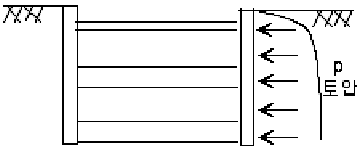
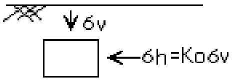
11장 토 압

~흙막이 구조물에 작용하는 하중을 계산하기 위한 수평방향의 하중이다.
ex) 옹벽, (가설)흙막이벽, 지중지하벽

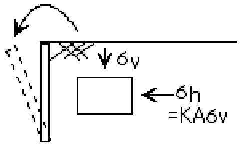


11.2 토압의 종류

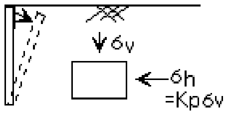
①정지 토압=Ko
②주동 토압=Ka
③수동 토압=Kp



<정지토압>



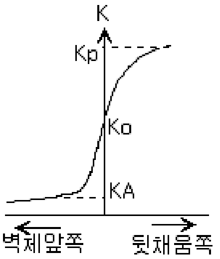
<수중토압>



<수동토압>

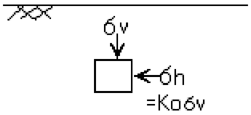
˙토압계수

$$K = \frac{\sigma_h}{\sigma_v}$$

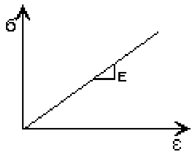


<벽체범위>

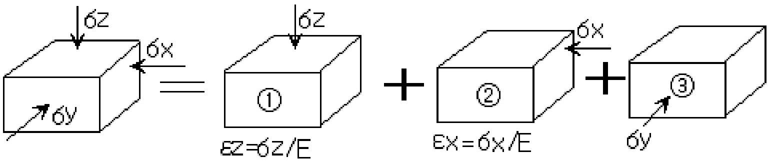
11.3 정지 토압계수



-지반을 탄성체로 가정→Hook's law를 따른다.



-중첩의 원리 적용가능



※포이송비

$$Hook's\ law: \sigma = E\epsilon_a \text{ 여기서}, \epsilon_a = \frac{dl}{l}$$

$$\mu = -\frac{\epsilon_l(\text{횡변형율})}{\epsilon_a(\text{축변형율})}(\text{정의}) \rightarrow \epsilon_l = -\mu\epsilon_a = -\mu\frac{\sigma}{E}$$

$\varepsilon z = \frac{бz}{E}б$ $\qquad \varepsilon x = \frac{бx}{E}$ $\qquad \varepsilon y = \frac{бy}{E}$

$\varepsilon x = -\mu\varepsilon z = (-\mu \cdot \frac{бz}{E})$ $\qquad \varepsilon y = -\mu \cdot \frac{бx}{E}$ $\qquad \varepsilon x = -\mu \cdot \frac{бy}{E}$

$\varepsilon y = -\mu\varepsilon z = -\mu \cdot \frac{бz}{E}$ $\qquad \varepsilon t = -\mu \cdot \frac{бx}{E}$ $\qquad \varepsilon z = -\mu \cdot \frac{бy}{E}$

$$\rightarrow \varepsilon x = \frac{1}{E}[бx - \mu(бy + бz)]$$

$$\rightarrow \varepsilon y = \frac{1}{E}[бy - \mu(бx + бz)]$$

$$\rightarrow \varepsilon z = \frac{1}{E}[бz - \mu(бx + бy)]$$

·정지토압조건

→εx=εy=0인 조건에 해당

윗식에 대입

$бx=\mu(бy+бz)$

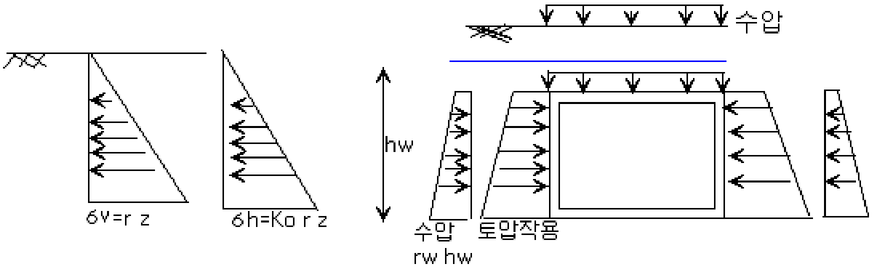
$бy=\mu(бx+бz)$ 위 식에대입 $\rightarrow бx = \frac{(1+\mu)\mu}{1-\mu^2} \cdot бz$

