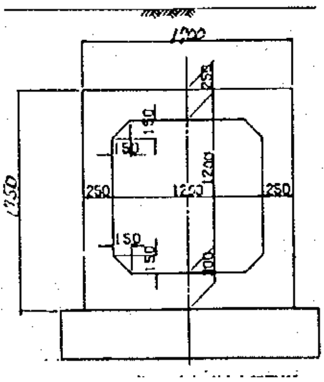
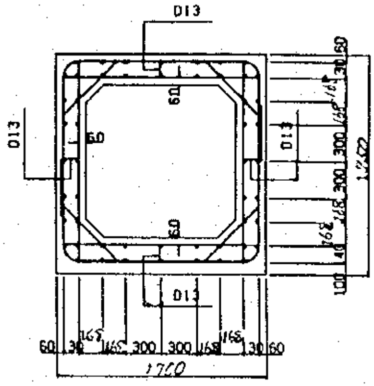
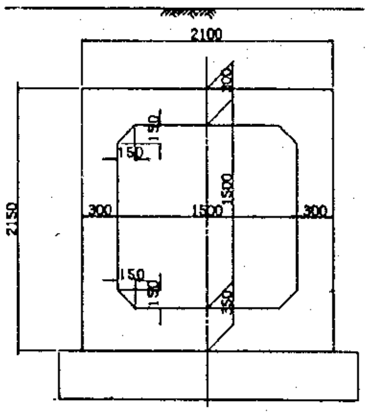
(3) Results

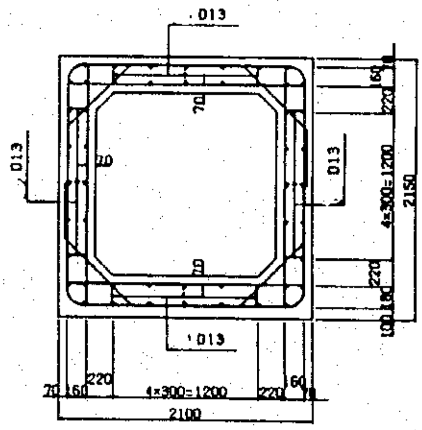
i) Type 1.2 × 1.2 m



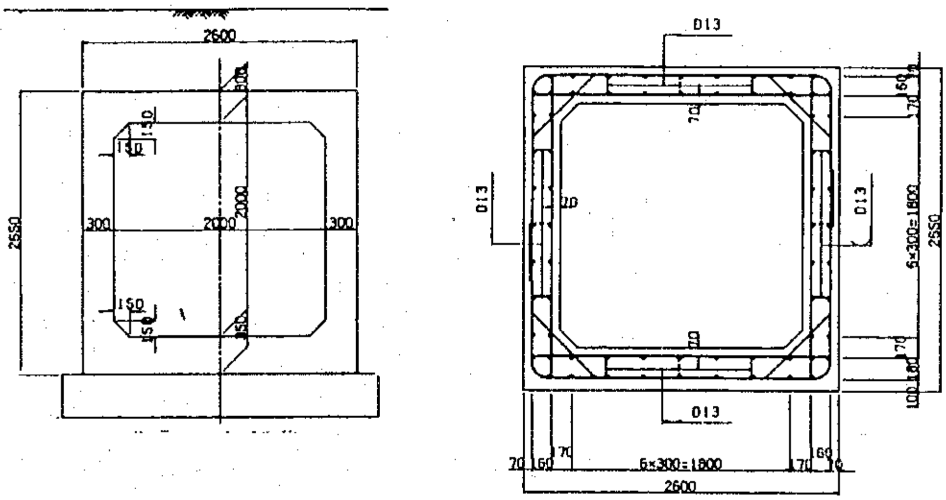


ii) Type 1.5 × 1.5 m

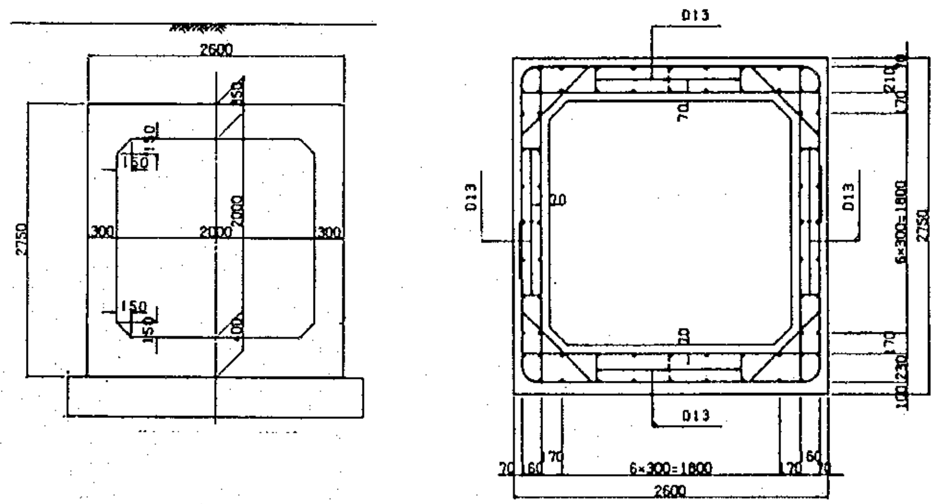




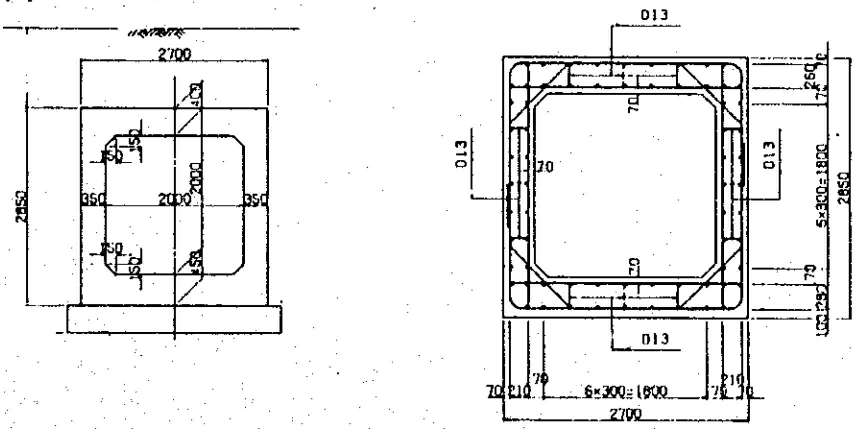
iii) Type 2.0 × 2.0 m (I)



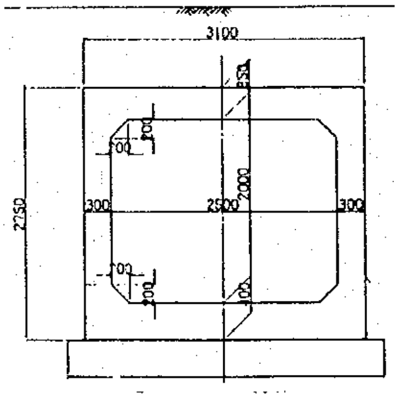
iv) Type 2.0 × 2.0 m (II)

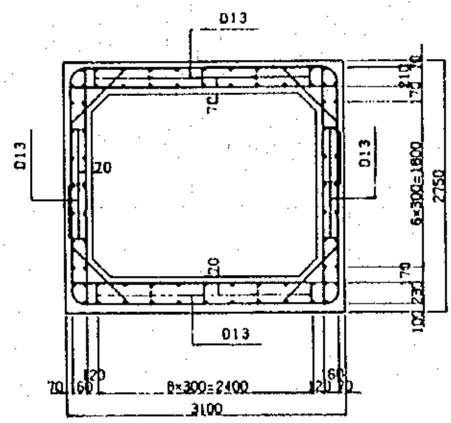


V) Type 2.0 × 2.0 m (III)

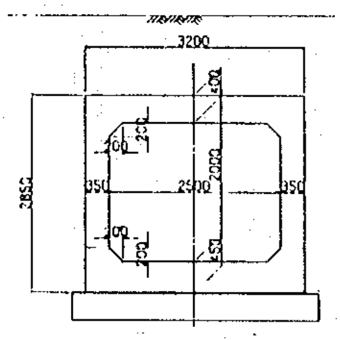


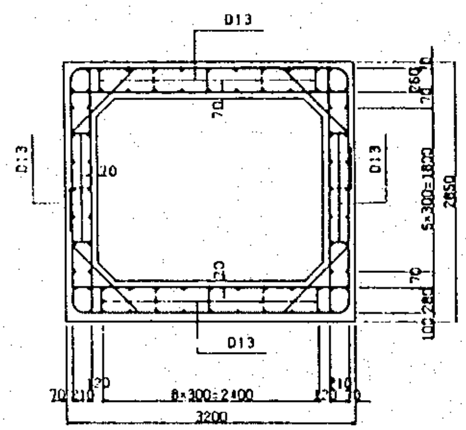
vi) Type 2.5 × 2.0 m (I)





vii) Type 2.5 × 2.0 m (II)





6.2. Bridge

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
Superstructure				
(1) Design Condition				
	Span : 24.00 m			
	Beam : 23.00 m			
	Width : 6.00 m			
	Pavement : Asphalt Concrete Minimum 5.00 cm			
	Cross Incline : 4.0 %			
	Concrete Design Strength : 210 kg/cm^2			
	Reinforced Bar : SD30			
	Allowable Stress :			
	$\sigma_{ca} = 70\ kg/cm^2$			
	$\tau_a = 36\ kg/cm^2$			
	$\sigma_{sa} = 1400\ kg/cm^2$			

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Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
(2) Slab Design	1) Continuous Beam			
(a) Dead Load	Average Pavement Thickness			
	30 + 1500 × 0.04 = 90 = 0.09 m			
	2.3 × 0.09 = 0.207 t/m²			
	Slab 2.4 × 0.2 = 0.48 t/m²			
	Total W_{d1} 0.207 + 0.48 = 0.687 t/m²			
	2) Cantilever Beam			
	Pavement W_{d2} 2.3 × (0.06 + 0.03) / 2 = 0.104 t/m²			
	Slab W_{d3} 2.4 × 0.2 = 0.48 t/m²			
	W_{d4} 2.4 × 0.1 = 0.24 t/m²			
	3) Curb			
	W_1 2.4 × 0.25 × 0.15 = 0.09 t/m			
	W_2 2.4 × 0.25 × 1.00 = 0.60 t/m			
(b) Bending Moment				
1) For Dead Load	(i) Continuous Beam			
	Beam $M_{d1} = W_d \times \ell^2/10 = 0.687 \times 1.0^2/10$			
	= 0.069 t·m			
	$M_{ud1} = 1.3\,M_{d1} = 1.3 \times 0.069 = 0.089$ t·m			
	Point $M_{d2} = -W_d \times \ell^2/10 = -0.687 \times 1.0^2/10$			
	= −0.069			
	$M_{ud2} = 1.3\,M_{d2} = -0.069 \times 1.3 = -0.089$ t·m			

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Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(ii) Cantilever Beam			
	Pavement			
	$-W_{d2} \times \ell^2/2 = -0.104 \times 0.30^2/2 = -0.005$ t.m			
	Slab			
	$-W_{d3} \times \ell_2^2/2 = -0.48 \times 0.80^2/2 = -0.154$ t.m			
	$-W_{d4} \times \ell_2^2/6 = -0.24 \times 0.80^2/6 = -0.026$ t.m			
	Curb			
	$-W_1 \ell_1 = -0.09 \times (0.80 - 0.25 - 0.25/2)$			
	$= -0.038$ t.m			
	$-W_2 \ell_2 = -0.60 \times (0.80 - 0.25/2)$			
	$= -0.405$ t.m			
	Total			
	$M_{d3} - 0.005 - 0.154 - 0.026 - 0.038 - 0.405 = -0.628$	t.m		
	$M_{ud3} = 1.3 \times M_d = 1.3 \times -0.628 = -0.816$ t.m			
2) Live Load	(i) Continuous Beam			
	Beam $M_{lx} = 1.2 \times 0.8 (0.12 \times 1.00 + 0.07) \times 8.0$			
	$= 1.459$ t.m			
	$M_{ul} = 2.5\ M_{lx}$			
	$= 2.5 \times 1.459 = 3.647$ t.m			
	Beam Vertical Direction			
	$M_{ly} = 1.2 \times 0.8 (0.10 \times 1.00 + 0.04) \times 8.0$			
	$= 1.075$ t.m			
	$M_{uy} = 2.5\ M_{ly}$			
	$= 2.5 \times 1.075 = 2.688$ t.m			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Support Bending Moment			
	$M_{lx} = -1.2 \times (0.15 l + 0.125) P$			
	$= -1.2 \times (0.15 \times 1.00 + 0.125) \times 8.0$			
	$= -2.640$ t·m			
	$M_{ulx} = 2.5 \times -2.640$			
	$= -6.6$ t·m			
	ii) Cantilever Beam			
	$l = 0.80 - 0.25 - 0.25 - 0.25$			
	$= 0.05$ m			
	$M_{lx} = -1.2 pl / (1.30 l + 0.25)$			
	$= -1.2 \times 8.0 \times 0.05 / (1.3 \times 0.05 + 0.25)$			
	$= -1.524$ t·m			
	$M_{ulx} = 2.5 M_{lx}$			
	$= -2.5 \times 1.524 = -3.810$ t·m			
	$M_{ly} = 1.2 \times (0.15 l + 0.13) P$			
	$= 1.2 \times (0.15 \times 0.05 + 0.13) \times 8.0$			
	$= 1.32$ t·m			
	$M_{uly} = 2.5 \times 1.32$			
	$= 3.300$ t·m			
	$M_h = -0.25 \times (\frac{0.30}{2} + 0.03 + 0.90)$			
	$= -0.27$ t·m			
	$M_{uh} = 2.5 \times -0.27$			
	$= -0.675$ t·m			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
(3) Sharing Force	In case of			
	σ_{ca} = 80 kg/cm² ⇨ C_1 = 0.261			
	σ_{sa} = 1600 kg/cm² C_2 = 0.00280			
	1) Continuous Beam Span Middle			
	$d = C_1\sqrt{Mx/b}$			
	$= 0.261 \times \sqrt{(6900 + 145900)/100}$			
	= 10.202 cm			
	Actual d			
	20.000 − (3.000 + 1.59/2)			
	= 16.205 cm > 10.202 ∴ Safety.			
	Reinforing Bar Volume			
	$Asx = Mx / \sigma_{sa} \cdot \frac{7}{8} d$			
	= 152800 × 8 / 1600 × 7 × 16.205			
	= 6.735 cm²			
	Asy = 107500 × 8 / 1600 × 7 × (16.205 − 1.600)			
	= 5.257 cm²			
	Asx Direction			
	D16 = 1.986 cm², 20.0 cm pitch			
	Asx = 1.986 × 100.0/20.0 = 9.93 cm²			
	Asy Direction			
	D16 = 1.986 cm², 20.0 cm pitch			
	Asy = 1.986 × 100.0/20.0 = 9.93 cm²			

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Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	2) Continuous Beam Support			
	$d = 0.261 \times \sqrt{(6900 + 264000)}/100$			
	$= 13.585$ cm			
	Actual $d = 30.000 - (3.000 + 1.590/2)$			
	$= 26.205$ cm			
	$Asx = 270900 \times 8 / (1600 \times 7 \times 26.205)$			
	$= 7.384$ cm^2			
	D16 , 20.0 cm Pitch			
	$Asx = 9.93$ cm^2			
	3) Cantilever Beam			
	$d = 0.261 \times \sqrt{(62800 + 152900 + 27000)}/100$			
	$= 12.845$ cm			
	Actual $d = 30.000 - (3.000 + 1.590/2)$			
	$= 26.205$ cm			
	$Asx = 242200 \times 8 / (1400 \times 7 \times 26.205)$			
	$= 6.602$ cm^2			
	D16 20.0 cm Pitch			
	$Asx = 9.93$ cm^2			

