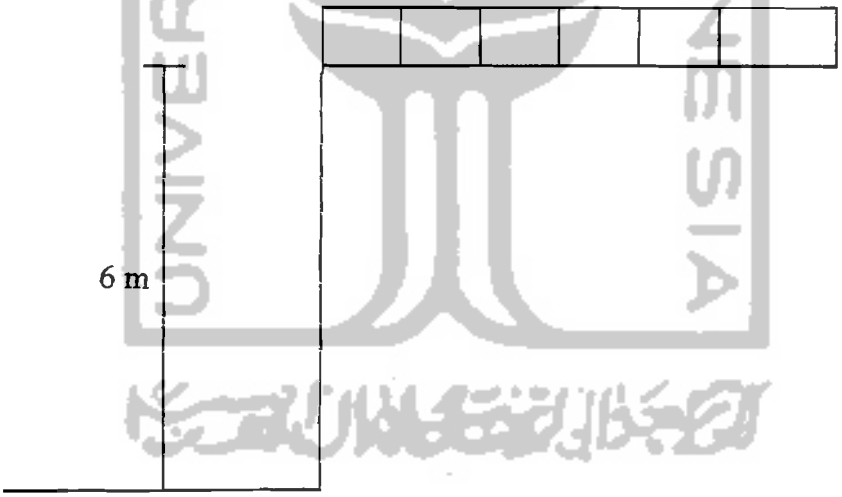
BAB V

ANALISIS PERKUATAN TANAH

5.1 Data Perencanaan

Lereng dengan ketinggian 6,00 meter direncanakan untuk dari muka tanah (+0,00) sampai kedalaman 6,00 meter menggunakan perkuatan tanah dengan geotekstil (*Sheet reinsforced dan Strip reinsforced)*



Gambar 5.1 Kondisi Lereng

Data tanah :

Kadar air = 10 % ; *Specific gravity* = 2,60 ; kadar pori = 30 %. Muka air tanah pada kedalaman = 12 meter dibawah muka tanah. Kuat geser tanah dan kuat dukung tanah efektif, dihasilkan dari data uji triaksial *Consolidated Drained* dengan 3 buah sampel (dihitung dengan grafik dan analitik).

Data uji triaksial *Consolidated Drained*

Tabel 5.1 Data Uji Triaksial *Consolidated Drained*

	beban deviator kg	tekanan air pori kg/cm²	tekanan radial kg/cm²
Sampel 1	40	0,40	1,00
Sampel 2	55	0,80	1,80
Sampel 3	70	1,00	2,00

F sampel tanah = 25 cm²

Data geotekstil

Sheet reinsforced, kuat tarik = 6000 kg / cm²

Strip reinsforced ukuran 8 cm x 0,5 cm , kuat tarik = 4500 kg / cm² ; *facing* beton bertulang tebal 7 cm, bentuk dan ukuran standar. Satu *facing* ditahan oleh empat *strip reinsforced.*

Data beban luar

Diatas muka tanah dipasang konblok setebal 15 cm dan dibawah konblok terdapat lapisann pasir setebal 20 cm.

5.2 Menentukan Parameter Tanah

5.2.1 Menentukan Parameter Tegangan Tanah

Data tanah :

Kadar air (w) = 10 %

Specific gravity (berat jenis tanah) = 2,60

Kadar pori (n) = 30 %

Penyelesaian :

$$e = \frac{n}{1-n} = \frac{0,3}{1-0,3} = 0,4286$$

$$\gamma = \frac{(1+w).Gs.\gamma w}{1+e} = \frac{(1+0,10).2,6.9,81}{1+0,4286} = 19,64kN/m^3 = 1,964T/m^3$$

5.2.2 Menentukan Parameter Kuat Geser Tanah

Data uji triaksial *Consolidated Drained*

Tabel 5.1 Data Uji Triaksial *Consolidated Drained*

	beban deviator	tekanan air pori	tekanan radial
	kg	kg/cm²	kg/cm²
Sampel 1	40	0,40	1,00
Sampel 2	55	0,80	1,80
Sampel 3	70	1,00	2,00

F sampel tanah = 25 cm²

Penyelesaian :

σ_1 = tekanan deviator yang memecahkan tanah

P = beban deviator yang memecahkan tanah

A = luas tampang contoh tanah

σ_1 = tekanan vertikal

σ_3 = tekanan cell ; u = tekanan air pori

a. Sampel 1

$\sigma_{11} = \sigma_{11} - \sigma_{31}$

$\sigma_{11} = P / A = 40 / 25 = 1{,}60$ kg / cm²

$\sigma_{31} = 1{,}00$ kg / cm²

$\sigma_{11} = \sigma_{11} + \sigma_{31}$

$= 1{,}60 + 1{,}00$

$= 2{,}60$ kg / cm²

$(\sigma_{11} + \sigma_{31}) / 2 = (2{,}60 + 1{,}00) / 2 = 1{,}80$ kg /cm²

$(\sigma_{11} - \sigma_{31}) / 2 = (2{,}60 - 1{,}00) / 2 = 0{,}80$ kg /cm²

Menentukan nilai parameter kuat geser dalam keadaan tekanan efektif

$u_1 = 0{,}40$ kg /cm²

$\sigma'_{11} = \sigma_{11} - u_1 = 2{,}60 - 0{,}40 = 2{,}20$ kg /cm²

$\sigma'_{31} = \sigma_{31} - u_1 = 1{,}00 - 0{,}40 = 0{,}60$ kg /cm²

$(\sigma'_{11} + \sigma'_{31}) / 2 = (2{,}20 + 0.60) / 2 = 1{,}40$ kg /cm²

$(\sigma'_{11} - \sigma'_{31}) / 2 = (2{,}20 - 0{,}60) / 2 = 0{,}80$ kg /cm²

b . Sampel 2

$\sigma_{12} = \sigma_{12} - \sigma_{32}$

$\sigma_{12} = P / A = 55 / 25 = 2{,}20$ kg / cm²

$\sigma_{32} = 1{,}80$ kg / cm²

$\sigma_{12} = \sigma_{12} + \sigma_{32}$

$= 2{,}20 + 1{,}80$

$= 4{,}00 \text{ kg / cm}^2$

$(\sigma_{12} + \sigma_{32}) / 2 = (4{,}00 + 1{,}80) / 2 = 2{,}90 \text{ kg /cm}^2$

$(\sigma_{12} - \sigma_{32}) / 2 = (4{,}00 - 1{,}80) / 2 = 1{,}10 \text{ kg /cm}^2$

Menentukan nilai parameter kuat geser dalam keadaan tekanan efektif

$u_2 = 0{,}80 \text{ kg /cm}^2$

$\sigma'_{12} = \sigma_{12} - u_2 = 4{,}00 - 0{,}80 = 3{,}20 \text{ kg /cm}^2$

$\sigma'_{32} = \sigma_{32} - u_2 = 1{,}80 - 0{,}80 = 1{,}00 \text{ kg /cm}^2$

$(\sigma'_{12} + \sigma'_{32}) / 2 = (3{,}20 + 1.00) / 2 = 2{,}10 \text{ kg /cm}^2$

$(\sigma'_{12} - \sigma'_{32}) / 2 = (3{,}20 - 1{,}00) / 2 = 1{,}10 \text{ kg /cm}^2$

c. Sampel 3

$\sigma_{13} = \sigma_{13} - \sigma_{33}$

$\sigma_{13} = P / A = 70 / 25 = 2{,}80 \text{ kg / cm}^2$

$\sigma_{33} = 2{,}00 \text{ kg / cm}^2$

$\sigma_{13} = \sigma_{13} + \sigma_{33}$

$= 2{,}80 + 2{,}00$

$= 4{,}80 \text{ kg / cm}^2$

$(\sigma_{13} + \sigma_{33}) / 2 = (4{,}80 + 2{,}00) / 2 = 3{,}40 \text{ kg /cm}^2$

$(\sigma_{13} - \sigma_{33}) / 2 = (4{,}80 - 2{,}00) / 2 = 1{,}40 \text{ kg /cm}^2$

Menentukan nilai parameter kuat geser dalam keadaan tekanan efektif

$u_3 = 1{,}00 \text{ kg /cm}^2$

$\sigma'_{13} = \sigma_{13} - u_3 = 4{,}80 - 1{,}00 = 3{,}80$ kg /cm²

$\sigma'_{33} = \sigma_{33} - u_3 = 2{,}00 - 1{,}00 = 1{,}00$ kg /cm²

$(\sigma'_{13} + \sigma'_{33}) / 2 = (3{,}80 + 1.00) / 2 = 2{,}40$ kg /cm²

$(\sigma'_{13} - \sigma'_{33}) / 2 = (3{,}80 - 1{,}00) / 2 = 1{,}40$ kg /cm²

1. Menentukan besarnya parameter kuat geser tanah dan kuat dukung tanah efektif dengan cara analitik :

Rumus : $\sigma'_1 = \sigma'_3 . m'^2 + 2. c' . m'$

$m' = tg (45° + Ø / 2)$

Sampel 1	$2{,}20 = 0{,}60 . m'^2 + 2. c' . m'$	1)
Sampel 2	$3{,}20 = \quad . m'^2 + 2. c' . m'$	2)
Sampel 3	$3{,}80 = \quad . m'^2 + 2. c' . m'$	3)
	$9{,}20 = 2{,}60 . m'^2 + 6. c' . m'$	I)
1) x 2,20	$4{,}84 = 1{,}32 . m'^2 + 4{,}4. c' . m'$	
2) x 3,20	$10{,}24 = 3{,}20 . m'^2 + 6{,}4. c' . m'$	
3) x 3,80	$14{,}44 = 3{,}80 . m'^2 + 7{,}6. c' . m'$	
	$29{,}52 = 8{,}32 . m'^2 + 18{,}4. c' . m'$	II)
6 x II)	$177{,}12 = 49{,}92 . m'^2 + 110{,}4. c' . m'$	
18,4 x I)	$169{,}28 = 47{,}84 . m'^2 + 110{,}4. c' . m'$	
	$7{,}84 = 2{,}08. m'^2$	
	$m'^2 = 3{,}77$	

