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Analisis Stabilitas Dan Kapasitas Daya Dukung Dinding Penahan Tanah Tipe T Terbalik Menggunakan Metode Rankine

Stability and Bearing Capacity Analysis of Inverted T-Type Retaining Walls Using the Rankine Method

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ABSTRAK
Dinding penahan tanah merupakan salah satu elemen penting dalam konstruksi teknik sipil yang berfungsi untuk menahan gaya lateral dari tanah timbunan pada area dengan perbedaan elevasi. Stabilitas dinding penahan sangat bergantung pada dimensi geometris, sifat tanah di sekitar, serta beban yang bekerja pada struktur. Penelitian ini bertujuan untuk mengevaluasi stabilitas dinding penahan tanah tipe T terbalik (inverted T-shaped retaining wall) dengan tinggi 5,0 meter berdasarkan parameter teknis geoteknik dan geometri desain yang tersedia. Evaluasi dilakukan terhadap tiga kriteria utama yaitu kestabilan terhadap guling (overturning), geser (sliding), dan daya dukung tanah (bearing capacity). Data parameter tanah timbunan dan tanah pondasi diolah untuk menghitung gaya aktif lateral, gaya tahan struktur, dan tekanan tanah maksimum. Hasil analisis menunjukkan bahwa dengan parameter tanah yang digunakan serta dimensi dinding yang dirancang, struktur ini dapat memenuhi syarat stabilitas minimum sesuai standar teknis, baik untuk kondisi normal maupun seismik.

ABSTRACT
Retaining walls are essential structural elements in civil engineering construction, designed to resist lateral earth pressures from backfill soils in areas with elevation differences. The stability of retaining walls is highly influenced by the geometric dimensions of the structure, the surrounding soil properties, and the external loads acting upon them. This study aims to evaluate the stability of an inverted T-shaped retaining wall with a height of 5.0 meters based on the available geotechnical parameters and structural geometry. The evaluation focuses on three main aspects: stability against overturning, sliding, and bearing capacity failure. The parameters of the backfill and foundation soils are used to calculate the lateral earth pressure, resisting forces due to the self-weight of the structure, and the maximum soil bearing pressure beneath the footing. The results of the analysis indicate that, with the parameters used, the retaining wall design meets the minimum stability requirements according to technical standards, under both normal and seismic loading conditions.

PENDAHULUAN

Perkembangan pembangunan infrastruktur di wilayah bertopografi curam seperti lereng, tebing, atau kawasan perbukitan menuntut adanya struktur penahan tanah untuk menjamin kestabilan lereng serta keselamatan pengguna. Salah satu solusi teknis yang umum digunakan adalah dinding penahan tanah (retaining wall), yang berfungsi menahan tekanan lateral akibat tanah timbunan, air tanah, atau beban luar lainnya. Pemilihan jenis dan desain dinding penahan tanah sangat ditentukan oleh kondisi lapangan, ketersediaan lahan, serta efisiensi struktur. Dinding penahan tanah tipe T terbalik (inverted T-shaped retaining wall) merupakan salah satu bentuk yang efisien karena memiliki alas lebar yang meningkatkan stabilitas tanpa memerlukan struktur penahan tambahan. Meskipun demikian, desain struktur ini tetap harus memenuhi persyaratan kestabilan terhadap tiga potensi keruntuhan utama, yaitu guling, geser, dan daya dukung tanah. Kegagalan dalam mempertimbangkan ketiga aspek tersebut dapat mengakibatkan keruntuhan struktur yang membahayakan keselamatan dan meningkatkan biaya rehabilitasi. Penelitian ini dilakukan untuk mengevaluasi stabilitas dinding penahan tanah tipe T terbalik setinggi 5,0 meter berdasarkan data geometri struktur dan parameter tanah yang telah ditentukan. Evaluasi dilakukan dengan menghitung gaya aktif tanah menggunakan teori Rankine, meninjau momen stabilisasi dan momen pengguling, serta menganalisis gaya geser dan tekanan maksimum tanah pondasi. Tujuan akhir dari penelitian ini adalah memastikan bahwa desain yang diajukan memenuhi persyaratan keamanan teknis yang berlaku dan dapat digunakan secara andal dalam proyek teknik sipil.