$\therefore бx = \frac{\mu}{1-\mu} \cdot бz$ $\qquad \therefore Ko = \frac{\mu}{1-\mu}$

-Jacky 공식 (경험공식)

for 사질토 → $Ko=1-\sin\phi'$

for 점성토 → $Ko=(1-\sin\phi')\sqrt{O.C.R}$ $\quad (O.C.R=\frac{\sigma_c'}{\sigma_{v0}'})$

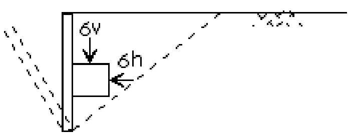


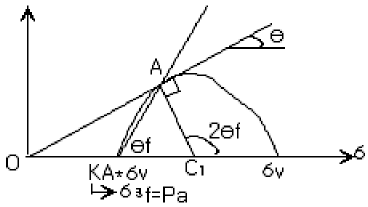
11.4 Ran kine의 토압이론

→벽면 마찰각을 무시한 토압이론

사질토(c=0) 인 경우

i)주동 토압



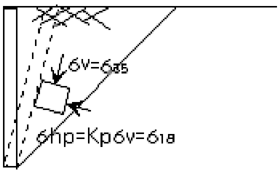


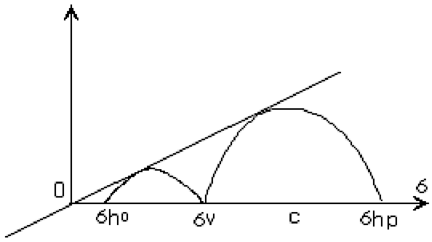
$$\sin\phi = \frac{CA}{OC} = \frac{\frac{(\sigma_v - \sigma_{ha})}{2}}{\frac{(\sigma_v + \sigma_{ha})}{2}} \quad \rightarrow \quad \frac{\sigma_{ha}}{\sigma_v} = \frac{1-\sin\phi}{1+\sin\phi} = \tan^2(45° - \frac{\phi}{2}) = K_a$$

$$\therefore \ Ka = \frac{1-\sin\phi}{1+\sin\phi}$$

$$2\Theta_f = 90° + \phi \quad \rightarrow \quad \theta_f = 45 + \frac{\phi}{2}$$

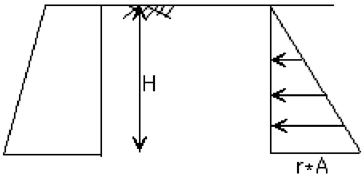
ii)수동 토압

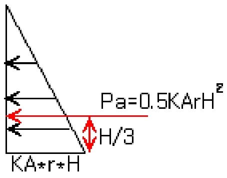


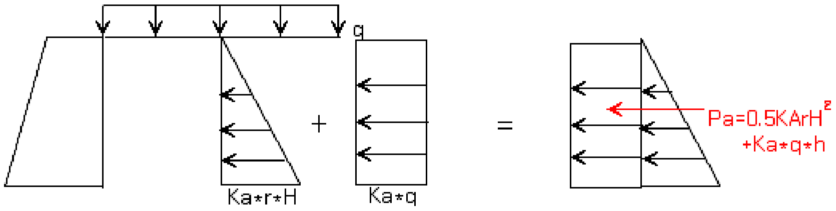


$$Kp = \frac{\sigma_{hp}}{\sigma_v} = \frac{1+\sin\phi}{1-\sin\phi} = \tan^2(45° + \frac{\phi}{2}) = \frac{1}{K_a}$$

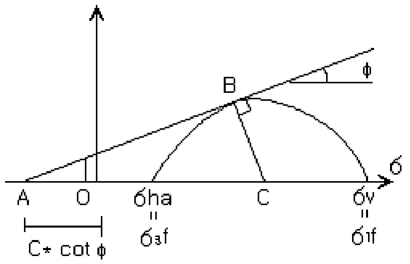
-주동 토압의 분포와 합력의 위치







2 점성토의 주동 및 수동토압(c≠0인 경우)