Didapatkan m' = 1,94

$m' = tg (45° + Ø' / 2)$

$1,94 = tg (45° + Ø' / 2)$

arc tg $1,94 = (45° + Ø' / 2)$ ⟶ $Ø' = 35,46°$

Harga m' = 1,94 dimasukan kedalam persamaan I) diperoleh harga c' = -0,0507

2. Menentukan besarnya parameter kuat geser tanah dan kuat dukung tanah efektif dengan cara grafik :

Diambil nilai rata-rata

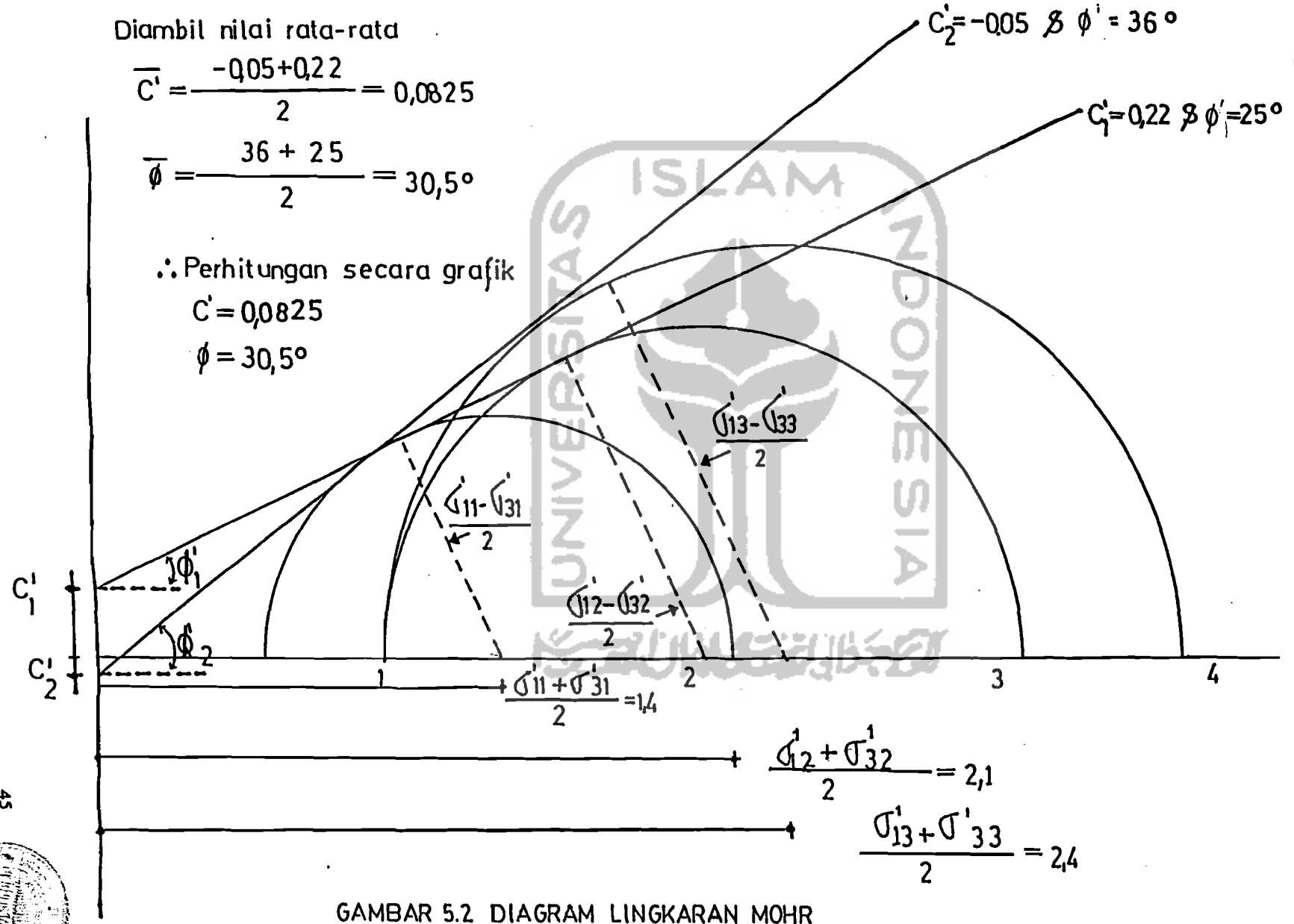
$$\overline{C'} = \frac{-0{,}05 + 0{,}22}{2} = 0{,}0825$$

$$\overline{\phi} = \frac{36 + 25}{2} = 30{,}5^\circ$$

∴ Perhitungan secara grafik

$C' = 0{,}0825$

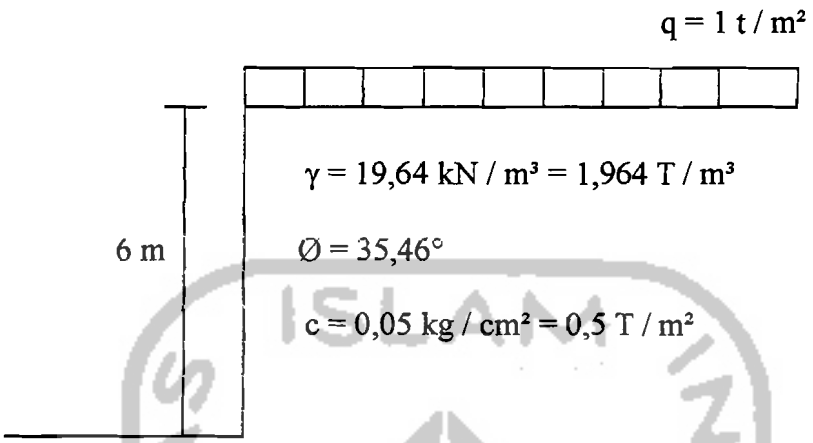
$\phi = 30{,}5^\circ$



GAMBAR 5.2 DIAGRAM LINGKARAN MOHR
UNTUK MENENTUKAN HARGA ϕ DAN C'

5.3 Analisis Perkuatan Tanah

5.3.1 Perkuatan Tanah Dengan *Sheet Reinsforced*



Gambar 5 . 3 Kondisi Lereng

Ditinjau tiap 1 meter arah panjang ⊥ bidang gambar

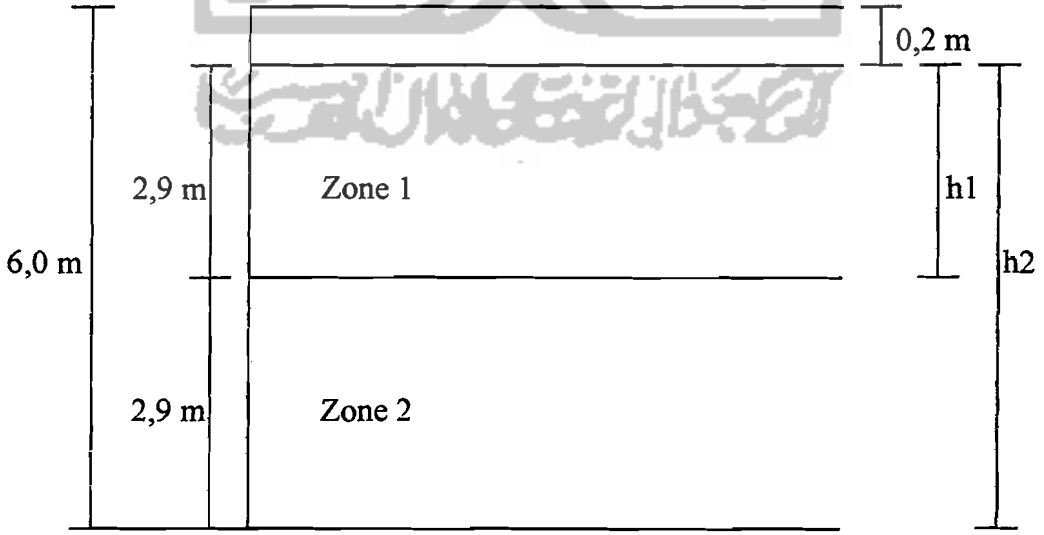
A. Menentukan lebar antara geotekstil

Geotekstil menggunakan Stabilenka 400 / 100 dengan kuat tarik :

