h_1) \cdot k_{a2} \cdot h_2 \qquad E_{a2^*} = \gamma' \cdot h_2 \cdot k_{a2} \cdot \frac{h_2}{2} = \gamma' \cdot k_{a2} \cdot \frac{h_2^2}{2}$$

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

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

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

$F_S < 1$ – nestabilan

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

$F_S > 1.5(2)$ – stabilan

$$F_S = \frac{\Sigma V \cdot tg\varphi + E_p}{\Sigma H} \geq 2$$ -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)

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

25

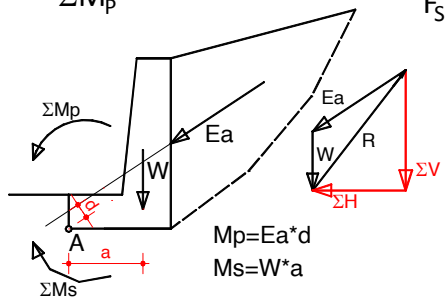
SIGURNOST NA PRETURANJE

$$F_S = \frac{\Sigma M_S}{\Sigma M_P} \geq 1.5$$

$F_S < 1$ – nestabilan

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

$F_S > 1.5$ – stabilan



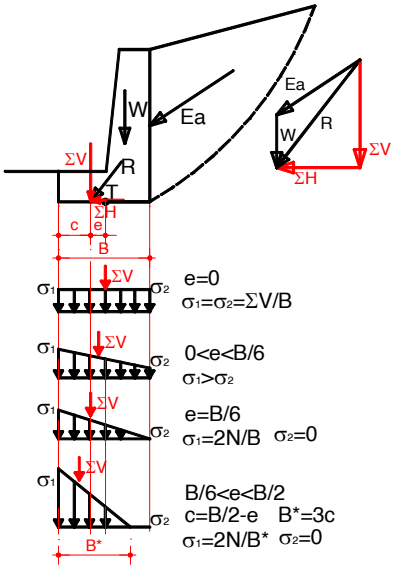
gde je

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

ΣMp 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 na konturi jezgra preseka

-da bude izvan jezgra preseka

-da bude van osnove temelja

e-ekscentricitet rezultante sila

$$e = \frac{\Sigma M_T}{\Sigma V}$$ Gde je

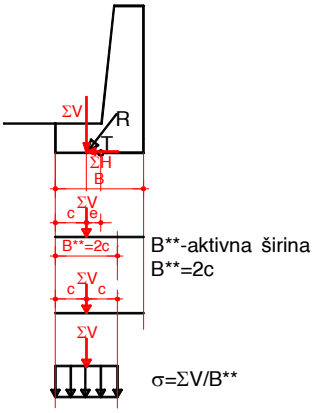
ΣM_T-suma momenata svih sila u odnosu na težište preseka

27

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

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

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



Granično opterećenje tla

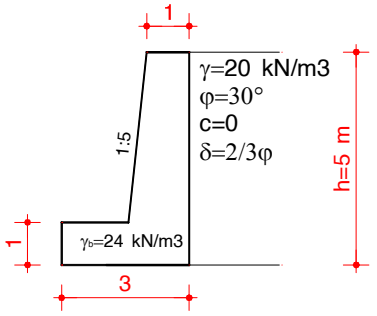
$\sigma=\Sigma V/B^{**}$ gde je $B^{**}=2c$

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

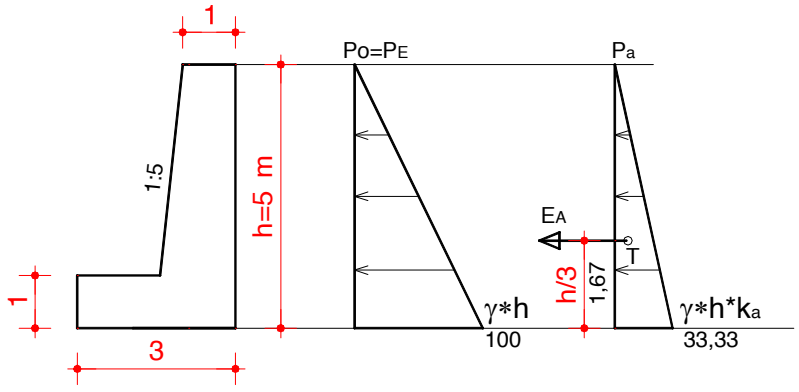
Rešenje

1. Efektivni pritisci u tlu $\mathbf{P_E=P_0}$ ($\mathbf{p_0=\gamma*h}$) –nema neutralnih napona
   $p_{0,0}$=0 kN/m^2
   $p_{0,1}$=20*5,0=100,0 kN/m^2