METODE

Evaluasi stabilitas dinding penahan tanah tipe T terbalik dilakukan dengan menggunakan pendekatan teoritis yang melibatkan dua metode utama dalam mekanika tanah, yaitu teori Rankine untuk gaya tekanan tanah lateral dan teori Terzaghi untuk menghitung daya dukung ultimit pondasi. Analisis dilakukan dalam tiga aspek utama: guling (overturning), geser (sliding), dan daya dukung tanah (bearing capacity), baik dalam kondisi normal maupun seismik.

Gaya Aktif Tanah (Metode Rankine)

1. Tanah bersifat homogen dan isotropik.
2. Bidang keruntuhan tanah berbentuk garis lurus.
3. Tanah berada dalam kondisi batas keseimbangan (limit equilibrium).
4. Tidak ada kohesi untuk tanah non-kohesif ($c = 0$), namun untuk tanah kohesif ($c \neq 0$) diperhitungkan.
5. Permukaan tanah dapat mendatar atau miring.
6. Dinding penahan tidak menahan gesekan (tidak ada gesekan antara tanah dan dinding).

Koefisien Tekanan Aktif (Ka) , c=0

Untuk tanah non-kohesif dengan permukaan tanah datar:

$$Ka = tan^2\left(45^2 - \frac{\emptyset}{2}\right) = \frac{1 - sin\emptyset}{1 + sin\emptyset}$$

Dimana :

Φ = sudut geser dalam tanah (friction angle)

Tekanan Aktif Rankine pada Kedalaman Tertentu (σ_a)

$$\sigma a = Ka.\gamma.h$$

di mana:

- σa = tekanan lateral aktif pada kedalaman hhh
- γ = berat jenis tanah (kN/m³)
- h = kedalaman dari permukaan tanah (m)

Gaya Tekan Total Aktif (P_a)

$$Pa = \frac{1}{2}Ka.\gamma.h$$

Pa = gaya aktif total (kN/m) terhadap dinding

- H = tinggi dinding (m)

Untuk Tanah Kohesif (c ≠ 0)

Jika tanah memiliki kohesi ccc, maka gaya aktif menjadi:

$$Pa = \frac{1}{2}Ka.\gamma.H^2 - 2c\sqrt{Ka}.H$$

$\sigma a = Ka.\gamma.h$-2c$\sqrt{Ka}.H$

Untuk Permukaan Tanah Miring (Sudut i)

Jika permukaan tanah miring dengan sudut i

$$Ka = \frac{\cos i - \sqrt{cos^2 i - cos^2\emptyset}}{\cos i + \sqrt{cos^2 i - cos^2\emptyset}}$$

Rumus ini digunakan untuk memperhitungkan efek permukaan tanah yang miring terhadap tekanan lateral.

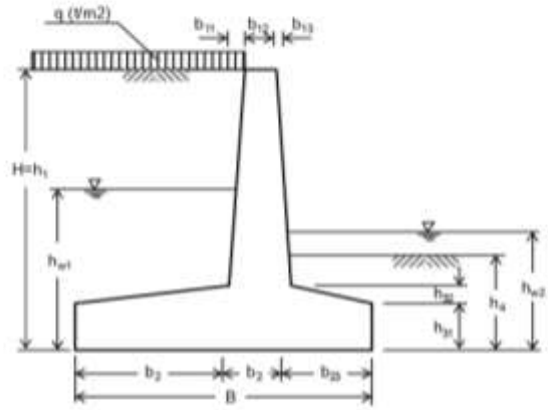
HASIL DAN PEMBAHASAN

Inverted T-shape Type Retaining Wall (H=5,0m)

1. Design Data

1.1 Dimensions

B	=	5,20	m	H	=	5,00	m
L	=	1,00	m (unit length)				
b_{11}	=	0,06	m	b_{21}	=	4,10	m
b_{12}	=	0,35	m	b_{22}	=	0,50	m
b_{13}	=	0,09	m	b_{23}	=	0,60	m
h_1	=	5,00	m	h_4	=	0,00	m
h_{31}	=	0,50	m	h_{w1}	=	2,50	m
h_{32}	=	0,00	m	h_{w2}	=	0,50	m



Section of Retaining Wall

1.2 Parameters

q	=	1,00	t/m² (for normal condition)
	=	0,00	t/m² (for seismic condition)
γ_c	=	2,40	t/m³
γ_w	=	1,00	t/m³