Tu = 40 T / m

Ta = Tu / 3 = 40 / 3 = 13,3333 T / m

Lereng dibagi menjadi dua zone



Gambar 5. 4 Pembagian Lereng Menjadi Dua Zone

Jarak antar lembar

a. Zone 1

$\sigma hc_1 = h_1 . \gamma . ko$

$= 2,9 . 1,964 . (1 - \sin \emptyset)$

$= 2,9 . 1,964 . (1 - \sin 35,46°)$

$= 2,3914 \ T / m^2$

Spacing : $Sv_1 = Ta / (\sigma hc_1 . SF)$ $SF = 1,5$

$= 13,3333 / (2,3914 . 1,5)$

$= 3,7170 \ m$

b. Zone 2

$\sigma hc_2 = h_2 . \gamma . ko$

$= 5,8 . 1,964 . (1 - \sin \emptyset)$

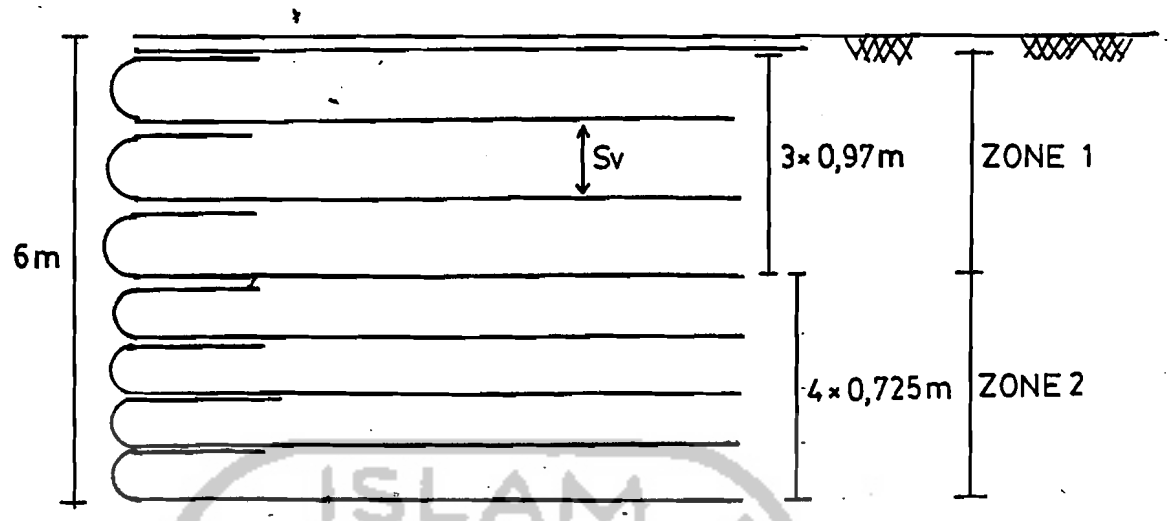
$= 5,8 . 1,964 . (1 - \sin 35,46°)$

$= 4,7828 \ T / m^2$

Spacing : $Sv_2 = Ta / (\sigma hc_2 . SF)$ $SF = 1,5$

$= 13,3333 / (4,7828 . 1,5)$

$= 1,8585 \ m$



Gambar 5.5 *Spacing* tiap *Zone*

B. Menentukan Panjang Geotekstil

Tinjauan stabilitas eksternal

1. Stabilitas terhadap geser

$Ka = \tan^2(45 - \emptyset / 2) = \tan^2(45 - 35{,}46° / 2) = 0{,}2657$

$SF = 1{,}5$

$$L = \frac{SF.Ka.(q + 0{,}5.\gamma.H)}{\gamma.\tan.\varphi} = \frac{1{,}5.0{,}2657.(1 + 0{,}5.1{,}964.6)}{1{,}964.\tan.35{,}46} = 1{,}96m$$

2. Stabilitas terhadap guling

$SF = 2{,}0$

$$L^2 = \frac{SF.H.Ka.(q + 1/3.\gamma.H)}{\gamma} = \frac{2.6.0{,}2657.(1 + 1/3.1{,}964.6)}{1{,}964} = 8.m \rightarrow L = 2{,}83.m$$

3. Stabilitas terhadap kapasitas dukung

$$\sigma_{ult} = qu..SF = 10.2 = 20T / m^2$$

$$L \le \frac{\sigma_{ult}}{H.\gamma + q} = \frac{20}{6.1{,}964 + 1} = 1{,}56.m$$

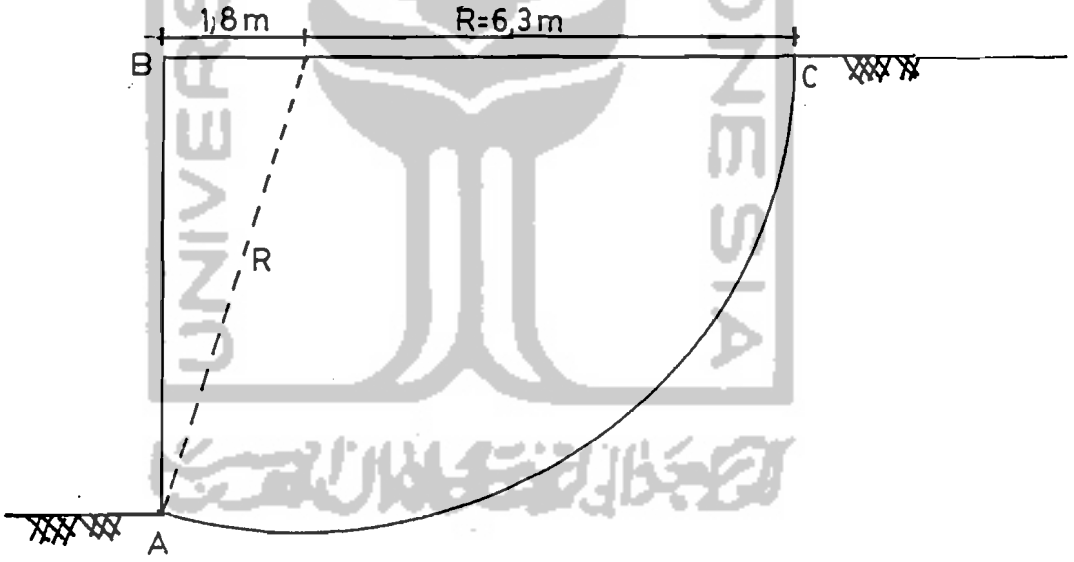
4. Eksentrisitas

$$1/6L = \frac{q.Ka.\frac{H^2}{2}. + \gamma.Ka.\frac{H^3}{6}}{H.L..\gamma + q.L} = \frac{1.0{,}2657.\frac{6^2}{2} + 1{,}964.0{,}2657.\frac{1}{6}.6^3}{6.L.1{,}964 + 1.L}$$

$$12{,}784.L^2 = 141{,}4119 \rightarrow L = 3{,}33.m$$

Digunakan L = 3 m

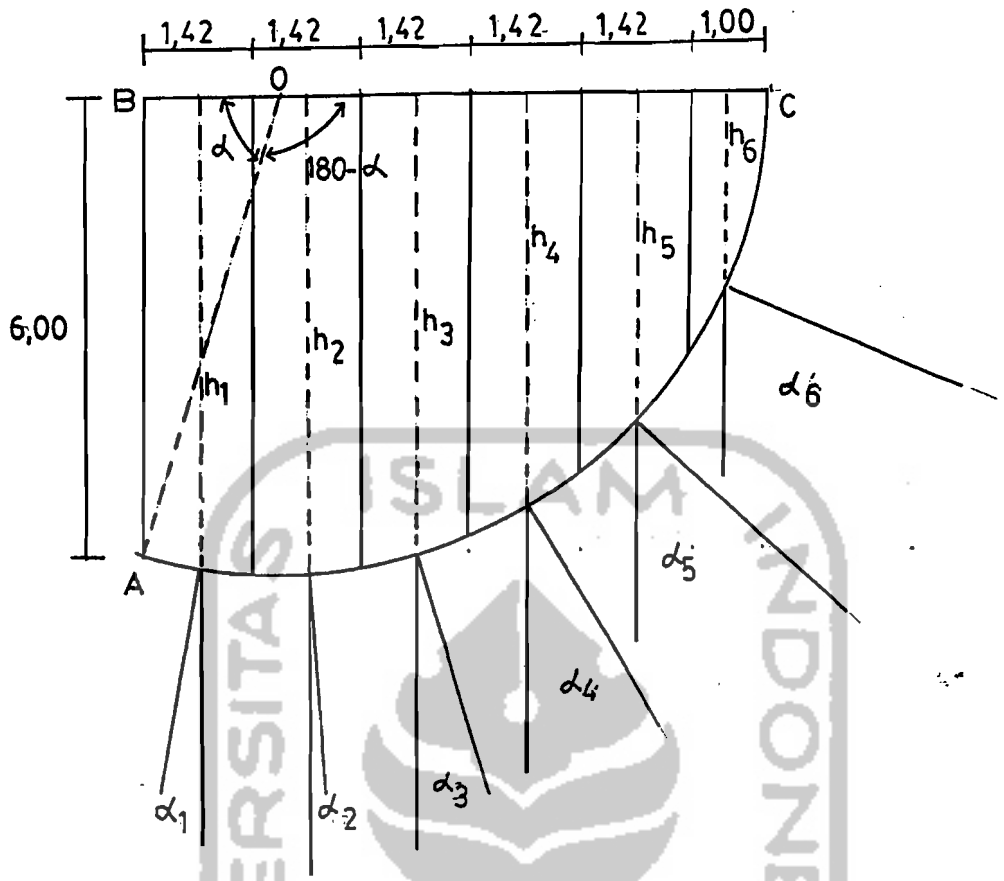
5. Stabilitas Lereng



Gambar 5.6. Bidang Longsor pada Lereng

Lingkaran longsor diasumsikan seperti gambar diatas

- pusat lingkaran berada pada jarak 1,8 m dari tepi lereng
- bidang longsor dibagi dalam 6 pias / bagian, 5 bagian dengan lebar 1,42 m ; 1 bagian dengan lebar 1 m