2. Koeficijent aktivnog pritiska tla
   $k_a=tg^2(45-\varphi/2)=tg^2(45-30/2)=0.33$

3. Aktivni pritisci tla $\mathbf{P_A=P_E \cdot k_a}$
   $p_{A,0}$=0 kN/m^2
   $p_{A,1}$=100,0*0.33=33,3 kN/m^2

30



4. Aktivna sila pritiska

$E_A=\gamma \cdot h \cdot ka \cdot h/2=33,33*5/2=83,25$ kN/m

31

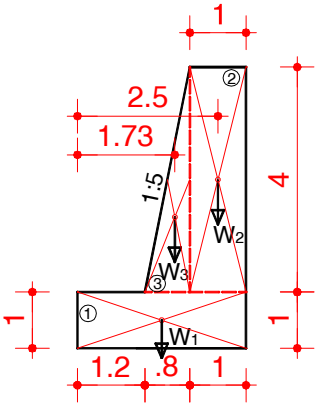
5. Težina zida

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

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

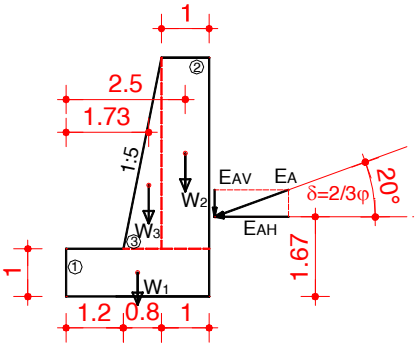
$W_3=0,8 \cdot 4/2 \cdot 24=$ 38,40 kN/m

$\Sigma W=206,40$ kN/m

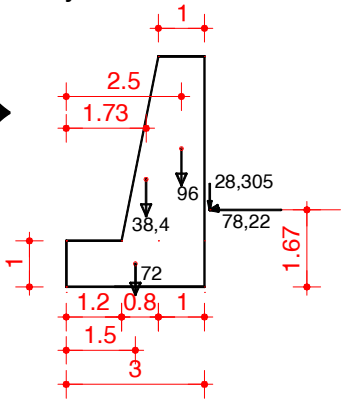


32

Dejstvo sila na zid



Vrednosti i položaj sila koje deluju na zid



6. Dejstvo aktivnih sila na zid

$E_{AV}=E_A\cdot\sin\delta=EA\cdot\sin(2/3\varphi)=83.25\cdot\sin20°=28,305$ kN/m

$E_{AH}=E_A\cdot\cos\delta=EA\cdot\cos(2/3\varphi)=83.25\cdot\cos20°=78,22$ kN/m

33

7. Sigurnost na klizanje

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

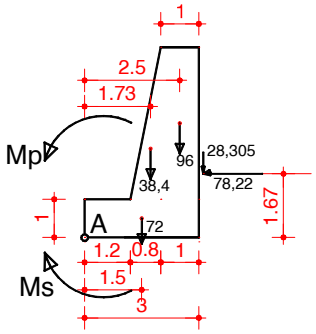
$$\Sigma V=\Sigma W+E_{AV}=206,4+28,3=234,7\text{kN/m}$$

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

$$F_S=\frac{234,7\cdot tg30^o}{78,22}=1.73>1.5-\text{stabilan}$$

8. Sigurnost na preturanje

$$F_S=\frac{\Sigma M_S}{\Sigma M_P}\geq 1.5$$



34

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

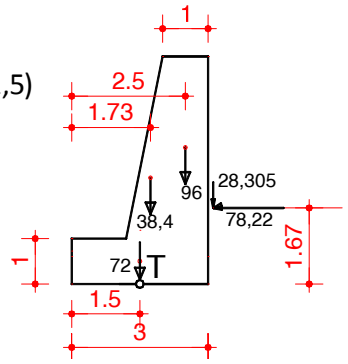
$$\Sigma M_P = E_{AH} \cdot 1{,}67 = 78{,}22 \cdot 1{,}67 = 130{,}36 \text{kNm/m}$$

$$F_S = \frac{\Sigma M_S}{\Sigma M_P} = \frac{499{,}33}{130{,}36} = 3{,}83 > 1.5 - \text{stabilan}$$