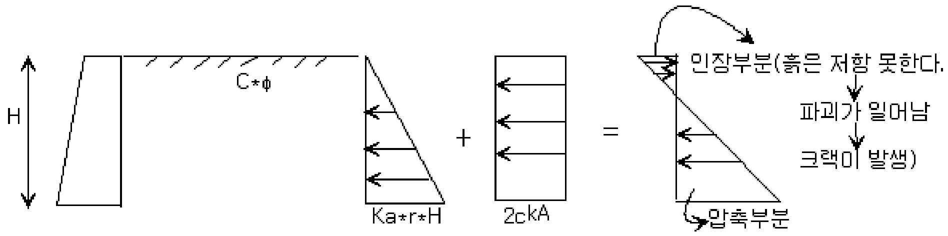
$$\sin\phi = \frac{CB}{AO+OC}$$

$$= \frac{(\sigma_v - \sigma_{ha})/2}{c \cdot \cot\phi + (\sigma_v + \sigma_{ha})/2}$$

$$\sigma_{ha} = \left(\frac{1-\sin\phi}{1+\sin\phi}\right)\sigma_v - 2 \cdot c\frac{\cos\phi}{1+\sin\phi}$$

$$= K_a \cdot \gamma \cdot z - 2c\sqrt{K_a}$$

-토압분포



-인장깊이 선정

$\sigma_{ha}=0$인 시점

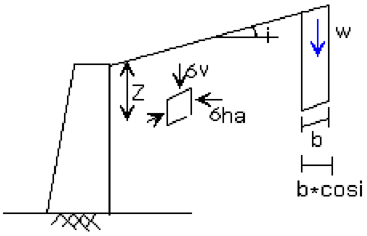
$$\sigma_{ha} = K_a \cdot \gamma \cdot Z_0 - 2C\sqrt{K_a} = 0$$

$$\therefore Z_c = \frac{2C}{\gamma} \cdot \frac{1}{\sqrt{Kp}} = \frac{2C}{\gamma} \cdot \sqrt{Kp}$$

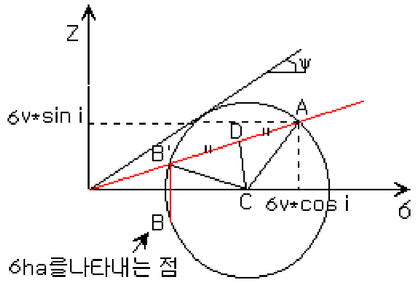
-수동토압계수

$$\sigma_{hp} = K_p \cdot \gamma \cdot Z + 2C\sqrt{K_p} \qquad \left(Kp = \frac{1+\sin\phi}{1-\sin\phi}\right)$$

-지표면이 경사진 경우에 대한 토압



$\sigma v = W/b = Z * b' * \cos i * \gamma / b'$
$= \gamma Z * \cos i$



$$Ka = \frac{\sigma ha}{\sigma v}$$

$OA^2 = \sigma v^2 \cdot \cos^2 i + \sigma v^2 \cdot \sin^2 i = \sigma v^2(\cos^2 i + \sin^2 i)$

$OA = \sigma v$

$OB = \sigma ha$

$$Ka = \frac{OB}{OA} = \frac{OB - AD}{OD + AD}$$

$OD = OC \cdot \cos\ I$

$AD = \sqrt{AC^2 - CD^2}$ $(AC = OC \cdot \sin\psi,\ CD = OC \cdot \sin\ I)$

$$\therefore Ka = \frac{OC \cdot \cos i - \sqrt{OC^2 \cdot \sin^2\phi + OC^2 \cdot \sin^2 i}}{OC \cdot \cos i + \sqrt{OC^2 \cdot \sin^2\phi - OC^2 \cdot \sin^2 i}} = \frac{\cos i - \sqrt{\sin^2\phi - \sin^2 i}}{\cos i + \sqrt{\sin^2\phi - \sin^2 i}}$$

$$= \frac{\cos i - \sqrt{\cos^2 i - \cos^2\phi}}{\cos i + \sqrt{\cos^2 i - \cos^2\phi}} = \frac{1}{Kp}$$

$\sigma ha = KA \cdot \sigma v = KA \cdot \gamma \cdot z \cdot \cos\ i$

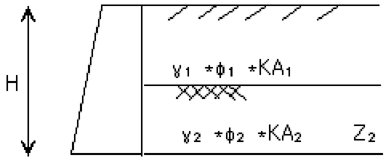
$\therefore Pa = \frac{1}{2} KA \cdot \gamma \cdot H^2 \cdot \cos\ I$