Gambar 5.7. Pembagian daerah Longsor menjadi Enam Pias

Menentukan panjang busur AC

$$\alpha. = arc.\tan\frac{6}{1,8} = 73,3^0$$

$$Panjang.busur.AC = \frac{180-\alpha}{360}.2.\pi.R = \frac{180-73,3^0}{360}.2.\pi.6,3 = 11,732.m$$

Angka keamanan

$$SF = \frac{L_{AC}.C + \sum N.\tan\varphi}{\sum T}.\rangle.1,5$$

dengan :

L_{AC} = Panjang busur bidang longsor AC = 11,732 m

C = kohesi tanah = 0,5 T / m²

ϕ = sudut gesek dalam tanah = 35,46°

$\sum N = Wi.\cos \alpha_1$

$\sum T = Wi.\sin \alpha_1$

w = Berat tiap bagian permeter panjang = bi.hi. γ

γ = Berat volume tanah = 1,964 T / m³

h = Tinggi permukaan dari dasar bidang longsor = ai / tan α_1

R = Jari-jari lingkaran longsor = 6,3 m

ai = Jarak horisontal pusat pias dari pusat lingkaran

α_1 = Sudut geser singgung masing-masing pias

= arc sin ai / R

Tabel 5.2 Perhitungan Stabilitas Lereng

Pias	b (m)	ai (m)	αi (°)	h (m)	W (ton)	cos α_i	sin αi	N (ton)	T (ton)
1	1,42	1,09	9,96	6,207	17,311	0,9849	0,1730	17,0496	2,9948
2	1,42	0,33	3,0	6,297	17,562	0,9986	0,0523	17,5374	0,9185
3	1,42	1,75	16,13	6,051	16,876	0,9606	0,2778	16,2111	4,6882
4	1,42	3,17	30,21	5,444	15,183	0,8642	0,5032	13,1211	7,6401
5	1,42	4,59	46,77	4,315	12,034	0,6849	0,7286	8,2421	8,7680
6	1,42	5,80	67,02	2,460	6,861	0,3904	0,9206	2,6785	6,3162
								74,8398	31,3258

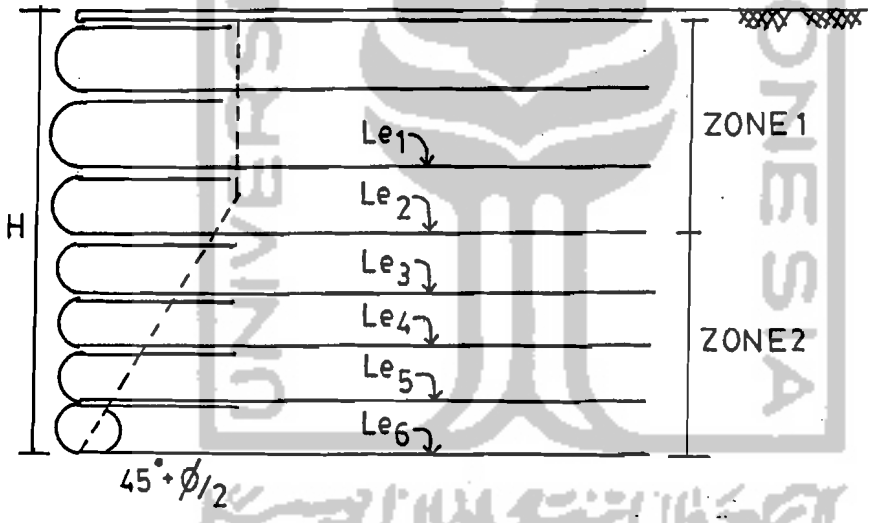
Maka angka keamanan :

$$SF = \frac{L_{AC}.C + \sum N.\tan.\varphi}{\sum T}$$

$$SF = \frac{(11{,}732x0{,}5) + (74{,}839x\tan.35{,}46)}{31{,}3258} = 1{,}89.).1{,}5 \rightarrow Ok$$

C. Stabilitas Internal

Panjang efektif geotekstil (Le) :



Gambar 5.8 Panjang Efektif Geotekstil

Perhitungan angka keamanan tiap lembar geotekstil :

Ko = 1 - sin Ø = 1 - sin 35,46° = 0,4199

Ka = 0,2657

Ta = 13,3333 T / m'

γ = 1,964 T / m³

μ = tan 2.Ø / 3 = tan 2.35,46° / 3 = 0,4377

Kedalaman 1,17 m

$z = 1{,}17$ m ; $Sv = 0{,}97$ m ; $SF = 1{,}5$

$\sigma hc_1 = 2{,}3914$ T / m²

$Le_1 = 1{,}2$ m

Gaya horisontal yang dipikul geotekstil

$FH = Sv \cdot ko \cdot z \cdot \gamma$

$= 0{,}97 \cdot 0{,}4199 \cdot 1{,}17 \cdot 1{,}964$

$= 0{,}9359$ T / m'

Gaya horisontal yang ditahan geotekstil akibat gesekan dengan tanah

$Pf = 2 \cdot \gamma \cdot z \cdot Le \cdot \mu$

$= 2 \cdot 1{,}964 \cdot 1{,}17 \cdot 1{,}2 \cdot 0{,}4377$

$= 2{,}4139$ T / m'

Angka keamanan

$SF = Pf / FH = 2{,}4139 / 0{,}9359 = 2{,}579 > 1{,}5$

Panjang geotekstil *overlapping*

$lo = (\sigma hc_1 \cdot Sv \cdot SF) / (2 \cdot \gamma \cdot z \cdot \mu)$

$= (2{,}3914 \cdot 0.97 \cdot 1{,}5) / (2 \cdot 1{,}964 \cdot 1{,}17 \cdot 0{,}4377) = 1{,}7297$ m

Kedalaman 2,14 m

$z = 2{,}14$ m ; $Sv = 0{,}97$ m ; $SF = 1{,}5$

$\sigma hc_1 = 2{,}3914$ T / m²

$Le_1 = 1{,}2$ m

Gaya horisontal yang dipikul geotekstil

$FH = Sv \cdot ko \cdot z \cdot \gamma$

$= 0{,}97 \cdot 0{,}4199 \cdot 2{,}14 \cdot 1{,}964$

$= 1{,}7119$ T / m'

Gaya horisontal yang ditahan geotekstil akibat gesekan dengan tanah

$Pf = 2 \cdot \gamma \cdot z \cdot Le \cdot \mu$

$= 2 \cdot 1{,}964 \cdot 2{,}14 \cdot 1{,}2 \cdot 0{,}4377$

$= 4{,}4151$ T / m'

Angka keamanan

$SF = Pf / FH = 4{,}4151 / 1{,}7119 = 2{,}58 > 1{,}5$

Panjang geotekstil *overlapping*

$lo = (\sigma hc_1 \cdot Sv \cdot SF) / (2 \cdot \gamma \cdot z \cdot \mu)$

$= (2{,}3914 \cdot 0.97 \cdot 1{,}5) / (2 \cdot 1{,}964 \cdot 2{,}14 \cdot 0{,}4377) = 0{,}9457$ m

Kedalaman 3,00 m

$z = 3{,}00$ m ; $Sv = 0{,}97$ m ; $SF = 1{,}5$

$\sigma hc_1 = 2{,}3914$ T / m²

$Le_2 = 1{,}52$ m

Gaya horisontal yang dipikul geotekstil

$FH = Sv \cdot ko \cdot z \cdot \gamma$

$= 0{,}97 \cdot 0{,}4199 \cdot 3{,}00 \cdot 1{,}964$

$= 2{,}3998$ T / m'

Gaya horisontal yang ditahan geotekstil akibat gesekan dengan tanah

$Pf = 2 . \gamma . z . Le . \mu$

$= 2 . 1{,}964 . 3{,}00 . 1{,}52 . 0{,}4377$

$= 7{,}8399$ T / m'