9. Kontrola ivičnih napona

$$\Sigma M_T = W_1 \cdot 0 + W_2 \cdot (2{,}5 - 1{,}5) + W_3 \cdot (1{,}73 - 1{,}5)$$
$$+ E_{AV} \cdot 1.5 - \Sigma M_P =$$
$$96 \cdot 1{,}0 + 38{,}4 \cdot 0{,}23 + 28{,}3 \cdot 1{,}5 - 130{,}36 =$$
$$\Sigma M_T = 147{,}28 - 130{,}36 = 16{,}92 \text{kNm/m}$$

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



35

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

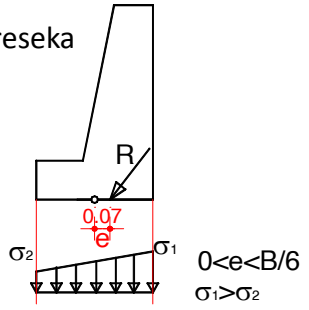
Određivanje napona

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

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

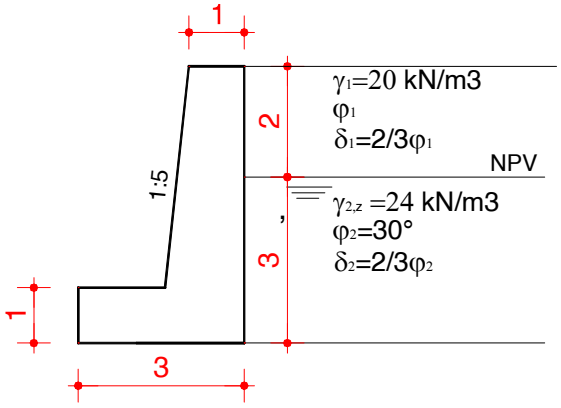
$$\sigma_1 = 78{,}23 \cdot 1{,}14 = 89{,}18 \text{kN/m}^2$$