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Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Span Vertical Direction			
	Slab Thickness at Live Load Point			
	20.000 + 10.000 x 75.000 / 80.000			
	= 29.375 cm			
	d = 29.375 − (3.000 + 1.590 + 1.270/2)			
	= 24.150 cm			
	Asy = 132000 x 8 / (1600 x 7 x 24.150)			
	= 3.904 cm^2			
	D13 20.0cm Pitch			
	Asy = 6.35 cm^2			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(d) Bending Stress			
	$\sigma_c = 2M / kjbd^2$ $\sigma_s = M / A_s jd$			
	1) Continuous Beam Middle			
	As (cm²) = 9.93			
	d (cm) = 16.21			
	M (t-m) = 1.53			
	k = 0.429			
	j = 0.857			
	$\sigma_c = 2 \times 153000 / (0.429 \times 0.857 \times 100 \times 16.21^2)$			
	= 31.675 kg/cm²			
	$\sigma_s = 153000 / (9.93 \times 0.857 \times 16.21)$			
	= 1109 kg/cm²			
	2) Continuous Beam Point			
	As = 9.93			
	d = 26.21			
	M = 2.71			
	k = 0.429			
	j = 0.857			
	$\sigma_c = 2 \times 271000 / (0.429 \times 0.857 \times 100 \times 26.21^2)$			
	= 21.460 kg/cm²			
	$\sigma_s = 271000 / (9.93 \times 0.857 \times 26.21)$			
	= 1215 kg/cm²			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	3) Vertical Direction Cantilever Beam			
	As : 6.35			
	d = 24.15			
	M = 132			
	k = 0.429			
	j = 0.857			
	$\sigma c = 2 \times 132000 / (0.429 \times 0.857 \times 100 \times 24.15^2)$			
	$= 12.312$ kg/cm²			
	$\sigma s = 132000 / (6.35 \times 0.857 \times 24.15)$			
	$= 1004$ kg/cm²			
	4) Cantilever Beam Span Direction			
	As = 9.93			
	d = 26.21			
	M = 242			
	k = 0.429			
	j = 0.857			
	$\sigma c = 2 \times 242000 / (0.429 \times 0.857 \times 26.21^2 \times 100)$			
	$= 19.163$ kg/cm²			
	$\sigma s = 242000 / (9.93 \times 0.857 \times 26.21)$			
	$= 1085$ kg/cm²			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	5) Continuous Vertical Direction			
	$As = 8.45$			
	$d = 16.205 - 1.59 = 14.615$			
	$M = 107500$			
	$k = 0.429$			
	$j = 0.857$			
	$\sigma_c = 2 \times 107500 / (0.429 \times 0.857 \times 14.62^2 \times 100)$			
	$= 27.359$ kg/cm²			
	$\sigma_s = 107500 / (8.45 \times 0.857 \times 14.62)$			
	$= 1015$ kg/cm²			
	(e) Check for Maximum Bending Moment			
	Resisting Moment			
	$Mur = As\,\sigma_{sy}(d - \frac{1}{2} \cdot As\,\sigma_{sy} / 0.85\,\sigma_{ck}\,b)$			
	$\sigma_{sy} = 3{,}000$ kg/cm²			
	$\sigma_{ck} = 240$ kg/cm²			
	$Mur = As \times 3000\,(d - As \times 3000 / 2 \times 0.85 \times 240 \times 100)$			
	$= 3000\,As\,(d - 0.074\,As)$			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	1) Beam Direction Continuous Beam Middle			
	d (cm) = 16.21			
	As (cm²) = 9.93			
	Mur = 3000 x 9.93 (16.21 - 0.074 x 9.93)			
	= 709103 / 100000			
	= 4.610 t·m > Mu = 0.089 + 3.647			
	= 3.736			
	2) Beam Direction Continuous Beam Support			
	d = 26.21			
	As = 9.93			
	Mur = 7.589 t·m > Mu = |-0.089 - 6.600|			
	= 6.689			
	3) Vertical Direction Continuous Beam			
	d = 14.62			
	As: 8.45			
	Mur = 3000 x 8.45 (14.62 - 0.074 x 8.45)			
	= 354766 / 100000			
	= 3.548 t·m > Mu = 2.688 t·m			
	4) Cantilever Beam Direction			
	d = 26.21			
	As = 9.93			
	Mur = 3000 x 9.93 (26.21 - 0.074 x 9.93)			
	= 758906 / 100000			
	= 7.589 t·m > Mu = |-0.816 - 3.810 - 0.675|			
	= |-5.301|			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	5) Cantilever Beam Vertical Direction			
	d = 24.15			
	As = 6.35			
	Mur = 3000 x 6.35 (24.15 - 0.074 x 6.35)			
	= 451106 / 100000			
	= 4.511 t-m > Mu = 2.688			
	f) Additional Bar			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
(3) Main Girder				
a) Dead Load	Pavement			
	2.3 t/m³ x 0.090 m X 6.000 m			
	= 1.242 t/m			
	Curb			
	$(W_1 + W_2) \times 2$			
	= (0.09 t/m + 0.60 t/m) x 2			
	= 1.38 t/m			
	Slab			
	2.4 t/m³ x 7.00 m X 0.20 m			
	= 3.36 t/m			
	Haunch			
	2.4 t/m³ x {(0.80 x 0.10 x 1/2 x 2) +			
	(0.10 x 0.3 x 1/2 x 6)}			
	= 0.408 t/m			
	Web			
	2.4 t/m³ x 0.60 x 1.80 x 4			
	= 10.368 t/m			
	Total 1.242 + 1.38 + 3.36 + 0.408 + 10.368			
	= 16.758 t/m			
	Per Girder			
	w = 16.758/4 = 4.190 t/m			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Cross Beam			
	$2.4 \times 1.70 \times 0.30 \times 1.0 \times 3$			
	$= 3.672$ t			
	Per Girder			
	$W = 3.672 / 4 = 0.918$ t			
b) Live Load	Impact Coefficient			
	$i = 7/(20+\ell) = 7/(20+23)$			
	$= 0.163$			
	L Load			
	P_1 $5.0\,t \times 6.0\,m \times (1 + 0.163)$			
	$= 34.89$ t			
	P_2 $0.35\,t \times 6.0\,m \times (1 + 0.163)$			34.77
	$= 2.442$ t/m			
	L Load per Girder			
	Outside Girder			
	$P_1^1 = 34.89 / 4 \times 1.1 = 9.595$ t			
	$P_2^1 = 2.442 / 4 \times 1.1 = 0.672$ t			
	Inside Girder			
	$P_1^2 = 34.89 / 4 \times 0.95 = 8.286$ t			
	$P_2^2 = 2.442 / 4 \times 0.95 = 0.580$ t			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
c) Bending Moment	Calculate from Influence Line			
and	< Bending Moment >			
Sharing Force	1) $l/8 = 23.000/8 = 2.875$			
	$\eta_{max} = 2.875 \times 7/8 = 2.516$			
	$\eta_{1/2} = 2.875/2 = 1.438$			
	$A = 23.0 \times 2.516 \times 1/2 = 28.934$			
	$Aw = 28.934 \times 4.190 = 121.233$			
	$\eta_{1/2} W = 1.438 \times 0.918 = 1.320$			
	$Md = Aw + \eta_{1/2} W$			
	$= 121.233 + 1.320 = 122.553$ t·m			
	Outside Girder			
	$Ap_2^1 = 28.934 \times 0.672 = 19.444$ t·m			
	$\eta_{max} P_1^1 = 2.516 \times 9.595 = 24.141$ t·m			
	$Ml = Ap_2^1 + \eta_{max} P_1^1 = 19.444 + 24.141 = 43.585$ t·m			
	$M = Md + Ml = 122.553 + 43.585 = 166.138$ t·m			
	$Mu = 1.3Md + 2.5Ml = 1.3 \times 122.553 + 2.5 \times 43.585$			
	$= 268.281$ t·m			
	Inside Girder			
	$Ap_2^2 = 28.934 \times 0.580 = 16.782$ t·m			
	$\eta_{max} P_1^2 = 2.516 \times 8.286 = 20.848$ t·m			
	$Ml = Ap_2^2 + \eta_{max} P_1^2 = 16.782 + 20.848 = 37.630$ t·m			
	$M = Md + Ml = 122.553 + 37.630 = 160.183$ t·m			
	$Mu = 1.3Md + 2.5Ml = 1.3 \times 122.553 + 2.5 \times 37.63$			
	$= 253.394$ t·m			

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Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	ii) $l/4 = 23.000/4 = 5.750$ m			
	$\eta_{max} = 5.750 \times 3/4 = 4.313$			
	$\eta_{1/2} = 5.75/2 = 2.875$			
	$A = 23.000 \times 4.313/2 = 49.600$			
	$A_w = 49.600 \times 4.190 = 207.824$			
	$\eta_{1/2} W = 2.875 \times 0.918 = 2.639$			
	$M_d = 207.824 + 2.639 = 210.463$			
	Outside Girder			
	$A_{P_2}^{1} = 49.600 \times 0.672 = 33.331$			
	$\eta_{max} P_1^{1} = 4.313 \times 9.595 = 41.383$			
	$M_l = 33.331 + 41.383 = 74.714$			
	$M = 210.463 + 74.714 = 285.177$			
	$M_u = 1.3 \times 210.463 + 2.5 \times 74.714 = 460.387$ t.m			
	Inside Girder			
	$A_{P_2}^{2} = 49.600 \times 0.580 = 28.768$			
	$\eta_{max} P_1^{2} = 4.313 \times 8.286 = 35.738$			
	$M_l = 28.768 + 35.738 = 64.506$			
	$M = 210.463 + 64.506 = 274.969$ t.m			
	$M_u = 1.3 \times 210.463 + 2.5 \times 64.506 = 434.867$ t.m			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	iii) $3l/8 = 23.000 \times 3/8 = 8.625$			
	$\eta_{max} = 8.625 \times 5/8 = 5.391$			
	$\eta_{1/2} = 8.625/2 = 4.313$			
	$A = 23.000 \times 5.391/2 = 61.997$			
	$A_w = 61.997 \times 4.190 = 259.767$			
	$\eta_{1/2} W = 4.313 \times 0.918 = 3.959$			
	$M_d = 259.767 + 3.959 = 263.726$ t.m			
	Outside Girder			
	$A p_2^1 = 61.997 \times 0.672 = 41.662$			
	$\eta_{max} P_1^1 = 5.391 \times 9.595 = 51.727$			
	$M_l = 41.662 + 51.727 = 93.389$			
	$M = 263.726 + 93.389 = 357.115$			
	$M_u = 1.3 \times 263.726 + 2.5 \times 93.389 = 576.316$ t.m			
	Inside Girder			
	$A p_2^2 = 61.997 \times 0.580 = 35.958$			
	$\eta_{max} P_1^2 = 5.391 \times 8.286 = 44.670$			
	$M_l = 35.958 + 44.670 = 80.628$			
	$M = 263.726 + 80.628 = 344.354$			
	$M_u = 1.3 \times 263.726 + 2.5 \times 80.628 = 544.414$ t.m			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	iv) $l/2 = 23.000/2 = 11.500$			
	$\eta_{max} = 11.500/2 = 5.750$			
	$\eta_{1/2} = 11.500/2 = 5.750$			
	$A = 23.000 \times 5.750/2 = 66.125$			
	$A\omega = 66.125 \times 4.190 = 277.064$			
	$\eta_{1/2} W = 5.75 \times 0.918 = 5.279$			
	$Md = 277.064 + 5.279 = 282.343$ t.m			
	Outside Girder			
	$Ap_2^1 = 66.125 \times 0.672 = 44.436$			
	$\eta_{max} P_1^1 = 5.750 \times 9.595 = 55.171$			
	$Ml = 44.436 + 55.171 = 99.607$ t.m			
	$M = 282.343 + 99.607 = 381.950$ t.m			
	$Mu = 1.3 \times 282.343 + 2.5 \times 99.607 = 616.063$	t.m		
	Inside Girder			
	$Ap_2^2 = 66.125 \times 0.580 = 38.353$			
	$\eta_{max} P_1^2 = 5.75 \times 8.286 = 47.645$			
	$Ml = 38.353 + 47.645 = 85.998$			
	$M = 282.343 + 85.998 = 368.341$			
	$Mu = 1.3 \times 282.343 + 2.5 \times 85.998$			
	$= 582.041$ t.m			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	< Sharing Force >			
	i) Support			
	$\eta_{max} = 1.0$			
	$\eta_{1/2} = 0.5$			
	$A = 23.000 \times 1.0 \times 1/2 = 11.500$			
	$A_w = 11.500 \times 4.190 = 48.185$			
	$\eta_{1/2} W = 0.5 \times 0.918 = 0.459$			
	$S_d = A_w + \eta_{1/2} W = 48.185 + 0.459 = 48.644\,t$			
	Outside Girder			
	$A_{p2}^{1} = 11.500 \times 0.672 = 7.728$			
	$\eta_{max} P_1^{1} = 1.0 \times 9.595 = 9.595$			
	$S_l = A_{p2}^{1} + \eta_{max} P_1^{1} = 7.728 + 9.595 = 17.323\,t$			
	$S = S_d + S_l = 48.644 + 17.323 = 65.967\,t$			
	$S_u = 1.3 S_d + 2.5 S_l = 1.3 \times 48.644 + 2.5 \times 17.323$			
	$= 106.545\,t$			
	Inside Girder			
	$A_{p2}^{2} = 11.500 \times 0.580 = 6.670$			
	$\eta_{max} P_1^{2} = 1.0 \times 8.286 = 8.286$			
	$S_l = 6.670 + 8.286 = 14.956$			
	$S = 48.644 + 14.956 = 63.600$			
	$S_u = 1.3 \times 48.644 + 2.5 \times 14.956 = 100.627\,t$			

Working Division:

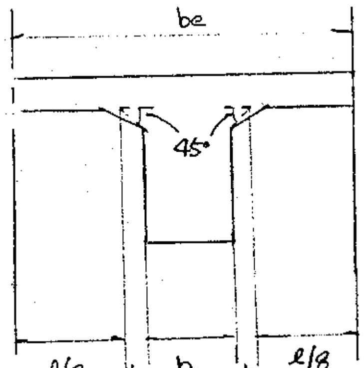
Description	Calculation Details	Unit	Quantity	Remarks
	ii) $l/2 = 11.500$			
	$\eta_{max} = 1 \times 11.5/23.0 = 0.5$			
	$\eta_{1/2} = 0.5$			
	$A = 11.500 \times 0.5 \times 1/2 = 2.875$			
	$A_w = 2.875 \times 4.190 = 12.046$			
	$\eta_{1/2} W = 0.5 \times 0.918 = 0.459$			
	$S_d = 12.046 + 0.459 = 12.505$ t			
	Outside Girder			
	$A_{p2}^1 = 2.875 \times 0.6512 = 1.932$			
	$\eta_{max} P_1^1 = 0.5 \times 9.595 = 4.798$			
	$S_l = 1.932 + 4.798 = 6.730$			
	$S = 12.505 + 6.730 = 19.235$ t			
	$S_u = 1.3 \times 12.505 + 2.5 \times 6.730 = 33.082$ t			
	Inside Girder			
	$A_{p2}^2 = 2.875 \times 0.580 = 1.668$			
	$\eta_{max} P_1^2 = 0.5 \times 8.286 = 4.143$			
	$S_l = 1.668 + 4.143 = 5.183$			
	$S = 12.505 + 5.183 = 17.688$ t			
	$S_u = 1.3 \times 12.505 + 2.5 \times 5.183 = 29.214$ t			

Working Division:

Description	Calculation Details	Unit	Quantity
	d) Section Calculation		
	1) Flange Effective Width		
	Inside Girder Fig. 1		
	$b_e' = b_0 + 2(b_s + \frac{1}{8}l)$		
	$= 0.600 + 2(0.100 + 1/8 \times 23.000)$		
	$= 6.550$ m		
	Center Span		
	$b_e = 1.0/2 \times 2$ nos $+ 0.6 = 1.6$ m		
	$\therefore b_e = 1.600$ m		
	Outside Girder Fig. 2		
	$b_e' = b_1 + b_s + \frac{1}{8}l$		
	$= (0.600 + 0.800) + 0.100 + 1/8 \times 23.000$		
	$= 4.375$ m		
	"1.600 m" is also applyed for Outside.		
	2) Reinforing Bar		
	i) Outside Girder Fig. 3		
	$A_s = M / (d - \frac{t}{2})\sigma_{sa}$		
	$= 381.950 \times 10^5 / (189 - 20 \times 1/2) \times 1800$		
	$= 118.544$ cm^2		
	D29		
	$118.544 \div 6.424 = 18.453$		
	$\therefore$ 19 Pieces.		
	$A_s = 6.424 \times 19 = 122.056$ cm^2		

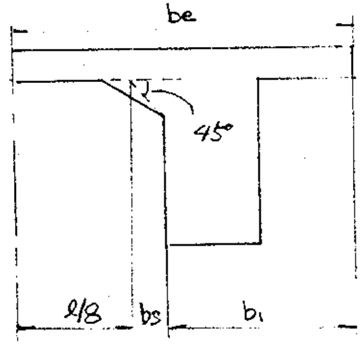
Remarks

Fig. 1



23/8 = 2.875

Fig. 2



Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	ii) Inside Girder			
	$As = M / (d - \frac{t}{2}) \sigma sa$			
	$= 368.341 \times 10^5 / (189 - 20 \times 1/2) \times 1800$			
	$= 114.321$ cm^2			
	D29 6.424			
	$114.321 \div 6.424 = 17.79$ ∴ 18 Pieces			
	$As = 6.424 \times 18 = 115.632$ cm^2			
	e) Bending Stress			
	i) Outside Girder			
	$x = \frac{nAs\,d + bt^2/2}{nAs + bt}$			
	$= \frac{15 \times 122.056 \times 189 + (160 \times 20^2)/2}{15 \times 122.056 + 160 \times 20}$			
	$= 75.142$			
	$y' = \frac{(3x - 2t)t}{3(2x - t)}$			
	$= \frac{(3 \times 75.142 - 2 \times 20) \times 20}{3 \times (2 \times 75.142 - 20)}$			
	$= 9.488$			

6-54

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$\sigma_c = Mx / bt(x-\frac{t}{2})(d-y')$			
	$= \dfrac{381.95 \times 75.142}{160 \times 20(75.142 - \frac{20}{2})(189-9.488)}$			
	$= 76.698 < 80$ kg/cm²			
	$\sigma_s = M / As(d-y')$			
	$= \dfrac{381.95 \times 10^5}{122.056(189-9.448)}$			
	$= 1743 < 1800$ kg/cm²			
	ii) Inside Girder			
	$x = \dfrac{15 \times 115.632 \times 189 + (160 \times 20^2)/2}{15 \times 115.632 + 160 \times 20}$			
	$= 72.919$			
	$y' = \dfrac{(3 \times 72.919 - 2 \times 20) \times 20}{3 \times (2 \times 72.919 - 20)}$			
	$= 9.470$			
	$\sigma_c = \dfrac{368.341 \times 10^5 \times 72.919}{160 \times 20(72.919 - \frac{20}{2})(189-9.470)}$			
	$= 74.306$			
	$\sigma_s = \dfrac{368.341 \times 10^5}{115.632 \times (189-9.553)}$			
	$= 1775 < 1800$ kg/cm²			

6-43

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	f) Checking Bending Moment.			
	$t = 20.000\text{cm} > \frac{As\,\sigma_{sy}}{0.85\,\sigma_{ck}\,b}$			
	$= 122.056 \times 3000 / 0.85 \times 240 \times 160$			
	$= 11.218$ cm			
	$Mur = As\,\sigma_{sy}(d - \frac{1}{2} \cdot \frac{As\,\sigma_{sy}}{0.85\,\sigma\,b})$			
	$= 122.056 \times 3000 \times (189 - \frac{1}{2} \times 11.218)$			
	$= 671.519$ t.m $>$ Mu 616.063 t.m			
	g) Resisting Moment			
	$Mrc = \sigma_{ca}\,bt(1 - \frac{t}{2x})(d - y')$			
	$= 80 \times 160 \times 20(1 - 20/2 \times 75.142)(189 - 9.488)$			
	$= 398.393$ t.m			
	$Mrs = \sigma_{sa}\,As(d - y') = 1800 \times 122.056(189 - 9.488)$			
	$= 394.389$ t.m			
	h) Sharing Stress			
	$z = d - y' = 189 - 9.488 = 179.512$ cm			
	Outside Girder			
	$S = 106.545 - (106.545 - 33.082) \times 1.000 / 11.500$			
	$= 100.157$ t			
	Average Sharing Stress			
	$\tau_m = 100157 / 60 \times 189$			
	$= 8.832\ kg/cm^2 < 32\ kg/cm^2$			

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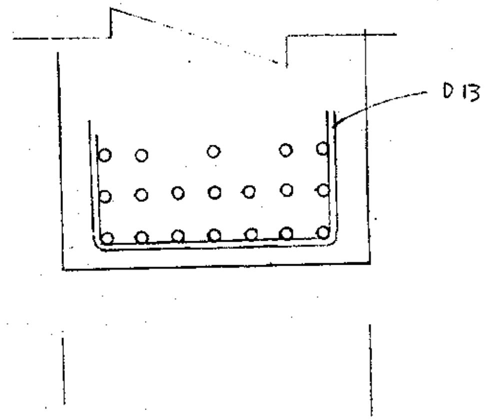
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	l/z			
	$\tau_m = 33.082 / 60 \times 189$			
	$= 2.917$ kg/cm²			
	i) Diagonal Tension Bar			
	Average Concrete Sharing Force			
	$\tau_{mc} = 3.9$ kg/cm²			
	8.832 kg/cm² - 3.9 kg/cm² = 4.932 kg/cm²			
	Stirrup accepts Sharing Forces more than half of 4.932 kg/cm².			
	Stirrup U style, D 13 mm, 35cm pitch			
	$\tau_{mv} = Av \sigma sy / 1.15 b_0 a$			
	$= \dfrac{1.267 \text{ cm}^2 \times 2 \times 3000 \text{ kg/cm}^2}{1.15 \times 60 \text{ cm} \times 35 \text{ cm}}$			
	$= 3.148$ kg/cm² $> 4.932/2 = 2.466$			
	Bent up Bar 2D29 100 cm Pitch			
	$\tau_{mb} = \sqrt{2} \cdot Ab \sigma sy / 1.15 b_0 a$			
	$= \sqrt{2} \times 6.424 \times 2 \times 3000 / 1.15 \times 60 \times 100$			
	$= 7.900$ kg/cm² $> (8.832 - 3.900 - 3.148)$			
	$= 1.784$ kg/cm²			