Angka keamanan

$SF = Pf / FH = 7{,}8399 / 2{,}3998 = 3{,}267 > 1{,}5$

Panjang geotekstil *overlapping*

$lo = (\sigma hc_1 . Sv . SF) / (2 . \gamma . z . \mu)$

$= (2{,}3914 . 0.97 . 1{,}5) / (2 . 1{,}964 . 3{,}00 . 0{,}4377) = 0{,}6746$ m

Kedalaman 3,725 m

$z = 3{,}725$ m ; $Sv = 0{,}725$ m ; $SF = 1{,}5$

$\sigma hc_2 = 4{,}7828$ T / m²

$Le_3 = 1{,}89$ m

Gaya horisontal yang dipikul geotekstil

$FH = Sv . ko . z . \gamma$

$= 0{,}725 . 0{,}4199 . 3{,}725 . 1{,}964$

$= 2{,}2272$ T / m'

Gaya horisontal yang ditahan geotekstil akibat gesekan dengan tanah

$Pf = 2 . \gamma . z . Le . \mu$

$= 2 . 1{,}964 . 3{,}725 . 1{,}89 . 0{,}4377$

$= 12{,}1042$ T / m'

Angka keamanan

SF = Pf / FH = 12,1042 / 2,2272 = 5,4347 > 1,5

Panjang geotekstil *overlapping*

lo = (σhc_1 . Sv. SF) / (2 . γ . z . μ)

= (4,7828 . 0.725 . 1,5) / (2 . 1,964 . 3,725 . 0,4377) = 0,8122 m

Kedalaman 4,45 m

z = 4,45 m ; Sv = 0,725 m ; SF = 1,5

σhc_2 = 4,7828 T / m²

Le_4 = 2,27 m

Gaya horisontal yang dipikul geotekstil

FH = Sv . ko . z . γ

= 0,725 . 0,4199 . 4,45 . 1,964

= 2,6606 T / m'

Gaya horisontal yang ditahan geotekstil akibat gesekan dengan tanah

Pf = 2 . γ . z . Le . μ

= 2 . 1,964 . 4,45. 2,27 . 0,4377

= 17,3674 T / m'

Angka keamanan

SF = Pf / FH = 17,3674 / 2,6606 = 6,528 > 1,5

Panjang geotekstil *overlapping*

lo = (σhc_1 . Sv. SF) / (2 . γ . z . μ)

= (4,7828 . 0.725 . 1,5) / (2 . 1,964 . 4,45 . 0,4377) = 0,6798 m

Kedalaman 5,175 m

z = 5,175 m ; Sv = 0,725 m ; SF = 1,5

σhc_2 = 4,7828 T / m²

Le_5 = 2,64 m

Gaya horisontal yang dipikul geotekstil

FH = Sv . ko . z . γ

= 0,725 . 0,4199 . 5,175 . 1,964

= 3,094 T / m'

Gaya horisontal yang ditahan geotekstil akibat gesekan dengan tanah

Pf = 2 . γ . z . Le . μ

= 2 . 1,964 . 5,175. 2,64 . 0,4377

= 23,4889 T / m'

Angka keamanan

SF = Pf / FH = 23,4889 / 3,0941 = 7,5915 > 1,5

Panjang geotekstil *overlapping*

lo = (σhc_1 . Sv. SF) / (2 . γ . z . μ)

= (4,7828 . 0.725 . 1,5) / (2 . 1,964 . 5,175 . 0,4377) = 0,5846 m

Kedalaman 6,00 m

z = 6,00 m ; Sv = 0,725 m ; SF = 1,5

σhc_2 = 4,7828 T / m²

Le_6 = 3,00 m

Gaya horisontal yang dipikul geotekstil

$FH = Sv \cdot ko \cdot z \cdot \gamma$

$= 0{,}725 \cdot 0{,}4199 \cdot 6{,}00 \cdot 1{,}964$

$= 3{,}5874$ T / m'

Gaya horisontal yang ditahan geotekstil akibat gesekan dengan tanah

$Pf = 2 \cdot \gamma \cdot z \cdot Le \cdot \mu$

$= 2 \cdot 1{,}964 \cdot 6{,}00 \cdot 3{,}00 \cdot 0{,}4377$

$= 30{,}9472$ T / m'

Angka keamanan

$SF = Pf / FH = 30{,}9472 / 3{,}5874 = 8{,}6266 > 1{,}5$

Panjang geotekstil *overlapping*

$lo = (\sigma hc_1 \cdot Sv \cdot SF) / (2 \cdot \gamma \cdot z \cdot \mu)$

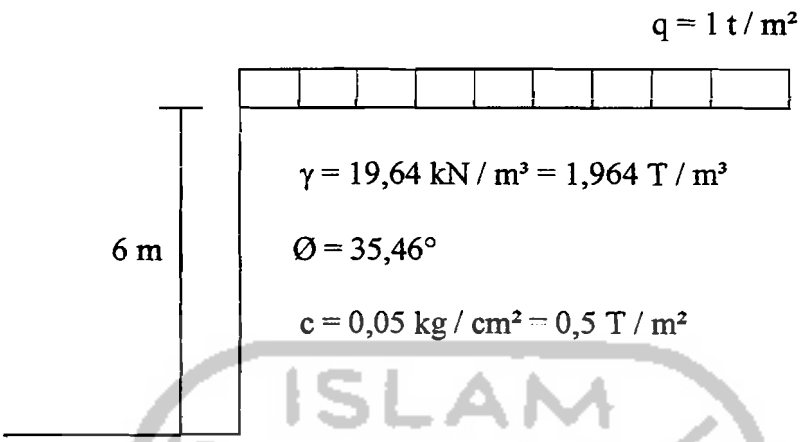
$= (4{,}7828 \cdot 0.725 \cdot 1{,}5) / (2 \cdot 1{,}964 \cdot 6{,}00 \cdot 0{,}4377) = 0{,}5042$ m

Tabel 5.3 Angka Keamanan dan Panjang Geotekstil *Overlapping*

No	Sv (m)	Z (m)	FH (T/m')	Le (m)	Pf (T/m')	σ_{hc} (T/m²)	Lo (m)	SF
1	0,97	1,17	0,9359	1,2	2,4139	2,3914	1,7297	2,579
2	0,97	2,14	1,7119	1,2	4,4151	2,3914	0,9457	2,580
3	0,97	3,00	2,3998	1,52	7,8399	2,3914	0,8746	3,267
4	0,725	3,725	2,2272	1,89	12,1042	4,7828	0,8122	5,4347
5	0,725	4,45	2,6606	2,27	17,3674	4,7828	0,6798	6,528
6	0,725	5,175	3,0940	2,64	23,4889	4,7828	0,5846	7,5915
7	0.725	6,00	3,5874	3,00	30,9472	4,7828	0,5042	8,6266

SF > 1,5 jadi panjang geotekstil yang digunakan 3 m

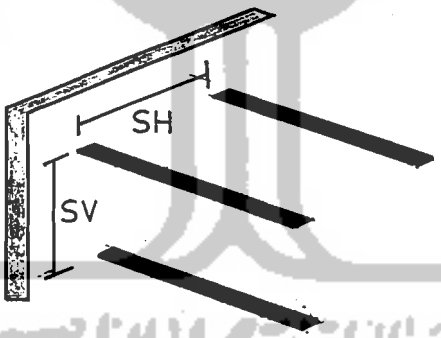
5.3.2 Perkuatan Tanah Dengan *Strip Reinsforced*



Gambar 5 . 9 Kondisi Lereng

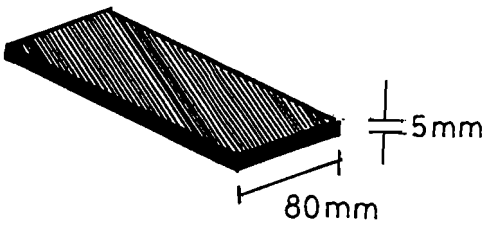
Data geotekstil :

Strip reinsforced ukuran 8 cm x 0,5 cm , kuat tarik = 4500 kg / cm² , menggunakan *facing* beton bertulang, dipakai *spacing* (jarak antara *strip*) SV = 0,70 m, SH = 1,00 m