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



36

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



37

1. Efektivni napon u tlu

Totalni naponi Po

$P_{o,1}$ = 0 kN/m²

$P_{o,2}$ = 20*2=40,0 kN/m²

$P_{o,3}$= 20*2+24*3=112,0 kN/m²

Neutralni napon U

U_1 = 0 kN/m²

U_2 = 0 kN/m²

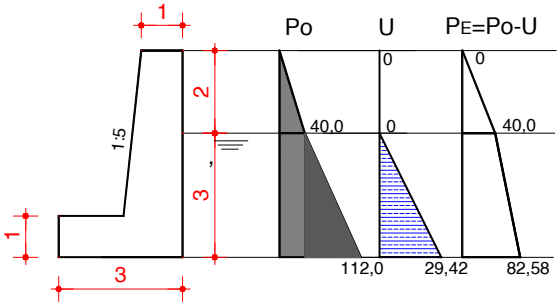
U_3= 9,807*3=29,42 kN/m²

Efektivni napon $P_E=P_0-U$

$P_{E,1}$ = 0 kN/m²

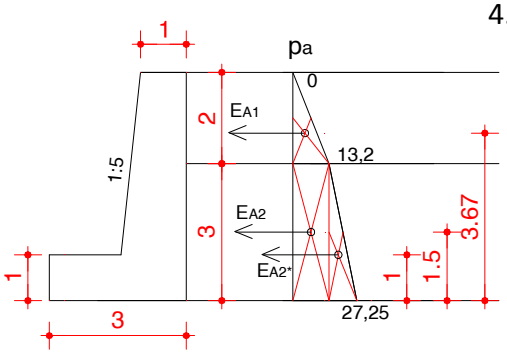
$P_{E,2}$ = 40,0-0=40,0 kN/m²

$P_{E,3}$= 112,0-29,42=82,58 kN/m²



38

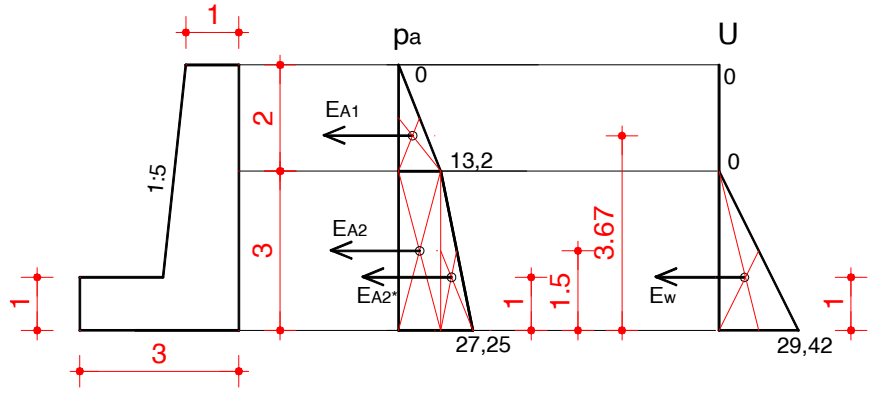
2. Koeficijent aktivnog pritiska tla
   $k_{a1}=tg^2(45-\varphi_1/2)=tg^2(45-30/2)=0.33$
   $k_{a2}=tg^2(45-\varphi_2/2)=tg^2(45-30/2)=0.33$
3. Dijagram aktivnih pritisaka tla $\mathbf{P_A=P_E\cdot k_a}$
   $p_{A,0}=0$ kN/m^2
   $p_{A,1}=40,0*0.33=13,20$ kN/m^2
   $p_{A,2}=82,58*0.33=27,25$ kN/m^2



4. Aktivne sila pritiska od tla
   $E_{A1}=13,2\cdot2/2=13,2$kN/m
   $E_{A2}=13,2\cdot3=39,6$kN/m
   $E_{A2*}=(27,25-13,2)\cdot3/2=$
   $E_{A2*}=21,08$kN/m

39

5. Sila pritiska od vode
   $E_w=29,42*3/2=44,13$kN/m

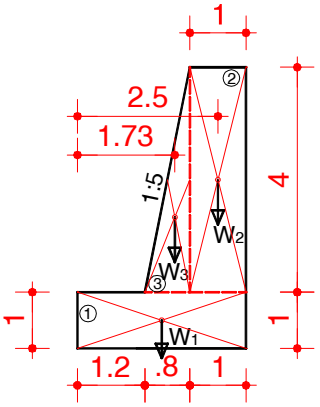


40

6. Težina zida

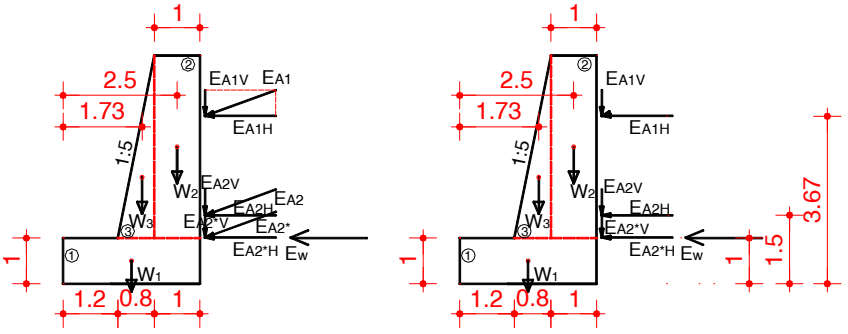
W_1=3·1·24= 72,0 kN/m
W_2=1·4·24= 96,0 kN/m
W_3=0,8·4/2 ·24= 38,40 kN/m