Backfill soil

γ_{soil}	=	1,80	t/m³
γ_{sat}	=	2,00	t/m³
c	=	0,00	t/m²
ϕ	=	30,00	°

Foundation soil

γ_s'	=	1,00	t/m³ ($=\gamma_{sat}-\gamma_w$)
c_B	=	0,00	t/m²
ϕ_B	=	30,00	°
μ	=	0,50	(Friction coefficient)

Safety factor

Overturning

normal	$\|e\|<B/6=0,87$m
seismic	$\|e\|<B/3=1,73$m

Sliding

normal	fs $\geq$ 2,00
seismic	fs $\geq$ 1,25

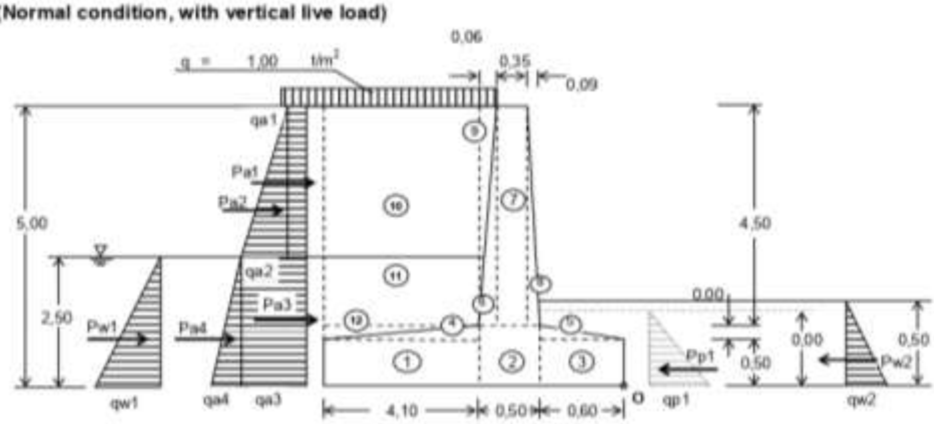
Reaction of foundation soil

normal	qmax$\leq$qa
	qa=qu/3
seismic	qmax$\leq$qae
	qae=qu/2

β	=	0,000	°	
α	=	0,000	°	(for stability analysis)
	=	0,764	°	(for structural analysis)
δ	=	0,000	°	(for stability analysis in normal condition, $\delta=\beta$)
	=	20,00	°	(for structural analysis in normal condition, $\delta=2/3\ \phi$)
	=	22,54	°	(for stability analysis in seismic condition, see Section 2.3)
	=	15,00	°	(for structural analysis in seismic condition, $\delta=1/2\ \phi$)
Φ	=	9,090	°	(= Arc tan(Kh)) Kh = 0,16

2. Stability Calculation

2.1 Case 1 (Normal condition, with vertical live load)



Acting Load in Case 1

No.	Description					H	Y	H x Y
Pa1	0,333	x	2,50			0,833	3,750	3,125
Pa2	1,500	x	2,50	x	0,50	1,875	3,333	6,250
Pa3	1,833	x	2,50			4,583	1,250	5,729
Pa4	0,833	x	2,50	x	0,50	1,042	0,833	0,868
Pw1	2,500	x	2,50	x	0,50	3,125	0,833	2,603
Pw2	-0,500	x	0,50	x	0,50	-0,125	0,167	-0,021
Pp1	0,000	x	0,00	x	0,50	0,000	0,000	0,000
Total						**11,333**		**18,555**

(3) Stability Calculation

a) Stability against overturning

B = 5,20 m

$$X = \frac{\Sigma W \times X - \Sigma H \times Y}{\Sigma W} = \frac{143{,}189 - 18{,}555}{50{,}083} = 2{,}489 \text{ m}$$

$$e = \frac{B}{2} - X = \frac{5{,}20}{2} - 2{,}489 = \mathbf{0{,}111} \text{ m} < B/6 = 0{,}867 \text{ m} \quad \textbf{OK !}$$

b) Stability against sliding

Sliding force : $\Sigma H = 11{,}333$ ton

Resistance : $HR = \mu \times \Sigma W = 0{,}50 \times 50{,}083 = 25{,}042$ ton

(friction coefficient : $\mu =$ 0,5)