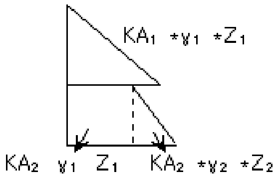
11.4 뒤채움이 이층이거나 지하수위가 있는 경우

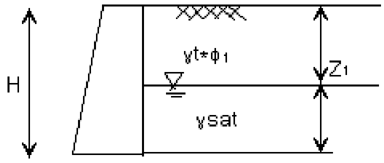
-주동토압

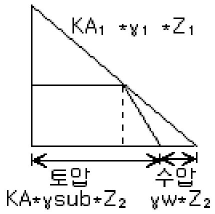
$\gamma sub = \gamma sat - \gamma w$

$= \frac{Gs - 1}{1 + e} \gamma w$



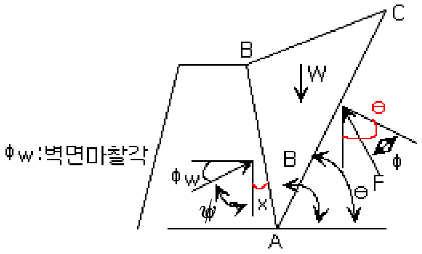


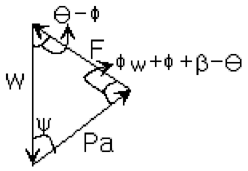




11.5 Coulomb의 토압이론 :~벽면에 마찰각을 고려한 토압이론

①c=0인 경우





x=90-(180-β)=β-90°

∴ψ=90-ϕw-(β-90)

=180-(β+ϕw)

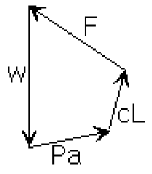
$$\frac{Pa}{\sin(\Theta-\phi)}=\frac{W}{\sin(\phi+\phi w+\beta-\Theta)}$$

$$\therefore\ PA=W\cdot\frac{\sin(\Theta-\phi)}{\sin(\phi+\phi w+\beta-\Theta)}$$

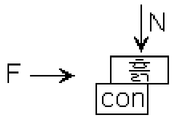
$\frac{dPA}{d\Theta}=0$일때의 Θ값 추정

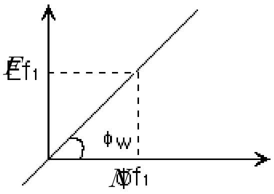
$$PA=\frac{\gamma H^2}{2}\left[\frac{\sin(\beta-\phi)\csc\beta}{\sqrt{\sin(\beta+\phi w)}+\sqrt{\frac{\sin(\phi+\phi w)\cdot\sin(\phi-i)}{\sin(\beta-i)}}}\right]^2$$

②C≠0인 경우



-벽면 마찰각(ϕw)





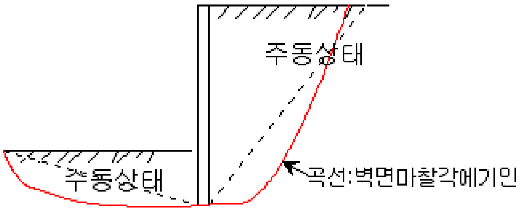
∴일반적으로는 $\phi w \fallingdotseq \frac{2}{3}\phi$로 가정

11.6실제 활동면의 현상

-수동토압의 경우 $\phi w>\frac{\phi}{3}$이면

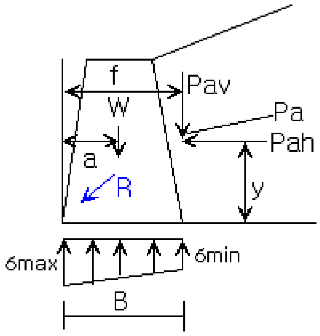
실제 수동토압과 현저한 차이발생

→직선파괴가정=수동토압의 크기를 실제 보다 크게 평가



11.7 옹벽의 안정

1.안정조건



①수평활동에 대한 안정

$$Fs=\frac{\text{수평저항력}}{\text{수평활동력}}=\frac{Ff}{Rh}=Rv\cdot\frac{\tan\phi w}{Rh}>1.5$$