ΣW=206,40 kN/m



41

Vrednosti i položaj sila koje deluju na zid

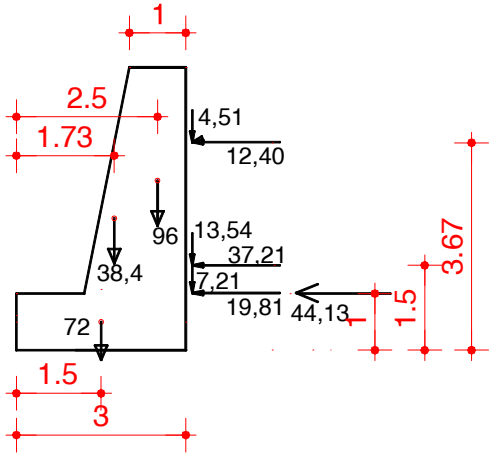


7. Dejstvo aktivnih sila na zid od tla

$E_{A1V}=E_{A1}\cdot\sin\delta=13,2\cdot\sin20°=4,51$ kN/m
$E_{A1H}=E_{A1}\cdot\cos\delta=13,2\cdot\cos20°=12,40$ kN/m
$E_{A2V}=E_{A2}\cdot\sin\delta=39,6\cdot\sin20°=13,54$ kN/m
$E_{A2H}=E_{A2}\cdot\cos\delta=39,6\cdot\cos20°=37,21$ kN/m
$E_{A2*V}=E_{A2*}\cdot\sin\delta=21,08\cdot\sin20°=7,21$ kN/m
$E_{A2*H}=E_{A2*}\cdot\cos\delta=21,08\cdot\cos20°=19,81$ kN/m

42

Vrednosti i položaj sila koje deluju na zid



ΣE_{AV}=4,51+13,54+7,21=25,26 kN/m
ΣV=25,26+96+38,4+72=231,66 kN/m
ΣH=12,40+37,21+19,81+44,13=113,55 kN/m

43

8. Sigurnost na klizanje

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

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

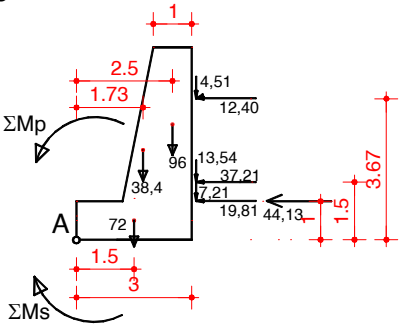
$$\Sigma H = \Sigma E_{AH} = 113{,}55 kN/m$$

$$F_S = \frac{231{,}66 \cdot tg30^o}{113{,}55} = 1.18 > 1.0$$

USLOVNO STABILAN ZID

9. Sigurnost na preturanje

$$F_S = \frac{\Sigma M_S}{\Sigma M_P} \geq 1.5$$



44

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

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

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

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

$$F_S = \frac{\Sigma M_S}{\Sigma M_P} = \frac{490{,}20}{165{,}26} = 2{,}96 > 1.5 - \text{stabilan}$$

10. Kontrola ivičnih napona

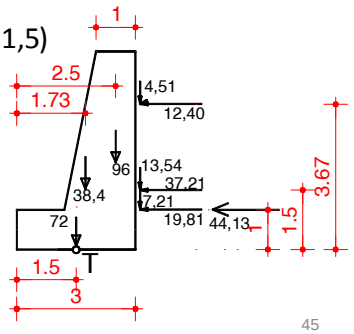
$$\Sigma M_T = W_1 \cdot 0 + W_2 \cdot (2{,}5 - 1{,}5) + W_3 \cdot (1{,}73 - 1{,}5)$$

$$+ E_{AV} \cdot 1.5 - \Sigma M_P =$$

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

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

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



45

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

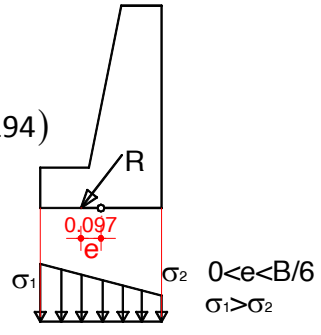
Određivanje napona

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

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

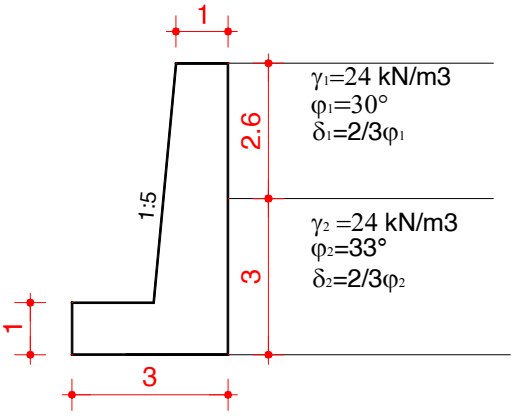
$$\sigma_1 = 77{,}22 \cdot 1{,}194 = 92{,}20 \text{kN/m}^2$$