6-47

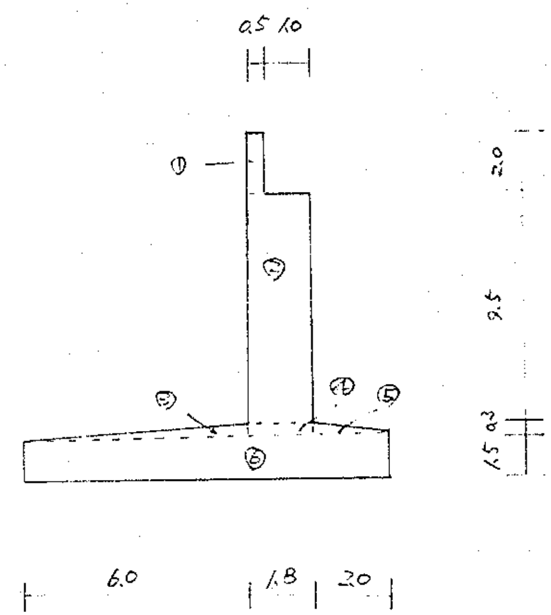
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	In case of Design Load			
	$S_B = 65.967t - (65.969 - 19.235) \times 1.0 / 11.500$			
	$= 61.903t$			
	$\tau_m = 61903 / 60 \times 189 = 5.549$ kg/cm²			
	Average Sharing Force for Tension Bar			
	$5.549 - 3.900 = 1.649$ kg/cm²			
	Average Sharing Force for Stirrup			
	$\tau_m = \dfrac{1.267 \times 2 \times 1800}{1.15 \times 60 \times 35}$			
	$= 1.889$ kg/cm² > 1.649 kg/cm²			
	∴ Reinforcing Bar is enough.			
	(i) Bond Stress			
	Outside Girder			
	$\tau_o = \dfrac{1.15S}{\Sigma Ud} = \dfrac{1.15 \times 65.967}{2 \times 9 \times 19 \times 189} = 1.174 < 16$ kg/cm²			
	Inside Girder			
	$\tau_o = \dfrac{1.15 \times 63600}{2 \times 9 \times 18 \times 189} = 1.194 < 16$ cm²			

Working Division: Conguillo I No.1

Description	Calculation Details	Unit	Quantity	Remarks
	Rio Membrillo Left Side			
	(1) Design Condition			
	Type : Inverted T-shape Abutment			
	All the condition is as same as Right Side.			
	(2) Load Condition			
	(a) Reaction from Girder			
	i) Normal Case			
	Vertical Rd = 194.58 tf			
	Rl = 45.61 tf			
	ii) Seismic Case			
	Vertical Rd = 194.58 tf			
	Horizontal H = 194.58 × 2.0 × 0.15			
	= 58.37 tf			
	(b) Body Weight			

	Ai	xi	yi	Aixi	Aiyi
1	0.5×2.0 = 1.0	3.25	12.3	3.25	12.3
2	(1.5+1.8)×9.5×1/2 = 15.68	2.83	6.55	44.37	102.70
	16.68	(2.86)	(6.89)	47.62	115.00
3	6.0×0.3×1/2 = 0.9	5.80	1.60	5.22	1.44
4	1.8×0.3 = 0.54	2.90	1.65	1.57	0.89
5	2.0×0.3×1/2 = 0.3	1.33	1.60	0.40	0.48
6	9.8×1.5 = 14.7	4.90	0.75	72.03	11.03
	16.44	(4.82)	(0.84)	79.22	13.84
GRAD TOTAL	33.12			84.44	128.84



6-49

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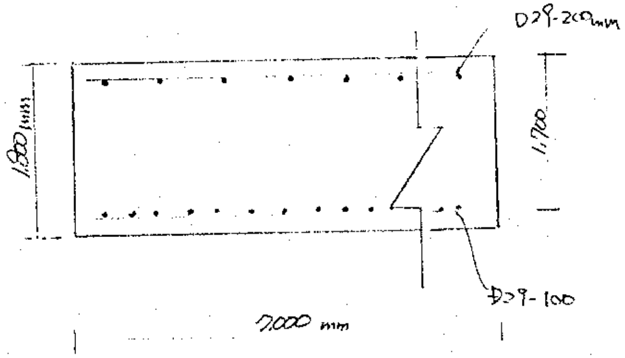
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	WALL WEIGHT W_1 16.68×7.0×2.4 = 280.22 tf			
	W_2 16.44×7.0×2.4 = 276.19 tf			
	SEISMIC W_{H1} 280.22×0.15 = 42.03 tf			
	W_{H2} 276.19×0.15 = 41.43 tf			
	(c) Earth Pressure at Abutment			
	Coefficient of Earth Pressure			
	K_A = 0.251			
	K_{EA} = 0.360			
	(3) Dimension of Member			
	(a) Allowable Stress			
	Concrete σ_{ck} = 240 kgf/cm²			
	Normal Case / Seismic Case			
	σ_{ca} = 80 kg/cm² / σ_{ca} = 120 kg/cm²			
	σ_{sa} = 120 kg/cm² / σ_{sa} = 2700 kg/cm²			
	τ_m = 3.9 kg/cm² / τ_m = 5.85 kg/cm²			
	(b) Wall Design			
	i) Normal Case			
	R_d = 194.58 tf			
	W_1 = 280.22 tf			
	P_{a1} = 1/2×0.251×1.8×11.5²×cos11.7×7.0			
	= 204.78 tf			
	P_{a2} = 1/2×0.251×1.0×11.5×cos11.7×7.0			
	= 9.89 tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$M = 204.78 \times 3.83 + 9.89 \times 5.75$			
	$= 841.17$ tf.m			
	$N = 194.58 + 280.22 = 474.80$ tf			
	$S = 204.78 + 9.89 = 214.67$ tf			
	ii) Seismic Case			
	$R_d = 194.58$ tf			
	$H = 58.37$ tf			
	$W_1 = 280.22$ tf			
	$W_{H1} = 42.03$ tf			
	$P_{a1} = 1/2 \times 0.360 \times 1.8 \times 11.5^2 \times \cos 0 \times 17.0$			
	$= 299.94$ tf			
	$M_E = 299.94 \times 3.83 + 58.37 \times 9.5 + 42.03 \times 5.09$			
	$= 1917.22$ tf.m			
	$N_E = 194.58 + 280.22 = 474.80$ tf			
	$S_E = 299.94 + 58.37 + 42.03 = 400.31$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(c) Stress Calculation			
	i) Normal Case			
	d = 170cm d' = 10cm b = 700cm U = 80cm			
	M = 841.17 tf.m N = 474.80 tf			
	As = 70 × 6.424 = 449.68 (D-29 10cm)			
	M' = M + NU = 841.17 + 474.80 × 0.8			
	= 1221.01 tf.m			
	np = 15 × 449.68 / 700×170 = 0.057			
	d'/d = 0.059 As'/As = 0.5			
	f = M/N + U = 841.17 × 10² / 474.80 + 80 = 257.16			
	f/d = 257.16 / 170 = 1.51			
	C = 5.18			
	S = 8.10			
	Z = 1.055			
	M'/bd² = 1221.01 × 10⁵ / 700×170² = 6.04 kg/cm²			
	σc = M'/bd² × C = 6.04 × 5.18 = 31.29 < 80 kg/cm²			
	σs = M'/bd² × S × n = 6.04 × 8.10 × 15 = 734 < 1800 kg/cm²			
	τm = H/bd × Z = 214.67 × 10³ / 700×170 × 1.055			
	= 1.90 < 3.9 kg/cm²			
	ii) Seismic Case			
	M'E = ME + NEU = 1917.22 + 474.80 × 0.8			
	= 2297.06 tf.m			
	f = ME/NE + U = 1917.22 × 10² / 474.80 + 80			
	= 483.80			
	f/d = 483.90 / 170 = 2.85			

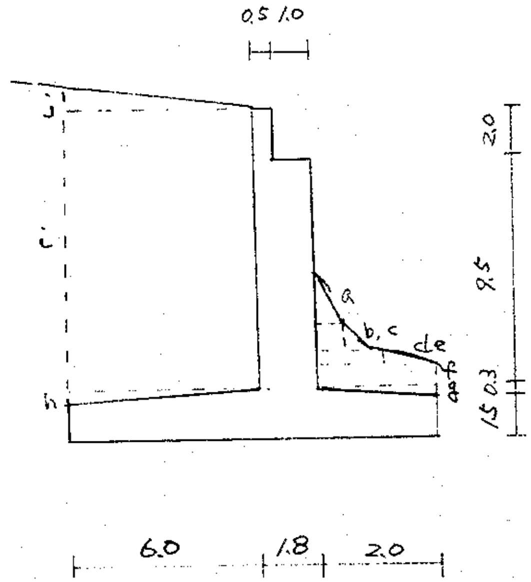
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$C = 6.08$			
	$S = 13.25$			
	$Z = 1.08$			
	$M'/bd^2 = 2297.06 \times 10^5 / 700 \times 170^2 = 11.35\ kg/cm^2$			
	$\sigma_c = M'/bd^2 \times C = 11.35 \times 6.08 = 69.01 < 120\ kg/cm^2$			
	$\sigma_s = M'/bd^2 \times S \times n = 11.35 \times 13.25 \times 15 = 2256 < 2900\ kg/cm^2$			
	$\tau_m = H/bd \times Z = 400.31 \times 10^3 / 700 \times 170 \times 1.08 = 3.63 < 5.85\ kg/cm^2$			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(4) Stability Calculation for Foundation			
	a) Weight on Footing			

	A_i	x_i	y_i	$A_i x_i$	$A_i y_i$
a	0.6×0.9 = 0.54	1.7	3.25	0.92	1.76
b	1.2×0.9×1/2 = 0.54	1.0	3.25	0.54	1.76
c	0.5×1.7 = 0.85	1.15	2.55	0.98	2.17
d	0.5×0.3×1/2 = 0.08	0.20	2.47	0.02	0.20
e	0.5×2.0 = 1.0	1.00	2.05	1.00	2.05
f	0.3×2.0×1/2 = 0.3	0.67	1.70	0.20	0.51
g	0.6×2.0×1/2 = 0.6	1.80	4.47	1.08	2.68
	3.91	(1.21)	(2.84)	4.74	11.13
h	6.0×0.3×1/2 = 0.9	7.8	1.7	7.02	1.53
i	6.0×11.5 = 69.0	6.8	7.55	469.2	520.95
j	6.0×0.4×1/2 = 1.2	7.8	13.43	9.36	16.12
	71.1	(6.83)	(7.58)	485.58	538.6



$W_3 = 3.91 \times 7.0 \times 1.8 = 49.27$ tf

$W_4 = 71.1 \times 7.0 \times 1.8 = 895.86$ tf

$W_{H4} = 895.86 \times 0.15 = 134.38$ tf

$K_A = 0.251$ $K_{EA} = 0.360$

$P_a = 1/2 \times 1.8 \times 13.7^2 \times 0.251 \times 7.0 = 296.79$ tf

$P_{EA} = 1/2 \times 1.8 \times 13.7^2 \times 0.360 \times 7.0 = 425.68$ tf

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$P_{aH} = 296.79 \times \cos 35° = 243.12$ tf			
	$P_{aV} = 296.79 \times \sin 35° = 170.23$ tf			
	$P_{EaH} = 425.68 \times \cos 17.5° = 405.98$ tf			
	$P_{EaV} = 425.68 \times \sin 17.5° = 128.00$ tf			
	Load on Ground ($q = 1.0$ tf/m²)			
	$P_{aS} = qHK_{aL} = 1.0 \times 13.7 \times 0.251 \times 7.0$			
	$= 24.07$ tf			
	$P_{aSH} = 24.07 \times \cos 35° = 19.72$ tf			
	$P_{aSV} = 24.07 \times \sin 35° = 13.81$ tf			
	$Q = 1.0 \times 6.0 \times 7.0 = 42.0$ tf			

6-65

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(b) Stability for Support			
	i) Normal Case			

	V	H	x	y	Mr	Mo
Rd	194.58	0	2.50	11.30	486.45	0
Rℓ	45.51	0	2.50	11.30	113.78	0
W1	280.22	0	2.86	6.87	801.43	0
W2	276.19	0	4.82	0.84	1331.24	0
W3	49.27	0	1.21	2.84	59.62	0
W4	895.86	0	6.83	7.58	6118.72	0
Pau	170.23	243.12	9.80	4.57	1668.25	1111.06
Pasu	13.81	19.72	9.80	6.85	135.34	135.08
Q	42.00	0	6.90	13.5	285.6	0
	1967.67	262.84			11000.43	1246.14

$x_o = Mr - Mo / V = 11000.43 - 1246.14 / 1967.67$

$= 4.96$ m

$e = \frac{B}{2} - x_o = 9.8/2 - 4.96 = -0.06$ m

$B' = B - 2e = 9.8 - 2 \times 0.06 = 9.68$ m

$A' = B' \cdot L = 9.68 \times 7.0 = 67.76$ m^2

$\beta = 1 - 0.4\, B'/L = 1 - 0.4 \times 9.68 / 7.0 = 0.447$

$Df = (2.6 + 4.2)/2 = 3.4$ m

$Df' = 1.8$ m

$k = 1 + 0.3\, Df'/B'$

$= 1 + 0.3 \times 1.8 / 9.68$

$= 1.06$

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$\gamma_1 = 1.8$ tf/m^3			
	$\gamma_2 = 1.8$ tf/m^3			
	$\phi = 35$			
	$\tan\theta = 262.84 / 1967.67$			
	$= 0.134$			
	$N_q = 25$			
	$N_r = 21$			
	$Q_{av} = 1/3\, Q_v = 1/3\, A' \times \{ k \gamma_1 D_f N_q + \gamma_2 B'/2\, \beta N_r \}$			
	$= 1/3 \times 67.76 \times \{ 1.06 \times 1.8 \times 3.4 \times 25 +$			
	$1.8 \times 9.68/2 \times 0.447 \times 21 \}$			
	$= 5510.23 > 1967.67$ tf			

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Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	ii) Seismic Case			

	V	H	x	y	Mt	Mo
Rd	194.58	58.39	2.50	11.00	48645	642.07
W_1	280.22	42.03	2.86	6.89	801.43	289.59
W_2	276.19	41.43	4.82	0.84	1331.24	34.80
W_3	49.27	0	1.21	2.84	59.62	0
W_4	895.86	134.38	6.83	7.58	6118.72	1018.60
Peav	128.00	405.98	9.80	4.53	1254.40	1839.09
	1824.12	682.19			10051.86	3824.15

x_o = 10051.86 − 3824.15 / 1824.12 = 3.41 m

e = 9.8/2 − 3.41 = 1.49 m

B' = 9.8 − 2 × 1.49 = 6.82 m

A' = 6.82 × 7.0 = 47.74 m^2

β = 1 − 0.4 × 6.82/7.00 = 0.610

k = 1 + 0.3 × 1.8/6.82 = 1.08

$\tan\theta$ = 682.19 / 1824.12 = 0.374

N_q = 13

N_r = 7

Q_{av} = 1/2 Q_v = 1/2 × 47.74 × {1.08 × 1.8 × 3.4 × 13 + 1.8 × 6.82/2 × 0.610 × 7}

= 2676.64 > 1824.12 tf

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(c) Stability for Over-Turning			
	i) Normal Case			
	$Mr = RaX + W_1X + W_2X + W_3X + W_4X + PavX + PasvX$			
	$= 486 + 801 + 1331 + 60 + 6119 + 1668 + 135$			
	$= 10600$ tf.m			
	$Mo = Pavy + Pasvy$			
	$= 1111 + 135 = 1246$ tf.m			
	$V = 194.58 + 280.22 + 276.19 + 49.27 + 895.86$			
	$+ 170.23 + 13.81$			
	$= 1881.26$ tf			
	$x_0 = 10600 - 1246 / 1881.26 = 4.97$ m			
	$e = \lvert 9.8/2 - 4.97 \rvert = 0.07 < 9.8/6 = 1.63$ m			
	ii) Seismic Case			
	$e = 1.49 \leq 1/3B = 3.27$ m			

Working Division:

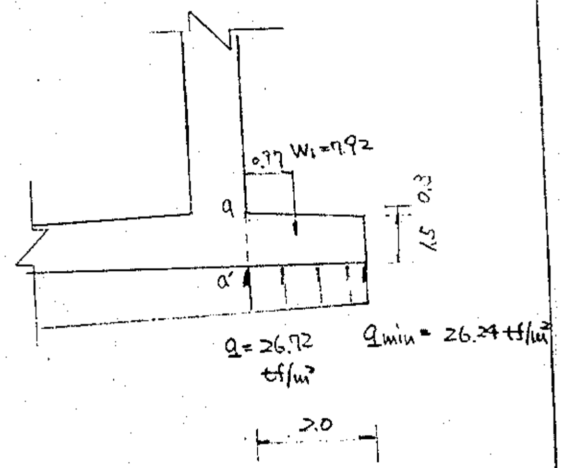
Description	Calculation Details	Unit	Quantity	Remarks
	(d) Stability for Sliding			
	i) Normal Case			
	$Ha = 1/1.5\ V + \tan\phi$			
	$V = 1881.26$ tf			
	$\phi_B = 2/3\phi$			
	$Ha = 1/1.5 \times 1881.26 \times \tan(35° \times 2/3)$			
	$= 541.00$ tf > 262.84 tf			
	ii) Seismic Case			
	$Ha = 1/1.2\ V \tan\phi_B$			
	$V = 1824.12$			
	$\phi_B = 2/3\phi$			
	$Ha = 1/1.2 \times 1824.12 \times \tan(35° \times 2/3)$			
	$= 655.71 < 682.19$ tf			
	Gravel Bedding is needed			
	$\phi_B = 0.6$			
	$Ha = 1/1.2 \times 1824.12 \times 0.6$			
	$= 912.06 > 682.19$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(5) Calculation of Ground Reaction			
	i) Normal Case			
	$q_{max}, q_{min} = V/L \cdot B \pm 6M_B/LB^2$			
	$= 1881.26/7.0 \times 9.8 \pm 6 \times 1881.26 \times 0.07/7.0 \times 9.8^2$			
	$= 27.42 \pm 1.18$			
	$q_{max} = 28.60$ tf/m²			
	$q_{min} = 26.24$ tf/m²			
	ii) Seismic Case			
	$q_{max} = 2V/L \times 3(B/2-e)$			
	$= 2 \times 1824.12/7.0 \times 3(9.8/2-1.49)$			
	$= 50.95$ tf			
	$x = 3(9.8/2-1.49)$			
	$= 10.23$ m			

Working Division:

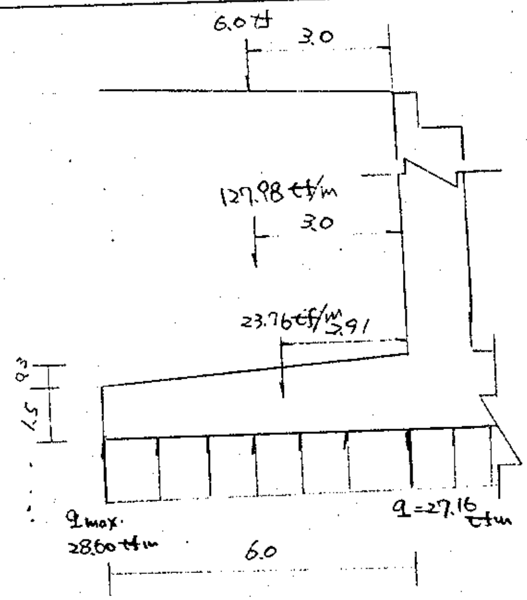
Description	Calculation Details	Unit	Quantity	Remarks
	(6) Design of Member Section			
	i) Normal Case			
	Section a-a'			
	$M_{F1} = -7.92 \times 0.97 + 1/2 \times 26.24 \times 2.0 \times 1.33 +$			
	$1/2 \times 26.72 \times 2.0 \times 0.67$			
	$= 45.12$ tf.m/m			
	$S_{F1} = -7.92 + 1/2 \times (26.24 + 26.72) \times 2.0$			
	$= 45.04$ tf			
	Stress Calculation			
	$A_s = 2.865\ cm^2 \times 9 = 20.06$ (D19 15cm)			
	$M' = M = 45.12$ tf.m			
	$np = 15 \times 20.06 / 100 \times 170 = 0.018$			
	$d'/d = 0.059$ $A_s'/A_s = 0.5$ $f/d = \infty$			
	$C = 11.65$ $S = 58.00$ $Z = 1.06$			
	$M'/bd^2 = 45.12 \times 10^5 / 100 \times 170^2 = 1.56\ kg/cm^2$			
	$\sigma_c = M'/bd^2 \times C = 1.56 \times 11.65 = 18.17 < 80\ kg/cm^2$			
	$\sigma_s = M'/bd^2 \times S \times n = 1.56 \times 58.0 \times 15 = 1357 < 1800\ kg/cm^2$			
	$\tau_m = H/bd \times Z = 45.04 \times 10^3 / 100 \times 170 \times 1.06$			
	$= 2.81 < 3.9\ kg/cm^2$			



Working Division:

Description	Calculation Details	Unit	Quantity
	Section b~b′		
	$M_{E2} = 1/2 \times 28.60 \times 6.0 \times 4.0 + 1/2 \times 27.16 \times 6.0 \times 2.0$		
	$- 6.0 \times 3.0 - 127.80 \times 3.0 - 23.76 \times 2.91$		
	$= 35.08$ tfm/m		
	$S_{E2} = 1/2\,(28.60 + 27.16) \times 6.0 - 6.0 - 127.98 - 23.76$		
	$= 9.54$ tf		
	Stress Calculation		
	$A_s = 20.06\ cm^2$ (D 19 15cm)		
	$M' = 35.08$ tf·m		
	$np = 0.018$		
	$d'/d = 0.059$ $A_s'/A_s = 0.5$ $f/d = \infty$		
	$C = 11.5$ $S = 58.0$ $Z = 1.06$		
	$M'/bd^2 = 35.08 \times 10^5 / 100 \times 170^2 = 1.21\ kg/cm^2$		
	$\sigma_c = M'/bd^2 \times C = 1.21 \times 11.5 = 13.92 < 80\ kg/cm^2$		
	$\sigma_s = M'/bd^2 \times S \times n = 1.21 \times 58.0 \times 15 = 1053 < 1800\ kg/cm^2$		
	$\tau_m = H/bd \times Z = 9.54 \times 10^3 / 100 \times 170 \times 1.06$		
	$= 0.59 < 3.9\ kg/cm^2$		

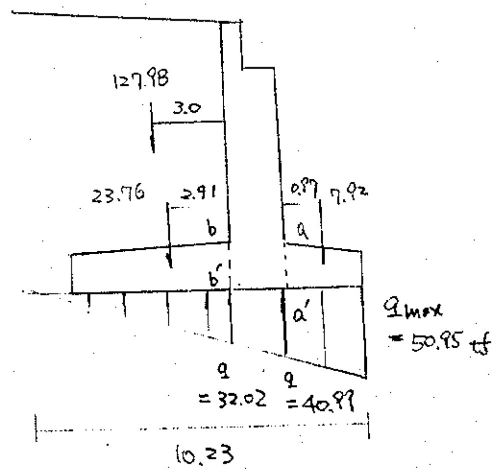
Remarks



Working Division:

Description	Calculation Details	Unit	Quantity
	ii) Seismic Case		
	Section a~a'		
	$M_{E1} = 1/2 \times 50.95 \times 2.0 \times 1.33 + 1/2 \times 40.99 \times 2.0 \times 0.67$		
	$- 7.92 \times 0.97$		
	$= 87.54$ tf·m		
	$S_{E1} = 1/2 (50.95 + 40.99) \times 2.0 - 7.92$		
	$= 84.02$ tf		
	Stress Calculation		
	$A_s = 2.865 \times 10 = 28.65$ (D29 10cm)		
	$H = 87.54$ tf·m		
	$np = 0.059$ $A's/A_s = 0.5$ $f/d = 0.0$		
	$C = 10.1$ $S = 43.0$ $Z = 1.068$		
	$H'/bd^2 = 87.54 \times 10^5 / 100 \times 170^2 = 3.03$ kg/cm²		
	$\sigma_c = H'/bd^2 \times C = 3.03 \times 10.1 = 30.6 < 120$ kg/cm²		
	$\sigma_s = H'/bd^2 \times S \times n = 3.03 \times 43 \times 15 = 1954.35 < 2700$ kg/cm²		
	$\tau_m = H/bd \times Z = 84.02 \times 10^3 / 100 \times 170 \times 1.068$		
	$= 5.28 < 5.85$ kg/cm²		

Remarks



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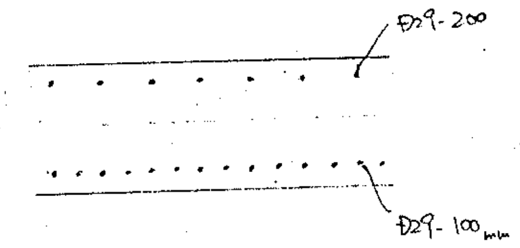
Working Division:

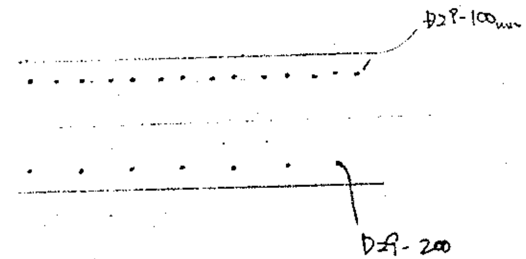
Description	Calculation Details	Unit	Quantity	Remarks
	Section b~b'			
	$M_{Fz} = 127.98 \times 3 + 23.76 \times 2.91 - 1/2 \times 32.02 \times 6.43 \times \frac{6.43}{3}$			
	$= 232.44$ tfm			
	$S_{Fz} = 127.98 + 23.76 - 1/2 \times 32.02 \times 6.43$			
	$= 48.80$ tf			
	$As = 6.424 \times 10 = 64.24\ cm^2$ (D29 10cm)			
	$M' = 232.44$ tfm			
	$np = 0.057$ $d'/d = 0.059$ $f/d = \infty$			
	$C = 6.95$			
	$S = 19.15$			
	$Z = 1.09$			
	$M'/bd^2 = 232.44 \times 10^5 / 100 \times 170^2 = 8.04\ kg/cm^2$			
	$\sigma_c = M'/bd^2 \times C = 8.04 \times 6.95 = 55.88 < 120\ kg/cm^2$			
	$\sigma_s = M'/bd^2 \times S \times n = 8.04 \times 19.15 \times 15 = 2309.49 < 2700\ kg/cm^2$			
	$\tau_m = H/bd \times Z = 48.8 \times 10^3 / 100 \times 170 \times 1.09$			
	$= 3.12 < 5.85\ kg/cm^2$			

Remarks:

Section a~a'



Section b~b'



6-24

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Rio Membrillo Right Side			
	(1) Design Condition			
	Type : Inverted T-shape Abutment			
	$h = 13.0$ m			
	$w = 7.0$ m			
	$\phi = 35°$			
	$c = 0$ tf/m²			
	$\theta = 0°$			
	$\delta = 35/3 = 11.7$			
	$\delta_E = 0$			
	Design Seismic Coefficient $K = 0.15$			
	Earth Pressure Design Seismic Coefficient $k = 0.15$			
	Soil Unit Weight $\gamma = 1.8$ tf/m³			
	(2) Load Condition			
	(a) Reaction from Girder			
	i) Normal Case			
	Vertical $Rd = (16.76 \times 23.0 + 3.67)/2$			
	$= 194.58$ tf			
	$Rl = (2.44 \times 23.0 + 34.89)/2$			
	$= 45.51$ tf			
	ii) Seismic Case			
	Vertical $Rd = 194.58$ tf			
	Horizontal $H = 194.58 \times 2.0$ m $\times 0.15$			
	$= 58.37$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks

(b) Body Weight

	Ai	xi	yi	Aixi	Aiyi
1	0.5×2.0 = 1.0	3.25	12.00	3.25	12.00
2	(1.5+1.8)×9.2×1/2 = 15.18	2.83	6.40	42.96	97.15
	16.18	(2.86)	(6.75)	46.21	109.15
3	2.0×0.3×1/2 = 0.3	1.33	1.60	0.40	0.48
4	1.8×0.3 = 0.54	2.90	1.65	1.57	0.89
5	6.0×0.3×1/2 = 0.9	5.80	1.60	5.22	1.44
6	9.8×1.5 = 14.7	4.90	0.75	72.03	11.03
	16.44	(4.82)	(0.84)	79.22	13.84
GRAD TOTAL	32.62			125.43	122.99

WALL WEIGHT W_1 16.18×7.0×2.4 = 271.82 tf

FOOTING WEIGHT W_2 16.44×7.0×2.4 = 276.19 tf

SEISMIC W_{H1} 271.82×0.15 = 40.77 tf

" W_{H2} 276.19×0.15 = 41.43 tf

(c) Earth Pressure at Abutment

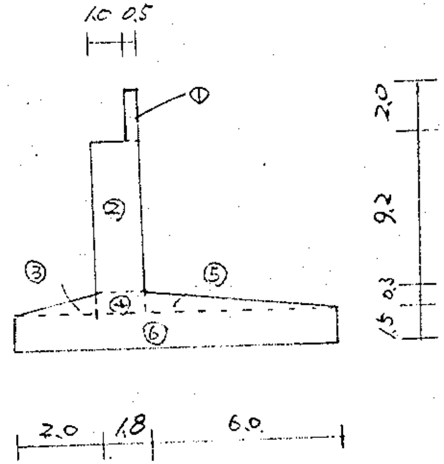
Coefficient of Earth Pressure

$$K_A = \frac{\cos^2(35-0)}{\cos^2 0 \cdot \cos(0+11.7) \times \left[1+\sqrt{\frac{\sin 46.7 \sin 35.0}{\cos 11.7 \cos 0}}\right]^2}$$

$= 0.671 / 0.979 \times 2.732 = 0.251$

$$K_{EA} = \frac{\cos^2 26.47}{\cos 8.53 \times \cos^2 0 \times \cos 8.53 \times \left[1+\sqrt{\frac{\sin 35 \sin 26.47}{\cos 8.53 \cos 0}}\right]}$$

$= 0.360$



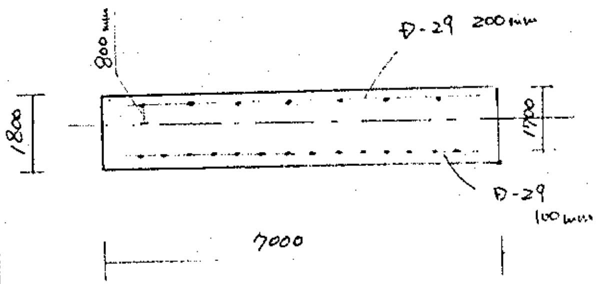
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(3) Dimension of Member			
	(a) Allowable Stress			
	Concrete $\sigma_{ck} = 240$ kgf/cm			
	Normal $\sigma_{ca} = 80$ kg/cm² Seismic $\sigma_{ca} = 120$ kg/cm²			
	$\sigma_{sa} = 1800$ kg/cm² $\sigma_{sa} = 2700$ kg/cm²			
	$\tau_m = 3.9$ kg/cm² $\tau_m = 5.85$ kg/cm²			
	(b) Wall Design			
	i) Normal Case			
	$R_d = 194.58$ tf			
	$W_1 = 271.82$ tf			
	$P_{a1} = 1/2 \times K_A \times r \times h^2 \times \cos\delta$			
	$= 1/2 \times 0.251 \times 1.8 \times 11.2^2 \times \cos 11.7 \times 7.0$			
	$= 194.24$ tf			
	$P_{a2} = 1/2\ K q\ h \cos\delta$			
	$= 1/2 \times 0.251 \times 1.0 \times 11.2 \times \cos 11.7 \times 7.0$			
	$= 9.63$ tf			
	$M = \Sigma Pe$			
	$= 194.24 \times 3.73 + 9.63 \times 5.60$			
	$= 778.44$ tf·m			
	$N = 194.58 + 271.82 = 466.40$ tf			
	$S = 194.24 + 9.63 = 203.87$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	ii) Seismic Case			
	$R_d = 194.58$ tf			
	$H = 58.37$ tf			
	$W_1 = 271.82$ tf			
	$W_{H1} = 40.77$ tf			
	$P_{a1} = 1/2 \times 0.360 \times 1.8 \times 11.2^2 \times \cos 0 \times 7.0$			
	$= 284.50$ tf			
	$M_E = 284.50 \times 3.73 + 58.37 \times 9.5 + 40.77 \times 4.95$			
	$= 1817.51$ tf·m			
	$N_E = 194.58 + 271.82 = 466.40$ tf			
	$S_E = 284.50 + 58.37 + 40.77 = 383.64$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(c) Stress Calculation			
	i) Normal Case			
	$d = 170$ cm $b = 700$ cm			
	$d' = 10$ cm			
	$M = 778.44$ tf.m $N = 475.27$ tf			
	$v = 80$ cm			
	$As = 70 \times 6.424 = 449.68$ (D29 10cm)			
	$M' = M + Nv = 778.44 + 475.27 \times 0.8$			
	$= 1158.66$ tf.m			
	$np = 15 \times 449.68 / 700 \times 170 = 0.057$			
	$d'/d = 10/170 = 0.059$			
	$As'/As = 0.5$			
	$f = M/N + v = 778.44 \times 10^2 / 475.27 + 80 = 243.79$			
	$f/d = 243.79/170 = 1.43$			
	$C = 5.08$			
	$S = 7.65$			
	$z = 1.05$			
	$M'/bd^2 = 1158.66 \times 10^5 / 700 \times 170^2 = 5.73$ kg/cm²			
	$\sigma_c = M'/bd^2 \cdot C = 5.73 \times 5.08 = 29.11 < 80$ kg/cm²			
	$\sigma_s = M'/bd^2 \cdot n = 5.73 \times 7.65 \times 15 = 657 < 1800$ kg/cm²			
	$\tau_m = H/bd = 203.87 / 700 \times 170 \times 10^3 \times 1.05$			
	$= 1.80 < 3.9$ kg/cm²			

8

6

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	ii) Seismic Case			
	$M_E' = M_E + N_E U = 1817.51 + 466.40 \times 0.8$			
	$= 2190.63$			
	$f = M_E / N_E + U = 1817.51 \times 10^2 / 46640 + 80$			
	$= 469.69$			
	$f/d = 469.69 / 170 = 2.76$			
	$C = 6.05$			
	$S = 12.95$			
	$z = 1.08$			
	$M'/bd^2 = 2190.63 \times 10^5 / 700 \times 170^2 =$			
	$= 10.83$ kg/cm²			
	$\sigma_c = M'/bd^2 \times C = 10.83 \times 6.05 = 65.52 < 120$ kg/cm²			
	$\sigma_s = M'/bd^2 \times S \times n = 10.83 \times 12.95 \times 15 = 2104 < 2700$ kg/cm²			
	$\tau_m = H/bdz = 383.64 \times 10^3 / 170 \times 700 \times 1.08$			
	$= 3.48 < 5.85$ kg/cm²			

6-18

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks

(4) Stability Calculation for Foundation

a) Weights on Footing

Soil

a $2.0 \times 1.8 \times 1/2 = 1.8$

b $2.0 \times 0.4 = 0.8$

c $2.0 \times 0.3 \times 1/2 = 0.3$

d $6.0 \times 0.4 \times 1/2 = 1.2$

e $6.0 \times 10.8 = 64.8$

f $6.0 \times 0.3 \times 1/2 = 0.9$

	A_i	x_i	y_i	$A_i x_i$	$A_i y_i$
a	1.8	1.33	3.10	2.39	5.58
b	0.8	1.00	2.00	0.80	1.60
c	0.3	0.67	1.70	0.20	0.51
	2.9	1.17	2.65	3.39	7.69
d	1.2	5.80	12.73	15.28	15.28
e	64.8	6.80	7.20	440.64	466.56
f	0.9	7.80	1.70	7.02	1.53
	66.9	6.80	7.23	462.94	483.37

$W_3 = 2.9 \times 7.0 \times 1.8 = 36.54$ tf

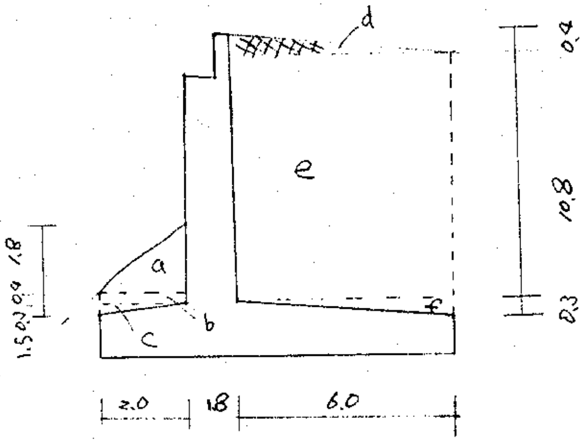
$W_4 = 66.9 \times 7.0 \times 1.8 = 842.94$ tf

$W_{H4} = 842.94 \times 0.15 = 126.44$ tf

Coefficient for Soil

$K_A = 0.251$

$K_{EA} = 0.360$



Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$P_a = 1/2 \times 1.8 \times 13.0^2 \times 0.251 \times 7.0 = 267.24$ tf			
	$P_{Ea} = 1/2 \times 1.8 \times 13.0^2 \times 0.360 \times 7.0 = 383.29$ tf			
	$P_{aH} = 267.24 \times \cos 35° = 218.91$ tf			
	$P_{aV} = 267.24 \times \sin 35° = 153.28$ tf			
	$P_{EaH} = 383.29 \times \cos 17.5° = 365.55$ tf			
	$P_{EaV} = 383.29 \times \sin 17.5° = 115.26$ tf			
	Load on Ground ($q = 1.0$ tf/m²)			
	$P_{as} = qHK_aL = 1.0 \times 13.0 \times 0.251 \times 7.0$			
	$= 22.84$ tf			
	$P_{asH} = 22.84 \times \cos 35° = 18.71$ tf			
	$P_{asV} = 22.84 \times \sin 35° = 13.10$ tf			
	$Q = 1.0 \times 6.0 \times 7.0 = 42.0$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(b) Stability for Support			
	i) Normal Case			