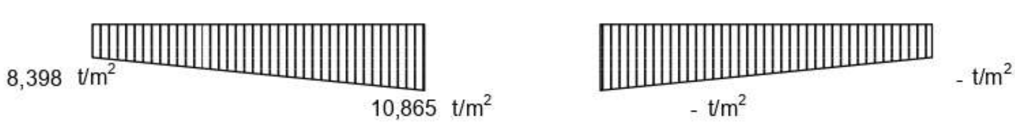
$$Fs = \frac{HR}{\Sigma H} = \frac{25{,}042}{11{,}333} = \mathbf{2{,}210} > 2{,}00 \quad \textbf{OK !}$$

c) Reaction of foundation soil

$$q1{,}2 = \frac{\Sigma W}{B} \times \left(1 \pm \frac{6 \times e}{B}\right)$$

$$q1 = \frac{50{,}083}{5{,}20} \times \left(1 + \frac{6 \times 0{,}111}{5{,}20}\right) = \mathbf{10{,}865} \text{ t/m}^2 < qa = 17{,}333 \text{ t/m}^2 \quad \textbf{OK !}$$

$$q2 = \frac{50{,}083}{5{,}20} \times \left(1 - \frac{6 \times 0{,}111}{5{,}20}\right) = \mathbf{8{,}398} \text{ t/m}^2 < qa = 17{,}333 \text{ t/m}^2 \quad \textbf{OK !}$$

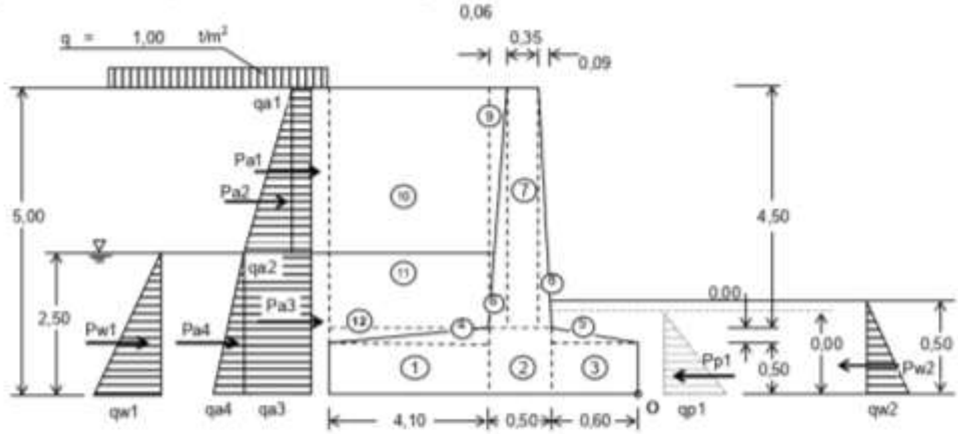


in case, e ≥ 0
(applicable)

in case, e < 0
(not applicable)

Reaction of Foundation Soil in Case 1

2.2 Case 2 (Normal condition, without vertical live load)



Acting Load in Case 2

(1) Vertical Load

No.	Description									W	X	W x X
1	0,50	x	4,10	x	2,40					4,920	3,150	15,500
2	0,50	x	0,50	x	2,40					0,600	0,850	0,510
3	0,50	x	0,60	x	2,40					0,720	0,300	0,220
4	0,50	x	0,00	x	4,10	x	2,40			0,000	2,467	0,000
5	0,50	x	0,00	x	0,60	x	2,40			0,000	0,200	0,000
6	0,50	x	4,50	x	0,06	x	2,40			0,324	1,080	0,350
7	4,50	x	0,35	x	2,40					3,780	0,865	3,270
8	0,50	x	4,50	x	0,09	x	2,40			0,486	0,660	0,320
9	0,50	x	4,50	x	0,06	x	1,80			0,243	1,080	0,260
10	4,10	x	2,50	x	1,80					18,450	3,150	58,120
11	4,10	x	2,00	x	2,00					16,400	3,150	51,660
12	0,50	x	4,10	x	0,00	x	2,00			0,000	3,833	0,000
Total										**45,923**		**130,210**

(2) Horizontal Load

Coefficient of Active earth pressure

Ka = **0,333** (for stability analysis)

Ka' = **0,303** (for structural analysis)