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



46

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 Po

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

$P_{o,2}$ = 24*2,4=62,4 kN/m^2

$P_{o,3}$= 62,4+20*3=122,4 kN/m^2

2. Koeficijent aktivnog pritiska tla

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

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

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

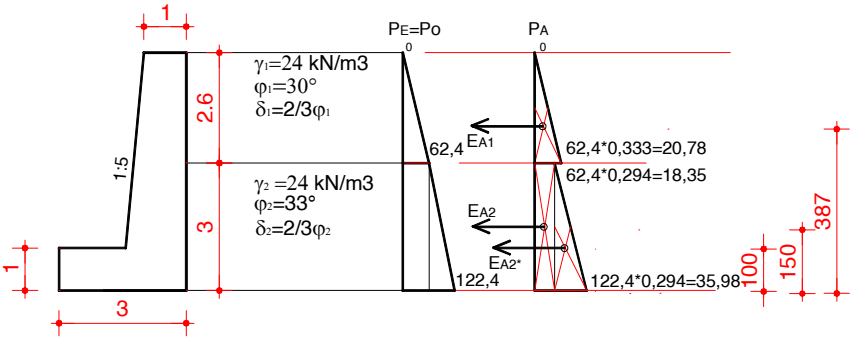
$p_{A,1}$=0 kN/m^2

$p^g_{A,2}$=62,4*0,333=20,78 kN/m^2

$p^d_{A,2}$=62,4*0,294=18,35 kN/m^2

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

48



4. Aktivne sila pritiska od tla

E_{A1}=20,78·2,6/2=27,01kN/m

E_{A2}=18,35·3=55,05kN/m

E_{A2*}=(35,98-18,35)·3/2=26,44kN/m

49

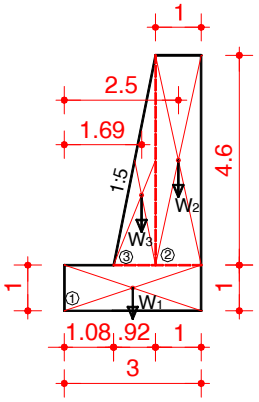
6. Težina zida

W_1=3·1·24= 72,00 kN/m

W_2=1·4,6·24= 110,40 kN/m

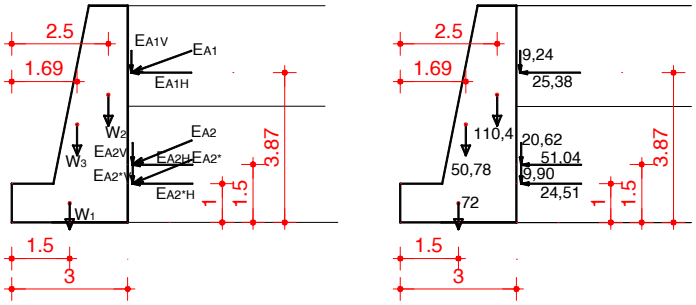
W_3=0,92·4,6/2 ·24= 50,78 kN/m

ΣW=233,18 kN/m



50

Vrednosti i položaj sila koje deluju na zid

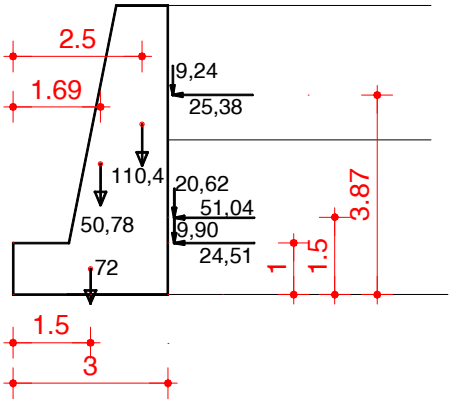


7. Dejstvo aktivnih sila na zid od tla

$E_{A1V}=E_{A1}\cdot\sin\delta_1$ =27,01·sin20°= 9,24 kN/m
$E_{A1H}=E_{A1}\cdot\cos\delta_1$ =27,01·cos20°=25,38 kN/m
$E_{A2V}=E_{A2}\cdot\sin\delta_2$ =55,05·sin22°= 20,62 kN/m
$E_{A2H}=E_{A2}\cdot\cos\delta_2$ =55,05·cos22°=51,04 kN/m
$E_{A2*V}=E_{A2*}\cdot\sin\delta_2$ =26,44·sin22°= 9,90 kN/m
$E_{A2*H}=E_{A2*}\cdot\cos\delta_2$ =26,44·cos22°=24,51 kN/m

51

Vrednosti i položaj sila koje deluju na zid



ΣE_{AV}=9,24+20,62+9,90=39,76 kN/m
