Chapter 4

DESIGN SUMMARY OF CULVERT BOX

4.1		*CULVERT BOX*	*II-4- 2*
	(1)	*CULVERT BOX, TYPE B1*	*II-4- 2*
	(2)	*CULVERT BOX, TYPE B3*	*II-4- 9*
	(3)	*CULVERT BOX, TYPE B4*	*II-4- 16*
	(4)	*CULVERT BOX, TYPE B6*	*II-4- 23*
	(5)	*CULVERT BOX, TYPE B9*	*II-4- 30*
	(6)	*CULVERT BOX, TYPE B10*	*II-4- 37*
	(7)	*CULVERT BOX, TYPE B11*	*II-4- 44*
	(8)	*CULVERT BOX, TYPE B12*	*II-4- 51*
	(9)	*CULVERT BOX, TYPE B14*	*II-4- 58*
4.2		*WING WALL*	*II-4- 65*
	(1)	*WING WALL, TYPE W1*	*II-4- 65*
	(2)	*WING WALL, TYPE W2*	*II-4- 70*
	(3)	*WING WALL, TYPE W3*	*II-4- 75*

4.1 CULVERT BOX

(1) CULVERT BOX, TYPE B1

DESIGN CALCULATION OF CULVERTS

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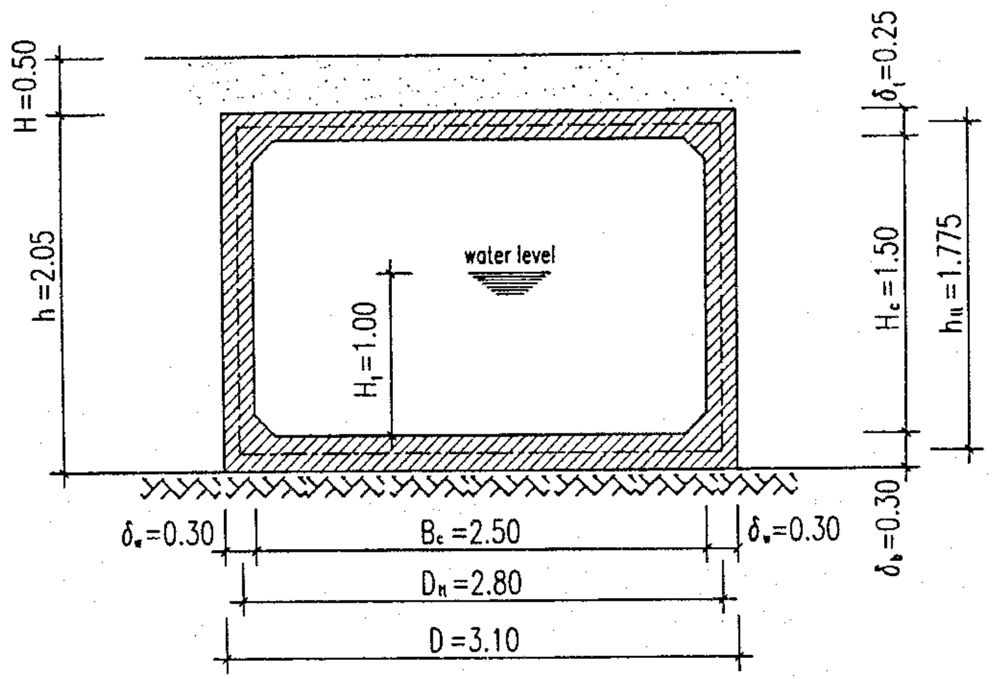
CULVERT TYPE B1

SINGLE BOX CULVERT DIMENSION 2.5x1.5 M.

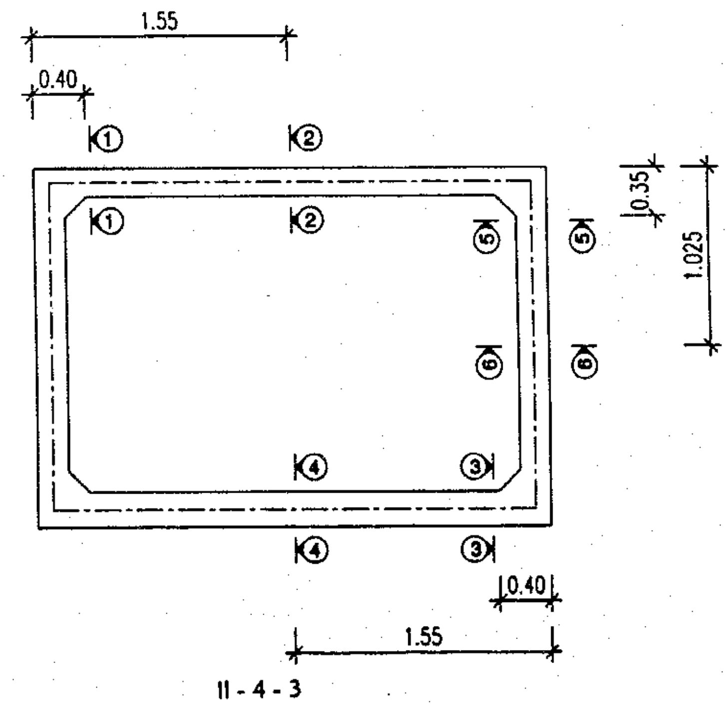
INTERCHANGE 2 – RAMP A – KM 0+300

SINGLE BOX CULVERT TYPE B1
(AT INTERCHANGE 2 - RAMP A - KM 0+300)

1.1 GENERAL VIEW



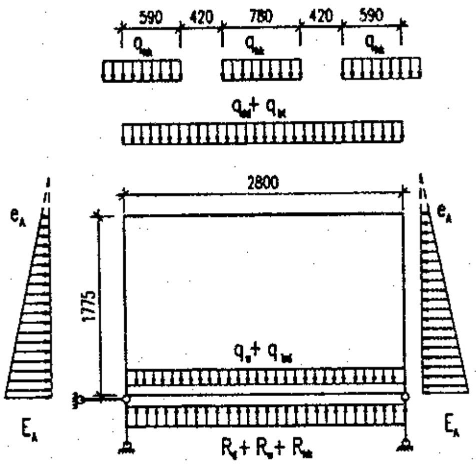
1.2 SECTION FOR CHECKING



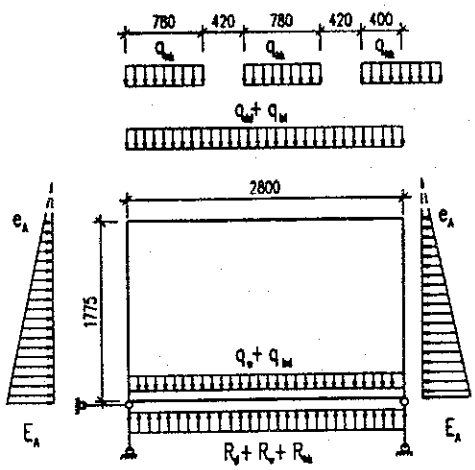
SINGLE BOX CULVERT TYPE B1
(AT INTERCHANGE 2 - RAMP A - KM 0+300)

1.3 CASE OF LOADNGS

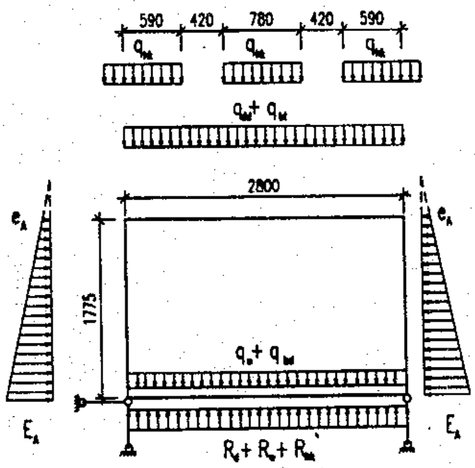
CASE 1 : STRENGTH I - 1



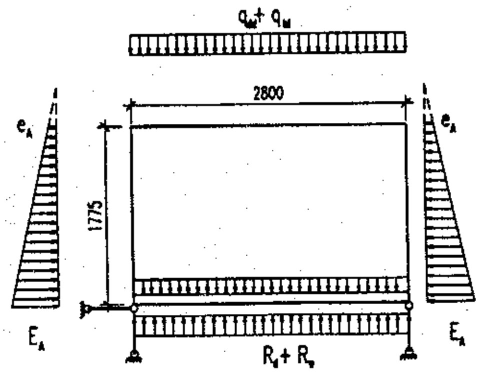
CASE 2 : STRENGTH I - 2



CASE 3 : SERVICE I



CASE 4 : STRENGTH IV



BOX CULVERT TYPE B1 (DIMENSION 2.5x1.5 M) At Interchange 2 - Ramp A - Km 0+300

1.4 Loading formulas

A	**DIMENSION OF BOX AND COEFFICIENTS**				
The typical of box culvert	single				
Thickness of filling layer above the top of box **H** (m)	0.50		Density of filling ground γ_H (T)		1.8
Inside width of box B_c (m)	2.50		Density of water γ_w (T/m^3)		1
Inside hight of box H_c (m)	1.50		Density of concrete γ_c (T/m^3)		2.5
Thickness of top slab δ_t (m)	0.25		Internal friction angle φ_H		30
Thickness of walls δ_w (m)	0.30		The coefficient of basement **S**		10
Thickness of bottom slab δ_b (m)	0.30		The angle of "HK80" axle load (with **H** < 1m) φ_t		30
Thickness of water level H_1 (m)	1.000		Half of single "HK80" axle load P_{hk} (T)		10
Outside width of the box **D** (m)	$D = B_c + 2 \times \delta_w$	=	2.5 + 2 x 0.30	=	3.10
Outside hight of the box **h** (m)	$h = H_c + \delta_t + \delta_b$	=	1.5 + 0.25 + 0.3	=	2.05
Calculating width of the box D_{tt} (m)	$D_{tt} = B_c + \delta_w$	=	2.5 + 0.3	=	2.80
Calculating hight of the box h_{tt} (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	1.5 + 0.25 / 2 + 0.3 / 2	=	1.775
The self weight of the box P_b (T)	$P_b = \gamma_c \times (H_c \times 2 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (1.5 x 2 x 0.3 + 3.1 x (0.25 + 0.3))	=	6.513
Horizontal pressure coefficient μ	$\mu = tg^2 (45^\circ - \varphi_H / 2)$	=	$tg^2 (45^\circ - 30^\circ)$	=	0.333
Coefficient **A**	$A = H / D$	=	0.5 / 3.1	=	0.161
Coefficient **C**	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.161 x 0.333 x tg 30°	=	1.031
a_1 (m)	$a_1 = 0.2 + 2 \times H \times tg\ \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
b_1 (m)	$b_1 = 0.8 + 2 \times H \times tg\ \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
Total width of "HK80" uniform load **W** (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38
Width of the third axle "HK80" uniform load W_2 (m)	$W_2 = D_{tt} - 2 \times 1.2$	=	2.8 - 2.4	=	0.40
B	**DEAD LOADS (without load factors)**				
The load of above filling layer q_{dd} (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.031 x 1.8 x 0.5	=	0.928
The max value of horizontal pressure E_A (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 2.05 - 0.3 / 2	=	1.365
The min value of horizontal pressure e_A (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.25 / 2)	=	0.375
The self weight uniform load of top slab q_{bt} (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.3	=	0.625
The self weight uniform load of bottom slab q_{bd} (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.30	=	0.750
Basement reaction of self weight loads R_{d1} (T/m)	$R_{d1} = P_b / D$	=	(6.513 / 3.1	=	2.101
Basement reaction of ground loads R_{d2} (T/m)	$R_{d2} = q_{dd}$	=	0.928	=	0.928
Basement reaction of dead loads R_d (T/m)	$R_d = R_{d1} + R_{d2}$	=	2.101 + 0.928	=	3.029
C	**WATER LOADS (without load factors)**				
The self weight uniform load of water q_w (T/m)	$q_w = H_1 \times \gamma_w$	=	1 x 1	=	1.000
Basement reaction of water load R_w (T/m)	$R_w = (q_w \times B_c) / D$	=	1 x 2.5 / 3.1	=	0.806
D	**LIVE LOADS (without load factors)**				
The uniform load of "HK80" axle q_{hk} (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
Basement reaction of "HK80" load R_{hk} (T/m)	$R_{hk} = q_{hk} \times (2xa_1 + W_2) / D$	=	9.34 x (2 x 0.78 + 0.4) / 3.10	=	5.889

1.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	load value	load factor	load value	load factor	load value
	DEAD LOADS						
1	The load of outside filling layer $\mathbf{q_{dd}}$ (T/m)	1.0	**0.928**	1.25	**1.160**	1.25	**1.160**
2	The max value of horizontal pressure $\mathbf{E_A}$ (T/m)	1.0	**1.365**	1.25	**1.706**	1.25	**1.706**
3	The min value of horizontal pressure $\mathbf{e_A}$ (T/m)	1.0	**0.375**	1.25	**0.469**	1.25	**0.469**
4	The self weight uniform load of top slab $\mathbf{q_{bt}}$ (T/m)	1.0	**0.625**	1.25	**0.781**	1.50	**0.938**
5	The self weight uniform load of bottom slab $\mathbf{q_{bd}}$ (T/m)	1.0	**0.750**	1.25	**0.938**	1.50	**1.125**
6	Basement reaction of self weight loads $\mathbf{R_{d1}}$ (T/m)	1.0	2.101	1.25	2.626	1.50	3.151
7	Basement reaction of ground loads $\mathbf{R_{d2}}$ (T/m)	1.0	0.928	1.25	1.160	1.25	1.160
8	Basement reaction of dead loads $\mathbf{R_d}$ (T/m)		**3.029**		**3.786**		**4.311**
	WATER LOADS						
9	The self weight uniform load of water $\mathbf{q_w}$ (T/m)	1.0	**1.000**	1	**1.000**	1.25	**1.250**
10	Basement reaction of water load $\mathbf{R_w}$ (T/m)	1.0	**0.806**	1	**0.806**	1.25	**1.008**
	LIVE LOADS						
11	The uniform load of "HK80" axle $\mathbf{q_{hk}}$ (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
12	Basement reaction of "HK80" load $\mathbf{R_{hk}}$ (T/m)	1.0	**5.889**	1.75	**10.306**	0	**0**

1.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6
	Case of loading		case 2	case 2	case 2	case 2	case 2	case 2
H	Depth of slab	(mm)	250	250	300	300	300	300
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	1608	1608	1608	1608	1608	1608
A's	Area of Compression Reinforcement	(mm2)	1608	905	1608	905	1608	1608
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24
β1	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	125.0	125.0	150.0	150.0	150.0	150.0
a	Depth of the Equivalent Stress Block	(mm)	109.8	109.8	131.8	131.8	131.8	131.8
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	200	200	250	250	250	250
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	10	9	13	12	13	13
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	9	9	12	11	12	12
	Factored Bending Moment Max.	(Tfm)	6.185	6.383	5.246	7.523	6.185	5.314
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK

1.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5
Case of loading		case 2	case 2	case 2
Section	Effective web bv (mm)	1000	1000	1000
Properties	Depth (mm)	250	300	300
	Effective depth dv (mm)	180	216	216
Factored Bending Moment Max Mu (Tfm)		6.185	5.246	6.185
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00
Factored Axial Force Nu (Tf)		1.31	0.62	19.72
Factored Shear Force Vu (Tf)		19.72	18.19	1.31
Design Shear Force Vu-f*Vp(Tf)		19.72	18.19	1.31
Shear Stress v (Mpa)		1.194	0.918	0.066
Concrete Strength f'c (Mpa)		24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000
Ratio of v/f'c		5E-02	4E-02	3E-03
As (mm2)		3217	3217	3217
Ac (m2)		0.400	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00
Angle θ		37.9	38.2	37.9
Cot(θ)		1.284	1.272	1.282
εx (Max)		7.27E-04	5.51E-04	6.00E-04
εx (Min)		2.03E-04	1.81E-04	1.63E-04
Value of θ		32.6	29.8	30.6
		28	28	27
Value of β		2.3830	2.4812	2.4542
		3.6783	3.7656	3.8375
Component of Shear Resistance Vc (Tf)		18	22	22
Spacing of Stirrups s (mm)		250	250	250
Stirrup Diameter (mm)		12	12	12
Area of Stirrups Av (mm2)		452	452	452
Angle of Inclination α		90	90	90
Component of Shear Resistance Vs (Tf)		20	27	26
Nominal Shear Resistance				
Vn1 = Vc + Vs + Vp (Tf)		38	49	48
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		110	132	132
Check (Min. Vn1,2 > Vu)		OK	OK	OK