Coefficient of Passive earth pressure

Kp = **3,000**

qa1 = Ka x q	=	0,333	ton/m
qa2 = Ka x (h_1 - h_{w1}) x γ_{soil}	=	1,500	ton/m
qa3 = qa1 + qa2	=	1,833	ton/m
qa4 = Ka x h_{w1} x (γ_{sat} - γ_w)	=	0,833	ton/m
qw 1 = h_{w1} x γ_w	=	2,500	ton/m
qw2 = h_{w2} x γ_w	=	0,500	ton/m
qp1 = Kp x h_4 x (γ_{sat} - γ_w)	=	0,000	ton/m

No.	Description						H	Y	H x Y
Pa1	0,333	x	2,50				0,833	3,750	3,125
Pa2	1,500	x	2,50	x	0,50		1,875	3,333	6,250
Pa3	1,833	x	2,50				4,583	1,250	5,729
Pa4	0,833	x	2,50	x	0,50		1,042	0,833	0,868
Pw1	2,500	x	2,50	x	0,50		3,125	0,833	2,603
Pw2	-0,500	x	0,50	x	0,50		-0,125	0,167	-0,021
Pp1	0,000	x	0,00	x	0,50		0,000	0,000	0,000
Total							**11,333**		**18,555**

(3) Stability Calculation

a) Stability against overturning

B = 5,20 m

$$X = \frac{\Sigma W \times X - \Sigma H \times Y}{\Sigma W} = \frac{130{,}210 - 18{,}555}{45{,}923} = 2{,}431 \text{ m}$$

$$e = \frac{B}{2} - X = \frac{5{,}20}{2} - 2{,}431 = \mathbf{0{,}169} \text{ m} < B/6 = 0{,}867 \text{ m} \quad \textbf{OK !}$$

b) Stability against sliding

Sliding force : ΣH = 11,333 ton

Resistance : $HR = \mu \times \Sigma W$ = 0,50 x 45,923 = 22,962 ton

(friction coefficient : μ = 0,5)

$$Fs = \frac{HR}{\Sigma H} = \frac{22{,}962}{11{,}333} = \mathbf{2{,}03} > 2{,}00 \quad \textbf{OK !}$$

c) Reaction of foundation soil

$$q1{,}2 = \frac{\Sigma W}{B} \times \left(1 \pm \frac{6 \times e}{B}\right)$$

$$q1 = \frac{45{,}923}{5{,}20} \times \left(1 + \frac{6 \times 0{,}169}{5{,}20}\right) = \mathbf{10{,}553} \text{ t/m}^2 < qa = 17{,}333 \text{ t/m}^2 \quad \textbf{OK !}$$

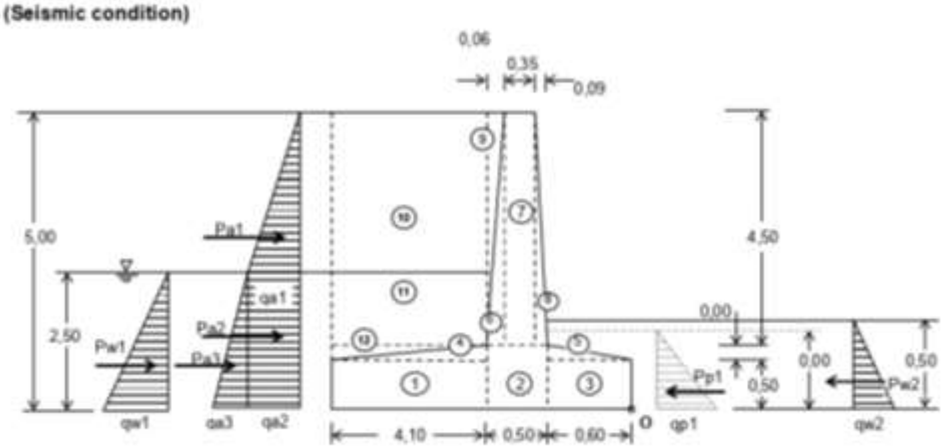
$$q2 = \frac{45{,}923}{5{,}20} \times \left(1 - \frac{6 \times 0{,}169}{5{,}20}\right) = \mathbf{7{,}109} \text{ t/m}^2 < qa = 17{,}333 \text{ t/m}^2 \quad \textbf{OK !}$$

in case, e ≥ 0 **(applicable)**

in case, e < 0 **(not applicable)**

Reaction of Foundation Soil in Case 2

2.3 Case 3 (Seismic condition)



Acting Load in Case 3

(1) Vertical Load = Same as Case 2

(2) Horizontal Load

ϕ	=	30,00 °	α	=	0,000 °	(for stability analysis)	Φ	=	9,090 °
β	=	0,00 °	α	=	0,764 °	(for structural analysis)	(Φ	=	Arc tan(Kh))
q	=	0,00 t/m² (for seismic condition)					Kh	=	0,16