$\Sigma V=\Sigma E_{AV}+\Sigma W$=39,76+233,18=272,94 kN/m
ΣH=25,38+51,04+24,51=100,93 kN/m

52

8. Sigurnost na klizanje

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

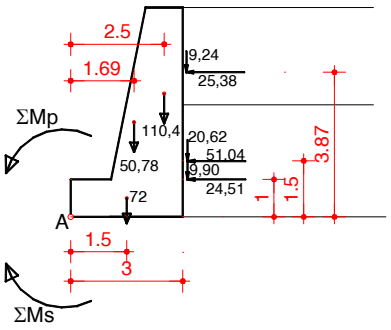
$$\Sigma V = \Sigma W + \Sigma E_{AV} = 272{,}94 kN/m$$

$$\Sigma H = \Sigma E_{AH} = 100{,}93 kN/m$$

$$F_S = \frac{272{,}94 \cdot tg33^o}{100{,}93} = 1.76 > 1.5 \text{STABILAN ZID}$$

9. Sigurnost na preturanje

$$F_S = \frac{\Sigma M_S}{\Sigma M_P} \geq 1.5$$



53

$$\Sigma M_S = 72 \cdot 1{,}5 + 110{,}4 \cdot 2{,}5 + 50{,}78 \cdot 1{,}69 + 39{,}76 \cdot 3{,}0 = 589{,}10 kNm/m$$

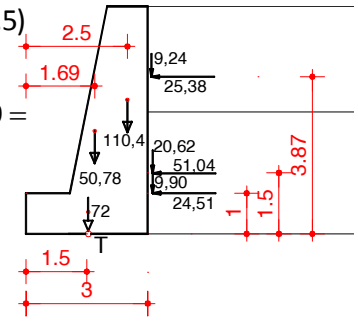
$$\Sigma M_P = 24{,}51 \cdot 1{,}0 + 51{,}04 \cdot 1{,}5 + 25{,}38 \cdot 3{,}87 = 199{,}29 kNm/m$$

$$F_S = \frac{\Sigma M_S}{\Sigma M_P} = \frac{589{,}10}{199{,}29} = 2{,}95 > 1.5 - \text{stabilan}$$

10. Kontrola ivičnih napona

$$\Sigma M_T = W_1 \cdot 0 + W_2 \cdot (2{,}5 - 1{,}5) + W_3 \cdot (1{,}69 - 1{,}5)$$
$$+ E_{AV} \cdot 1.5 - \Sigma M_P =$$
$$110{,}4 \cdot 1{,}0 + 50{,}78 \cdot 0{,}19 + 39{,}76 \cdot 1{,}5 - 199{,}29 =$$
$$\Sigma M_T = 179{,}69 - 199{,}29 = -19{,}60 kNm/m$$

$$e = \frac{\Sigma M_T}{\Sigma V} = \frac{-19{,}60}{272{,}94} = -0{,}071 m = -7{,}1 cm$$



54

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

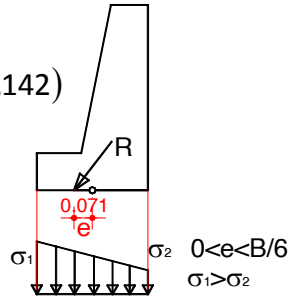
Određivanje napona

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

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

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

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



55