DESIGN CALCULATION OF CULVERTS

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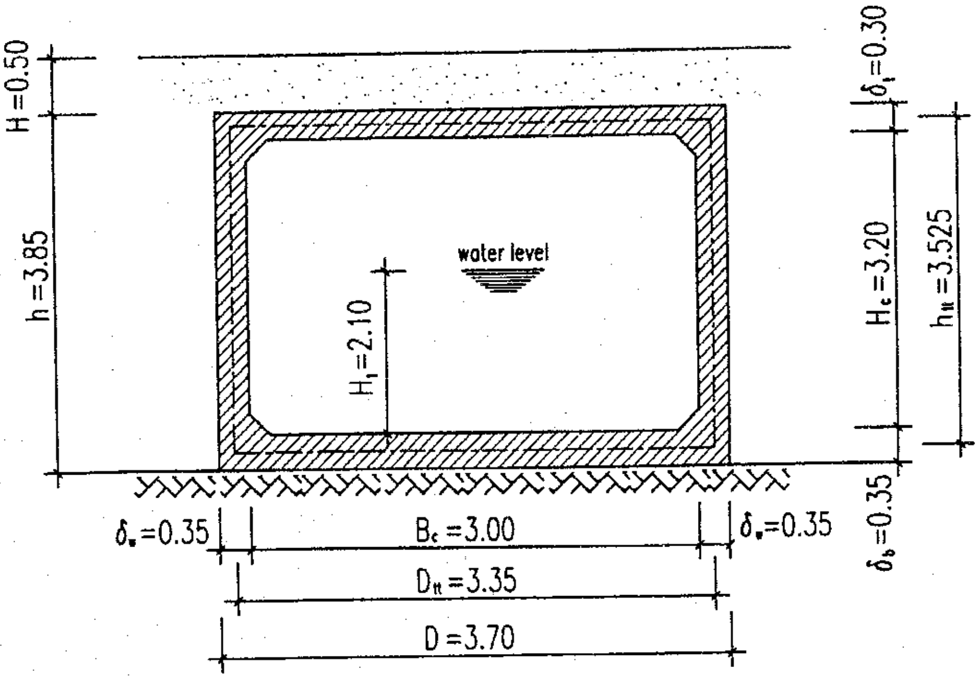
CULVERT TYPE B3

SINGLE BOX CULVERT DIMENSION 3.0x3.2 M.

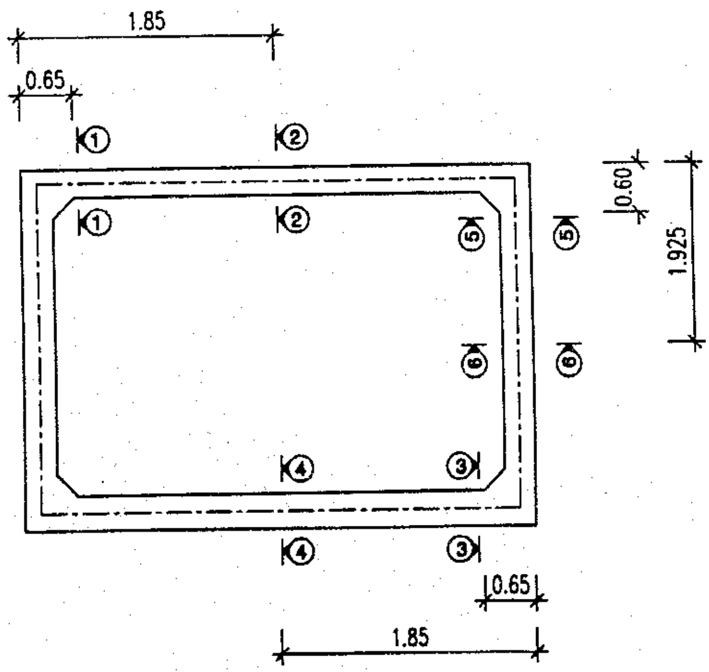
STATION KM 0+183.7

SINGLE BOX CULVERT TYPE B3
(AT STATION 0+183.7)

3.1 GENERAL VIEW



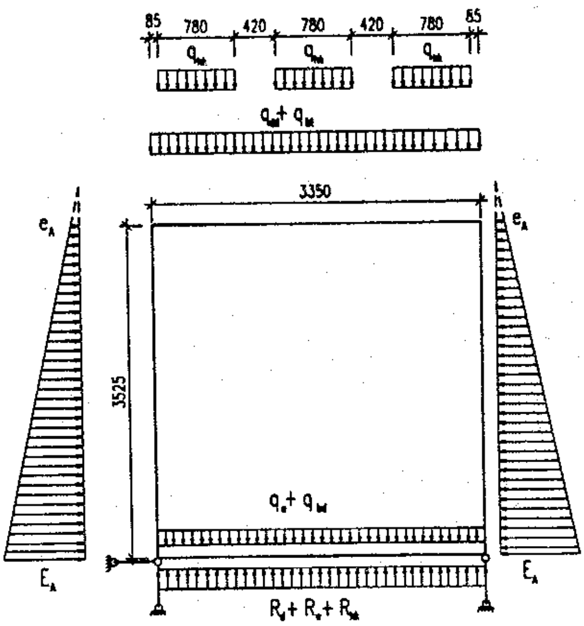
3.2 SECTION FOR CHECKING



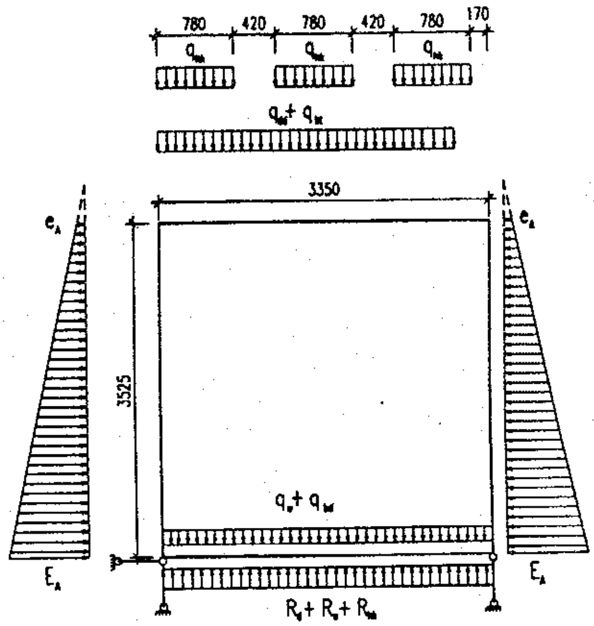
SINGLE BOX CULVERT TYPE B3
(AT STATION 0+183.7)

3.3 CASES OF LOADINGS

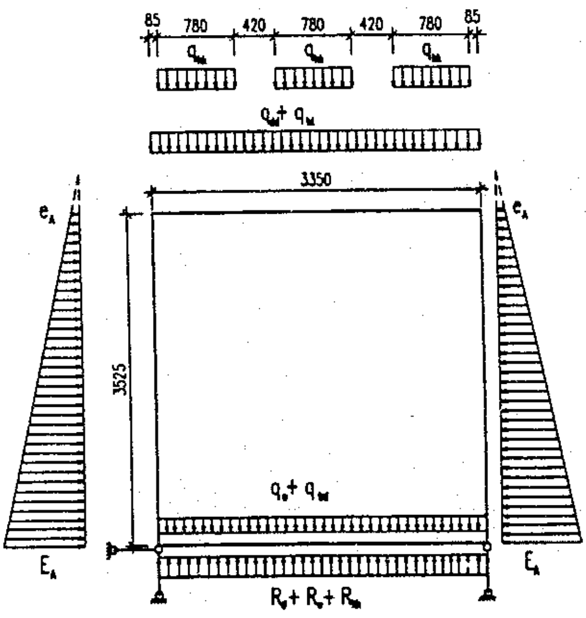
CASE 1 : STRENGTH I - 1



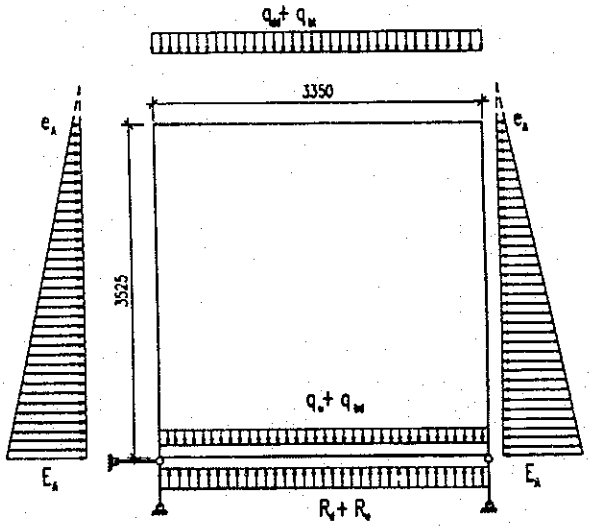
CASE 2 : STRENGTH I - 2



CASE 3 : SERVICE I



CASE 4 : STRENG IV



BOX CULVERT TYPE B3 (DIMENSION 3.0x3.2 M) At station Km 0+183.7

3.4 Loading formulas

A	**DIMENSION OF BOX AND COEFFICIENTS**					
	The typical of box culvert	single				
	Thickness of filling layer above the top of box **H** (m)	0.50		Density of filling ground γ_H (T)		1.8
	Inside width of box B_c (m)	3.00		Density of water γ_w (T/m^3)		1
	Inside hight of box H_c (m)	3.20		Density of concrete γ_c (T/m^3)		2.5
	Thickness of top slab δ_t (m)	0.30		Internal friction angle φ_H		30
	Thickness of walls δ_w (m)	0.35		The coefficient of basement **S**		10
	Thickness of bottom slab δ_b (m)	0.35		The angle of "HK80" axle load (with H < 1m) φ_t		30
	Thickness of water level H_1 (m)	2.100		Half of single "HK80" axle load P_{hk} (T)		10
	Outside width of the box **D** (m)	$D = B_c + 2 \times \delta_w$	=	3 + 2 x 0.35	=	3.70
	Outside hight of the box **h** (m)	$h = H_c + \delta_t + \delta_b$	=	3.2 + 0.3 + 0.35	=	3.85
	Calculating width of the box D_{tt} (m)	$D_{tt} = B_c + \delta_w$	=	3 + 0.35	=	3.35
	Calculating hight of the box h_{tt} (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	3.2 + 0.3 / 2 + 0.35 / 2	=	3.525
	The self weight of the box P_b (T)	$P_b = \gamma_c \times (H_c \times 2 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (3.2 x 2 x 0.35 + 3.7 x (0.3 + 0.35))	=	11.613
	Horizontal pressure coefficient μ	$\mu = tg^2 (45° - \varphi_H / 2)$	=	tg^2 (45° - 30°)	=	0.333
	Coefficient **A**	$A = H / D$	=	0.5 / 3.7	=	0.135
	Coefficient **C**	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.135 x 0.333 x tg 30°	=	1.026
	a_1 (m)	$a_1 = 0.2 + 2 \times H \times tg\, \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
	b_1 (m)	$b_1 = 0.8 + 2 \times H \times tg\, \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
	Total width of "HK80" uniform load **W** (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38
B	**DEAD LOADS (without load factors)**					
	The load of above filling layer q_{dd} (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.026 x 1.8 x 0.5	=	0.923
	The max value of horizontal pressure E_A (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 3.85 - 0.35 / 2	=	2.415
	The min value of horizontal pressure e_A (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.3 / 2)	=	0.390
	The self weight uniform load of top slab q_{bt} (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.3	=	0.750
	The self weight uniform load of bottom slab q_{bd} (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.35	=	0.875
	Basement reaction of self weight loads R_{d1} (T/m)	$R_{d1} = P_b / D$	=	(11.613 / 3.7	=	3.139
	Basement reaction of ground loads R_{d2} (T/m)	$R_{d2} = q_{dd}$	=	0.923	=	0.923
	Basement reaction of dead loads R_d (T/m)	$R_d = R_{d1} + R_{d2}$	=	3.139 + 0.923	=	4.062
C	**WATER LOADS (without load factors)**					
	The self weight uniform load of water q_w (T/m)	$q_w = H_1 \times \gamma_w$	=	2.1 x 1	=	2.100
	Basement reaction of water load R_w (T/m)	$R_w = (q_w \times B_c) / D$	=	2.1 x 3 / 3.7	=	1.703
D	**LIVE LOADS (without load factors)**					
	The uniform load of "HK80" axle q_{hk} (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
	Basement reaction of "HK80" load R_{hk} (T/m)	$R_{hk} = 3 \times q_{hk} \times a_1 / D$	=	3 x 9.34 x 0.78 / 3.7	=	5.887

3.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	forcers	load factor	forcers	load factor	forcers
	DEAD LOADS						
1	The load of outside filling layer $\mathbf{q_{dd}}$ (T/m)	1.0	**0.923**	1.25	**1.154**	1.25	**1.154**
2	The max value of horizontal pressure $\mathbf{E_A}$ (T/m)	1.0	**2.415**	1.25	**3.019**	1.25	**3.019**
3	The min value of horizontal pressure $\mathbf{e_A}$ (T/m)	1.0	**0.390**	1.25	**0.488**	1.25	**0.488**
4	The self weight uniform load of top slab $\mathbf{q_{bt}}$ (T/m)	1.0	**0.750**	1.25	**0.938**	1.50	**1.125**
5	The self weight uniform load of bottom slab $\mathbf{q_{bd}}$ (T/m)	1.0	**0.875**	1.25	**1.094**	1.50	**1.313**
6	Basement reaction of self weight loads $\mathbf{R_{d1}}$ (T/m)	1.0	3.139	1.25	3.923	1.50	4.708
7	Basement reaction of ground loads $\mathbf{R_{d2}}$ (T/m)	1.0	0.923	1.25	1.154	1.25	1.154
8	Basement reaction of dead loads $\mathbf{R_d}$ (T/m)		**4.062**		**5.077**		**5.862**
	WATER LOADS						
9	The self weight uniform load of water $\mathbf{q_w}$ (T/m)	1.0	**2.100**	1	**2.100**	1.25	**2.625**
10	Basement reaction of water load $\mathbf{R_w}$ (T/m)	1.0	**1.703**	1	**1.703**	1.25	**2.128**
	LIVE LOADS						
11	The uniform load of "HK80" axle $\mathbf{q_{hk}}$ (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
12	Basement reaction of "HK80" load $\mathbf{R_{hk}}$ (T/m)	1.0	**5.887**	1.75	**10.302**	0	**0**

3.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6
	Case of loading		case 1	case 1	case 1	case 2	case 1	case 1
H	Depth of slab	(mm)	300	300	350	350	350	350
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	2061	2061	2061	2061	1608	1608
A's	Area of Compression Reinforcement	(mm2)	1608	905	1608	905	1608	1608
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24
β1	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	150.0	150.0	175.0	175.0	175.0	175.0
a	Depth of the Equivalent Stress Block	(mm)	131.8	131.8	153.8	153.8	153.8	153.8
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	250	250	300	300	300	300
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	16	16	20	19	16	16
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	14	14	18	17	14	14
	Factored Bending Moment Max.	(Tfm)	8.168	10.258	7.149	12.357	8.168	4.985
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK

3.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5
Case of loading		case 1	case 1	case 1
Section	Effective web bv (mm)	1000	1000	1000
Properties	Depth (mm)	300	350	350
	Effective depth dv (mm)	216	252	252
Factored Bending Moment Max Mu (Tfm)		8.168	7.149	8.168
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00
Factored Axial Force Nu (Tf)		2.64	3.55	22.63
Factored Shear Force Vu (Tf)		22.63	23.27	2.64
Design Shear Force Vu-f*Vp(Tf)		22.63	23.27	2.64
Shear Stress v (Mpa)		1.142	1.007	0.114
Concrete Strength f'c (Mpa)		24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000
Ratio of v/f'c		5E-02	4E-02	5E-03
As (mm2)		3669	3669	3217
Ac (m2)		0.400	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00
Angle θ		33.1	31.5	32.2
Cot(θ)		1.534	1.630	1.590
εx (Max)		7.55E-04	6.56E-04	6.99E-04
εx (Min)		2.50E-04	2.77E-04	2.05E-04
Value of θ		33.1	31.5	32.2
		28	29	28
Value of β		2.3671	2.4224	2.3987
		3.4911	3.3835	3.6719
Component of Shear Resistance Vc (Tf)		21	25	25
Spacing of Stirrups s (mm)		250	250	250
Stirrup Diameter (mm)		12	0	0
Area of Stirrups Av (mm2)		452	0	0
Angle of Inclination α		90	90	90
Component of Shear Resistance Vs (Tf)		24	0	0
Nominal Shear Resistance				
Vn1 = Vc + Vs + Vp (Tf)		45	25	25
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		132	154	154
Check (Min. Vn1,2 > Vu)		OK	OK	OK

DESIGN CALCULATION OF CULVERTS

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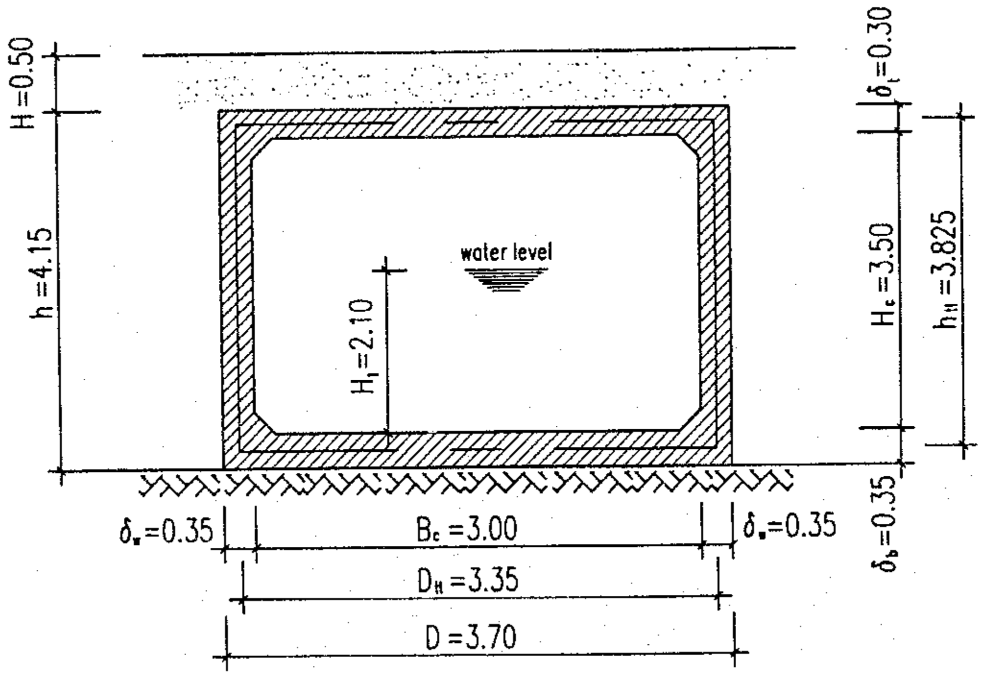
CULVERT TYPE B4

SINGLE BOX CULVERT DIMENSION 3.0x3.5 M.

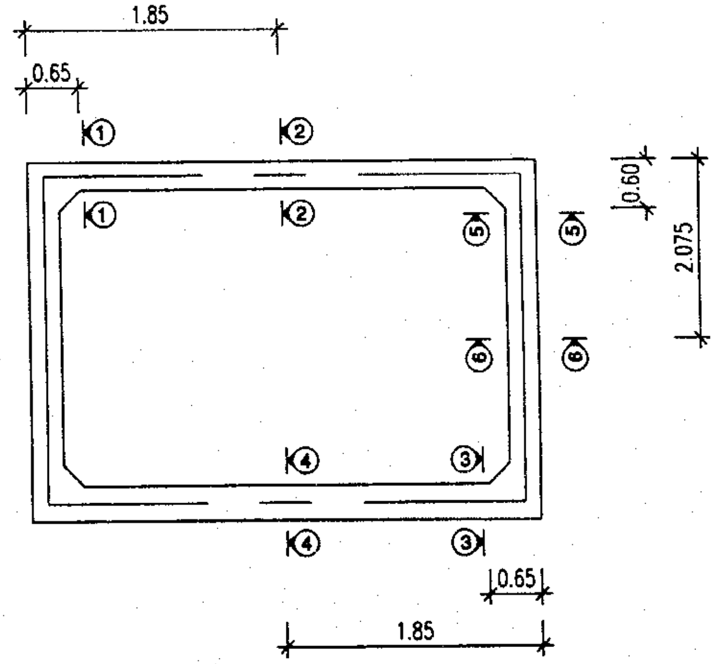
STATION KM 1+560

SINGLE BOX CULVERT TYPE B4
(AT SATION 1+560)

4.1 GENERAL VIEW



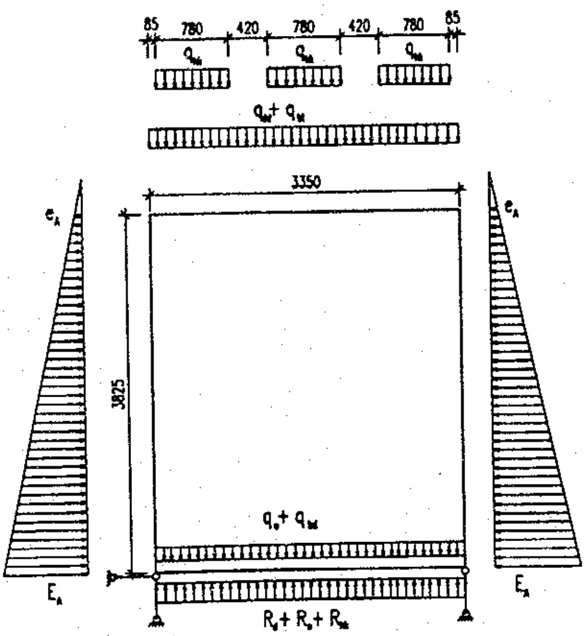
4.2 SECTION FOR CHECKING



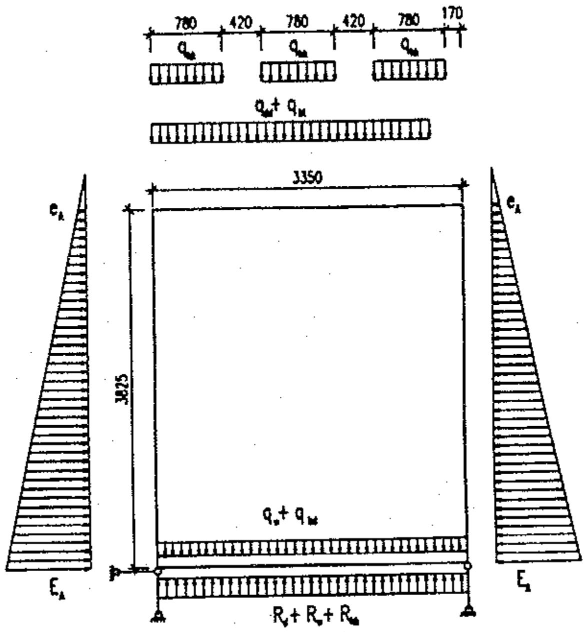
SINGLE BOX CULVERT TYPE B4
(AT SATION 1+560)

4.3 CASES OF LOADINGS

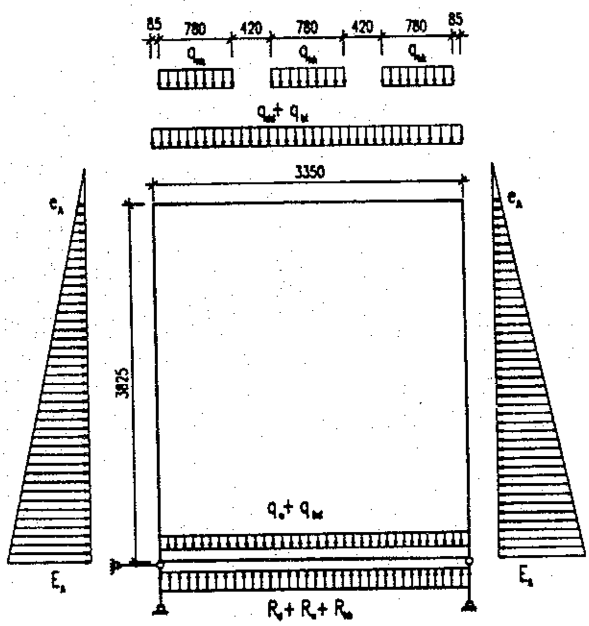
CASE 1 : STRENGTH I - 1



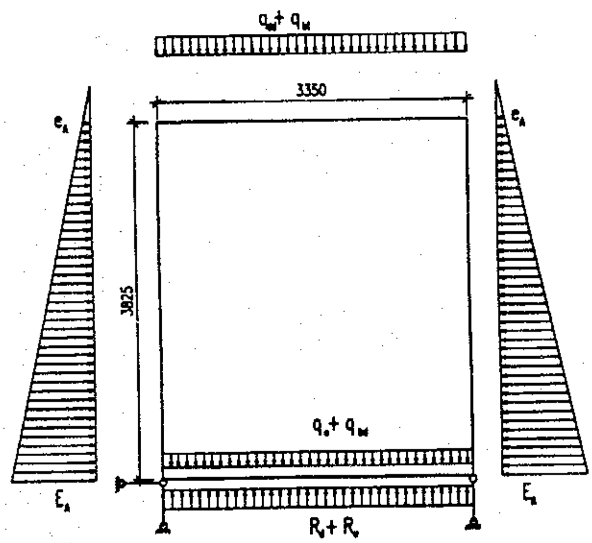
CASE 2 : STRENGTH I - 2



CASE 3 : SERVICE I



CASE 4 : STRENG IV



4.4 Loading formulas

A	**DIMENSION OF BOX AND COEFFICIENTS**					
	The typical of box culvert	single				
	Thickness of filling layer above the top of box **H** (m)	0.50		Density of filling ground γ_H (T)		1.8
	Inside width of box $\mathbf{B_c}$ (m)	3.00		Density of water γ_w (T/m^3)		1
	Inside hight of box $\mathbf{H_c}$ (m)	3.50		Density of concrete γ_c (T/m^3)		2.5
	Thickness of top slab δ_t (m)	0.30		Internal friction angle φ_H		30
	Thickness of walls δ_w (m)	0.35		The coefficient of basement **S**		10
	Thickness of bottom slab δ_b (m)	0.35		The angle of "HK80" axle load (with **H** < 1m) φ_t		30
	Thickness of water level $\mathbf{H_1}$ (m)	2.100		Half of single "HK80" axle load $\mathbf{P_{hk}}$ (T)		10
	Outside width of the box **D** (m)	$D = B_c + 2 \times \delta_w$	=	3 + 2 x 0.35	=	3.70
	Outside hight of the box **h** (m)	$h = H_c + \delta_t + \delta_b$	=	3.5 + 0.3 + 0.35	=	4.15
	Calculating width of the box $\mathbf{D_{tt}}$ (m)	$D_{tt} = B_c + \delta_w$	=	3 + 0.35	=	3.35
	Calculating hight of the box $\mathbf{h_{tt}}$ (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	3.5 + 0.3 / 2 + 0.35 / 2	=	3.825
	The self weight of the box $\mathbf{P_b}$ (T)	$P_b = \gamma_c \times (H_c \times 2 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (3.5 x 2 x 0.35 + 3.7 x (0.3 + 0.35))	=	12.138
	Horizontal pressure coefficient μ	$\mu = tg^2 (45^\circ - \varphi_H / 2)$	=	tg^2 (45° - 30°)	=	0.333
	Coefficient **A**	$A = H / D$	=	0.5 / 3.7	=	0.135
	Coefficient **C**	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.135 x 0.333 x tg 30°	=	1.026
	$\mathbf{a_1}$ (m)	$a_1 = 0.2 + 2 \times H \times tg\, \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
	$\mathbf{b_1}$ (m)	$b_1 = 0.8 + 2 \times H \times tg\, \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
	Total width of "HK80" uniform load **W** (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38
B	**DEAD LOADS (without load factors)**					
	The load of above filling layer q_{dd} (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.026 x 1.8 x 0.5	=	0.923
	The max value of horizontal pressure E_A (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 4.15 - 0.35 / 2	=	2.595
	The min value of horizontal pressure $\mathbf{e_A}$ (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.3 / 2)	=	0.390
	The self weight uniform load of top slab $\mathbf{q_{bt}}$ (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.3	=	0.750
	The self weight uniform load of bottom slab $\mathbf{q_{bd}}$ (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.35	=	0.875
	Basement reaction of self weight loads $\mathbf{R_{d1}}$ (T/m)	$R_{d1} = P_b / D$	=	(12.138 / 3.7	=	3.280
	Basement reaction of ground loads $\mathbf{R_{d2}}$ (T/m)	$R_{d2} = q_{dd}$	=	0.923	=	0.923
	Basement reaction of dead loads $\mathbf{R_d}$ (T/m)	$R_d = R_{d1} + R_{d2}$	=	3.28 + 0.923	=	4.204
C	**WATER LOADS (without load factors)**					
	The self weight uniform load of water $\mathbf{q_w}$ (T/m)	$q_w = H_1 \times \gamma_w$	=	2.1 x 1	=	2.100
	Basement reaction of water load $\mathbf{R_w}$ (T/m)	$R_w = (q_w \times B_c) / D$	=	2.1 x 3 / 3.7	=	1.703
D	**LIVE LOADS (without load factors)**					
	The uniform load of "HK80" axle $\mathbf{q_{hk}}$ (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
	Basement reaction of "HK80" load $\mathbf{R_{hk}}$ (T/m)	$R_{hk} = 3 \times q_{hk} \times a_1 / D$	=	3 x 9.34 x 0.78 / 3.7	=	5.887

4.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	forcers	load factor	forcers	load factor	forcers
	DEAD LOADS						
1	The load of outside filling layer q_{dd} (T/m)	1.0	**0.923**	1.25	**1.154**	1.25	**1.154**
2	The max value of horizontal pressure E_A (T/m)	1.0	**2.595**	1.25	**3.244**	1.25	**3.244**
3	The min value of horizontal pressure e_A (T/m)	1.0	**0.390**	1.25	**0.488**	1.25	**0.488**
4	The self weight uniform load of top slab q_{bt} (T/m)	1.0	**0.750**	1.25	**0.938**	1.50	**1.125**
5	The self weight uniform load of bottom slab q_{bd} (T/m)	1.0	**0.875**	1.25	**1.094**	1.50	**1.313**
6	Basement reaction of self weight loads R_{d1} (T/m)	1.0	3.280	1.25	4.101	1.50	4.921
7	Basement reaction of ground loads R_{d2} (T/m)	1.0	0.923	1.25	1.154	1.25	1.154
8	Basement reaction of dead loads R_d (T/m)		**4.204**		**5.255**		**6.075**
	WATER LOADS						
9	The self weight uniform load of water q_w (T/m)	1.0	**2.100**	1	**2.100**	1.25	**2.625**
10	Basement reaction of water load R_w (T/m)	1.0	**1.703**	1	**1.703**	1.25	**2.128**
	LIVE LOADS						
11	The uniform load of "HK80" axle q_{hk} (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
12	Basement reaction of "HK80" load R_{hk} (T/m)	1.0	**5.887**	1.75	**10.302**	0	**0**