Coefficient of Active earth pressure

$$Kae = \frac{\cos^2(\phi-\Phi-\alpha)}{\cos\Phi \times \cos^2\alpha \times \cos(\alpha+\delta+\Phi) \times \left[1+\sqrt{\dfrac{\sin(\phi+\delta) \times \sin(\phi-\beta-\Phi)}{\cos(\alpha+\delta+\Phi) \times \cos(\alpha-\beta)}}\right]^2}$$

(for stability analysis)

α = 0,000 ° $\quad\quad$ δ = 22,54 °

$$\tan\delta = \frac{\sin\phi \ \sin(\Phi+\Delta-\beta)}{1-\sin\phi \ \cos(\Phi+\Delta-\beta)}$$

$$\sin\Delta = \frac{\sin(\Phi+\beta)}{\sin\phi}$$

$\sin(\Phi+\beta)$ =	0,158		$\sin\phi$	=	0,500
$\sin\Delta$ =	0,316	then	Δ	=	18,42
$\sin(\Phi+\Delta-\beta)$ =	0,462		$\cos(\Phi+\Delta-\beta)$=		0,887
$\tan\delta$ =	0,415				

$\cos^2(\phi-\Phi-\alpha)$=	0,873	$\sin(\phi+\delta)$	=	0,794
$\cos\Phi$ =	0,987	$\sin(\phi-\beta-\Phi)$	=	0,357
$\cos^2\alpha$ =	1,000	$\cos(\alpha-\beta)$	=	1,000
$\cos(\alpha+\delta+\Phi$ =	0,851			

Kae = **0,418** (for stability analysis)

(for structural analysis)

α =	0,764 °	δ =	15,00 °
$Cos^2(\phi-\Phi-\alpha)$=	0,881	$Sin(\phi+\delta)$ =	0,707
$Cos\Phi$ =	0,987	$Sin(\phi-\beta-\Phi)$ =	0,357
$Cos^2\alpha$ =	1,000	$Cos(\alpha-\beta)$ =	1,000
$Cos(\alpha+\delta+\Phi)$=	0,907		

Kae = **0,422** (for structural analysis)

Coefficient of Passive earth pressure

$$Kpe = \frac{Cos^2(\phi-\Phi+\alpha)}{Cos\Phi \times Cos^2\alpha \times Cos(\alpha+\delta-\Phi) \times \left[1-\sqrt{\dfrac{Sin(\phi-\delta) \times Sin(\phi+\beta-\Phi)}{Cos(\alpha+\delta-\Phi) \times Cos(\alpha-\beta)}}\right]^2}$$

α =	0,000 °	δ =	22,54 °
$Cos^2(\phi-\Phi+\alpha)$=	0,873	$Sin(\phi-\delta)$ =	0,130
$Cos\Phi$ =	0,987	$Sin(\phi+\beta-\Phi)$ =	0,357
$Cos^2\alpha$ =	1,000	$Cos(\alpha-\beta)$ =	1,000
$Cos(\alpha+\delta-\Phi)$=	0,973		

Kpe = **1,488**

qa1 = Kae x (h_1 - h_{w1}) x γ_{soil}	=	1,881 ton/m
qa2 = qa2	=	1,881 ton/m
qa3 = Kae x h_{w1} x (γ_{sat} - γ_w)	=	1,045 ton/m
qw 1 = h_{w1} x γ_w	=	2,500 ton/m
qw 2 = h_{w2} x γ_w	=	0,500 ton/m
qp1 = Kp x h_4 x (γ_{sat} - γ_w)	=	0,000 ton/m