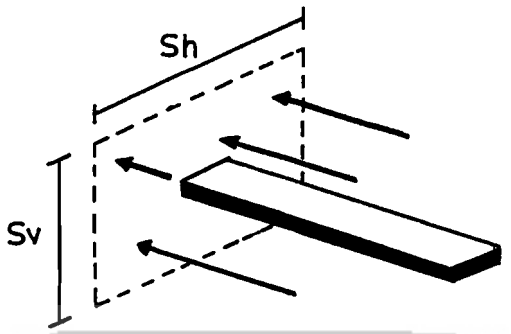


Gambar 5.10 *Facing element*

Gunakan ukuran strip : 80 mm x 5 mm

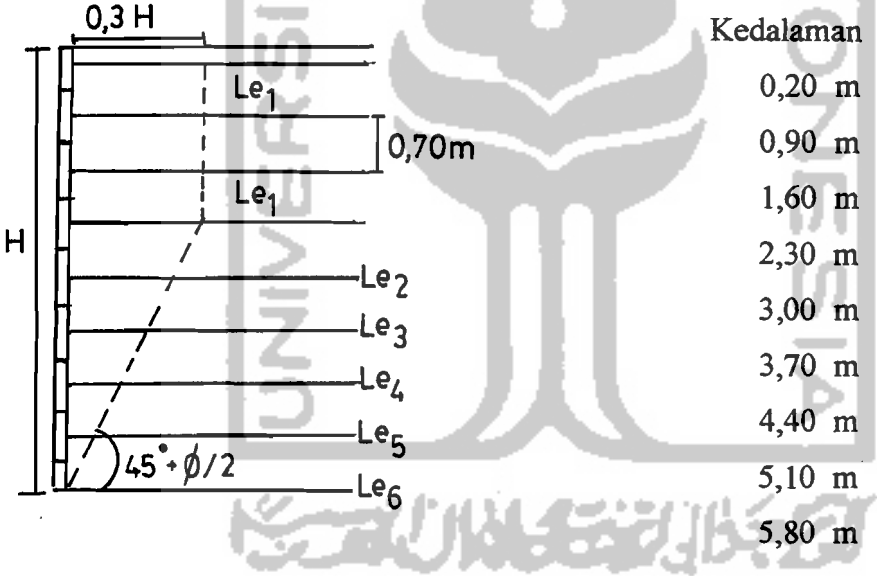


Gambar 5.11 Strip



Gambar 5.12 Luas Bidang yang Dipikul Satu Strip

Gunakan bilinier garis keruntuhan



Gambar 5.13 Desain Perkuatan

ko =1 - sin Ø = 1 - sin 35,46° = 0,4199 ; ka = tan² (45° - Ø / 2) = 0,2657

Digunakan strip ukuran : 80 mm x 5 mm

σ_{ijin} tarik = 4500 kg / cm² = 4,5 Ton / cm²

$Le_1 = 3 - (0,3 . 6) = 3 - 1,8 = 1,2$ m

$Le_2 = (3 - 1,8) + 0,52 \times 0,70 = 1,564$ m

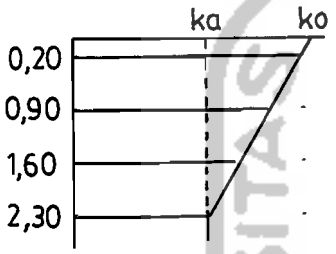
$Le_3 = (3 - 1,8) + 0,52 \times 1,40 = 1,928$ m

$Le_4 = (3 - 1,8) + 0,52 \times 2,10 = 2,292$ m

$Le_5 = (3 - 1,8) + 0,52 \times 2,80 = 2,656$ m

$Le_6 = (3 - 1,8) + 0,52 \times 3,50 = 3,00$ m

Distribusi tegangan horisontal



Kedalaman (m)	k
0,20	0,4065
0,90	0,3462
1,60	0,2992
2,30	0,2657
3,00	0,2657
3,70	0,2657
4,40	0,2657
5,10	0,2657
5,80	0,2657

A. *External Stability*

1. *Sliding along the base*

$$Ka = \tan^2.(45^0 - \frac{\varphi}{2}) = \tan^2.(45^0 - \frac{35,46^0}{2}) = 0,2657$$

$$L = \frac{SF.Ka.(q + \gamma..\frac{H}{2})}{\gamma..\tan\varphi} = \frac{1,5.0,2657.(1 + 1,96.\frac{6}{2})}{1,96.\tan 35,46^0} = 1,9642m$$

2.*Overturning about the toe*

$$L^2 = \frac{SF.H.Ka.(q+1/3.\gamma.H)}{\gamma} = \frac{2.6.0{,}2657.(1+1/3.1{,}96.6)}{1{,}96} = 8{,}0035$$

$$L = 2{,}829.m$$

3. *Bearing capacity*

Berat tanah untuk *reinsforcement* = L . H . 1 . γ = L x 6 x 1 x 1,964 = 11,76L

Berat tanah : q = (11,76 + 1).L = 12.76.L ton = σ_v

$$L = \frac{SF.\sigma_v}{q_{ult}} = \frac{SF.(12{,}76.L)}{30} \Rightarrow SF = \frac{30.L}{12{,}76.L}; untuk.L = 2{,}00.m$$

$$SF = \frac{60}{25{,}52} = 2{,}35 \rightarrow Jadi.L \geq 2{,}00.m \rightarrow OK$$

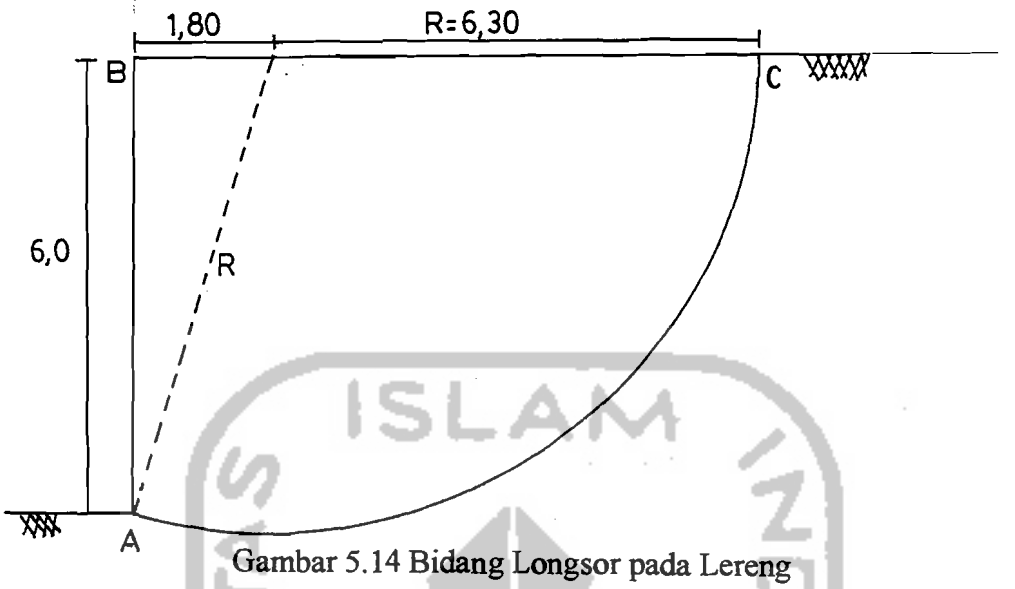
4. Eksentrisitas

$$1/6.L = \frac{q.Ka.H^2/2 + \gamma.Ka..H.3/6}{H.L.\gamma + q.L} = \frac{1.0{,}2657.36/2 + 1{,}96.0{,}2657.6.3/6}{6.L.1{,}96 + 1.L}$$

$$L^2 = \frac{6{,}344916.6}{12{,}76} = 2{,}9835 \rightarrow L = 1{,}73.m$$

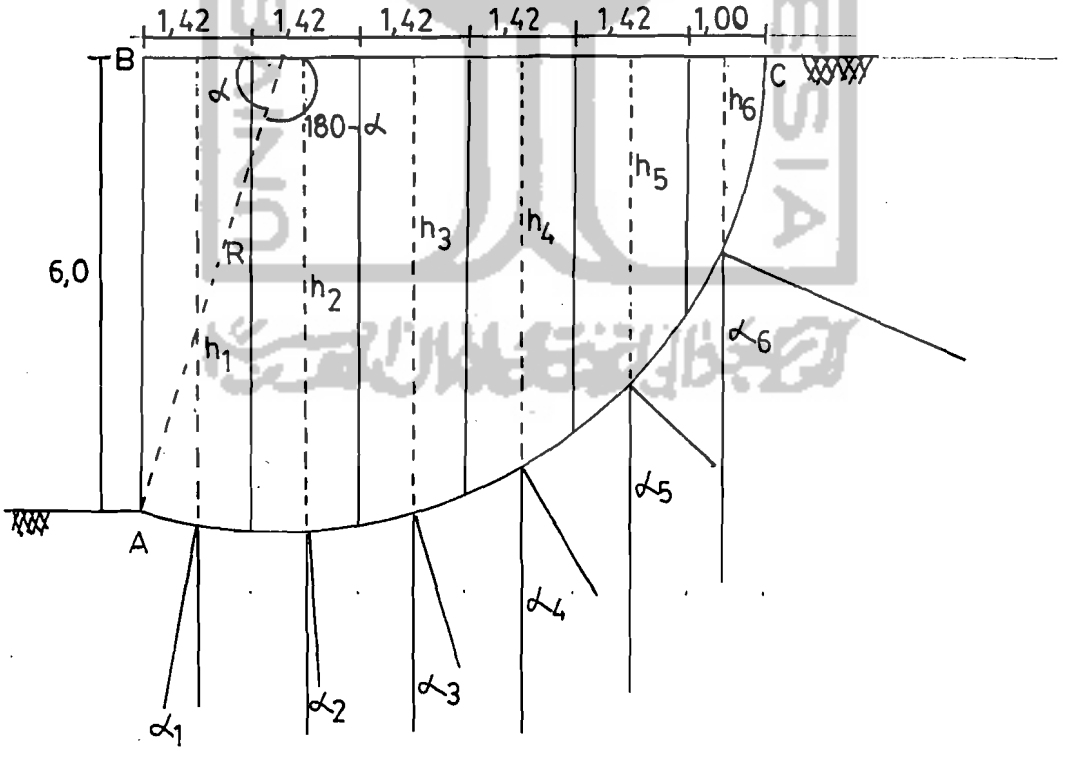
Digunakan L = 3 meter

5.*Slope stability*



Gambar 5.14 Bidang Longsor pada Lereng

Lingkaran longsor diasumsikan seperti tergambar, dengan pusat lingkaran pada muka tanah, 1,8 meter dari tepi. Bidang longsor AC dibagi dalam 6 pias / bagian, 5 bagian dengan lebar 1,42 meter dan 1 bagian dengan lebar 1 meter