4.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6
	Case of loading		case 1	case 1	case2	case 1	case 1	case 1
H	Depth of slab	(mm)	300	300	350	350	350	350
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	2827	2262	2375	2262	1810	1810
A's	Area of Compression Reinforcement	(mm2)	1608	905	1608	905	1608	1608
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24
β1	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	150.0	150.0	175.0	175.0	175.0	175.0
a	Depth of the Equivalent Stress Block	(mm)	131.8	131.8	153.8	153.8	153.8	153.8
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	250	250	300	300	300	300
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	22	17	23	21	18	18
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	20	15	21	19	16	16
	Factored Bending Moment Max.	(Tfm)	8.060	10.404	7.962	13.516	8.060	4.561
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK

4.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5
Case of loading		case 1	case2	case 1
Section	Effective web bv (mm)	1000	1000	1000
Properties	Depth (mm)	300	350	350
	Effective depth dv (mm)	216	252	252
Factored Bending Moment Max Mu (Tfm)		8.060	7.962	8.060
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00
Factored Axial Force Nu (Tf)		2.72	4.43	22.65
Factored Shear Force Vu (Tf)		22.65	26.36	2.72
Design Shear Force Vu-f*Vp(Tf)		22.65	26.36	2.72
Shear Stress v (Mpa)		1.143	1.140	0.118
Concrete Strength f'c (Mpa)		24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000
Ratio of v/f'c		5E-02	5E-02	5E-03
As (mm2)		4436	3984	3418
Ac (m2)		0.400	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00
Angle θ		36.5	36.1	34.6
Cot(θ)		1.351	1.373	1.448
εx (Max)		5.97E-04	6.39E-04	6.50E-04
εx (Min)		1.84E-04	2.50E-04	1.91E-04
Value of θ		30.5	31.2	31.4
		28	29	28
Value of β		2.4558	2.4321	2.4261
		3.7533	3.4894	3.7269
Component of Shear Resistance Vc (Tf)		22	25	25
Spacing of Stirrups s (mm)		250	250	250
Stirrup Diameter (mm)		12	12	0
Area of Stirrups Av (mm2)		452	452	0
Angle of Inclination α		90	90	90
Component of Shear Resistance Vs (Tf)		26	30	0
Nominal Shear Resistance				
Vn1 = Vc + Vs + Vp (Tf)		48	55	25
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		132	154	154
Check (Min. Vn1,2 > Vu)		OK	OK	OK

DESIGN CALCULATION OF CULVERTS

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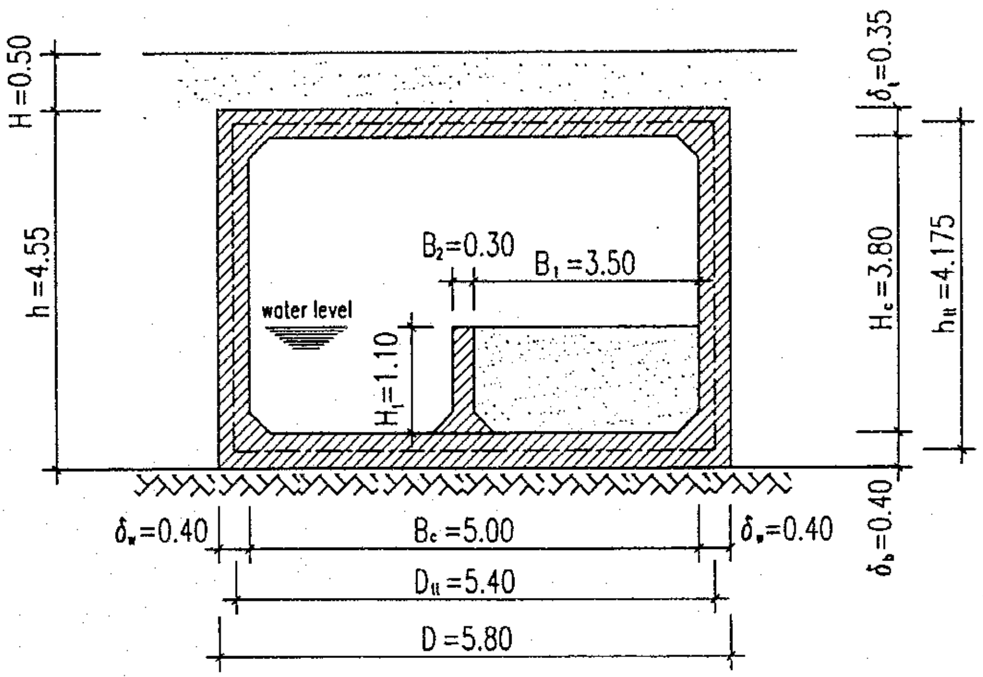
CULVERT TYPE B6

SINGLE BOX CULVERT DIMENSION 5.0x3.8 M.

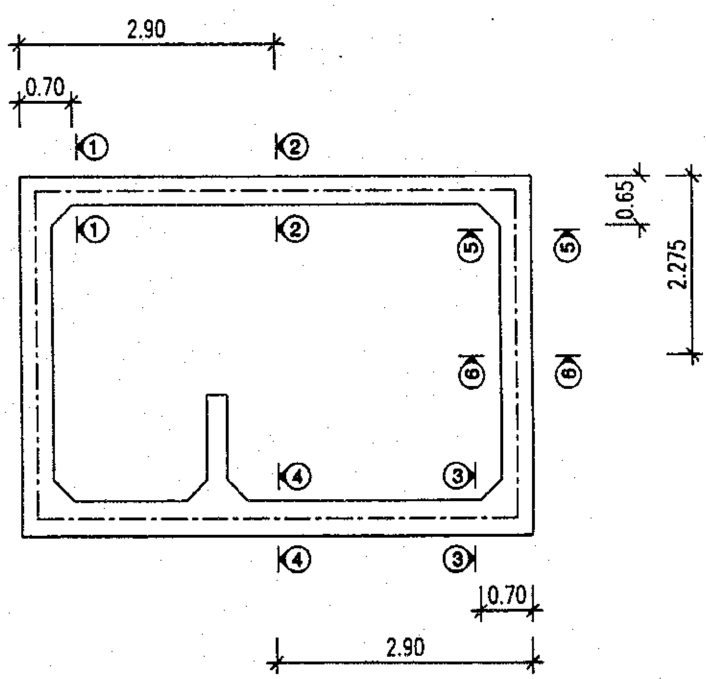
STATION KM 2+620

SINGLE BOX CULVERT TYPE B6
(AT STATION 2+620)

6.1 GENERAL VIEW



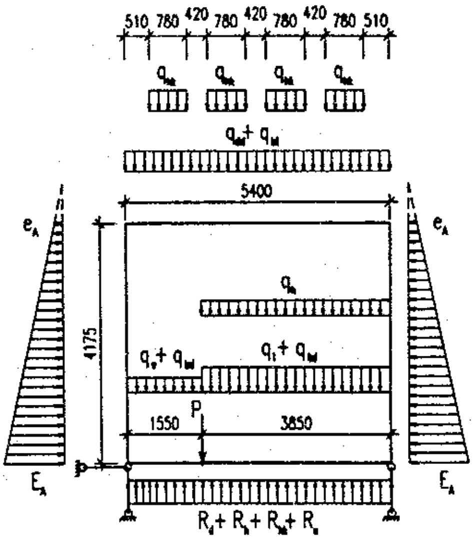
6.2 SECTION FOR CHECKING



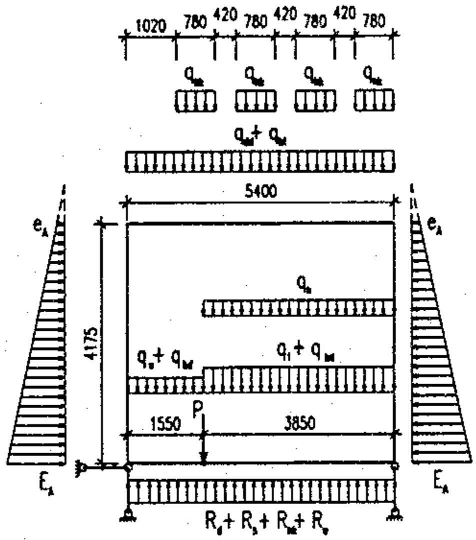
SINGLE BOX CULVERT TYPE B6
(AT STATION 2+620)

6.3 CASES OF LOADINGS

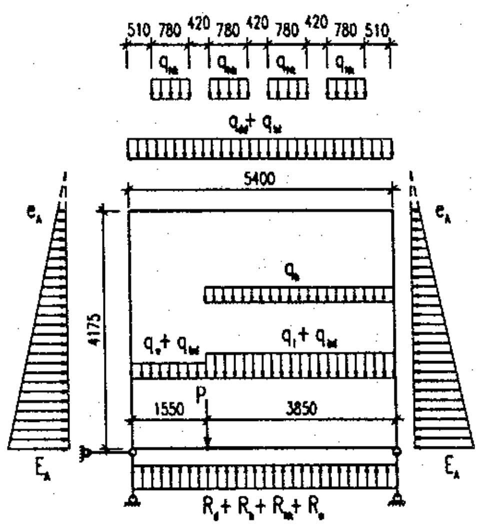
CASE 1 : STRENG I - 1



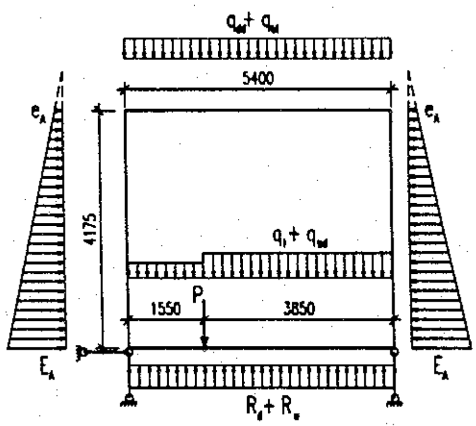
CASE 2 : STRENGTH I - 2



CASE 3 : SERVICE I



CASE 4 : STRENG IV



BOX CULVERT TYPE B6 (DIMENSION 5.0x3.8 M) At station Km 2+620

6.4 Loading formulas

A. DIMENSION OF BOX AND COEFFICIENTS

The typical of box culvert	single		
Thickness of filling layer above the top of box H (m)	0.50	Density of filling ground γ_H (T)	1.8
Inside width of box B_c (m)	5.00	Density of water γ_w (T/m^3)	1
Inside hight of box H_c (m)	3.80	Density of concrete γ_c (T/m^3)	2.5
Thickness of top slab δ_t (m)	0.35	Internal friction angle φ_H	30
Thickness of walls δ_w (m)	0.40	The coefficient of basement S	10
Thickness of bottom slab δ_b (m)	0.40	The angle of "HK80" axle load (with H < 1m) φ_t	30
Thickness of filling layer inside the box H_1 (m)	1.100	Half of single "HK80" axle load P_{hk} (T)	10
Width of filling layer inside the box B_1 (m)	3.50	Width of retaining wall inside the box B_2 (m)	0.30

Outside width of the box D (m)	$D = B_c + 2 \times \delta_w$	=	5 + 2 x 0.40	=	5.80
Outside hight of the box h (m)	$h = H_c + \delta_t + \delta_b$	=	3.8 + 0.35 + 0.4	=	4.55
Calculating width of the box D_tt (m)	$D_{tt} = B_c + \delta_w$	=	5 + 0.4	=	5.40
Calculating hight of the box h_{tt} (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	3.8 + 0.35/2 + 0.4 / 2	=	4.175
The self weight of the box P_b (T)	$P_b = \gamma_c \times (H_c \times 2 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (3.8 x 2 x 0.4 + 5.8 x (0.35 + 0.4))	=	18.475
Horizontal pressure coefficient μ	$\mu = tg^2 (45° - \varphi_H / 2)$	=	tg^2 (45° - 30°)	=	0.333
Coefficient A	$A = H / D$	=	0.5 / 5.8	=	0.086
Coefficient C	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.086 x 0.333 x tg 30°	=	1.017
a_1 (m)	$a_1 = 0.2 + 2 \times H \times tg\ \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
b_1 (m)	$b_1 = 0.8 + 2 \times H \times tg\ \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
Total width of "HK80" uniform load W (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38

B. DEAD LOADS (without load factors)

The load of above filling layer q_{dd} (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.017 x 1.8 x 0.5	=	0.915
The load of inside filling layer q_1 (T/m)	$q_1 = \gamma_H \times H_1$	=	1.8 x 1.1	=	1.980
The max value of horizontal pressure E_A (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 4.55 - 0.4 / 2	=	2.805
The min value of horizontal pressure e_A (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.35 / 2)	=	0.405
The concentrated load of retaining wall P (T)	$P = \gamma_c \times H_1 \times B_2$	=	2.5 x 1.1 x 0.3	=	0.825
The self weight uniform load of top slab q_{bt} (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.4	=	0.875
The self weight uniform load of bottom slab q_{bd} (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.40	=	1.000
Basement reaction of self weight loads R_{d1} (T/m)	$R_{d1} = (P_b + P) / D$	=	(18.475 + 0.825 / 5.8	=	3.328
Basement reaction of ground loads R_{d2} (T/m)	$R_{d2} = (q_1 \times B_1) / D + q_{dd}$	=	(1.98 x 3.5) / 5.8 + 0.915	=	2.110
Basement reaction of dead loads R_d (T/m)	$R_d = R_{d1} + R_{d2}$	=	3.328 + 2.110	=	5.437

C. WATER LOADS (without load factors)

The self weight uniform load of water q_w (T/m)	$q_w = H_1 \times \gamma_w$	=	1.1 x 1	=	1.100
Basement reaction of water load R_w (T/m)	$R_w = q_w \times (B_c - B_1 - B_2) / D$	=	1.1 x 5 - 3.5 - 0.3) / 5.8	=	0.228

D. LIVE LOADS (without load factors)

The uniform load of "HK80" axle q_{hk} (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
The load of crossing road inside the box q_h (T/m^2)	(In arcodance with Vietnames standard)			=	0.300
Basement reaction of crossing road load R_h (T/m)	$R_h = q_h \times B_1 / D$	=	0.3 x 3.5 / 5.8	=	0.181
Basement reaction of "HK80" load R_{hk} (T/m)	$R_{hk} = 4 \times q_{hk} \times a_1 / D$	=	4 x 9.34 x 0.78 / 5.8	=	5.007

6.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	forcers	load factor	forcers	load factor	forcers
	DEAD LOADS						
1	The load of outside filling layer $\mathbf{q_{dd}}$ (T/m)	1.0	**0.915**	1.25	**1.144**	1.25	**1.144**
2	The load of inside filling layer $\mathbf{q_1}$ (T/m)	1.0	**1.980**	1.25	**2.475**	1.25	**2.475**
3	The max value of horizontal pressure $\mathbf{E_A}$ (T/m)	1.0	**2.805**	1.25	**3.506**	1.25	**3.506**
4	The min value of horizontal pressure $\mathbf{e_A}$ (T/m)	1.0	**0.405**	1.25	**0.506**	1.25	**0.506**
5	The concentrated load of retaining wall inside box **P** (T)	1.0	**0.825**	1.25	**1.031**	1.50	**1.238**
6	The self weight uniform load of top slab $\mathbf{q_{bt}}$ (T/m)	1.0	**0.875**	1.25	**1.094**	1.50	**1.313**
7	The self weight uniform load of bottom slab $\mathbf{q_{bd}}$ (T/m)	1.0	**1.000**	1.25	**1.250**	1.50	**1.500**
8	Basement reaction of self weight loads $\mathbf{R_{d1}}$ (T/m)	1.0	**3.328**	1.25	**4.159**	1.50	**4.991**
9	Basement reaction of ground loads $\mathbf{R_{d2}}$ (T/m)	1.0	**2.110**	1.25	**2.637**	1.25	**2.637**
10	Basement reaction of dead loads $\mathbf{R_d}$ (T/m)		**5.437**		**6.797**		**7.629**
	WATER LOADS						
11	The self weight uniform load of water $\mathbf{q_w}$ (T/m)	1.0	**1.100**	1	**1.100**	1.25	**1.375**
12	Basement reaction of water load $\mathbf{R_w}$ (T/m)	1.0	**0.228**	1	**0.228**	1.25	**0.284**
	LIVE LOADS						
13	The uniform load of "HK80" axle $\mathbf{q_{hk}}$ (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
14	The load of crossing road inside the box $\mathbf{q_h}$ (T/m^2)	1.0	**0.300**	1.75	**0.525**	0	**0**
15	Basement reaction of crossing road load $\mathbf{R_h}$ (T/m)	1.0	**0.181**	1.75	**0.317**	0	**0**
16	Basement reaction of "HK80" load $\mathbf{R_{hk}}$ (T/m)	1.0	**5.007**	1.75	**8.763**	0	**0**