	V	H	x	y	Mr	Mo
Rd	194.58	0	2.50	11.00	486	0
Rl	45.51	0	2.50	11.00	114	0
W_1	271.82	0	2.86	6.75	777	0
W_2	276.19	0	4.82	0.84	1331	0
W_3	36.54	0	1.17	2.65	43	0
W_4	842.94	0	6.80	7.23	5732	0
Pav	153.28	218.91	9.80	4.33	1502	948
Pasv	13.10	18.71	9.80	6.50	128	122
Q	42.00	0	6.80	13.00	286	0
	1875.96	237.62			10399	1090

$x_o = Mr - Mo / V = 10399 - 1090 / 1875.96 = 4.97$ m

$e = \frac{B}{2} - x_o = \frac{9.8}{2} - 4.97 = -0.07$ m

$B' = B - 2e = 9.8 - 2 \times 0.07 = 9.66$ m

$A' = B' \cdot L = 9.66 \times 7.0 = 67.62$ m^2

$\beta = 1 - 0.4 B'/L = 1 - 0.4 \times 9.66 / 7.0 = 0.448$

$Df = (2.0 + 3.8)/2 = 2.9$ m

$Df' = 1.8$ m

$K = 1 + 0.3 Df'/B'$

$= 1 + 0.3 \times 1.8 / 9.66 = 1.06$

6-84

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$r_1 = 1.8$ tf/m³			
	$r_2 = 1.8$ tf/m³			
	$\phi = 35°$			
	$\tan\theta = H/V = 237.62/1875.96$			
	$= 0.127$			
	$N_q = 25$			
	$N_r = 22$			
	$Q_{av} = 1/3\,Q_v = 1/3\,A' \times \{k\,r_1\,D_f\,N_q + r_2\,B'/2\,\beta\,N_r\}$			
	$= 1/3 \times 67.62 \times \{1.06 \times 1.8 \times 2.9 \times 25 +$			
	$1.8 \times 9.66/2 \times 0.448 \times 22\}$			
	$= 5049.37 > 1875.96$ tf			

6-85

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks

ii) Seismic Case

	V	H	x	y	Mr	Mo
Rd	194.58	58.37	2.50	11.00	486	642
W1	271.82	40.77	2.86	6.75	777	275
W2	276.19	41.43	4.82	0.84	1331	35
W3	36.54	0	1.17	2.65	43	0
W4	842.94	126.44	6.80	7.23	5732	914
Peqv	115.26	365.55	9.80	4.33	1130	1583
	1737.33	632.56			9499	3449

$x_o = 9499 - 3449 / 1737.33 = 3.48$ m

$e = 9.8/2 - 3.48 = 1.42$ m

$B' = 9.8 - 2 \times 1.42 = 6.96$ m

$A' = 6.96 \times 7.00 = 48.72$ m^2

$\beta = 1 - 0.4 \times 6.96 / 7.00 = 0.602$

$k = 1 + 0.3 \times 1.8 / 6.96 = 1.08$

$\tan\theta = 632.56 / 1737.33 = 0.364$

$N_q = 14.0$

$N_r = 8.0$

$Q_{av} = 1/2\ Q_v = 1/2 \times 48.72 \times \{1.08 \times 1.8 \times 2.9 \times 14 +$
$1.8 \times 6.96/2 \times 0.602 \times 8.0\}$
$= 2653 > 1737$ tf

6-86

5-7

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(c) Stability for Over - Turning			
	i) Normal Case			
	$M_r = R_d x + W_1 x + W_2 x + W_3 x + W_4 x + P_{av} x + P_{asv} x$			
	$= 486 + 114 + 777 + 43 + 5732 + 1502 + 128$			
	$= 8782$ tf·m			
	$M_o = P_{av} y + P_{asv} y$			
	$= 948 + 122 = 1070$ tf·m			
	$V = 194.58 + 271.82 + 276.19 + 36.54 + 842.94 +$			
	$153.28 + 13.10$			
	$= 1788.45$ tf			
	$x_o = 8782 - 1070 / 1788.45 = 4.31$ m			
	$e = \lvert 19.8/2 - 4.31 \rvert = 0.59\,m < 9.8/6 = 1.63\,m$			
	ii) Seismic Case			
	$e = 1.42m < 1/3B = 3.27\,m$			

6-87

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(d) Stability for Sliding			
	i) Normal Case			
	$Ha = 1/1.5\, V \tan\phi_B$			
	$V = 1788.45$ tf			
	$\phi_B = 2/3\,\phi$			
	$Ha = 1/1.5 \times 1788.45 \times \tan(35° \times 2/3)$			
	$= 514.31$ tf > 237.62 tf			
	ii) Seismic Case			
	$Ha = 1/1.2\, V \tan\phi_B$			
	$V = 1737.33$ tf			
	$\phi_B = 2/3\,\phi$			
	$Ha = 1/1.2 \times 1737.33 \times \tan(35° \times 2/3)$			
	$= 624.51$ tf < 632.56 tf			
	∴ Grevel Bedding is needed.			
	$\phi_B = 0.6$			
	$Ha = 1/1.2 \times 1737.33 \times 0.6$			
	$= 868.67$ tf > 632.56 tf			

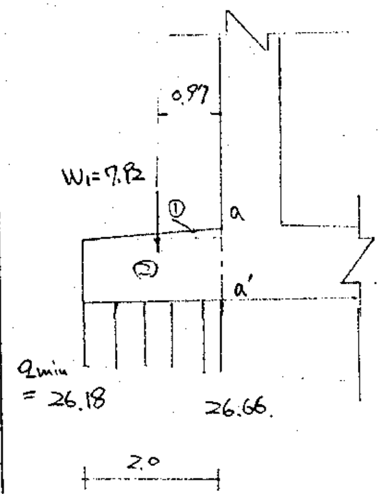
6-88

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(5) Calculation of Ground Reaction			
	i) Normal Case			
	$\left.\begin{matrix} q_{max} \\ q_{min} \end{matrix}\right\} = V/L{\cdot}B \pm 6M_B/L{\cdot}B^2$			
	$= 1875.96/7.0\times9.8 \pm 6\times1875.96\times0.07/7.0\times9.8^2$			
	$= 27.35 \pm 1.17$			
	$q_{max} = 28.52$ tf/m²			
	$q_{min} = 26.18$ tf/m²			
	ii) Seismic Case			
	$q_{max} = 2V/L\times3(B/2 - e)$			
	$= 2\times1737.33/7.0\times3(9.8/2 - 1.42)$			
	$= 47.55$ tf/m²			
	$x = 3(9.8/2 - 1.42)$			
	$= 10.44$ m			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(6) Design of Member Section			
	i) Normal Case			
	Section a ~ a′			
	Body Weight			
	A_i x			
	① $2.0\times0.3\times1/2\times2.4=0.72$ 0.67			
	② $2.0\times1.5\times2.4=7.20$ 1.00			
	7.92 0.97			
	$M_{F1}=-7.92\times0.97+1/2\times26.18\times2.0\times1.33+$			
	$1/2\times26.66\times2.0\times0.67$			
	$=45.00$ tf.m/m			
	$S_{F1}=(26.18+26.66)\times1/2\times2.0-7.92$			
	$=44.92$ tf.			
	Stress Calculation			
	$A_s=2.865\ cm^2\times7=20.06$ (D19 15cm)			
	$M'=M=45.00$ tf.m			
	$np=15\times20.06/170\times100=0.018$			
	$d'/d=0.059$ $A_s'/A_s=0.5$ $f/d=\infty$			
	$C=11.65$ $S=58.00$ $Z=1.06$			
	$M'/bd^2=45.00\times10^5/100\times170^2=1.56\ kg/cm^2$			
	$\sigma_c=M'/bd^2=1.56\times11.65=18.17<80\ kg/cm^2$			
	$\sigma_s=M'/bd^2\,S\,n=1.56\times580\times15=1357<1800\ kg/cm^2$			
	$\tau_m=H/bd\cdot Z=44.92\times10^3/100\times170\times1.06$			
	$=2.80<3.9\ kg/cm^2$			



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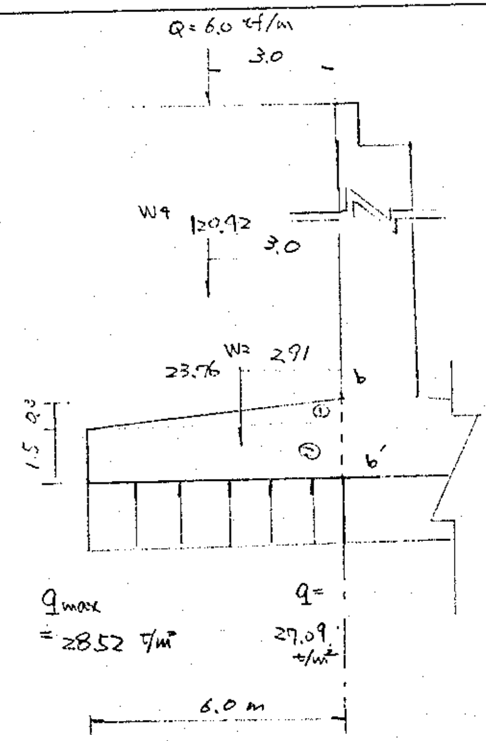
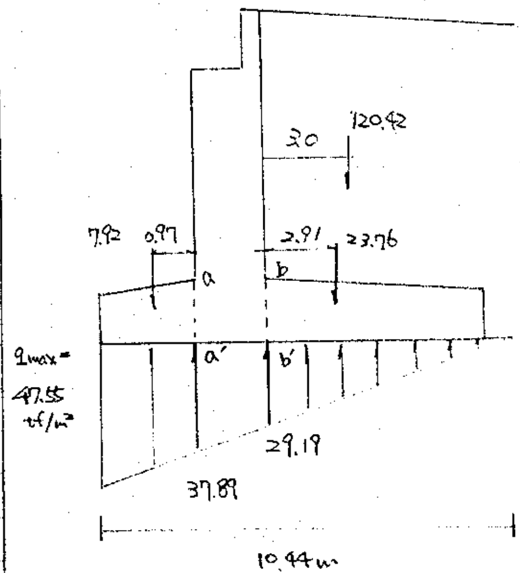
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Section b ~ b′			
	Body Weight			
	Ai x			
	① 6.0×0.3×1/2×2.4 = 2.16 2.0			
	② 6.0×1.5×2.4 = 21.6 3.0			
	23.76 2.91			
	$Q = 1.0\times6.0 = 6.0$ tf/m			
	$M_{F2} = 1/2\times28.52\times6.0\times4.0 + 1/2\times27.09\times6.0\times2.0$			
	$-23.76\times2.91 - 120.42\times3.0 - 6.0\times3.0$			
	$= 56.38$ tf.m			
	$S_{F2} = 1/2(28.52+27.09)\times6.0 - 23.76 - 120.42 - 6.0$			
	$= 16.65$ tf			
	Stress Calculation			
	$As = 20.06$ (Φ19 15cm pitch)			
	$M' = M = 56.38$ tf.m			
	$np = 0.018$			
	$d'/d = 0.059$ $A's/As = 0.5$ $f/d = \infty$			
	$C = 11.5$ $S = 58.0$ $Z = 1.06$			
	$M'/bd^2 = 56.38\times10^5/100\times170^2 = 1.95$ kg/cm²			
	$\sigma c = M'/bd^2 \times C = 1.95\times11.5 = 22.43 < 80$ kg/cm²			
	$\sigma s = M'/bd^2 \times S\times n = 1.95\times58\times15 = 1697 < 1800$ kg/cm²			
	$\tau m = H/bd\times Z = 16.65\times10^3/100\times170\times1.06$			
	$= 1.04 < 3.9$ kg/cm²			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	ii) Seismic Case			
	Section a~a'			
	$M_{EI} = 1/2 \times 47.55 \times 2.0 \times 1.33 + 1/2 \times 37.89 \times 2.0 \times 0.67$			
	$- 7.92 \times 0.97$			
	$= 80.95$ tf.m/m			
	$S_{EI} = 1/2(47.55+37.89) \times 2.0 - 7.92$			
	$= 77.52$ tf			
	Stress Calculation			
	$As = 2.865 \times 10 = 28.65$ (D19 10cm Pitch)			
	$M = 80.95$ tf.m			
	$np = 15 \times 28.65 / 100 \times 170 = 0.025$			
	$d'/d = 0.059$ $A's/As = 0.5$ $f/d = \infty$			
	$C = 10.1$			
	$S = 43.0$			
	$Z = 1.068$			
	$M'/bd^2 = 80.95 \times 10^5 / 100 \times 170^2$			
	$= 2.80$			
	$\sigma_c = M'/bd^2 \times C = 2.80 \times 10.1 = 28.28 < 120$ kg/cm²			
	$\sigma_s = M'/bd^2 \times S \times n = 2.80 \times 43.0 \times 15 = 1806 < 2700$ kg/cm²			
	$\tau_m = H/bd \times Z = 77.52 \times 10^3 / 100 \times 170 \times 1.068$			
	$= 4.87 < 5.95$ kg/cm²			



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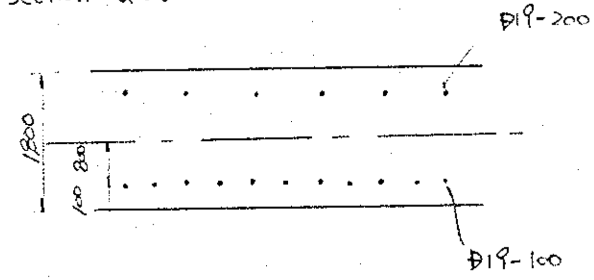
Working Division:

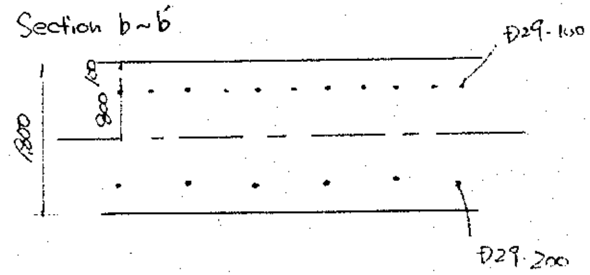
Description	Calculation Details	Unit	Quantity
	Section b~b'		
	$M_{F2} = 120.42 \times 3.0 + 23.76 \times 2.91 - 1/2 \times 29.19 \times 6.64 \times \frac{6.64}{3}$		
	$= 215.91$ tf·m/m		
	$S_{F2} = 120.42 + 23.76 - 29.19 \times 6.64 \times 1/2$		
	$= 47.27$ tf		
	$A_s = 6.424 \times 10 = 64.24$ (D29 10cm)		
	$M' = 215.91$ tf·m		
	$np = 15 \times 64.24 / 100 \times 170 = 0.057$		
	$d'/d = 0.059$ $A_s'/A_s = 0.5$ $f/d = \infty$		
	$C = 6.95$		
	$S = 19.15$		
	$Z = 1.09$		
	$M'/bd^2 = 215.91 \times 10^5 / 100 \times 170^2 = 7.47$		
	$\sigma_c = M'/bd^2 \times C = 7.47 \times 6.95 = 51.92 < 120$ kg/cm²		
	$\sigma_s = M'/bd^2 \times S \times n = 7.47 \times 19.15 \times 15 = 2146 < 2700$ kg/cm²		
	$\tau_m = H/bd \times Z = 47.27 \times 10^3 / 100 \times 170 \times 1.09$		
	$= 3.03 < 5.85$ kg/cm²		

Remarks

Section a~a'



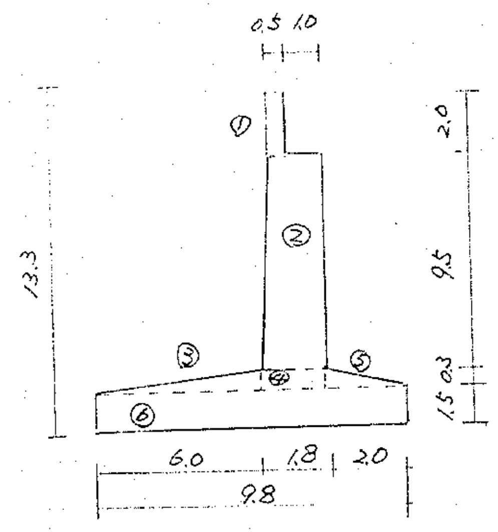
Section b~b'



Working Division: Conguillo I No. 2

Description	Calculation Details	Unit	Quantity	Remarks
Left Side	(1) Design Condition			
	Type : Inverted T-Shape Abutment			
	h = 13.0 m			
	w = 7.0 m			
	ϕ = 35°			
	c = 0 tf/m²			
	θ = 0°			
	δ = 35/3 = 11.7			
	δ_E = 0			
	Design Seismic Coefficient k = 0.15			
	Earth Pressure Design Seismic Coefficient k = 0.15			
	Soil Unit Weight			
	γ = 1.8 tf/m³			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(2) Load Condition			
	(a) Reaction			
	Normal Case			
	Vertical Rd = 16.8×23.0 + 3.7/2			
	= 195.05 tf			
	Rl = 2.4×23.0 + 34.9/2			
	= 45.05 tf			
	Seismic Case			
	Vertical Rd = 195.05 tf			
	Horizontal H = 195.05 × 2.0 × 0.2			
	= 78.01 tf			
	(b) Body Weight			

	Ai	xi(m)	yi(m)	Aixi	Aiyi
1	0.5×2.0 = 1.00	3.25	12.30	3.25	12.30
2	9.5×(1.5+1.8)/2 = 15.68	2.83	6.55	44.37	102.70
	16.68	2.86	6.89	47.62	115.00
3	6.0×0.3×1/2 = 0.90	5.80	1.60	5.22	1.44
4	1.8×0.3 = 0.54	2.90	1.65	1.57	0.89
5	2.0×0.3×1/2 = 0.3	1.33	1.60	0.40	2.13
6	9.8×1.5 = 14.7	4.90	0.75	72.03	11.03
	16.44	4.82	0.84	79.22	15.49
GRAND TOTAL	33.12			126.84	130.49