Gambar 5.15 Pembagian Daerah Longsor menjadi Enam Pias

Menentukan panjang busur AC

$$\alpha = arc.\tan.\frac{6}{1,8} = 73,3^0$$

$$Panjang.busur.AC = \frac{180-\alpha}{360}.2.\pi.R = \frac{180-73,3}{360}.2.\pi.6,3 = 11,732.m$$

Angka keamanan

$$SF = \frac{L_{AC}.C + \sum N.\tan\varphi}{\sum T}.\rangle.1,5$$

Dengan :

L_{AC}	=	Panjang busur bidang longsor AC	= 11,732 m
C	=	kohesi tanah	= 0,5 T / m²
ϕ	=	sudut gesek dalam tanah	= 35,46°
$\sum N$	=	Wi.cos α_1	
$\sum T$	=	Wi.sin α_1	
w	=	Berat tiap bagian permeter panjang	= bi.hi. γ
γ	=	Berat volume tanah	= 1,964 T / m³
h	=	Tinggi permukaan dari dasar bidang longsor	= ai / tan α_1
R	=	Jari-jari lingkaran longsor	= 6,3 m
ai	=	Jarak horisontal pusat pias dari pusat lingkaran	
α_1	=	Sudut geser singgung masing-masing pias	
	=	arc sin ai / R	

Tabel 5.4 Perhitungan Stabilitas Lereng

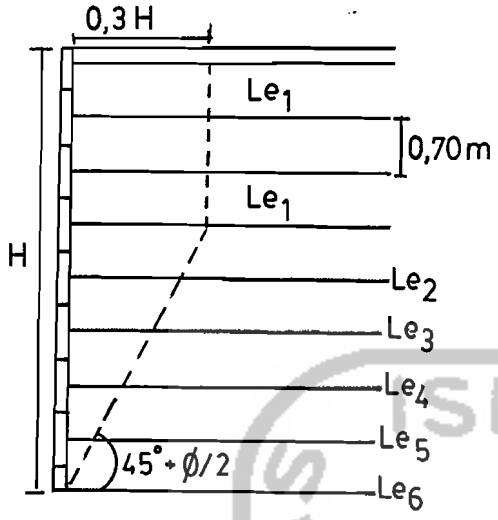
Pias	b (m)	ai (m)	αi (°)	h (m)	W (ton)	cos α_i	sin α_i	N (ton)	T (ton)
1	1,42	1,09	9,96	6,207	17,311	0,9849	0,1730	17,0496	2,9948
2	1,42	0,33	3,0	6,297	17,562	0,9986	0,0523	17,5374	0,9185
3	1,42	1,75	16,13	6,051	16,876	0,9606	0,2778	16,2111	4,6882
4	1,42	3,17	30,21	5,444	15,183	0,8642	0,5032	13,1211	7,6401
5	1,42	4,59	46,77	4,315	12,034	0,6849	0,7286	8,2421	8,7680
6	1,42	5,80	67,02	2,460	6,861	0,3904	0,9206	2,6785	6,3162
								74,8398	31,3258

Maka angka keamanan :

$$SF = \frac{L_{AC}.C + \sum N.\tan.\varphi}{\sum T}$$

$$SF = \frac{(11,732x0,5) + (74,839x\tan.35,46)}{31,3258} = 1,89.).1,5 \rightarrow Ok$$

B. *Internal Stability*



ko =1 - sin Ø = 1 - sin 35,46° = 0,4199 ; ka = tan² (45° - Ø / 2) = 0,2657

Digunakan strip ukuran : 80 mm x 5 mm

σ_{ijin} tarik = 4500 kg / cm² = 4,5 Ton / cm²

Le_1 = 3 - (0,3 . 6) = 3 - 1,8 = 1,2 m

Le_2 = (3 - 1,8) + 0,52 x 0,70 = 1,564 m

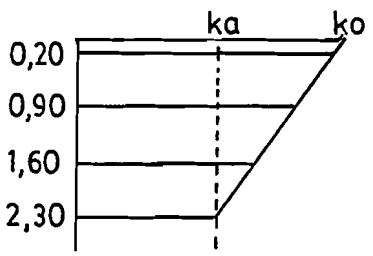
Le_3 = (3 - 1,8) + 0,52 x 1,40 = 1,928 m

Le_4 = (3 - 1,8) + 0,52 x 2,10 = 2,292 m

Le_5 = (3 - 1,8) + 0,52 x 2,80 = 2,656 m

Le_6 = (3 - 1,8) + 0,52 x 3,50 = 3,00 m

Distribusi tegangan horisontal



Kedalaman (m)	k
0,20	0,4065
0,90	0,3462
1,60	0,2992
2,30	0,2657
3,00	0,2657
3,70	0,2657
4,40	0,2657
5,10	0,2657
5,80	0,2657

Kedalaman 0,20 m

k = 0.4065 , A = Sh x Sv = 0,54 m^2

Gaya horisontal yang dipikul : FH = Sh . Sv . γ . z . k

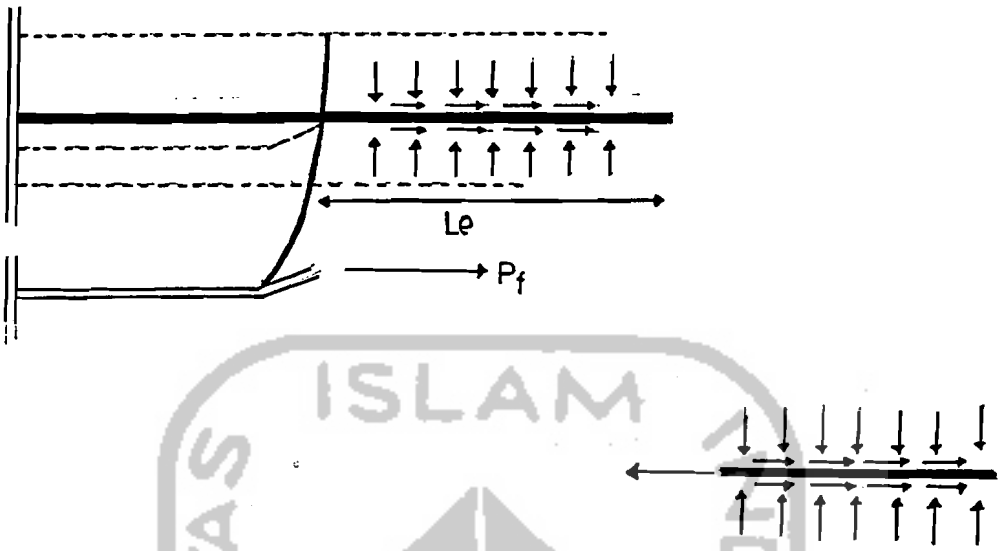
= 0,54 . 1,964 . 0,20 . 0,4065

= 0,0862 T

Kapasitas tarik *reinsforcement* : FT = Ar . σ_{ijin} = 8 . 0,5 .4,5 =18 ton

SF terhadap *rupture* = FT / FH = 18 / 0,0862 = 208,82 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :



$Pf = 2 . b . \gamma . z . u^* . Le_1 = 2 . 0,08 . 1,964 . 0,20 . 1,5 . 1,2 = 0,1129$ T / m'

SF terhadap *pullout* = Pf / FH = 0,1129 / 0,0862 = 1,31 > 1 OK

Panjang geotekstil *overlapping*

$lo = (\sigma hc_1 . Sv . SF) / (2 . \gamma . z . \mu)$

$= (1,7318 . 0,2 . 1,5) / (2 . 1,964 . 0,2 . 0,4377) = 1,5109$ m

Kedalaman 0,90 m

k = 0,3462 , A = Sh x Sv = 0,54 m²

Gaya horisontal yang dipikul : FH = Sh . Sv . γ . z . k

= 0,54 . 1,964 . 0,90 . 0,3462

= 0,3304 T

Kapasitas tarik *reinsforcement* : FT = Ar . σ_{ijin} = 8 . 0,5 .4,5 =18 ton

SF terhadap *rupture* = FT / FH = 18 / 0,3304 = 54,48 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :

$Pf = 2 . b . \gamma . z . u^* . Le_1 = 2 . 0,08 . 1,964 . 0,90 . 1,5 . 1,2 = 0,5091$ T