6.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6
	Case of loading		case 1	case 2	case2	case 1	case 1	case 1
H	Depth of slab	(mm)	350	350	400	400	400	400
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	3519	3380	3519	3380	2827	2827
A's	Area of Compression Reinforcement	(mm2)	2513	905	2513	905	1608	1608
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24
β1	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	175.0	175.0	200.0	200.0	200.0	200.0
a	Depth of the Equivalent Stress Block	(mm)	153.8	153.8	175.7	175.7	175.7	175.7
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	300	300	350	350	350	350
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	34	31	40	37	32	32
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	31	28	36	33	29	29
	Factored Bending Moment Max.	(Tfm)	22.056	24.593	17.433	26.492	22.056	15.392
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK

6.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5
Case of loading		case 1	case2	case 1
Section	Effective web bv (mm)	1000	1000	1000
Properties	Depth (mm)	350	400	400
	Effective depth dv (mm)	252	288	288
Factored Bending Moment Max Mu (Tfm)		22.056	17.433	22.056
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00
Factored Axial Force Nu (Tf)		4.33	4.31	31.56
Factored Shear Force Vu (Tf)		31.56	32.21	4.33
Design Shear Force Vu-f*Vp(Tf)		31.56	32.21	4.33
Shear Stress v (Mpa)		1.365	1.219	0.164
Concrete Strength f'c (Mpa)		24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000
Ratio of v/f'c		6E-02	5E-02	7E-03
As (mm2)		6032	6032	4436
Ac (m2)		0.400	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00
Angle θ		35.0	32.5	36.5
Cot(θ)		1.429	1.572	1.350
εx (Max)		9.13E-04	7.16E-04	1.05E-03
εx (Min)		2.01E-04	2.23E-04	2.07E-04
Value of θ		35.0	32.5	36.5
		28	28	28
Value of β		2.2625	2.3880	2.2000
		3.5693	3.5824	3.6628
Component of Shear Resistance Vc (Tf)		24	29	26
Spacing of Stirrups s (mm)		250	250	250
Stirrup Diameter (mm)		12	12	12
Area of Stirrups Av (mm2)		452	452	452
Angle of Inclination α		90	90	90
Component of Shear Resistance Vs (Tf)		26	33	28
Nominal Shear Resistance				
Vn1 = Vc + Vs + Vp (Tf)		50	61	54
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		154	176	176
Check (Min. Vn1,2 > Vu)		OK	OK	OK

DESIGN CALCULATION OF CULVERTS

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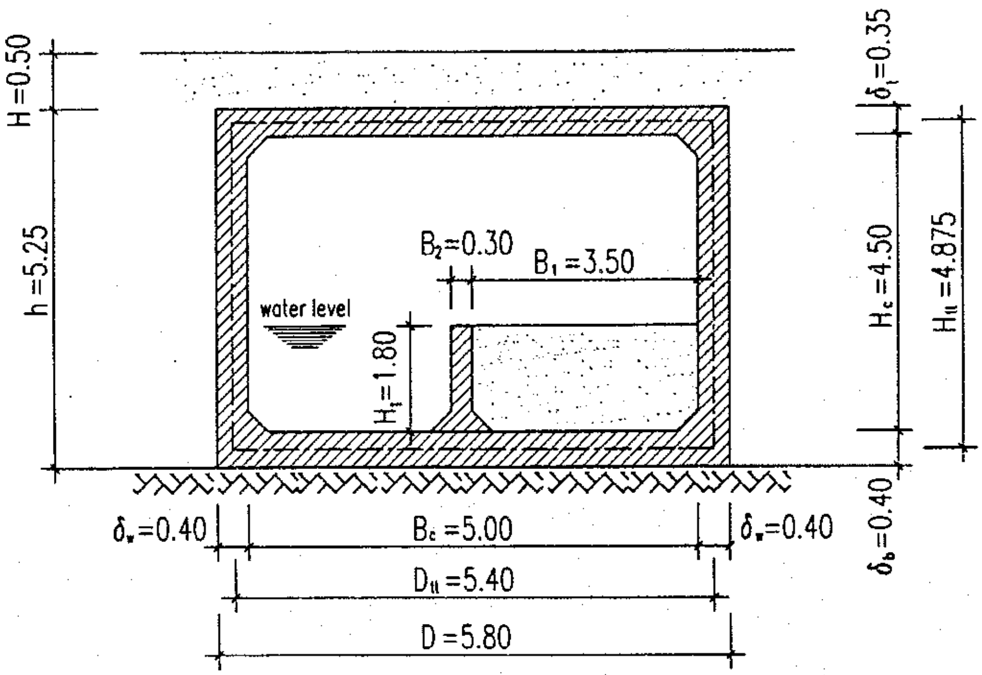
CULVERT TYPE B9

SINGLE BOX CULVERT DIMENSION 5.0x4.5 M.

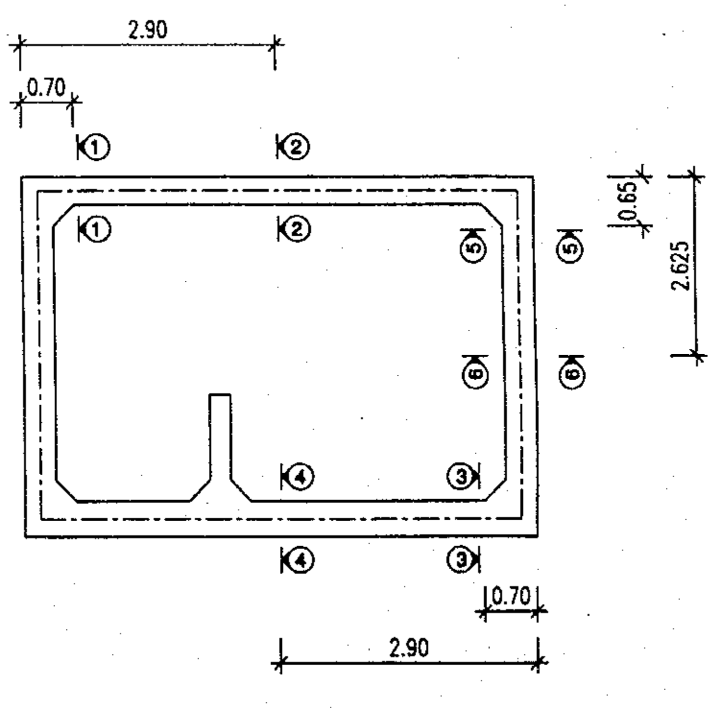
STATION KM 1+063.2

SINGLE BOX CULVERT TYPE B9
(AT STATION 1+063.2)

9.1 GENERAL VIEW



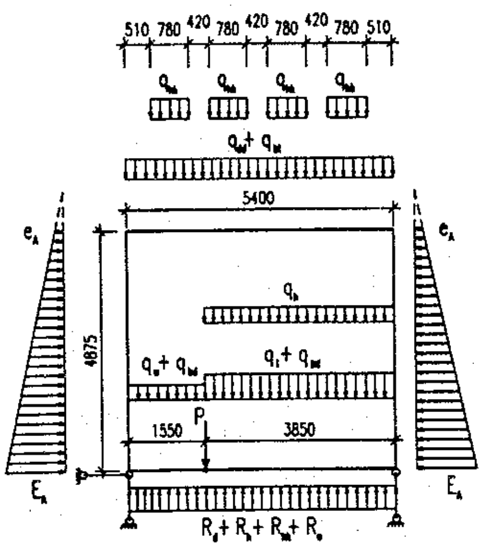
9.2 SECTION FOR CHECKING



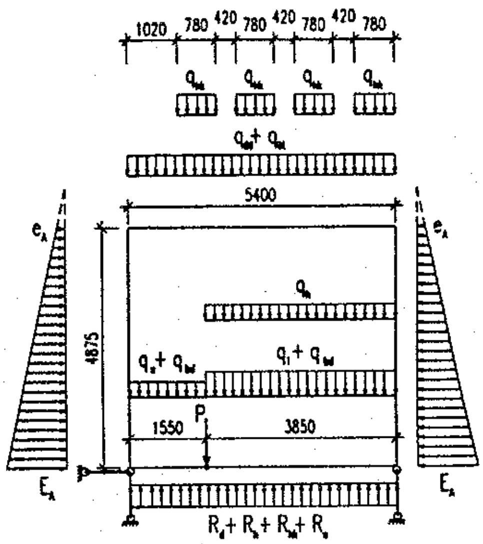
SINGLE BOX CULVERT TYPE B9
(AT STATION 1+063.2)

9.3 CASES OF LOADINGS

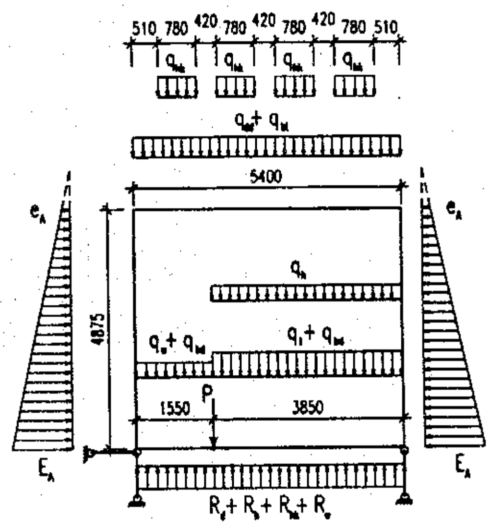
CASE 1 : STRENGTH I - 1



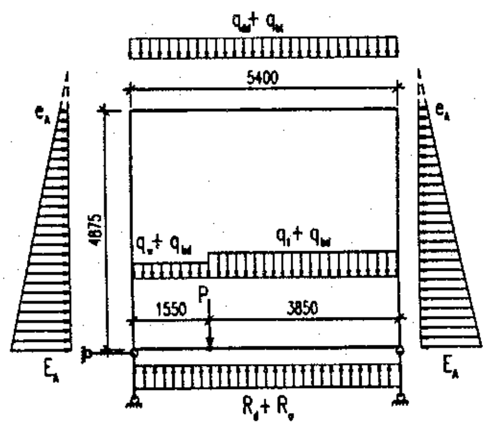
CASE 2 : STRENGTH I - 2



CASE 3 : SERVICE I



CASE 4 : STRENG IV



9.4 Loading formulas

A	**DIMENSION OF BOX AND COEFFICIENTS**					
	The typical of box culvert	single				
	Thickness of filling layer above the top of box **H** (m)	0.50		Density of filling ground γ_H (T)		1.8
	Inside width of box $\mathbf{B_c}$ (m)	5.00		Density of water γ_w (T/m^3)		1
	Inside hight of box $\mathbf{H_c}$ (m)	4.50		Density of concrete γ_c (T/m^3)		2.5
	Thickness of top slab δ_t (m)	0.35		Internal friction angle φ_H		30
	Thickness of walls δ_w (m)	0.40		The coefficient of basement **S**		10
	Thickness of bottom slab δ_b (m)	0.40		The angle of "HK80" axle load (with H < 1m) φ_t		30
	Thickness of filling layer inside the box $\mathbf{H_1}$ (m)	1.800		Half of single "HK80" axle load $\mathbf{P_{hk}}$ (T)		10
	Width of filling layer inside the box $\mathbf{B_1}$ (m)	3.50		Width of retaining wall inside the box $\mathbf{B_2}$ (m)		0.30
	Outside width of the box **D** (m)	$D = B_c + 2 \times \delta_w$	=	5 + 2 x 0.40	=	5.80
	Outside hight of the box **h** (m)	$h = H_c + \delta_t + \delta_b$	=	4.5 + 0.35 + 0.4	=	5.25
	Calculating width of the box $\mathbf{D_{tt}}$ (m)	$D_{tt} = B_c + \delta_w$	=	5 + 0.4	=	5.40
	Calculating hight of the box $\mathbf{h_{tt}}$ (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	4.5 + 0.35/2 + 0.4 / 2	=	4.875
	The self weight of the box $\mathbf{P_b}$ (T)	$P_b = \gamma_c \times (H_c \times 2 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (4.5 x 2 x 0.4 + 5.8 x (0.35 + 0.4))	=	19.875
	Horizontal pressure coefficient μ	$\mu = tg^2 (45° - \varphi_H / 2)$	=	tg^2 (45° - 30°)	=	0.333
	Coefficient **A**	$A = H / D$	=	0.5 / 5.8	=	0.086
	Coefficient **C**	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.086 x 0.333 x tg 30°	=	1.017
	$\mathbf{a_1}$ (m)	$a_1 = 0.2 + 2 \times H \times tg\ \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
	$\mathbf{b_1}$ (m)	$b_1 = 0.8 + 2 \times H \times tg\ \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
	Total width of "HK80" uniform load **W** (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38
B	**DEAD LOADS (without load factors)**					
	The load of above filling layer $\mathbf{q_{dd}}$ (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.017 x 1.8 x 0.5	=	0.915
	The load of inside filling layer $\mathbf{q_1}$ (T/m)	$q_1 = \gamma_H \times H_1$	=	1.8 x 1.8	=	3.240
	The max value of horizontal pressure $\mathbf{E_A}$ (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 5.25 - 0.4 / 2	=	3.225
	The min value of horizontal pressure $\mathbf{e_A}$ (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.35 / 2)	=	0.405
	The concentrated load of retaining wall **P** (T)	$P = \gamma_c \times H_1 \times B_2$	=	2.5 x 1.8 x 0.3	=	1.350
	The self weight uniform load of top slab $\mathbf{q_{bt}}$ (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.4	=	0.875
	The self weight uniform load of bottom slab $\mathbf{q_{bd}}$ (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.40	=	1.000
	Basement reaction of self weight loads $\mathbf{R_{d1}}$ (T/m)	$R_{d1} = (P_b + P) / D$	=	(19.875 + 1.35 / 5.8	=	3.659
	Basement reaction of ground loads $\mathbf{R_{d2}}$ (T/m)	$R_{d2} = (q_1 \times B_1) / D + q_{dd}$	=	(3.24 x 3.5) / 5.8 + 0.915	=	2.870
	Basement reaction of dead loads $\mathbf{R_d}$ (T/m)	$R_d = R_{d1} + R_{d2}$	=	3.659 + 2.870	=	6.530
C	**WATER LOADS (without load factors)**					
	The self weight uniform load of water $\mathbf{q_w}$ (T/m)	$q_w = H_1 \times \gamma_w$	=	1.8 x 1	=	1.800
	Basement reaction of water load $\mathbf{R_w}$ (T/m)	$R_w = q_w \times (B_c - B_1 - B_2) / D$	=	1.8 x 5 - 3.5 - 0.3) / 5.8	=	0.372
D	**LIVE LOADS (without load factors)**					
	The uniform load of "HK80" axle $\mathbf{q_{hk}}$ (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
	The load of crossing road inside the box $\mathbf{q_h}$ (T/m^2)	(in arcodance with Vietnames standard)			=	0.300
	Basement reaction of crossing road load $\mathbf{R_h}$ (T/m)	$R_h = q_h \times B_1 / D$	=	0.3 x 3.5 / 5.8	=	0.181
	Basement reaction of "HK80" load $\mathbf{R_{hk}}$ (T/m)	$R_{hk} = 4 \times q_{hk} \times a_1 / D$	=	4 x 9.34 x 0.78 / 5.8	=	5.007