No.	Description	H	Y	H x Y
1	0,16 x 4,92	0,787	0,250	0,197
2	0,16 x 0,60	0,096	0,250	0,024
3	0,16 x 0,72	0,115	0,250	0,029
4	0,16 x 0,00	0,000	0,500	0,000
5	0,16 x 0,00	0,000	0,500	0,000
6	0,16 x 0,32	0,052	2,000	0,104
7	0,16 x 3,78	0,605	2,750	1,663
8	0,16 x 0,49	0,078	2,000	0,156
9	0,16 x 0,24	0,039	3,500	0,136
10	0,16 x 18,45	2,952	3,750	11,070
11	0,16 x 16,40	2,624	1,500	3,936
12	0,16 x 0,00	0,000	0,500	0,000
Pw1	0,50 x 2,50 x 2,50	3,125	0,833	2,604
Pw2	0,50 x -0,50 x 0,50	-0,125	0,167	-0,021
Pa1	0,50 x 1,88 x 2,50	2,351	3,333	7,838
pa2	1,88 x 2,50	4,703	1,250	5,878
Pa3	0,50 x 1,045 x 2,50	1,306	0,833	1,088
Pp1	0,000 x 0,50 x 0,50	0,000	0,000	0,000
Total		**18,708**		**34,701**

2.4 Bearing Capacity of soil

(1) Design Data

ϕ_B	=	30,00	°	c_B	=	0,00	t/m^2	γ_s'	=	1,00	t/m^3 (=$\gamma_{sat}-\gamma_w$)
B	=	5,20	m	z	=	0,00	m	L	=	1,00	m (unit length)

(2) Ultimate Bearing Capacity of soil, (qu)

Calculation of ultimate bearing capacity will be obtained by applying the following Terzaghi's formula :

$$qu = (\alpha \times c \times Nc) + (\gamma_{soil}' \times z \times Nq) + (\beta \times \gamma_{soil} \times B \times N\gamma)$$

Shape factor (Table 2.5 of KP-06)

α = 1,00 β = 0,50

Shape of footing : 1 (strip)

Shape of footing		α	β
1 strip		1,00	0,50
2 square		1,30	0,40
3 rectangular, B x L		1,13	0,40
	($B \le L$)	(= 1.09 + 0.21 B/L)	
	($B > L$)	(= 1.09 + 0.21 L/B)	
4 circular, diameter = B		1,30	0,30

Bearing capacity factor (Figure 2.3 of KP-06, by Capper)

Nc = 36,0 Nq = 23,0 Nγ = 20,0

ϕ	Nc	Nq	Nγ
0	5,7	0,0	0,0
5	7,0	1,4	0,0
10	9,0	2,7	0,2
15	12,0	4,5	2,3
20	17,0	7,5	4,7
25	24,0	13,0	9,5
30	36,0	23,0	20,0
35	57,0	44,0	41,0
37	70,0	50,0	55,0
39 >	82,0	50,0	73,0

$(\alpha \times c \times Nc)$ = 0,000

$(\gamma_{soil} \times z \times Nq)$ = 0,000

$(\beta \times \gamma_{soil} \times B \times N\gamma)$ = 52,000

qu = **52,000** t/m^2

(3) Allowable Bearing Capacity of soil, (qa)

qa = qu / 3 = **17,333** t/m^2 (safety factor = 3 , normal condition)

qae = qu / 2 = **26,000** t/m^2 (safety factor = 2 , seismic condition)

(3) Stability Calculation

a) Stability against overturning

$B = 5{,}20 \text{ m}$

$$X = \frac{\Sigma W \times X - \Sigma H \times Y}{\Sigma W} = \frac{143{,}189 - 34{,}701}{50{,}083} = 2{,}166 \text{ m}$$

$$e = \frac{B}{2} - X = \frac{5{,}20}{2} - 2{,}166 = \mathbf{0{,}434} \text{ m} < B/3 = 1{,}733 \text{ m} \quad \textbf{OK !}$$

b) Stability against sliding

Sliding force : $\Sigma H = 18{,}708$ ton

Resistance : $HR = \mu \times \Sigma W = 0{,}50 \times 50{,}083 = 25{,}042$ ton

(friction coefficient : $\mu = 0{,}5$)

$$Fs = \frac{HR}{\Sigma H} = \frac{25{,}042}{18{,}708} = 1{,}34 > 1{,}25 \quad \textbf{OK !}$$