SF terhadap *pullout* = Pf / FH = 0,5091 / 0,3304 = 1,54 > 1 OK

Panjang geotekstil *overlapping*

$lo = (\sigma hc_1 . Sv . SF) / (2 . \gamma . z . \mu)$

$= (1,7318 . 0,70 . 1,5) / (2 . 1,964 . 0,90 . 0,4377) = 1,175$ m

Kedalaman 1,60 m

k = 0,2992 , A = Sh x Sv = 0,54 m^2

Gaya horisontal yang dipikul : $FH = Sh . Sv . \gamma . z . k$

$= 0,54 . 1,964 . 1,60 . 0,2992$

$= 0,5077$ T

Kapasitas tarik *reinsforcement* : $FT = Ar . \sigma_{ijin} = 8 . 0,5 .4,5 = 18$ ton

SF terhadap *rupture* = FT / FH = 18 / 0,5077 = 35,45 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :

$Pf = 2 . b . \gamma . z . u^* . Le_1 = 2 . 0,08 . 1,964 . 1,60 . 1,5 . 1,2 = 0,9050$ T

SF terhadap *pullout* = Pf / FH = 0,9050 / 0,5077 = 1,78 > 1 OK

Panjang geotekstil *overlapping*

$lo = (\sigma hc_1 . Sv . SF) / (2 . \gamma . z . \mu)$

$= (1,7318 . 0,54 . 1,5) / (2 . 1,964 . 1,60 . 0,4377) = 0,66$ m

Kedalaman 2,30 m

k = 0,2657 , A = Sh x Sv = 0,54 m²

Gaya horisontal yang dipikul : FH = Sh . Sv . γ . z . k

= 0,54 . 1,964 . 2,30 . 0,2657

= 0,6481 T

Kapasitas tarik *reinsforcement* : FT = Ar . σ_{ijin} = 8 . 0,5 .4,5 =18 ton

SF terhadap *rupture* = FT / FH = 18 / 0,6481 = 27,77 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :

Pf = 2 . b . γ . z . u* . Le_1 = 2 . 0,08 . 1,964 . 2,30 . 1,5 . 1,2 = 1,3010 T

SF terhadap *pullout* = Pf / FH = 1,3010 / 0,6481 = 2,01 > 1 OK

Panjang geotekstil *overlapping*

lo = (σhc_1 . Sv. SF) / (2 . γ . z . μ)

= (1,7318 . 0,70 . 1,5) / (2 . 1,964 . 2,30 . 0,4377) = 0,46 m

Kedalaman 3,00 m

k = 0,2657 , A = Sh x Sv = 0,54 m²

Gaya horisontal yang dipikul : FH = Sh . Sv . γ . z . k

= 0,54 . 1,964 . 3,00 . 0,2657

= 0,8454 T

Kapasitas tarik *reinsforcement* : FT = Ar . σ_{ijin} = 8 . 0,5 .4,5 =18 ton

SF terhadap *rupture* = FT / FH = 18 / 0,8454 = 21,29 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :

$Pf = 2 . b . \gamma . z . u^* . Le_2 = 2 . 0{,}08 . 1{,}964 . 3{,}00.1{,}5 . 1{,}564 = 2{,}2116$ T

SF terhadap *pullout* = Pf / FH = 2,2116 / 0,8454 = 2,62 > 1 OK

Panjang geotekstil *overlapping*

$lo = (\sigma hc_2 . Sv . SF) / (2 . \gamma . z . \mu)$

$= (4{,}7832 . 0{,}70 . 1{,}5) / (2 . 1{,}964 . 3{,}00 . 0{,}4377) = 0{,}97$ m

Kedalaman 3,70 m

k = 0,2657 , A = Sh x Sv = 0,54 m^2

Gaya horisontal yang dipikul : FH = Sh . Sv . γ . z . k

= 0,54 . 1,964 . 3,70 . 0,2657

= 1,0426 T

Kapasitas tarik *reinsforcement* : FT = Ar . σ_{ijin} = 8 . 0,5 .4,5 =18 ton

SF terhadap *rupture* = FT / FH = 18 / 1,0426 = 17,26 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :

$Pf = 2 . b . \gamma . z . u^* . Le_3 = 2 . 0{,}08 . 1{,}964 . 3.70 . 1{,}5 . 1{,}928 = 3{,}3625$ T

SF terhadap *pullout* = Pf / FH = 3,3625 / 1,0426 = 3,23 > 1 OK

Panjang geotekstil *overlapping*

$lo = (\sigma hc_2 . Sv . SF) / (2 . \gamma . z . \mu)$

$= (4{,}7832 . 0{,}70 . 1{,}5) / (2 . 1{,}964 . 3{,}70 . 0{,}4377) = 0{,}79$ m

Kedalaman 4,40 m

k = 0,2657 , A = Sh x Sv = 0,54 m²

Gaya horisontal yang dipikul : FH = Sh . Sv . γ . z . k

= 0,54 . 1,964 . 4,40 . 0,2657

= 1,2399 T

Kapasitas tarik *reinsforcement* : FT = Ar . σ_{ijin} = 8 . 0,5 .4,5 =18 ton

SF terhadap *rupture* = FT / FH = 18 / 1,2399 = 14,52 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :

Pf = 2 . b . γ . z . u* . Le_4 = 2 . 0,08 . 1,964 . 4,40 . 1,5 . 2,292 = 4,7536 T

SF terhadap *pullout* = Pf / FH = 4,7536 / 1,2399 = 3,84 > 1 OK

Panjang geotekstil *overlapping*

lo = (σhc_2 . Sv. SF) / (2 . γ . z . μ)

= (4,7832 . 0,70 . 1,5) / (2 . 1,964 . 4,40 . 0,4377) = 0,66 m

Kedalaman 5,10 m

k = 0,2657 , A = Sh x Sv = 0,54 m²

Gaya horisontal yang dipikul : FH = Sh . Sv . γ . z . k

= 0,54 . 1,964 . 5,10 . 0,2657

= 1,4371 T

Kapasitas tarik *reinsforcement* : FT = Ar . σ_{ijin} = 8 . 0,5 .4,5 =18 ton

SF terhadap *rupture* = FT / FH = 18 / 1,4371 = 12,52 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :

$Pf = 2 . b . \gamma . z . u^* . Le_5 = 2 . 0,08 . 1,964 . 5,10 . 1,5 . 2,656 = 6,3849$ T

SF terhadap *pullout* = Pf / FH = 6,3849 / 1,4371 = 4,44 > 1 OK

Panjang geotekstil *overlapping*

$lo = (\sigma hc_2 . Sv . SF) / (2 . \gamma . z . \mu)$

$= (4,7832 . 0,70 . 1,5) / (2 . 1,964 . 5,10 . 0,4377) = 0,57$ m

Kedalaman 5,80 m

k = 0,2657 , A = Sh x Sv = 0,54 m²

Gaya horisontal yang dipikul : $FH = Sh . Sv . \gamma . z . k$

$= 0,54 . 1,964 . 5,80 . 0,2657$

$= 1,6344$ T

Kapasitas tarik *reinsforcement* : $FT = Ar . \sigma_{ijin} = 8 . 0,5 .4,5 = 18$ ton

SF terhadap *rupture* = FT / FH = 18 / 1,6344 = 11,01 > 1 OK

Gaya horisontal yang ditahan *reinsforcement* akibat dipegang oleh tanah :

$Pf = 2 . b . \gamma . z . u^* . Le_6 = 2 . 0,08 . 1,964 . 5,80 . 1,5 . 3,50 = 9,5686$ T

SF terhadap *pullout* = Pf / FH = 9,5686 / 1,6344 = 5,85 > 1 OK

Panjang geotekstil *overlapping*

$lo = (\sigma hc_2 . Sv . SF) / (2 . \gamma . z . \mu)$

$= (4,7832 . 0,70 . 1,5) / (2 . 1,964 . 5,80 . 0,4377) = 0,5$ m

Tabel 5.5 Angka Keamanan dan Panjang Geotekstil *Overlapping*

No	Sv (m)	Z (m)	FH (T)	Le (m)	Pf (T)	σ_h (T/m²)	Lo (m)	SF
1	0,2	0,2	0,0862	1,2	0,1129	1,7318	1,51	1,31
2	0,70	0,90	0,3304	1,2	0,5091	1,7318	1,18	1,54
3	0,70	1,60	0,5077	1,2	0,9050	1,7318	0,66	1,78
4	0,70	2,30	0,6481	1,2	1,3010	1,7318	0,46	2,01
5	0,70	3,00	0,8454	1,564	2,2116	4,7832	0,97	2,62
6	0,70	3,70	1,0426	1,928	3,3625	4,7832	0,79	3,23
7	0,70	4,40	1,2399	2,292	4,7536	4,7832	0,66	3,84
8	0.70	5,10	1,4371	2,656	6,3849	4,7832	0,57	4,44
9	0,70	5,80	1,6344	3,50	9,5686	4,7832	0,50	5,85

SF > 1,5 jadi panjang geotekstil yang digunakan 3 m

Kesimpulan

Panjang *reinsforcement strip* dengan L = 3,00 meter aman dipakai untuk konstruksi dengan SF terhadap *pullout* sebagai berikut:

Tabel 5.6 Hasil Perhitungan Kedalaman Terhadap SF

Kedalaman (m)	SF terhadap *pullout*
0,20	1,31
0,90	1,54
1,60	1,78
2,30	2,01
3,00	2,62
3,70	3,23
4,40	3,84
5,10	4,44
5,80	5,85