9.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	forcers	load factor	forcers	load factor	forcers
	DEAD LOADS						
1	The load of outside filling layer q_{dd} (T/m)	1.0	**0.915**	1.25	**1.144**	1.25	**1.144**
2	The load of inside filling layer q_1 (T/m)	1.0	**3.240**	1.25	**4.050**	1.25	**4.050**
3	The max value of horizontal pressure E_A (T/m)	1.0	**3.225**	1.25	**4.031**	1.25	**4.031**
4	The min value of horizontal pressure e_A (T/m)	1.0	**0.405**	1.25	**0.506**	1.25	**0.506**
5	The concentrated load of retaining wall inside box **P** (T)	1.0	**1.350**	1.25	**1.688**	1.50	**2.025**
6	The self weight uniform load of top slab q_{bt} (T/m)	1.0	**0.875**	1.25	**1.094**	1.50	**1.313**
7	The self weight uniform load of bottom slab q_{bd} (T/m)	1.0	**1.000**	1.25	**1.250**	1.50	**1.500**
8	Basement reaction of self weight loads R_{d1} (T/m)	1.0	3.659	1.25	4.574	1.50	5.489
9	Basement reaction of ground loads R_{d2} (T/m)	1.0	2.870	1.25	3.588	1.25	3.588
10	Basement reaction of dead loads R_d (T/m)		**6.530**		**8.162**		**9.077**
	WATER LOADS						
11	The self weight uniform load of water q_w (T/m)	1.0	**1.800**	1	**1.800**	1.25	**2.250**
12	Basement reaction of water load R_w (T/m)	1.0	**0.372**	1	**0.372**	1.25	**0.466**
	LIVE LOADS						
13	The uniform load of "HK80" axle q_{hk} (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
14	The load of crossing road inside the box q_h (T/m^2)	1.0	**0.300**	1.75	**0.525**	0	**0**
15	Basement reaction of crossing road load R_h (T/m)	1.0	**0.181**	1.75	**0.317**	0	**0**
16	Basement reaction of "HK80" load R_{hk} (T/m)	1.0	**5.007**	1.75	**8.763**	0	**0**

9.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6
	Case of loading		case 1	case 2	case2	case 1	case 1	case 1
H	Depth of slab	(mm)	350	350	400	400	400	400
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	3519	3380	3519	3380	2375	2375
A's	Area of Compression Reinforcement	(mm2)	905	905	905	905	905	905
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24
β1	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	175.0	175.0	200.0	200.0	200.0	200.0
a	Depth of the Equivalent Stress Block	(mm)	153.8	153.8	175.7	175.7	175.7	175.7
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	300	300	350	350	350	350
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	32	31	38	37	26	26
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	29	28	34	33	24	24
	Factored Bending Moment Max.	(Tfm)	21.667	24.959	17.090	26.584	21.667	12.710
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK

9.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5
Case of loading		case 1	case2	case 1
Section	Effective web bv (mm)	1000	1000	1000
Properties	Depth (mm)	350	400	400
	Effective depth dv (mm)	252	288	288
Factored Bending Moment Max Mu (Tfm)		21.667	17.090	21.667
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00
Factored Axial Force Nu (Tf)		5.10	6.18	31.56
Factored Shear Force Vu (Tf)		31.56	32.03	5.10
Design Shear Force Vu-f*Vp(Tf)		31.56	32.03	5.10
Shear Stress v (Mpa)		1.365	1.212	0.193
Concrete Strength f'c (Mpa)		24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000
Ratio of v/f'c		6E-02	5E-02	8E-03
As (mm2)		4423	4423	3280
Ac (m2)		0.400	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00
Angle θ		37.9	35.3	40.1
Cot(θ)		1.282	1.410	1.186
εx (Max)		1.21E-03	9.43E-04	1.41E-03
εx (Min)		2.53E-04	2.85E-04	2.81E-04
Value of θ		37.9	35.3	40.1
		28	29	29
Value of β		2.0976	2.2608	2.0025
		3.3487	3.3455	3.3676
Component of Shear Resistance Vc (Tf)		22	27	24
Spacing of Stirrups s (mm)		250	250	250
Stirrup Diameter (mm)		12	12	12
Area of Stirrups Av (mm2)		452	452	452
Angle of Inclination α		90	90	90
Component of Shear Resistance Vs (Tf)		23	29	25
Nominal Shear Resistance				
Vn1 = Vc + Vs + Vp (Tf)		45	56	49
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		154	176	176
Check (Min. Vn1,2 > Vu)		OK	OK	OK

DESIGN CALCULATION OF CULVERTS

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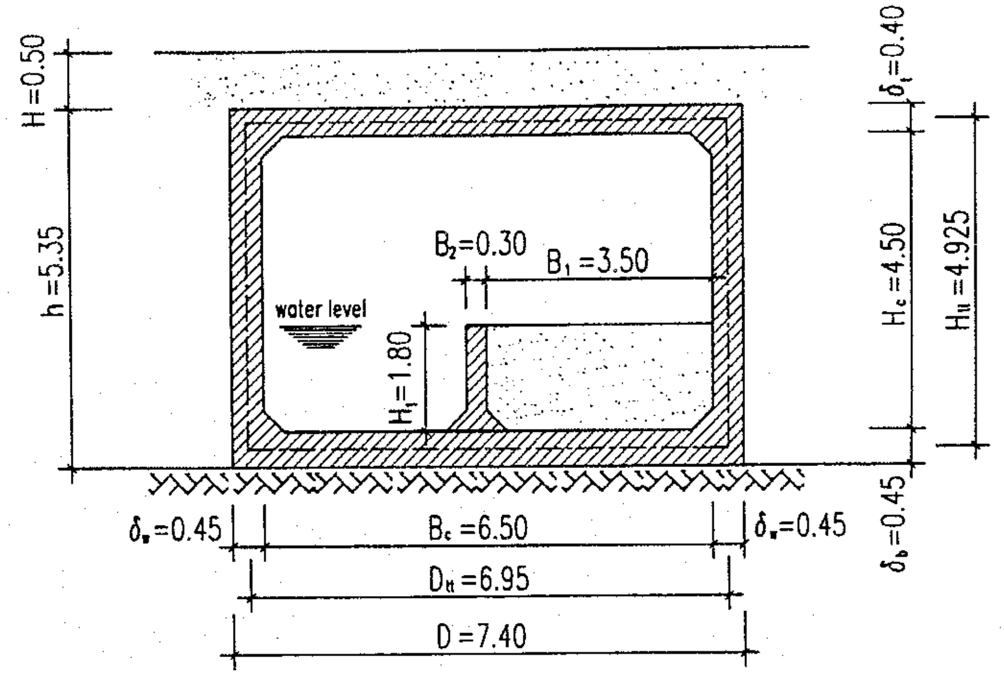
CULVERT TYPE B10

SINGLE BOX CULVERT DIMENSION 6.5x4.5 M.

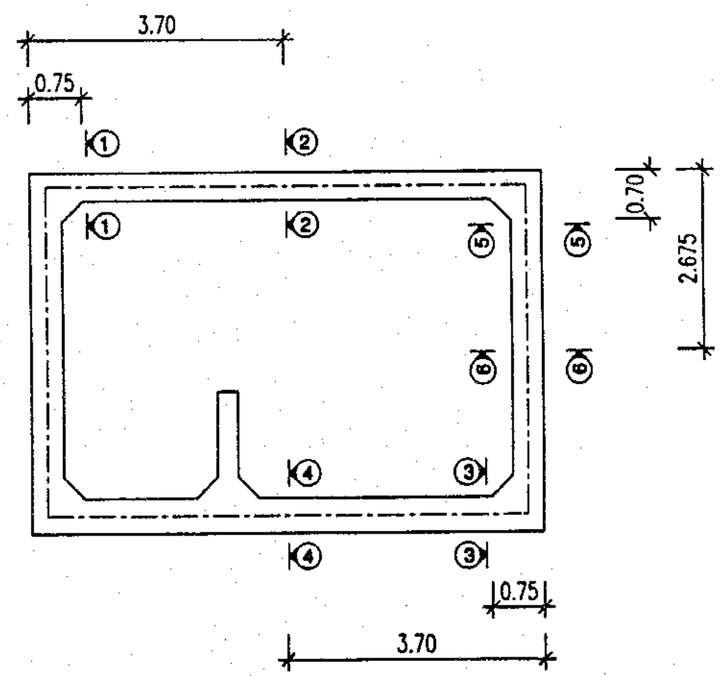
STATION KM 4+640

SINGLE BOX CULVERT TYPE B10
(AT STATION 4+640)

10.1 GENERAL VIEW



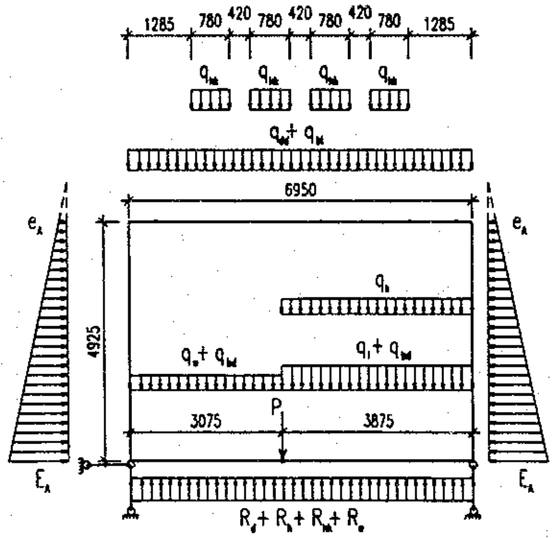
10.2 SECTION FOR CHECKING



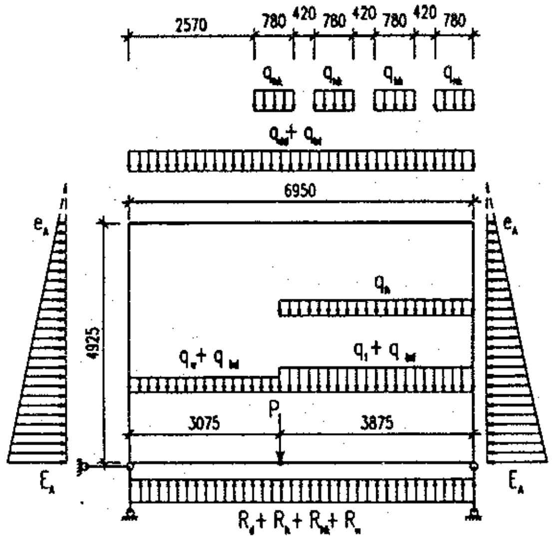
SINGLE BOX CULVERT TYPE B10
(STATION 04+460)

10.3 CASES OF LOADINGS

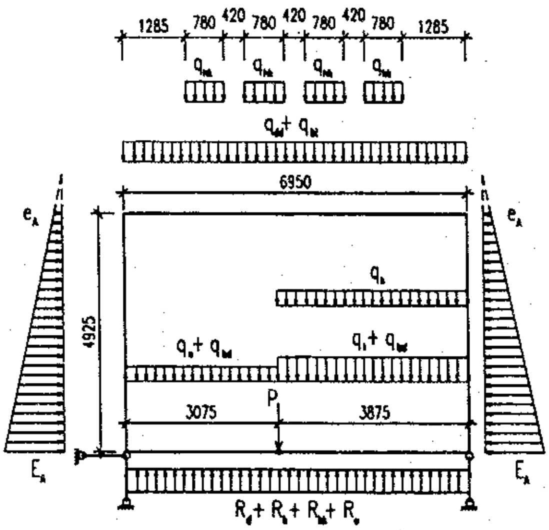
CASE 1 : STRENGTH I - 1



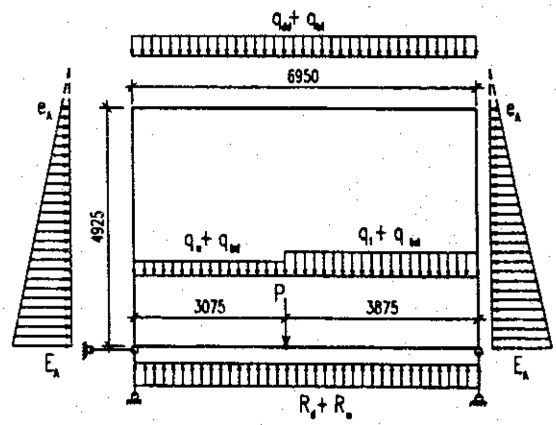
CASE 2 : STRENGTH I - 2



CASE 3 : SERVICE I



CASE 4 : STRENGTH IV



10.4 Loading formulas

A. DIMENSION OF BOX AND COEFFICIENTS

The typical of box culvert	single		
Thickness of filling layer above the top of box H (m)	0.50	Density of filling ground γ_H (T)	1.8
Inside width of box B_c (m)	6.50	Density of water γ_w (T/m^3)	1
Inside hight of box H_c (m)	4.50	Density of concrete γ_c (T/m^3)	2.5
Thickness of top slab δ_t (m)	0.40	Internal friction angle φ_H	30
Thickness of walls δ_w (m)	0.45	The coefficient of basement S	10
Thickness of bottom slab δ_b (m)	0.45	The angle of "HK80" axle load (with H < 1m) φ_t	30
Thickness of filling layer inside the box H_1 (m)	1.800	Half of single "HK80" axle load P_{hk} (T)	10
Width of filling layer inside the box B_1 (m)	3.50	Width of retaining wall inside the box B_2 (m)	0.30

Outside width of the box D (m)	$D = B_c + 2 \times \delta_w$	=	6.5 + 2 x 0.45	=	7.40
Outside hight of the box h (m)	$h = H_c + \delta_t + \delta_b$	=	4.5 + 0.4 + 0.45	=	5.35
Calculating width of the box D_{tt} (m)	$D_{tt} = B_c + \delta_w$	=	6.5 + 0.45	=	6.95
Calculating hight of the box h_{tt} (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	4.5 + 0.4/2 + 0.45 / 2	=	4.925
The self weight of the box P_b (T)	$P_b = \gamma_c \times (H_c \times 2 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (4.5 x 2 x 0.45 + 7.4 x (0.4 + 0.45))	=	25.850
Horizontal pressure coefficient μ	$\mu = tg^2 (45° - \varphi_H / 2)$	=	tg^2 (45° - 30°)	=	0.333
Coefficient A	$A = H / D$	=	0.5 / 7.4	=	0.068
Coefficient C	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.068 x 0.333 x tg 30°	=	1.013
a_1 (m)	$a_1 = 0.2 + 2 \times H \times tg\, \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
b_1 (m)	$b_1 = 0.8 + 2 \times H \times tg\, \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
Total width of "HK80" uniform load W (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38

B. DEAD LOADS (without load factors)

The load of above filling layer q_{dd} (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.013 x 1.8 x 0.5	=	0.912
The load of inside filling layer q_1 (T/m)	$q_1 = \gamma_H \times H_1$	=	1.8 x 1.8	=	3.240
The max value of horizontal pressure E_A (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 5.35 - 0.45 / 2	=	3.255
The min value of horizontal pressure e_A (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.4 / 2)	=	0.420
The concentrated load of retaining wall P (T)	$P = \gamma_c \times H_1 \times B_2$	=	2.5 x 1.8 x 0.3	=	1.350
The self weight uniform load of top slab q_{bt} (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.4	=	1.000
The self weight uniform load of bottom slab q_{bd} (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.45	=	1.125
Basement reaction of self weight loads R_{d1} (T/m)	$R_{d1} = (P_b + P) / D$	=	(25.85 + 1.35 / 7.4	=	3.676
Basement reaction of ground loads R_{d2} (T/m)	$R_{d2} = (q_1 \times B_1) / D + q_{dd}$	=	(3.24 x 3.5) / 7.4 + 0.912	=	2.444
Basement reaction of dead loads R_d (T/m)	$R_d = R_{d1} + R_{d2}$	=	3.676 + 2.444	=	6.120

C. WATER LOADS (without load factors)

The self weight uniform load of water q_w (T/m)	$q_w = H_1 \times \gamma_w$	=	1.8 x 1	=	1.800
Basement reaction of water load R_w (T/m)	$R_w = q_w \times (B_c - B_1 - B_2) / D$	=	1.8 x 6.5 - 3.5 - 0.3) / 7.4	=	0.657

D. LIVE LOADS (without load factors)

The uniform load of "HK80" axle q_{hk} (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
The load of crossing road inside the box q_h (T/m^2)	(In arcodance with Vietnames standard)			=	0.300
Basement reaction of crossing road load R_h (T/m)	$R_h = q_h \times B_1 / D$	=	0.3 x 3.5 / 7.4	=	0.142
Basement reaction of "HK80" load R_{hk} (T/m)	$R_{hk} = 4 \times q_{hk} \times a_1 / D$	=	4 x 9.34 x 0.78 / 7.4	=	3.925