WALL WEIGHT W_1 16.68 × 7.0 × 2.4 t/m³ = 280.22 tf

FOOTING WEIGHT W_2 16.44 × 7.0 × 2.4 t/m³ = 276.19 tf

SEISMIC W_{H1} 280.22 × 0.15 = 42.03 tf/m

SEISMIC W_{H2} 276.19 × 0.15 = 41.43 tf/m

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(C) Earth Pressure at Abutment			
	Coefficient of Earth Pressure			
	$K_A = \dfrac{\cos^2(35-0)}{\cos^2 0 \cdot \cos(0+11.7) \times \left(1+\sqrt{\sin 46.7 \sin 35 / \cos 11.7 \cos 0}\right)^2}$			
	$= 0.671 / 0.979 \times 2.732$			
	$= 0.251$			
	$K_{EA} = \dfrac{\cos^2 26.47}{\cos 8.53 \times \cos^2 0 \times \cos 8.53 \times \left(1+\sqrt{\sin 35 \sin 26.47 / \cos 8.53 \cos 0}\right)^2}$			
	$= 0.801 / 0.989 \times 0.989 \times (1+\sqrt{0.574 \times 0.446 / 0.989})^2$			
	$= 0.801 / 2.229 = 0.360$			
	(3) Dimension of Member			
	(a) Allowable Stress			
	Concrete $\sigma_{ck} = 240$ kgf/cm			
	Normal Case $\sigma_{ca} = 80$ kgf/cm²			
	$\tau_{ca} = 3.9$ kgf/cm²			
	$\sigma_{sa} = 1800$ kgf/cm²			
	Seismic Case $\sigma_{ca} = 120$ kgf/cm²			
	$\tau_{ca} = 5.85$ kgf/cm²			
	$\sigma_{sa} = 2700$ kgf/cm²			

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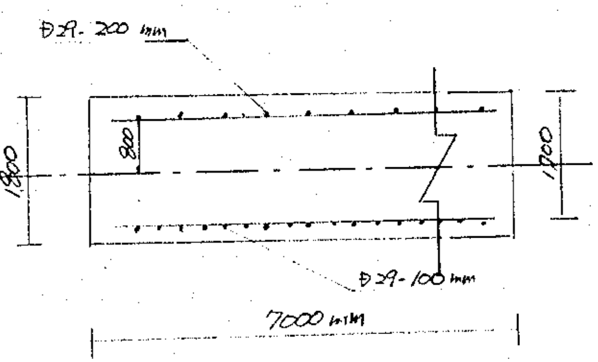
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(b) Wall Design			
	i) Normal Case			
	- Superstructure Reaction $R_d = 195.05$ tf			
	- Body Weight $W_1 = 280.22$ tf			
	- Soil Pressure $P_{a1} = 1/2 \times K_A \times r \times h^2 \times \cos\delta$			
	$= 1/2 \times 0.251 \times 1.8 \times 11.5^2 \times \cos 11.7 \times 7.0$			
	$= 204.75$ tf			
	- Soil Pressure for Load $P_{a2} = 1/2 \times K_A \times q \times h \times \cos\delta$			
	$= 1/2 \times 0.251 \times 1.0 \times 11.5 \times \cos 11.7 \times 7.0$			
	$= 9.87$ tf			
	- Bending Moment $M = 204.75 \times 3.83 + 9.87 \times 5.75$			
	$= 840.95$ tf·m			
	$N = 195.05 + 280.22 = 475.27$ tf			
	$S = 204.75 + 9.87 = 214.62$ tf			
	ii) Seismic Case			
	$R_d = 195.05$ tf $H = 58.52$ tf			
	$W_1 = 280.22$ tf $WH1 = 42.03$ tf			
	$P_{a1} = 1/2 \times 1.8 \times 0.360 \times 11.5^2 \times \cos 0 \times 7.0$			
	$= 299.95$ tf			
	$M_E = 58.52 \times 9.5 + 42.03 \times 5.09 + 299.95 \times 3.83$			
	$= 1923.72$ tm			
	$N_E = 195.05 + 280.22 = 475.27$ tf			
	$S_E = 58.52 + 42.03 + 299.95$			
	$= 400.50$ tf			

Working Division:

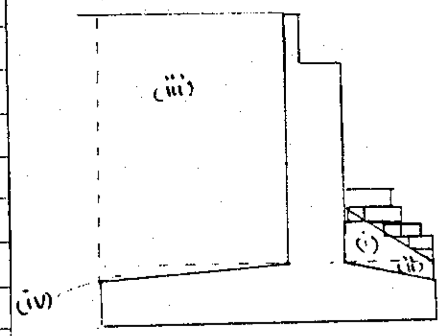
Description	Calculation Details	Unit	Quantity	Remarks
	(4) Stress Calculation			
	i) Normal Case			
	$A_s = 700/10 \times 6.424 = 449.68\ cm^2$			
	$A'_s = 700/20 \times 6.424 = 224.84\ cm^2$			
	$M' = H + Nu = 840.95 + 475.27 \times 0.8 = 1221.17\ tf{\cdot}m$			
	$np = 15 \times 449.68/170 \times 700 = 0.057$			
	$d'/d = 10/170 = 0.059$			
	$A'_s/A_s = 0.5$			
	$f = M/N + u = 840.95 \times 10^2/475.27 + 80 = 256.94$			
	$f/d = 256.94/170 = 1.51$			
	$C = 5.19 \quad S = 8.11 \quad Z = 1.055$			
	$M'/bd^2 = 1221.17 \times 10^5/700 \times 170^2 = 6.04\ kg/cm^2$			
	$\sigma_c = M'/bd^2 \times C = 6.04 \times 5.19 = 31.35 < 80\ kg/cm^2$			
	$\sigma_s = M'/bd^2 \times S \times n = 6.04 \times 8.11 \times 15 = 735 < 1800\ kg/cm^2$			
	$\tau_m = H/bd \times Z = 214.62 \times 10^3/700 \times 170 \times 1.055$			
	$= 1.90 < 3.9\ kg/cm^2$			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	ii) Seismic Case			
	$M'_E = M_E + N_{EU} = 1923.72 + 475.27 \times 0.80$			
	$= 2303.94$ tf.m			
	$np = 0.057$			
	$d'/d = 0.059$			
	$A's/As = 0.5$			
	$f = M_E/N_E + U = 1923.72 \times 10^3/475.27 + 80$			
	$= 484.76$			
	$f/d = 484.76/170 = 2.85$			
	$C = 6.12$ $S = 13.15$ $Z = 1.085$			
	$M'/bd^2 = 2303.94/700 \times 170^2 \times 10^5 = 11.39$			
	$\sigma c = M'/bd \times C = 11.39 \times 6.12 = 69.71 < 120$ kg/cm²			
	$\sigma s = M'/bd \times S \times n = 11.39 \times 13.15 \times 15 = 2247 < 2700$ kg/cm²			
	$\tau_m = H/bd \times Z = 400.50 \times 10^3 / 170 \times 700 \times 1.085$			
	$= 3.65 < 5.85$ kg/cm²			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(5) Stability Calculation for Foundation			
	(a) Weights on Footing			
	Soil			
	i) 2.0 × 0.3 × 1/2 = 0.3			
	ii) 2.0 × 1.5 × 1/2 = 1.5			
	iii) 6.0 × 11.5 = 69.0			
	iv) 6.0 × 0.3 × 1/2 = 0.9			
	Gabion			
	1.0 × 0.5 × 5 nos = 2.5			



	Ai	Xi	Yi	AiXi	AiYi
i)	0.3	1.33	1.70	0.40	0.51
ii)	1.5	0.67	2.30	1.01	3.45
	1.8	0.78	2.20	1.41	3.96
iii)	69.0	6.80	7.55	469.20	520.95
iv)	0.9	7.80	1.70	7.02	1.53
	69.9	6.81	7.47	476.22	522.48

Gabion

i	0.25	0.25	2.55	0.06	0.64
ii	1.00	1.00	3.05	1.00	3.05
iii	0.75	1.25	3.55	0.94	2.66
iv	0.50	1.50	4.05	0.75	2.03
	2.50	1.10	3.35	2.75	8.38

$W_3 = 1.8 \times 7.0 \times 1.8 + 2.5 \times 7.0 \times 2.3 = 62.93$ tf

$W_4 = 69.9 \times 7.0 \times 1.8 = 880.74$ tf

$W_{H4} = 880.74 \times 0.15 = 132.11$ tf

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Coefficient for Soil			
	$K_A = 0.251 \quad K_{EA} = 0.360$			
	$P_a = 1/2 \times 1.8 \times 13.3^2 \times 0.251 \times 7.0 = 279.72$ tf			
	$P_{EA} = 1/2 \times 1.8 \times 13.3^2 \times 0.360 \times 7.0 = 401.19$ tf			
	$P_{aH} = 279.72 \times \cos 35° = 229.13$ tf			
	$P_{aV} = 279.72 \times \sin 35° = 160.44$ tf			
	$P_{EaH} = 401.19 \times \cos 17.5° = 382.62$ tf			
	$P_{EaV} = 401.19 \times \sin 17.5° = 120.64$ tf			
	Load on Ground ($q = 1.0$ tf/m²)			
	$P_{as} = qHK_{AL} = 1.0 \times 13.3 \times 0.251 \times 7.0$			
	$= 23.37$ tf			
	$P_{asH} = 23.37 \times \cos 35° = 19.14$ tf			
	$P_{asV} = 23.37 \times \sin 35° = 13.40$ tf			
	$Q = 1.0 \times 6.0 \times 7.0 = 42.0$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(b) Stability for Support			
	i) Normal Case			

	V	H	x	y	Hr	Mo
Rd	195.05	0	2.50	11.30	488	0
Rl	45.05	0	2.50	11.30	113	0
W_1	288.02	0	2.86	6.89	801	0
W_2	279.19	0	4.82	0.84	1346	0
W_3	62.93	0	0.97	2.87	61	0
W_4	880.74	0	6.81	7.47	5998	0
Pav	160.44	229.13	9.80	4.43	1572	1015
Pasv	13.40	19.14	9.80	6.65	131	127
Q	42.00	0	6.80	13.30	286	0
	1966.82	248.27			10796	1142

$x_o = Hr - Mo/V = 10796 - 1142/1966.82 = 4.91$ m

$e = \frac{B}{2} - x_o = 9.8/2 - 4.91 = -0.01$ m

$B' = B - 2e = 9.8 - 2\times0.01 = 9.78$ m

$A' = B' \times L = 9.78 \times 7.0 = 68.46$ m^2

$\beta = 1 - 0.4B'/L = 1 - 0.4\times9.78/7.0 = 0.441$

$Df = 3.2$ m $Df' = 1.8$m $K = 1+0.3Df'/B' = 1.06$

$\gamma_1 = 1.8$ tf/m $\gamma_2 = 1.8$ tf/m $\phi = 35°$

$\tan\theta = 248.27/1966.82 = 0.126$ $Nq = 26$ $N\gamma = 23$

$Qa = 1/3 \times 68.46 \times \{1.06\times1.8\times3.2\times26 + 1.8\times9.78/2\times0.441\times23\}$

$= 5659.91 > 1966.82$ tf

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks

ii) Seismic Case

	V	H	x	y	Hr	Ho
Ra	195.05	78.01	2.50	11.30	488	882
W_1	288.02	42.03	2.86	6.89	801	290
W_2	279.19	41.43	4.82	0.84	1346	35
W_3	62.93	0	1.17	2.65	74	0
W_4	880.74	132.11	6.80	7.23	5989	955
P_{EAV}	120.64	382.62	9.80	4.43	1182	1695
	1826.57	676.20			9880	3857

$x_0 = 9880 - 3857 / 1826.57 = 3.30\,m$

$e = 9.8/2 - 3.30 = 1.60\,m$

$B' = 9.8 - 2 \times 1.60 = 6.60\,m$

$A' = 6.60 \times 7.0 = 46.20\,m^2$

$\beta = 1 - 0.4 \times 6.60 / 7.00 = 0.623$

$k = 1 + 0.3 \times 1.8 / 6.60 = 1.08$

$\tan\theta = 676.20 / 1826.57 = 0.370$

$N_q = 14$

$N_r = 7.3$

$Q_{aw} = 1/2\, Q_{u} = 1/2 \times 46.20 \times \{1.08 \times 1.8 \times 3.2 \times 14 + 1.8 \times 6.60/2 \times 0.623 \times 7.3\}$

$= 2635.84 > 1826.57$ tf.

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Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(c) Stability for Over-Turning			
	i) Normal Case			
	$Mr = Ra x + W_1 x + W_2 x + W_3 x + W_4 x + Pav x + Pasv x$			
	$= 488 + 801 + 1346 + 61 + 5998 + 1572 + 131$			
	$= 10397$ tf·m			
	$Mo = Pav y + Pasv y = 1015 + 127 = 1142$ tfm			
	$V = 195.05 + 288.02 + 279.19 + 62.93 + 880.74$			
	$+ 160.44 + 13.40$			
	$= 1879.77$ tf			
	$x = 10397 - 1142 / 1879.77 = 4.92$ m			
	$e = 9.8/2 - 4.92 = 0.02 < 9.8/6 = 1.63$ m			
	ii) Seismic			
	$e = 1.60\ m < \frac{1}{3}B = 3.27\ m$			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	d) Stability for Sliding			
	i) Normal Case			
	$Ha = 1/1.5\, V \times \tan\phi_B$			
	$V = 1879.77$ tf			
	$\phi_B = 2/3\,\phi$			
	$Ha = 1/1.5 \times 1879.77 \times \tan(35° \times 2/3)$			
	$= 540.57$ tf > 248.27 tf			
	ii) Seismic Case			
	$Ha = 1/1.2\, V \tan\phi_B$			
	$V = 1826.57$ tf			
	$\phi_B = 2/3\,\phi$			
	$Ha = 1/1.2 \times 1826.57 \times \tan(35° \times 2/3)$			
	$= 656.59$ tf < 676.20 tf			
	Ha is not enough, so gravel bedding is needed.			
	$\phi_B = 0.6$			
	$Ha = 1/1.2 \times 1826.57 \times 0.6$			
	$= 913.29$ tf > 676.20 tf			

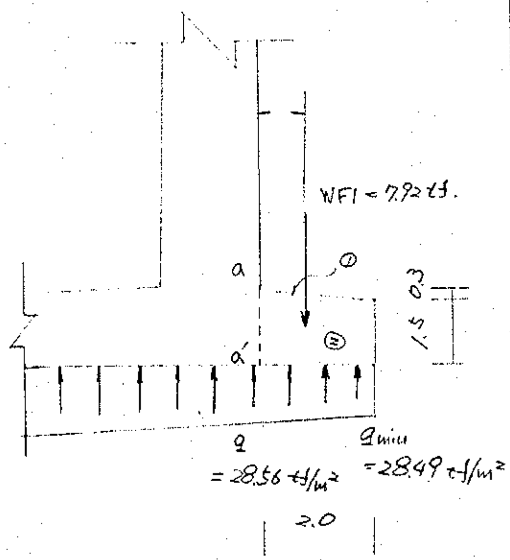
G-rov

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(5) Calculation of Ground Reaction			
	i) Normal Case			
	$\left.\begin{matrix} q_{max} \\ q_{min} \end{matrix}\right\} = \frac{V}{L \cdot B} \pm \frac{6HB}{L \cdot B^2}$			
	$= 1966.82/7.0 \times 9.8 \pm 6 \times 1966.82 \times 0.01/7.0 \times 9.8^2$			
	$= 28.67 \pm 0.18$			
	$q_{max} = 28.85$ tf/m²			
	$q_{min} = 28.49$ tf/m²			
	ii) Seismic Case			
	$q_{max} = 2V/L \times 3(\frac{B}{2} - e)$			
	$= 2 \times 1826.57/7.0 \times 3(9.8/2 - 1.60)$			
	$= 52.71$ tf/m²			
	$x = 3(9.8/2 - 1.60) = 9.9$ m			

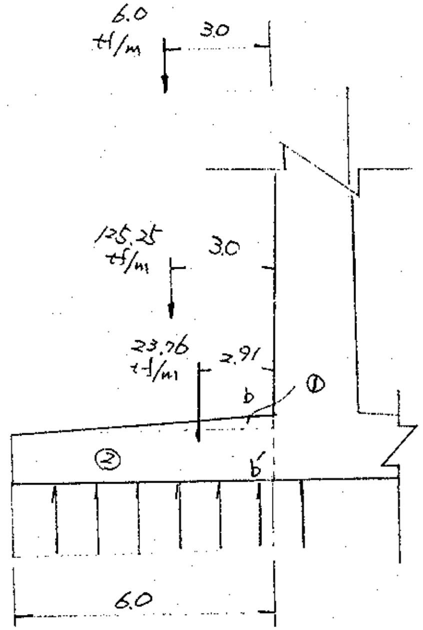
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(6) Design of Member Section			
	i) Normal Case			
	Section a~a'			
	Body Weight			
	Ai x			
	1 $20 \times 0.3 \times 1/2 \times 2.4 = 0.72$ 0.67			
	2 $20 \times 1.5 \times 2.4 = 7.2$ 1.00			
	7.92 0.97			
	$M_{F1} = -7.92 \times 0.97 + 1/2 \times 28.49 \times 2.0 \times 1.33 + 1/2 \times 28.56 \times 2.0 \times 0.67$			
	$= 49.34$ tf·m/m			
	$S_{F1} = 1/2 (28.49 + 28.56) \times 2.0 - 7.92 = 49.13$ tf/m			
	Stress Calculation			
	$As = 2.865 \times 7 = 20.06$ (φ19 15cm pitch)			
	$M' = 49.34$ tfm			
	$np = 15 \times 20.06 / 170 \times 100 = 0.018$			
	$d'/d = 0.059$ $A's/As = 0.5$ $f'/d = \infty$			
	$C = 11.65$ $S = 58.00$ $Z = 1.06$			
	$M'/bd^2 = 49.34 \times 10^5 / 100 \times 170^2 = 1.71$			
	$\sigma_c = 1.71 \times 11.65 = 19.92 < 80$ kg/cm²			
	$\sigma_s = 1.71 \times 58.00 \times 15 = 1487.7 < 1800$ kg/cm²			
	$\tau_m = 49.13 / 100 \times 170 \times 10^3 \times 1.06$			
	$= 3.06 < 3.90$ kg/cm²			

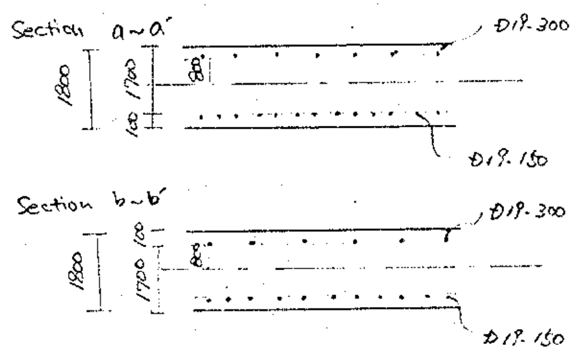


Working Division:

Description	Calculation Details		Unit	Quantity	Remarks
	Section b~b'				
	Body Weight				
	Ai	x			
	6.0 x 0.3 x 1/2 x 2.4 = 2.16	2.0			
	6.0 x 1.5 x 2.4 = 21.6	3.0			
	23.76	2.91			
	$Q = 1.0 \times 6.0 = 6.0$ tf/m				
	$M_{Fz} = 1/2 \times 28.63 \times 6.0 \times 2.0 + 1/2 \times 28.85 \times 6.0 \times 4.0$				
	$- 23.76 \times 2.91 - 125.25 \times 3.0 - 6.0 \times 3.0$				
	$= 55.09$ tf.m				
	$S_{Fz} = 1/2 (28.63 + 28.85) \times 6.0 - 23.76 - 125.25 - 6.0$				
	$= 17.43$ tf				
	Stress Calculation				
	$A_s = 20.06$ (D19 15 cm pitch)				
	$M' = 55.09$ tf.m				
	$np = 0.018$				
	$d'/d = 0.059$ $A_s'/A_s = 0.5$ $f/d = \infty$				
	$C = 11.5$ $S = 58.0$ $Z = 1.06$				
	$M'/bd^2 = 55.09 \times 10^5 / 100 \times 170^2 = 1.91$ kg/cm²				
	$\sigma_c = 1.91 \times 11.5 = 21.97 < 80$ kg/cm²				
	$\sigma_s = 1.91 \times 58.0 \times 15 = 1661.7 < 1800$ kg/cm²				
	$\tau_m = 17.43 \times 10^3 / 100 \times 170 \times 1.06 = 1.09 < 3.9$ kg/cm²				



$q_{max} = 28.85$ tf/m² $q = 28.63$ tf/m²



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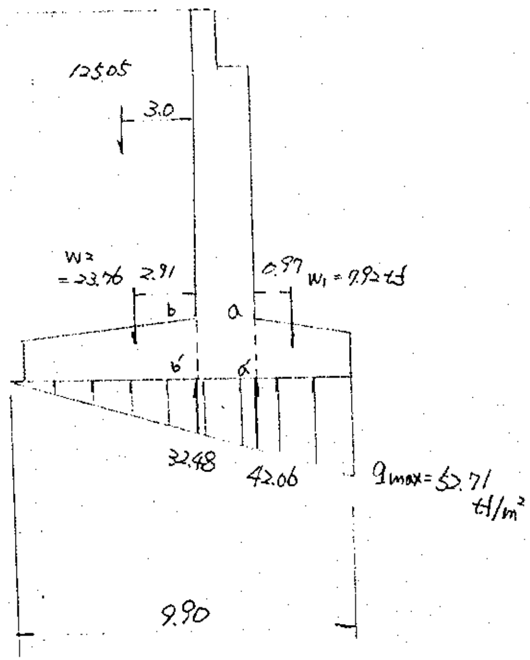
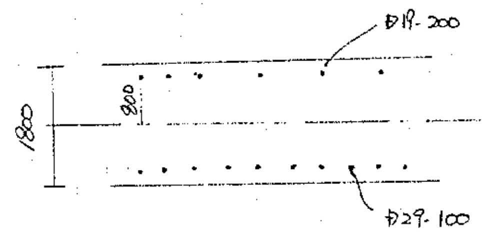
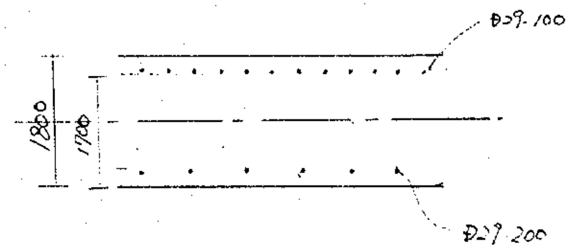
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	ii) Seismic Case			
	Section a~a'			
	$M_{FL} = 1/2 \times 52.71 \times 1.33 \times 2.0 + 1/2 \times 42.06 \times 0.67 \times 2.0$			
	$- 7.92 \times 0.97$			
	$= 90.60$ tf·m			
	$S_{EL} = 1/2 \times (52.71 + 42.06) \times 2.0 - 7.92$			
	$= 86.85$ tf			
	Stress Calculation			
	$As = 2.865 \times 10 = 28.65\ cm^2$ (D19 10cm pitch)			
	$M' = M_{FL} = 90.60$ tf·m			
	$np = 0.015 \times 28.65 / 170 \times 100 = 0.025$			
	$d'/d = 0.059$ $A's/As = 0.5$ $f/d = \infty$			
	$C = 10.1$ $S = 43.0$ $Z = 1.068$			
	$M'/bd^2 = 90.60 \times 10^5 / 100 \times 170^2 = 3.13\ kg/cm^2$			
	$\sigma_c = 3.13 \times 10.1 = 30.61 < 120\ kg/cm^2$			
	$\sigma_s = 3.13 \times 43.0 \times 15 = 2018 < 2700\ kg/cm^2$			
	$\tau_m = 86.85 \times 10^3 / 100 \times 170 \times 1.068 = 5.46 < 5.85\ kg/cm^2$			



Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Section b~b'			
	$H_{F2} = 125.25 \times 3.0 + 23.76 \times 2.91 - 1/2 \times 32.48 \times 6.1 \times \frac{6.1}{3}$			
	$= 243.46$ tf·m			
	$S_{E2} = 125.25 + 23.76 - 1/2 \times 32.48 \times 6.1$			
	$= 49.95$ tf			
	Stress Calculation			
	$A_s = 6.424 \times 10 = 64.24$ (D29 10cm)			
	$M' = 243.46$ tfm			
	$np = 15 \times 64.24 / 100 \times 170 = 0.057$			
	$d'/d = 0.059$ $A_s'/A_s = 0.5$ $f/d = \infty$			
	$C = 6.95$ $S = 19.15$ $Z = 1.09$			
	$M'/bd^2 = 243.46 \times 10^5 / 100 \times 170^2 = 8.43$			
	$\sigma_c = 8.43 \times 6.95 = 58.59 < 120$ kg/cm²			
	$\sigma_s = 8.43 \times 19.15 \times 15 = 2421.52 < 2700$ kg/cm²			
	$\tau_m = 49.95 \times 10^3 / 100 \times 170 \times 1.09$			
	$= 3.20 < 5.85$ kg/cm²			

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Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
Right Side	(1) Design Condition			

All the condition is as same as Left side.

(2) Load Condition

(a) Reaction from Girder

i) Normal Case

Vertical Rd = 195.05 tf

Rl = 45.05 tf

ii) Seismic Case

Vertical Rd = 195.05 tf

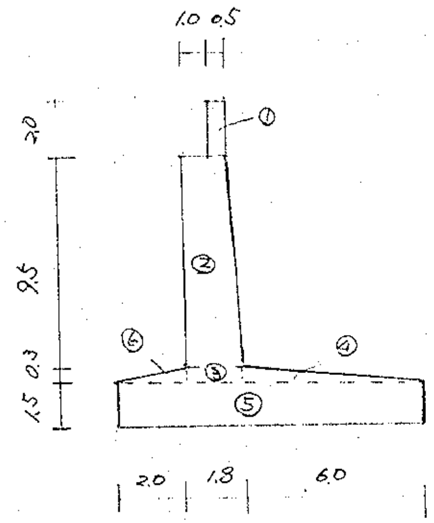
Horizontal H = 195.05 x 0.2 x 0.15

= 58.52 tf

(b) Body Weight

i) Normal Case

	Ai	xi	yi	xiAi	yiAi
1	0.5 x 2.0 = 1.0	3.25	12.30	3.25	12.30
2	(1.5 x 1.8) x 9.5 x 1/2 = 15.68	2.83	6.55	44.37	102.70
	16.68	(2.86)	(6.89)	47.62	115.00
	1.8 x 0.3 = 0.54	2.90	1.75	1.57	0.95
	6.0 x 0.3 x 1/2 = 0.9	5.80	1.60	5.22	1.44
	9.8 x 1.5 = 14.7	4.90	0.75	72.03	11.03
	2.0 x 0.3 x 1/2 = 0.3	1.33	1.60	0.40	0.48
	16.44	(4.82)	(0.84)	79.22	15.49
	33.12			126.84	130.49

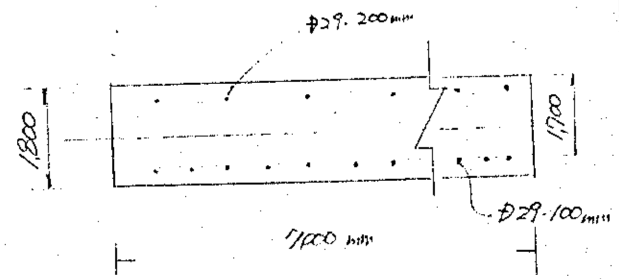


Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	WALL WEIGHT W_1 16.68×7.0×2.4 = 280.22 tf			
	FOOTING WEIGHT W_2 16.44×7.0×2.4 = 276.19 tf			
	SEISMIC W_{H1} 280.22×0.15 = 42.03 tf			
	W_{H2} 276.19×0.15 = 41.43 tf			
	(c) Earth Pressure at Abutment			
	Coefficient of Earth Pressure is as same as			
	Left Side.			
	K_A = 0.251			
	K_{EA} = 0.360			
	(3) Dimension of Member			
	(a) Allowable Stress			
	σ_{ck} = 240 kg/cm²			
	σ_{ca} = 80 kg/cm² 120 kg/cm²			
	σ_{sa} = 1800 kg/cm² 2700 kg/cm²			
	τ_m = 3.9 kg/cm² 5.85 kg/cm²			
	(b) Wall Design			
	i) Normal Case			
	R_d = 195.05 tf			
	W_1 = 280.22 tf			
	P_{a1} = 1/2 × 0.251 × 1.8 × 11.5² × cos11.7 × 7.0			
	= 204.75 tf			
	P_{a2} = 1/2 × 0.251 × 1.0 × 11.5 × cos11.7 × 7.0			
	= 9.87 tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$M = \Sigma Pe$			
	$= 204.75 \times 3.83 + 9.87 \times 5.75$			
	$= 840.95$ tf.m			
	$N = 195.05 + 280.22 = 475.27$ tf			
	$S = 204.75 + 9.87 = 214.62$ tf			
	ii) Seismic Case			
	$Rd = 195.05$ tf $H = 58.52$ tf			
	$W_1 = 280.22$ tf $W_{H1} = 42.03$ tf			
	$M_E = 58.52 \times 9.5 + 42.03 \times 5.09 + 299.95 \times 3.83$			
	$= 1923.72$ tf.m			
	$P_{a1} = 1/2 \times 1.8 \times 0.360 \times 11.5^2 \times \cos 50 \times 7.0$			
	$= 299.95$ tf			
	$N_E = 195.05 + 280.22 = 475.27$ tf			
	$S_E = 58.52 + 42.03 + 299.95 = 400.50$ tf			
	(c) Stress Calculation			
	i) Normal Case			
	$A_s = 70 \times 6.424 = 449.68$ cm^2			
	$A_s' = 35 \times 6.424 = 224.84$ cm^2			
	$M' = M + Nu = 840.95 + 475.27 \times 0.8 = 1221.17$ tf.m			
	$np = 15 \times 449.68 / 170 \times 700 = 0.057$			
	$d'/d = 10/170 = 0.059$ $A_s'/A_s = 0.5$			
	$f = M/N + u = 840.95 \times 10^2 / 475.27 + 80 = 256.94$			
	$f/d = 256.94/170 = 1.51$			
	$C = 5.19$			
	$S = 8.11$			
	$Z = 1.055$			

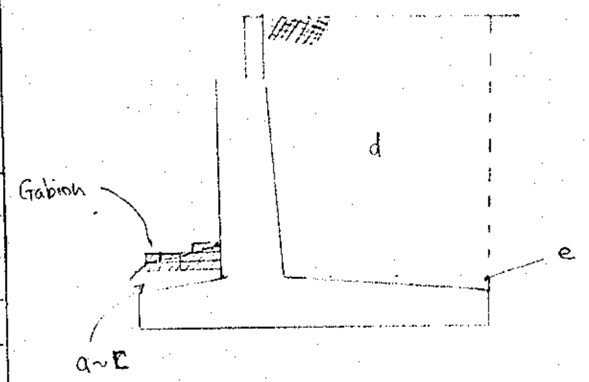


Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$M'/bd^2 = 1221.17 \times 10^5 / 700 \times 170^2 = 6.04$ kg/cm²			
	$\sigma_c = 6.04 \times 5.19 = 31.35 < 80$ kg/cm²			
	$\sigma_s = 6.04 \times 8.11 \times 15 = 735 < 1800$ kg/cm²			
	$\tau_m = 214.62 \times 10^3 / 700 \times 170 \times 1.055$			
	$= 1.90 < 3.9$ kg/cm²			
	ii) Seismic Case			
	$M_E' = M_E + N_E U = 1923.72 + 475.27 \times 0.80$			
	$= 2303.94$ tf.m			
	$np = 0.057$ $d'/d = 0.059$ $A's/As = 0.5$			
	$f = M_E/N_E + U = 1923.72 \times 10^3 / 475.27 + 80$			
	$= 484.76$			
	$f/d = 484.76/170 = 2.85$			
	$C = 6.12$ $S = 13.15$ $Z = 1.085$			
	$M'/bd = 2303.94 \times 10^5 / 700 \times 170^2 = 11.39$			
	$\sigma_c = 11.39 \times 6.12 = 69.71 < 120$ kg/cm²			
	$\sigma_s = 11.39 \times 13.15 \times 15 = 2247 < 2700$ kg/cm²			
	$\tau_m = 400.50 \times 10^3 / 700 \times 170 \times 1.085 = 3.65 < 5.85$ kg/cm²			
	(4) Stability Calculation for Foundation			
	a) Weights on Footing			
	Soil $2.0 \times 0.3 \times 1/2 = 0.3$			
	$2.0 \times 1.5 \times 1/2 = 1.5$			
	$6.0 \times 0.3 \times 1/2 = 0.9$			
	$6.0 \times 11.5 = 69.0$			
	$6.0 \times 0.5 \times 1/2 = 1.5$			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Ai xi yi xiAi yiAi			
	0.3 0.67 1.70 0.201 0.51			
	2.0 1.33 2.80 2.660 5.60			
	2.3 1.24 2.66 2.861 6.11			
	0.9 7.8 1.70 7.02 1.53			
	69.0 6.8 7.55 469.20 714.15			
	1.5 7.8 13.47 11.70 22.31			
	71.4 6.83 7.60 487.92 737.99			
	Gabion			
	0.25 0.25 2.55 0.06 0.64			
	0.75 0.75 3.05 0.56 2.29			
	0.75 1.25 3.55 0.94 2.66			
	0.50 1.50 4.05 0.75 2.03			
	2.25 (1.03) (3.38) 2.31 7.62			
	$W_3 = 2.3 \times 7.0 \times 1.8 + 2.25 \times 7.0 \times 2.3 = 65.21$ tf			
	$W_4 = 71.4 \times 7.0 \times 1.8 = 899.64$ tf			
	$W_{H4} = 899.64 \times 0.15 = 134.95$ tf			
	Coefficient for Soil			
	$K_A = 0.251$ $K_{EA} = 0.360$			
	$P_a = 1/2 \times 1.8 \times 13.3^2 \times 0.251 \times 7.0 = 279.72$ tf			
	$P_{Ea} = 1/2 \times 1.8 \times 13.3^2 \times 0.360 \times 7.0 = 401.19$ tf			
	$P_{aH} = 279.72 \times \cos 35° = 229.13$ tf			
	$P_{aV} = 279.72 \times \sin 35° = 160.44$ tf			
	$P_{EaH} = 401.19 \times \cos 17.5° = 382.62$ tf			
	$P_{EaV} = 401.19 \times \sin 17.5° = 120.64$ tf			



Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Load on Ground			
	$P_{as} = \gamma H K_{AL} = 1.0 \times 13.3 \times 0.251 \times 7.0 = 23.37$ tf			
	$P_{asH} = 23.37 \times \cos 35° = 19.14$ tf			
	$P_{asV} = 23.37 \times \sin 35° = 13.40$ tf			
	$Q = 1.0 \times 6.0 \times 7.0 = 42.0$ tf			
	(b) Stability for Support			
	i) Normal Case			

	V	H	x	y	Hr	Mo
Rd	195.05	0	2.5	11.3	488	0
Rl	45.05	0	2.5	11.3	113	0
W_1	288.02	0	2.86	6.87	861	0
W_2	279.19	0	4.82	0.84	1346	0
W_3	65.21	0	1.14	3.02	74	0
W_4	899.64	0	6.83	7.60	6145	0
Pav	160.44	229.13	9.80	4.43	1572	1015
Pasv	13.40	19.14	9.80	6.65	131	127
Q	42.00	0	6.80	13.30	286	0
	1988.00	248.27			10956	1142

$x_o = 10956 - 1142 / 1988.00 = 4.94$ m

$e = B/2 - x_o = 9.8/2 - 4.94 = -0.04$ m

$B' = B - 2e = 9.8 - 2 \times 0.04 = 9.72$ m

$A' = B' \times L = 9.72 \times 7.0 = 68.04$ m²

$\beta = 1 - 0.4 \times B'/L = 1 - 0.4 \times 9.72/7.0 = 0.445$

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$D_f = 3.0$ m $\quad D_f' = 1.8$ m			
	$k = 1 + 0.3\,D_f'/B' = 1 + 0.3 \times 1.8/9.72 = 1.06$			
	$\tan\theta = 248.27 / 1988 = 0.125$			
	$N_q = 25$			
	$N_r = 23$			
	$Q_{av} = 1/3 \times 68.04 \times \{1.06 \times 1.8 \times 3.0 \times 25 + 1.8 \times 9.72/2 \times 0.445 \times 23\}$			
	$= 5276.18 > 1988$ tf			
	ii) Seismic Case			

	V	H	x	y	Hr	Ho
Rd	195.05	78.01	2.50	11.30	488	882
W1	288.02	42.03	2.86	6.89	801	290
W2	279.19	41.03	4.82	0.84	1346	35
W3	65.21	0	1.14	3.02	74	0
W4	899.64	134.95	6.83	7.60	6145	1026
PEav	120.64	382.62	9.80	4.43	1182	1695
	1847.75	678.64			10036	3928

$x_o = 10036 - 3928/1847.75 = 3.31$ m

$e = 9.8/2 - 3.31 = 1.59$ m

$B' = 9.8 - 2 \times 1.59 = 6.62$ m

$A' = 6.62 \times 7.0 = 46.34$ m²

$\beta = 1 - 0.4 \times 6.62/7.00 = 0.622$

$k = 1 + 0.3 \times 1.8/6.62 = 1.08$

$\tan\theta = 678.64 / 1847.75 = 0.367$

$N_q = 14 \qquad N_r = 8.0$

$Q_{av} = 1/2 \times 46.34 \times \{1.08 \times 1.8 \times 3.0 \times 14 + 1.8 \times 6.62/2 \times 0.622 \times 8.0\}$