②전도에 대한 안정

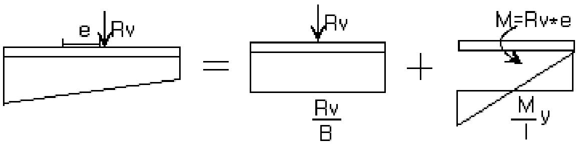
$$Fs=\frac{Mr(\text{저항모멘트})}{Mo(\text{활동모멘트})}=\frac{W\cdot a+Pav\cdot f}{Pah\cdot y}>1.5$$

③허용지지력 검토

$$Fs=\frac{qu}{\sigma\max}>3.0$$

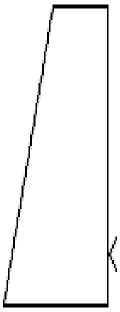
*편심

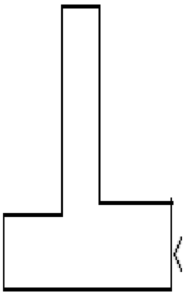
$$\frac{M}{I}\cdot y=\frac{Rv\ \cdot\ e}{\frac{1\ \cdot\ B^3}{12}}\cdot\left(\frac{B}{2}\right)=\frac{6Rv\ \cdot\ e}{B^2}$$

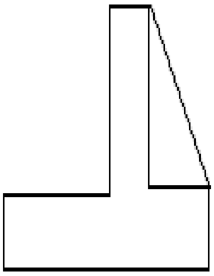


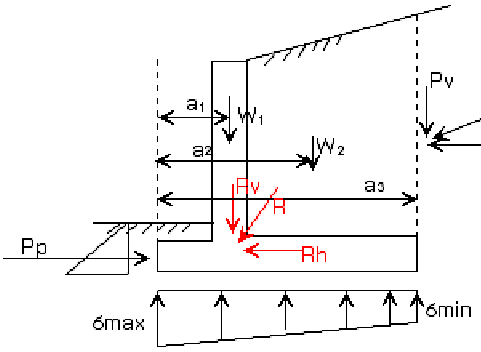
$$\therefore\ \sigma=\frac{Rv}{B}\left(1\pm\frac{6e}{B}\right)$$

-옹벽의 종류


〈중형식〉


〈역T형식〉


〈부벽식〉



(가상벽면에 토압작용)

-Rankine 토압이론을 적용

①옹벽의 수평활동안정

$$Fs = \frac{Rv \cdot \tan\phi w}{Rh(=Ph)} > 1.5$$

②전도활동에 대한 안정

$$Fs = \frac{저항모멘트}{활동모멘트} = \frac{W_1 a_1 + W_2 a_2}{P_h y - P_v a_3} > 1.5$$

③허용지지력에 대한 안정

$$Fs = \frac{qu}{\sigma \max} > 3 \qquad \left(qa(허용지지력) = \frac{qu}{3}(극한지지력) \right)$$

$$\therefore \ \sigma = \frac{Rv}{B}\left(1 \pm \frac{6e}{B}\right)$$

-6min=0인 조건에서

$$\rightarrow 1 - \frac{6 \cdot e}{B} = 0인\ 지점 \quad \rightarrow \quad e = \frac{B}{6}$$

6min값이 -값이 되면 인장력 발생

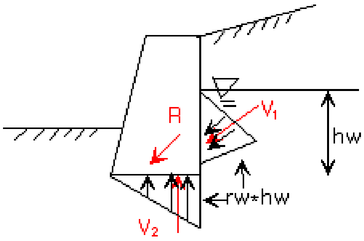
지반 반력에서 인장력이 발생하지 않도록 하기위한 최대편심 거리는 B/6이다.

(편심이 B/3안에 존재해야 한다.)

2.지하수위가 옹벽의 안정에 끼치는 영향

-활동에 대한 안전율

$$Fs = \frac{(Rv - V_2)\tan\phi w}{Rh + V_{1h}} > 1.5$$



3.옹벽에 작용하는 간이 토압분포

-by Terzoghi , Peck (단, 옹벽높이가 6m이내일 때)

$$Ph = \frac{1}{2} Kn \cdot H^2$$

$$Pv = \frac{1}{2} Kv \cdot H^2 \ \text{(i=0이면 → Pv=0) →Kv=0}$$

<도표이용>