10.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	forcers	load factor	forcers	load factor	forcers
	DEAD LOADS						
1	The load of outside filling layer q_{dd} (T/m)	1.0	**0.912**	1.25	**1.140**	1.25	**1.140**
2	The load of inside filling layer q_1 (T/m)	1.0	**3.240**	1.25	**4.050**	1.25	**4.050**
3	The max value of horizontal pressure E_A (T/m)	1.0	**3.255**	1.25	**4.069**	1.25	**4.069**
4	The min value of horizontal pressure e_A (T/m)	1.0	**0.420**	1.25	**0.525**	1.25	**0.525**
5	The concentrated load of retaining wall inside box **P** (T)	1.0	**1.350**	1.25	**1.688**	1.50	**2.025**
6	The self weight uniform load of top slab q_{bt} (T/m)	1.0	**1.000**	1.25	**1.250**	1.50	**1.500**
7	The self weight uniform load of bottom slab q_{bd} (T/m)	1.0	**1.125**	1.25	**1.406**	1.50	**1.688**
8	Basement reaction of self weight loads R_{d1} (T/m)	1.0	3.676	1.25	4.595	1.50	5.514
9	Basement reaction of ground loads R_{d2} (T/m)	1.0	2.444	1.25	3.055	1.25	3.055
10	Basement reaction of dead loads R_d (T/m)		**6.120**		**7.650**		**8.569**
	WATER LOADS						
11	The self weight uniform load of water q_w (T/m)	1.0	**1.800**	1	**1.800**	1.25	**2.250**
12	Basement reaction of water load R_w (T/m)	1.0	**0.657**	1	**0.657**	1.25	**0.821**
	LIVE LOADS						
13	The uniform load of "HK80" axle q_{hk} (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
14	The load of crossing road inside the box q_h (T/m^2)	1.0	**0.300**	1.75	**0.525**	0	**0**
15	Basement reaction of crossing road load R_h (T/m)	1.0	**0.142**	1.75	**0.249**	0	**0**
16	Basement reaction of "HK80" load R_{hk} (T/m)	1.0	**3.925**	1.75	**6.868**	0	**0**

10.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6
	Case of loading		case 1	case 1	case2	case 1	case 1	case 1
H	Depth of slab	(mm)	400	400	450	450	450	450
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	4888	4725	4888	4725	4072	4072
A's	Area of Compression Reinforcement	(mm2)	3619	905	3619	905	2036	2036
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24
$\beta 1$	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	200.0	200.0	225.0	225.0	225.0	225.0
a	Depth of the Equivalent Stress Block	(mm)	175.7	175.7	197.7	197.7	197.7	197.7
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	350	350	400	400	400	400
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	56	51	66	58	53	53
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	51	46	59	52	47	47
	Factored Bending Moment Max.	(Tfm)	34.215	38.505	26.716	36.098	34.215	23.039
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK

10.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5
Case of loading		case 1	case2	case 1
Section	Effective web bv (mm)	1000	1000	1000
Properties	Depth (mm)	400	450	450
	Effective depth dv (mm)	288	324	324
Factored Bending Moment Max Mu (Tfm)		34.215	26.716	34.215
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00
Factored Axial Force Nu (Tf)		6.04	6.36	33.88
Factored Shear Force Vu (Tf)		33.88	34.27	6.04
Design Shear Force Vu-f*Vp(Tf)		33.88	34.27	6.04
Shear Stress v (Mpa)		1.282	1.153	0.203
Concrete Strength f'c (Mpa)		24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000
Ratio of v/f'c		5E-02	5E-02	8E-03
As (mm2)		8507	8507	6107
Ac (m2)		0.400	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00
Angle θ		34.2	31.5	36.2
Cot(θ)		1.471	1.631	1.368
εx (Max)		8.46E-04	6.55E-04	1.02E-03
εx (Min)		1.61E-04	1.79E-04	1.69E-04
Value of θ		34.2	31.5	36.2
		27	28	28
Value of β		2.3092	2.4233	2.2203
		3.7935	3.7722	3.8131
Component of Shear Resistance Vc (Tf)		28	33	30
Spacing of Stirrups s (mm)		250	250	250
Stirrup Diameter (mm)		12	12	0
Area of Stirrups Av (mm2)		452	452	0
Angle of Inclination α		90	90	90
Component of Shear Resistance Vs (Tf)		30	38	0
Nominal Shear Resistance				
Vn1 = Vc + Vs + Vp (Tf)		58	71	30
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		176	198	198
Check (Min. Vn1,2 > Vu)		OK	OK	OK

DESIGN CALCULATION OF CULVERTS

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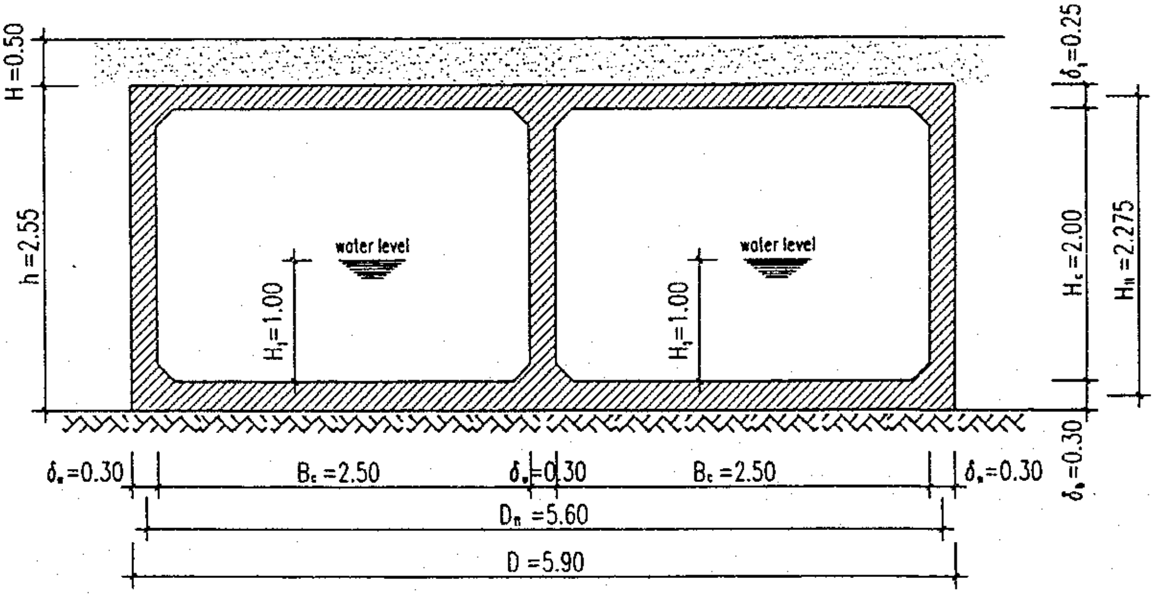
CULVERT TYPE B11

DOUBLE BOX CULVERT DIMENSION 2x2.5x1.5 M.

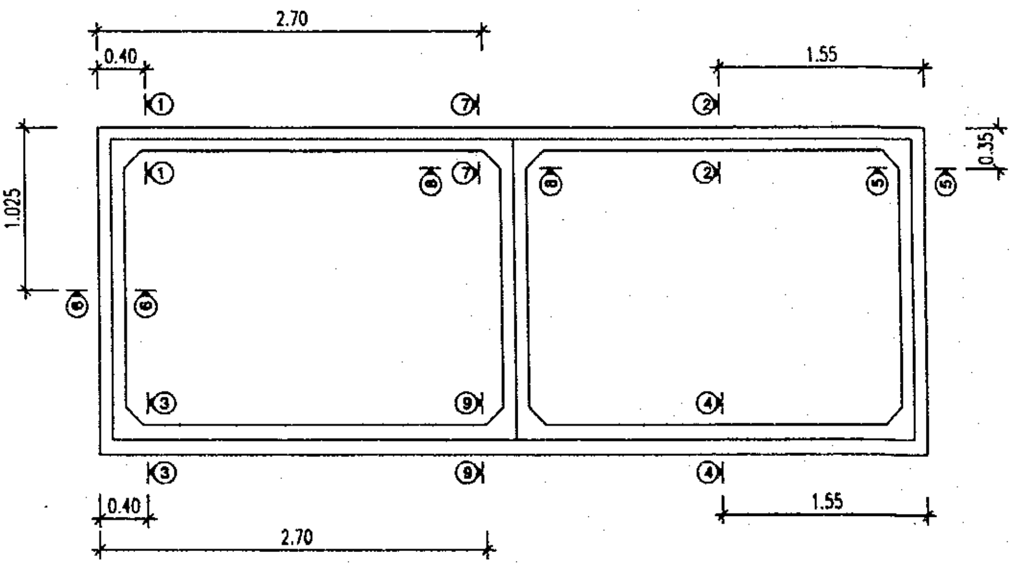
INTERCHANGE 2 - RAMP B - KM 0+223

DOUBLE BOX CULVERT TYPE B11
(AT INTERCHANGE 3 - RAMP A - KM 0+154)

11.1 GENERAL VIEW



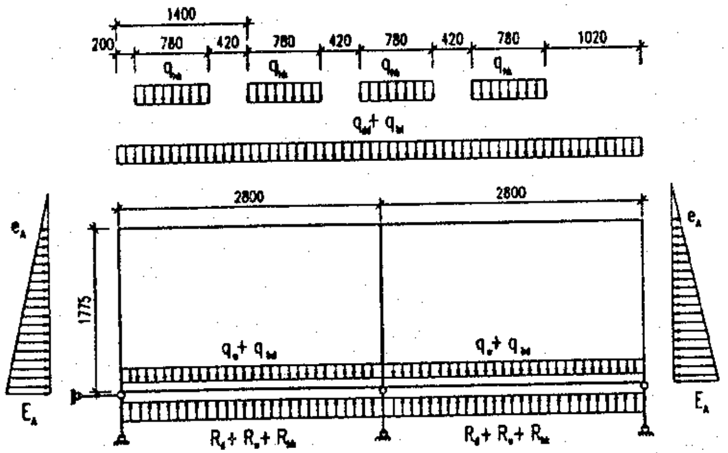
11.2 SECTIONS FOR CHEKING



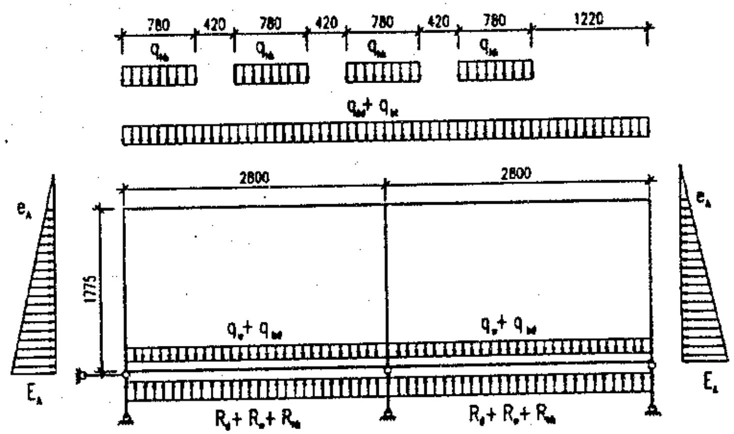
DOUBLE BOX CULVERT TYPE B11
(AT INTERCHANGE 3 - RAMP A - KM 0+154)

11.3 CASES OF LOADINGS

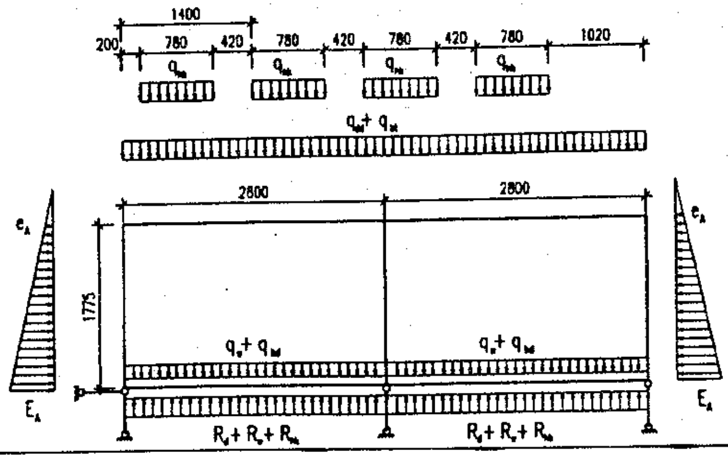
CASE 1 : STRENGTH I - 1



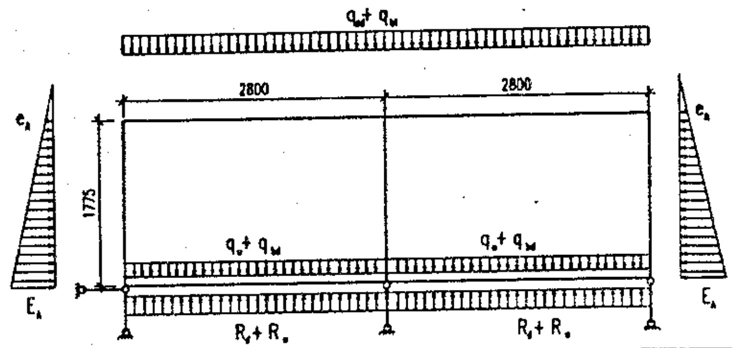
CASE 2 : STRENGTH I - 2



CASE 3 : SERVICE I



CASE 4 : STRENGTH IV



11.4 Loading formulas

A	**DIMENSION OF BOX AND COEFFICIENTS**					
	The typical of box culvert	double				
	Thickness of filling layer above the top of box H (m)	0.50		Density of filling ground γ_H (T)		1.8
	Inside width of box B_c (m)	2.50		Density of water γ_w (T/m^3)		1
	Inside hight of box H_c (m)	1.50		Density of concrete γ_c (T/m^3)		2.5
	Thickness of top slab δ_t (m)	0.25		Internal friction angle φ_H		30
	Thickness of walls δ_w (m)	0.30		The coefficient of basement S		10
	Thickness of bottom slab δ_b (m)	0.30		The angle of "HK80" axle load (with H < 1m) φ_t		30
	Thickness of water level H_1 (m)	1.00		Half of single "HK80" axle load P_{hk} (T)		10
	Outside width of the box **D** (m)	$D = 2 \times B_c + 3 \times \delta_w$	=	2 x 2.5 + 3 x 0.3	=	5.90
	Outside hight of the box **h** (m)	$h = H_c + \delta_t + \delta_b$	=	1.5 + 0.25 + 0.3	=	2.05
	Calculating width of the box D_{tt} (m)	$D_{tt} = 2 \times B_c + 3 \times \delta_w$	=	2 x 2.5 + 3 x 0.3	=	5.60
	Calculating hight of the box h_{tt} (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	1.5 + 0.25/2 + 0.3 / 2	=	1.775
	The self weight of the box P_b (T)	$P_b = \gamma_c \times (H_c \times 3 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (1.5 x 3 x 0.3 + 5.9 x (0.25 + 0.3))	=	11.49
	Horizontal pressure coefficient μ	$\mu = tg^2 (45° - \varphi_H / 2)$	=	tg^2 (45° - 30°)	=	0.333
	Coefficient **A**	$A = H / D$	=	0.5 / 5.9	=	0.085
	Coefficient **C**	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.085 x 0.333 x tg 30°	=	1.016
	a_1 (m)	$a_1 = 0.2 + 2 \times H \times tg\ \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
	b_1 (m)	$b_1 = 0.8 + 2 \times H \times tg\ \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
	Total width of "HK80" uniform load **W** (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38
B	**DEAD LOADS (without load factors)**					
	The load of above filling layer q_{dd} (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.016 x 1.8 x 0.5	=	0.915
	The max value of horizontal pressure E_A (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 2.05 - 0.3 / 2	=	1.365
	The min value of horizontal pressure e_A (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.25 / 2)	=	0.375
	The self weight uniform load of top slab q_{bt} (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.3	=	0.625
	The self weight uniform load of bottom slab q_{bd} (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.30	=	0.750
	Basement reaction of self weight loads R_{d1} (T/m)	$R_{d1} = P_b / D$	=	(11.4875 / 5.9	=	1.947
	Basement reaction of ground loads R_{d2} (T/m)	$R_{d2} = q_{dd}$	=		=	0.915
	Basement reaction of dead loads R_d (T/m)	$R_d = R_{d1} + R_{d2}$	=	1.947 + 0.915	=	2.862
C	**WATER LOADS (without load factors)**					
	The self weight uniform load of water q_w (T/m)	$q_w = H_1 \times \gamma_w$	=	1 x 1	=	1.000
	Basement reaction of water load R_w (T/m)	$R_w = q_w \times 2 \times B_c / D$	=	1 x 2 x 2.5 / 5.9	=	0.847
D	**LIVE LOADS (without load factors)**					
	The uniform load of "HK80" axle q_{hk} (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
	Basement reaction of "HK80" load R_{hk} (T/m)	$R_{hk} = 4 \times q_{hk} \times a_1 / D$	=	4 x 9.34 x 0.78 / 5.9	=	4.922