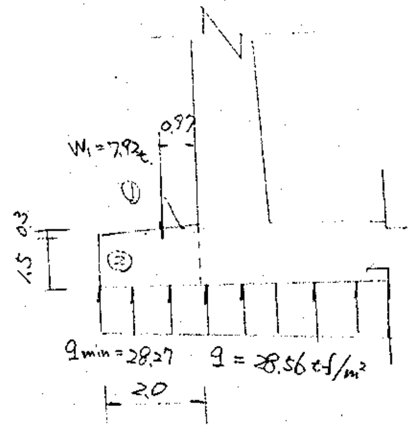
$= 2578.71 > 1847.75$ tf

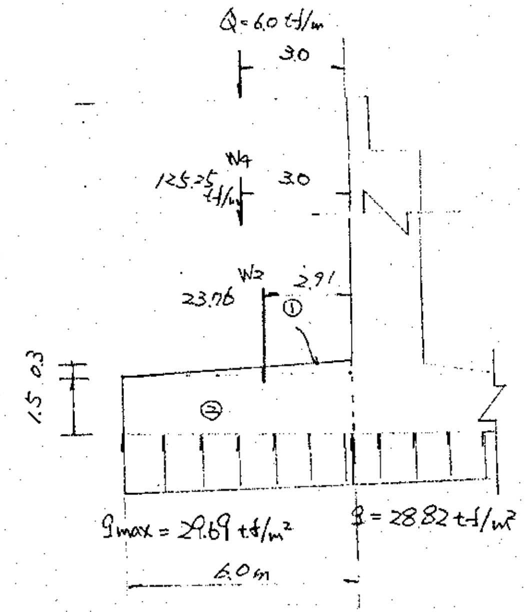
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(c) Stability for Over-Turning			
	i) Normal Case			
	$M_r = R_d x + W_1 x + W_2 x + W_3 x + W_4 x + P_{av} x + P_{asv} x$			
	$= 488 + 801 + 1346 + 74 + 6195 + 1572 + 131$			
	$= 10557$ tf.m			
	$M_o = P_{av} y + P_{asv} y = 1015 + 127 = 1142$ tf.m			
	$V = 195.05 + 288.02 + 279.19 + 65.21 + 899.64 +$			
	$160.44 + 13.40$			
	$= 1900.95$ tf			
	$x = 10557 - 1142 / 1900.95 = 4.95$ m			
	$e = \|9.8/2 - 4.95\| = 0.05 < 9.8/6 = 1.63$ m			
	ii) Seismic Case			
	$e = 1.59$ m $< 1/3 B = 3.27$ m			
	(d) Stability for Sliding			
	i) Normal Case			
	$H_a = 1/1.5 V \tan\phi_B$			
	$V = 1900.95$ tf $\quad \phi_B = 2/3\phi$			
	$H_a = 1/1.5 \times 1900.95 \times \tan(35 \times 2/3)$			
	$= 546.66$ tf > 248.27 tf			
	ii) Seismic Case			
	$H_a = 1/1.2 V \tan\phi_B$			
	$V = 1847.75$			
	$H_a = 1/1.2 \times 1847.75 \times \tan(2/3 \times 35°)$			
	$= 664.20 < 676.20$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$M_{F1} = -7.92 \times 0.97 + 1/2 \times 28.27 \times 2.0 \times 1.33 +$			
	$1/2 \times 28.56 \times 2.0 \times 0.67$			
	$= 59.88$ tf.m			
	$S_{F1} = 1/2\ (28.27 + 28.56) \times 2.0 - 7.92 = 48.91$ tf/m			
	Stress Calculation			
	$A_s = 2.865 \times 10 = 28.65$ (D19 10cm pitch)			
	$M' = 59.88$ tf.m			
	$np = 15 \times 28.65 / 170 \times 100 = 0.025$			
	$d'/d = 0.059$ $A_s'/A_s = 0.5$ $t'/d = \infty$			
	$C = 10.1$ $S = 43.0$ $Z = 1.068$			
	$M'/bd^2 = 59.88 \times 10^5 / 100 \times 170^2 = 2.07$			
	$\sigma c = 2.07 \times 10.1 = 20.91 < 80$ kg/cm^2			
	$\sigma s = 2.07 \times 43.0 \times 15 = 1335.15 < 1800$ kg/cm^2			
	$\tau m = 48.91 \times 10^3 / 100 \times 170 \times 1.068$			
	$= 3.07 < 3.9$ kg/cm^2			
	Section b~b			
	Body Weight			
	Ai x			
	$6.0 \times 0.3 \times 1/2 \times 2.4 = 2.16$ 2.0			
	$6.0 \times 1.5 \times 2.4 = 21.60$ 3.0			
	23.76 2.91			
	$Q = 1.0 \times 6.0 = 6.0$ tf/m			
	$M_{F2} = 1/2 \times 28.82 \times 6.0 \times 2.0 + 1/2 \times 29.69 \times 6.0 \times 4.0$			
	$- 23.76 \times 2.91 - 128.52 \times 3.0 - 6.0 \times 3.0$			
	$= 56.50$ tf.m			





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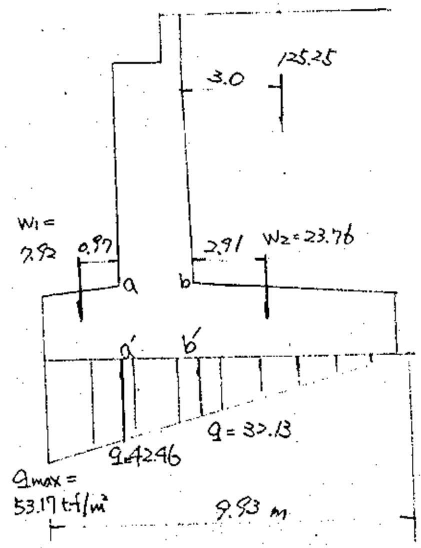
Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	In case of Gravel Bedding			
	$\phi_B = 0.6$			
	$Ha = 1/1.2 \times 1847.75 \times 0.6 = 923.88 > 676.20$ tf			
	(5) Calculation of Ground Reaction			
	i) Normal Case			
	$\left.\begin{matrix} q_{max} \\ q_{min} \end{matrix}\right\} = V/L \cdot B \pm 6H_B/L \cdot B^2$			
	$= 1988/7.0 \times 9.8 \pm 6 \times 1988 \times 0.09 / 7.0 \times 9.8^2$			
	$= 28.98 \pm 0.71$			
	$q_{max} = 29.69$ kg/cm²			
	$q_{min} = 28.27$ kg/cm²			
	ii) Seismic Case			
	$q_{max} = 2V/L \times 3(B/2 - e)$			
	$= 2 \times 1847.75 / 7.0 \times 3(9.8/2 - 1.59)$			
	$= 53.17$ tf/m²			
	$x = 3(9.8/2 - 1.59) = 9.93$ m			
	(6) Design of Member Section			
	i) Normal Case			
	Section a~a' — Body Weight			
	Ai — x			
	1) $2.0 \times 0.3 \times 1/2 \times 2.4 = 0.72$ — 0.67			
	2) $2.0 \times 1.5 \times 2.4 = 7.20$ — 1.00			
	7.92 — 0.97			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	$SF_2 = 1/2 \times (28.82 + 29.69) \times 6.0 - 23.76 - 128.52 - 6.0$			
	$= 16.35$ tf			
	Stress Calculation			
	$A_s = 28.65\ cm^2$ (D19 10cm pitch)			
	$M' = 56.50$ tf·m			
	$np = 0.025$ $d'/d = 0.059$ $A_s'/A_s = 0.5$ $f/d = \infty$			
	$C = 10.1$ $S = 43.0$ $Z = 1.068$			
	$M'/bd^2 = 56.50 \times 10^5 / 100 \times 170^2 = 1.96$			
	$\sigma_c = 1.96 \times 10.1 = 19.80 < 80\ kg/cm^2$			
	$\sigma_s = 1.96 \times 43 \times 15 = 1264.2 < 1800\ kg/cm^2$			
	$\tau_m = 16.35 \times 10^3 / 100 \times 170 \times 1.068 = 1.03 < 3.9\ kg/cm^2$			
	ii) Seismic Case			
	Section a~a'			
	$M_{E1} = 1/2 \times 53.17 \times 2.0 \times 1.33 + 1/2 \times 42.46 \times 2.0 \times 0.67$			
	$- 7.92 \times 0.97$			
	$= 91.48$ tf·m			
	$SF_1 = 1/2 \times (53.17 + 42.46) \times 2.0 - 7.92$			
	$= 87.71$ tf			
	Stress Calculation			
	$A_s = 28.65$ (D19 10cm)			
	$M' = 91.48$ tf·m			
	$np = 0.025$ $d'/d = 0.059$ $A_s'/A_s = 0.5$ $f/d = \infty$			

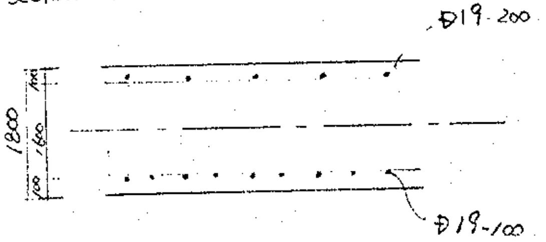


Working Division:

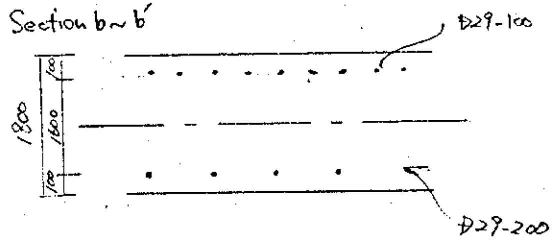
Description	Calculation Details	Unit	Quantity
	C=10.1 S=43.0 Z=1.068		
	$M'/bd^2 = 91.48 \times 10^5 / 100 \times 170^2 = 3.17$		
	$\sigma_c = 3.17 \times 10.1 = 32.02 < 120$ kg/cm²		
	$\sigma_s = 3.17 \times 43.0 \times 15 = 2044.7 < 2700$ kg/cm²		
	$\tau_m = 87.71 \times 10^3 / 100 \times 170 \times 1.068 = 5.51 < 5.85$ kg/cm²		
	Section b~b'		
	$M_{E2} = 128.52 \times 3.0 + 23.76 \times 2.91 - 1/2 \times 32.13 \times 6.13 \times \frac{6.13}{3}$		
	$= 253.48$		
	$S_{E2} = 128.52 + 23.76 - 1/2 \times 32.13 \times 6.13 = 53.80$ tf		
	Stress Calculation		
	$A = 6.424 \times 10 = 64.24$ cm² (D29 10cm)		
	$M' = 253.48$ tf.m		
	$np = 0.057$ $d'/d = 0.059$ $A's/As = 0.5$ $f/d = \infty$		
	C=6.95 S=19.15 Z=1.09		
	$M'/bd^2 = 253.48 \times 10^5 / 100 \times 170^2 = 8.77$		
	$\sigma_c = 8.77 \times 6.95 = 60.95 < 120$ kg/cm²		
	$\sigma_s = 8.77 \times 19.15 \times 15 = 2519.18 < 2700$ kg/cm²		
	$\tau_m = 53.80 \times 1000 / 100 \times 170 \times 1.09$		
	$= 3.45 < 5.85$ kg/cm²		

Remarks

Section a~a'



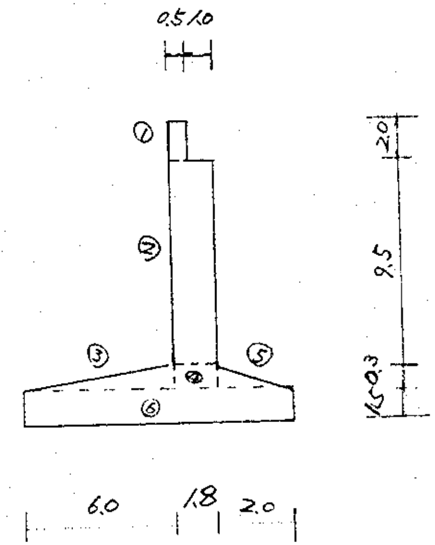
Section b~b'



Working Division: Meub Estero Cañales Left Side Membrillo outlet

Description	Calculation Details	Unit	Quantity	Remarks
	(1) Design Condition			
	Type : Inverted T-Shape Abutment			
	$h = 13.0$ m			
	$w = 7.0$ m			
	$\phi = 35°$			
	$C = 0$ tf/m²			
	$\theta = 0°$			
	$\delta = 35/3 = 11.7$			
	$\delta_E = 0$			
	Design Seismic Coefficient $K = 0.15$			
	Earth Pressure Design Seismic Coefficient $k = 0.15$			
	Bridge Seat			
	$S = 20 + 0.5 \times 23.0 = 31.50$			
	Soil Unit Weight $r = 1.8$ tf/m³			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
Estero Cañales Left	(2) Load Calcolation			
	(a) Reaction			
	Normal Case			
	Vertical Rd = 16.8 x 23.0 + 3.7 / 2			
	= 195.05 tf			
	Rl = 2.4 x 23.0 + 34.9 / 2			
	= 45.05 tf			
	Seismic Case			
	Vertical Rd = 195.05 tf			
	Horizontal H = 195.02 x 2.0m x 0.2			
	= 78.01 tf			
	(b) Body Weight			
	Ai (m²) Xi (m) Yi (m) Ai·Xi Ai·Yi			
	1 0.5 x 2.0 = 1.00 3.25 12.30 3.25 12.30			
	2 9.5x(1.5+1.8)/2 = 15.68 2.83 6.55 44.37 102.70			
	16.68 2.86 6.89 47.62 115.00			
	3 6.0 x 0.3 x ½ = 0.90 5.80 1.60 5.22 1.44			
	4 1.8 x 0.3 = 0.54 2.90 1.65 1.57 0.89			
	5 2.0 x 0.3 x ½ = 0.3 1.33 1.60 0.40 2.13			
	6 9.8 x 1.5 = 14.7 4.90 0.75 72.03 11.03			
	16.44 4.82 0.84 79.22 15.49			
	GRAND TOTAL 33.12 126.84 130.49			
	WALL WEIGHT W1 16.68 x 7.0 x 2.4 t/m = 280.22 tf			
	FOOTING WEIGHT W2 16.44 x 7.0 x 2.4 = 276.19 tf			
	SEISMIC WH1 280.22 x 0.15 = 42.03 tf·m			
	SEISMIC WH2 276.19 x 0.15 = 41.43 tf·m			

91
125

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
d) Section	c) Earth Pressure at Abutment			
	Coefficient of Earth Pressure			
	$K_A = \frac{\cos^2(\phi-\theta)}{\cos^2\theta \cdot \cos(\theta+\delta)} \times 1 / \left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\alpha)}{\cos(\theta+\delta)\cos(\theta-\alpha)}}\right]^2$			
$\phi = 35°$				
$\theta = 0°$	$= \frac{\cos^2(35-0)}{\cos^2 0 \cos(0+11.7)} \times \left[1+\sqrt{\frac{\sin 46.7 \sin 35.0}{\cos 11.7 \cos 0}}\right]^2$			
$\delta = \phi/3 = 11.7°$				
$\alpha = 0$				
$\delta_E = 0$	$= 0.671 / 0.979 \times 2.732$			
$\theta_0 = \tan^{-1}(0.15)$	$= 0.251$			
	$K_{EA} = \frac{\cos^2(\phi-\theta-\theta_0)}{\cos\theta_0 \cdot \cos^2\theta \cos(\theta+\theta_0+\delta_E)} \times \left[1+\sqrt{\frac{\sin(\phi+\delta_E)\sin(\phi-\alpha-\theta_0)}{\cos(\delta_E+\theta+\theta_E)\cos(\theta-\alpha)}}\right]^2$			
	$= \frac{\cos^2 26.47}{\cos 8.53 \times \cos^2 0 \times \cos 8.53} \times \left[1+\sqrt{\frac{\sin 35 \sin 26.47}{\cos 8.53 \cos 0}}\right]^2$			
	$= 0.801 / 0.989 \times 0.989 \times \left[1+\sqrt{\frac{0.574 \times 0.446}{0.989 \times 1}}\right]^2$			
	$= 0.801 / 2.227$			
	$= 0.360$			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	(3) Dimension of Member			
	(a) Allowable Stress			
	Concrete σ_{ck} = 240 kgf/cm			
	Normal Case σ_{ca} = 80 kgf/cm²			
	τ_{ca} = 3.9 kf/cm²			
	σ_{sa} = 1800 kgf/cm²			
	Seismic Case σ_{ca} = 120 kgf/cm²			
	τ_{ca} = 5.85 kgf/cm²			
	σ_{ca} = 2700 kgf/cm²			
	(b) Wall Design			
	Normal Case			
	Superstructure Reaction R_d = 195.05 tf			
	Body Weight W_1 = 280.22 tf			
	Soil Pressure P_{a1} = $1/2 \times K_A \times \gamma \times h^2 \cos\delta$			
	= $1/2 \times 0.251 \times 1.8 \times 11.5^2 \times \cos 11.7 \times 7.0$			
	= 204.75 tf			
	Soil Pressure for Load P_{a2} = $1/2\, K q h \cos\delta$			
	= $1/2 \times 0.251 \times 1.0 \times 11.5 \times \cos 11.7 \times 7.0$			
	= 9.87 tf			
	Seismic Case			
	R_d = 195.05 tf H = 58.52 tf			
	W_1 = 280.22 tf W_{H1} = 42.03 tf			
	P_{a1} = $1/2 \times 1.8 \times 0.360 \times 11.5^2 \times \cos 0 \times 7.0$			
	= 299.95 tf			

Working Division:

Description	Calculation Details	Unit	Quantity	Remarks
	Bending Moment			
	Normal Case			
	$M = \Sigma Pe$			
	$= 204.75 \times 3.83 + 9.87 \times 5.75$			
	$= 840.95$ tfm			
	$N = 195.05 + 280.22 = 475.27$ tf			
	$S = 204.75 + 9.87 = 214.62$ tf			
	Seismic Case			
	$M_E = 58.52 \times 9.5 + 42.03 \times 5.09 + 299.95 \times 3.83$			
	$= 1923.72$ tm			
	$N_E = 195.05 + 280.22 = 475.27$ tf			
	$S_E = 58.52 + 42.03 + 299.95$			
	$= 400.50$ tf			

Working Division:

Description	Calculation Details	Unit	Quantity
	Stress Calculation Normal Case		
$d' = 10cm$	$As = 700/10 \times 6.424 = 449.68\ cm^2$		
$d = 140\ cm$	$A's = 700/20 \times 6.424 = 224.84\ cm^2$		
$b = 700\ cm$	$M' = M + Nu = 840.95 + 475.27 \times 0.80 = 1221.17\ tf{\cdot}m$		
$M = 840.95\ t{\cdot}m$	$np = 15 \times 449.68 / 170 \times 700 = 0.057$		
$N = 475.27t$	$d'/d = 10/170 = 0.059$		
$u = 80\ cm$	$A's/As = 0.5$		
	$f = M/N + u = 840.95 \times 10^2 / 475.27 + 80 = 256.94$		
	$f/d = 256.94/170 = 1.51$		
	$C = 5.19$		
	$S = 8.11$		
	$Z = 1.055$		
	$M'/bd^2 = 1221.17 \times 10^5 / 700 \times 170^2 = 6.04\ kg/cm^2$		
	$\sigma_c = M'/bd^2 \times C = 6.04 \times 5.19 = 31.35 < 80\ kg/cm^2$		
	$\sigma_s = M'/bd^2 \times S\,n = 6.04 \times 8.11 \times 15 = 735 < 1800\ kg/cm^2$		
	$\tau = H/bd \times Z = 214.62 / 700 \times 170 \times 1.055 \times 10^3$		
	$= 1.90\ kg/cm^2$		

Remarks