c) Reaction of foundation soil

c-1) in case, $|e| \leq B/6$ **(applicable)**

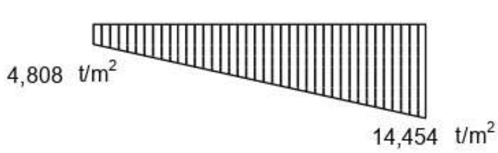
$$q1{,}2 = \frac{\Sigma W}{B} \times \left(1 \pm \frac{6 \times e}{B}\right)$$

$$q1 = \frac{50{,}083}{5{,}20} \times \left(1 + \frac{6 \times 0{,}434}{5{,}20}\right) = \mathbf{14{,}454} \text{ t/m}^2 < qae = 26{,}000 \text{ t/m}^2 \quad \textbf{OK !}$$

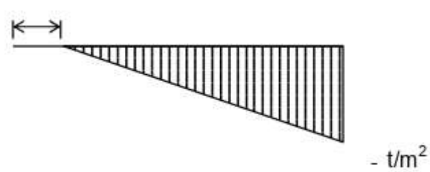
$$q2 = \frac{50{,}083}{5{,}20} \times \left(1 - \frac{6 \times 0{,}434}{5{,}20}\right) = \mathbf{4{,}808} \text{ t/m}^2 < qae = 26{,}000 \text{ t/m}^2 \quad \textbf{OK !}$$

c-2) in case, $B/6 < |e| \leq B/3$ **(not applicable)**

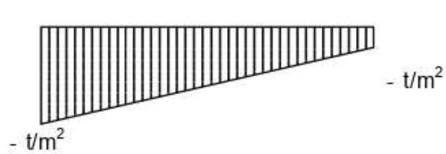
$$q1' = \frac{2 \times \Sigma W}{3 \times X} = \frac{\quad}{\quad} = - \text{ t/m}^2 \qquad qae = - \text{ t/m}^2$$



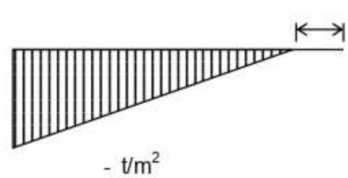
in case, $e \geq 0$ and $e \leq B/6$
(applicable)



in case, $e \geq 0$ and $B/6 < e \leq B/3$
(not applicable)



in case, $e < 0$ and $|e| \leq B/6$
(not applicable)



in case, $e < 0$ and $B/6 < |e| \leq B/3$
(not applicable)

<u>Reaction of Foundation Soil in Case 3</u>

KESIMPULAN

1. Nilai daya dukung tanah ultimit (qu) = 52 t/m²
2. Nilai daya dukung izin (qa) memadai untuk struktur dinding penahan tanah yang dibebani secara normal maupun seismik.
3. Daya dukung tanah masih dalam batas aman**,** selama tekanan maksimum di alas pondasi (qmax) tidak melebihi nilai qa tersebut (yakni 17,33 t/m² normal atau 26,00 t/m² seismik). Evaluasi desain dinding penahan tanah tipe T terbalik setinggi 5,0 m menunjukkan bahwa secara geoteknik, desain tersebut berpotensi stabil terhadap guling, geser, dan daya dukung tanah, asalkan data berat sendiri struktur dikonfirmasi. Diperlukan analisis lebih lanjut menggunakan perangkat lunak struktur dan investigasi geoteknik lapangan untuk validasi akhir.

REFERENSI

Bowles, J. E. (1997). *Foundation Analysis and Design* (5th ed.). McGraw-Hill.
Budhu, M. (2011). *Soil Mechanics and Foundations* (3rd ed.). John Wiley & Sons.
Das, B. M. (2010). *Principles of Foundation Engineering* (7th ed.). Cengage Learning.
Craig, R. F. (2004). *Soil Mechanics* (7th ed.). Spon Press.
Terzaghi, K., Peck, R. B., & Mesri, G. (1996). *Soil Mechanics in Engineering Practice* (3rd ed.). John Wiley & Sons.
Craig, R. F. (1987). *Mechanics of Soils* (2nd ed.). Van Nostrand Reinhold Company.
Hardiyatmo, H. C. (2014). *Mekanika Tanah I*. Gadjah Mada University Press.
Das, B. M. (2007). *Advanced Soil Mechanics* (3rd ed.). Taylor & Francis.