11.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	forcers	load factor	forcers	load factor	forcers
	DEAD LOADS						
1	The load of outside filling layer q_{dd} (T/m)	1.0	**0.915**	1.25	**1.143**	1.25	**1.143**
2	The max value of horizontal pressure E_A (T/m)	1.0	**1.365**	1.25	**1.706**	1.25	**1.706**
3	The min value of horizontal pressure e_A (T/m)	1.0	**0.375**	1.25	**0.469**	1.25	**0.469**
4	The self weight uniform load of top slab q_{bt} (T/m)	1.0	**0.625**	1.25	**0.781**	1.50	**0.938**
5	The self weight uniform load of bottom slab q_{bd} (T/m)	1.0	**0.750**	1.25	**0.938**	1.50	**1.125**
6	Basement reaction of self weight loads R_{d1} (T/m)	1.0	1.947	1.25	2.434	1.50	2.921
7	Basement reaction of ground loads R_{d2} (T/m)	1.0	0.915	1.25	1.143	1.25	1.143
8	Basement reaction of dead loads R_d (T/m)		**2.862**		**3.577**		**4.064**
	WATER LOADS						
9	The self weight uniform load of water q_w (T/m)	1.0	**1.000**	1	**1.000**	1.25	**1.250**
10	Basement reaction of water load R_w (T/m)	1.0	**0.847**	1	**0.847**	1.25	**1.059**
	LIVE LOADS						
11	The uniform load of "HK80" axle q_{hk} (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
12	Basement reaction of "HK80" load R_{hk} (T/m)	1.0	**4.922**	1.75	**8.614**	0	**0**

11.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6	Sec.7-7	Sec.9-9
	Case of loading		case 1	case 1	case 1	case 1	case 1	case 1	case 1	case 1
H	Depth of slab	(mm)	250	250	300	300	300	300	250	300
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	1608	1608	1608	1608	1608	1608	1822	1822
A's	Area of Compression Reinforcement	(mm2)	1608	905	905	905	1608	905	905	905
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24	24	24
β1	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	125.0	125.0	150.0	150.0	150.0	150.0	125.0	150.0
a	Depth of the Equivalent Stress Block	(mm)	109.8	109.8	131.8	131.8	131.8	131.8	109.8	131.8
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	200	200	250	250	250	250	200	250
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	10	9	12	12	13	12	11	14
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	9	9	11	11	12	11	10	13
	Factored Bending Moment Max.	(Tfm)	5.536	4.799	1.864	3.405	5.536	3.360	9.363	8.570
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK	OK	OK

11.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5	Sec.7-7	Sec.9-9
Case of loading		case 2	case 2	case 2	case 2	case 2
Section	Effective web bv (mm)	1000	1000	1000	1000	1000
Properties	Depth (mm)	250	300	300	250	300
	Effective depth dv (mm)	180	216	216	180	216
Factored Bending Moment Max Mu (Tfm)		5.536	1.864	5.536	9.363	8.570
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00	0.00	0.00
Factored Axial Force Nu (Tf)		2.85	0.92	16.11	2.85	2.12
Factored Shear Force Vu (Tf)		16.11	8.85	2.85	18.05	19.23
Design Shear Force Vu-f*Vp(Tf)		16.11	8.85	2.85	18.05	19.23
Shear Stress v (Mpa)		0.976	0.447	0.144	1.093	0.970
Concrete Strength f'c (Mpa)		24	24	24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000	390.000	390.000
Ratio of v/f'c		4E-02	2E-02	6E-03	5E-02	4E-02
As (mm2)		3217	2513	3217	2727	2727
Ac (m2)		0.400	0.450	0.450	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Angle θ		37.9	38.2	37.9	37.9	37.9
Cot(θ)		1.284	1.272	1.282	1.282	1.282
εx (Max)		6.48E-04	2.87E-04	5.41E-04	1.17E-03	9.55E-04
εx (Min)		1.79E-04	1.19E-04	1.51E-04	2.34E-04	2.41E-04
Value of θ		31.4	28.6	29.7	37.7	35.5
		28	27	27	28	28
Value of β		2.4270	3.3441	2.4868	2.1351	2.2555
		3.7725	4.0341	3.8873	3.5548	3.5266
Component of Shear Resistance Vc (Tf)		18	30	22	16	20
Spacing of Stirrups s (mm)		250	250	250	250	250
Stirrup Diameter (mm)		0	0	0	12	0
Area of Stirrups Av (mm2)		0	0	0	452	0
Angle of Inclination α		90	90	90	90	90
Component of Shear Resistance Vs (Tf)		0	0	0	17	0
Nominal Shear Resistance						
Vn1 = Vc + Vs + Vp (Tf)		18	30	22	33	20
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		110	132	132	110	132
Check (Min. Vn1,2 > Vu)		OK	OK	OK	OK	OK

DESIGN CALCULATION OF CULVERTS

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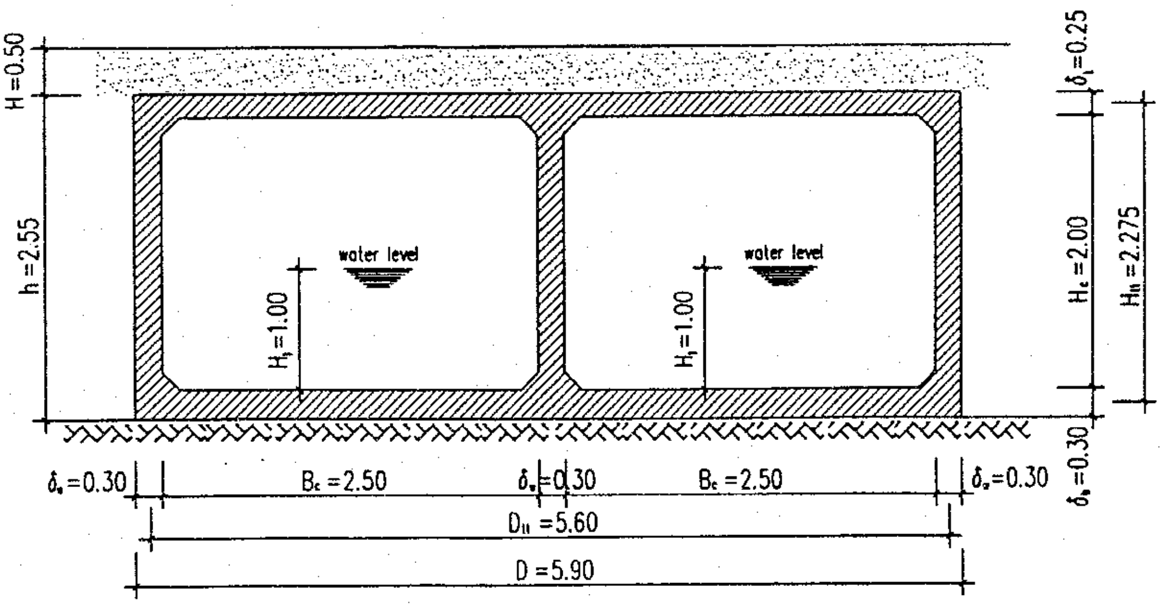
CULVERT TYPE B12

DOUBLE BOX CULVERT DIMENSION 2x2.5x2.0 M.

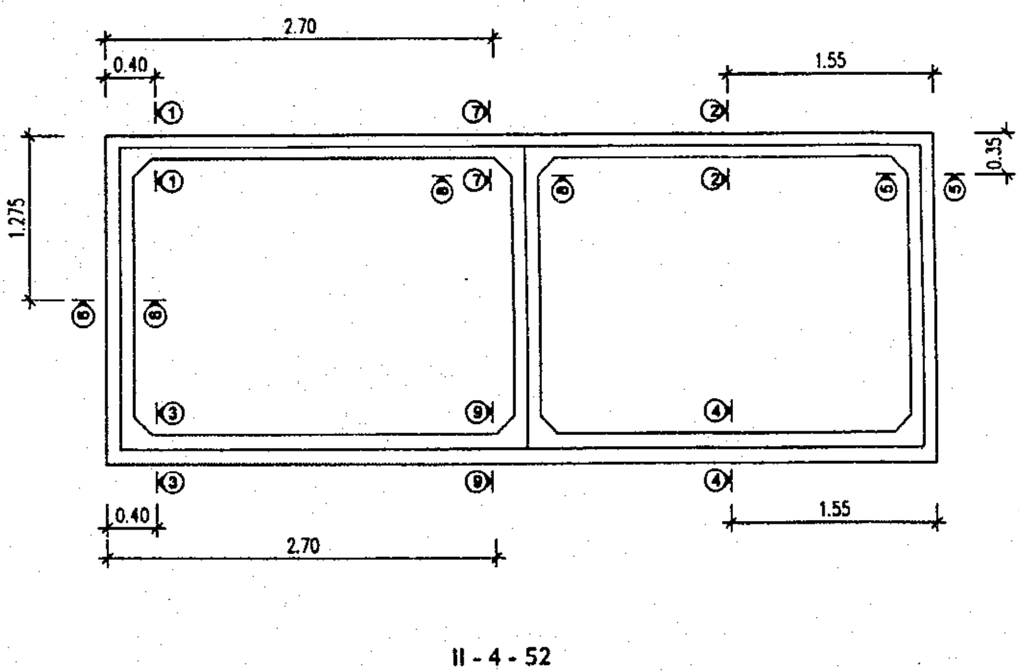
STATION KM 2+150

DOUBLE BOX CULVERT TYPE B12
(AT STATION 2+150)

12.1 GENERAL VIEW



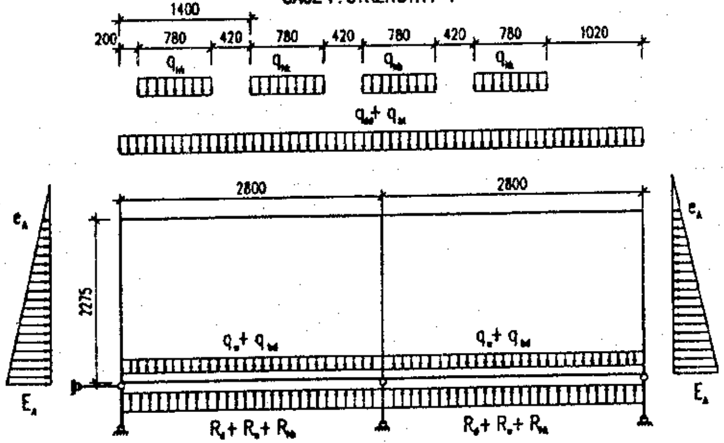
12.2 SECTIONS FOR CHEKING



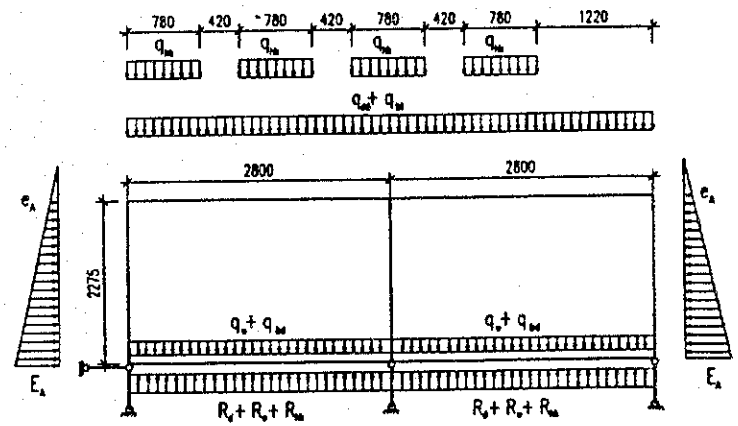
DOUBLE BOX CULVERT TYPE B12
(AT STATION 2+150)

12.3 CASES OF LOADINGS

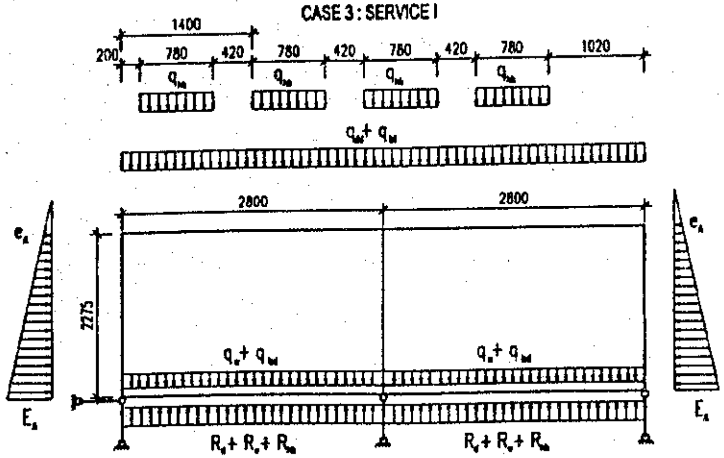
CASE 1 : STRENGTH I - 1



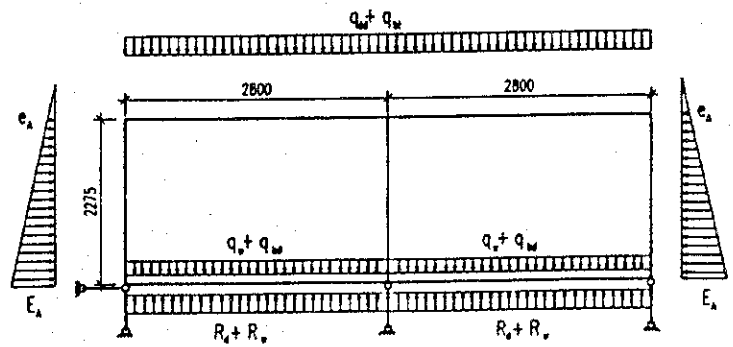
CASE 2 : STRENGTH I - 2



CASE 3 : SERVICE I



CASE 4 : SRTENGTH IV



12.4 Loading formulas

A	DIMENSION OF BOX AND COEFFICIENTS			
	The typical of box culvert	double		
	Thickness of filling layer above the top of box **H** (m)	0.50	Density of filling ground γ_H (T)	1.8
	Inside width of box **B_c** (m)	2.50	Density of water γ_w (T/m^3)	1
	Inside hight of box **H_c** (m)	2.00	Density of concrete γ_c (T/m^3)	2.5
	Thickness of top slab δ_t (m)	0.25	Internal friction angle φ_H	30
	Thickness of walls δ_w (m)	0.30	The coefficient of basement **S**	10
	Thickness of bottom slab δ_b (m)	0.30	The angle of "HK80" axle load (with **H** < 1m) φ_t	30
	Thickness of water level H_1 (m)	1.00	Half of single "HK80" axle load **P_{hk}** (T)	10

	Outside width of the box **D** (m)	$D = 2 \times B_c + 3 \times \delta_w$	=	2 x 2.5 + 3 x 0.3	=	5.90
	Outside hight of the box **h** (m)	$h = H_c + \delta_t + \delta_b$	=	2 + 0.25 + 0.3	=	2.55
	Calculating width of the box **D_{tt}** (m)	$D_{tt} = 2 \times B_c + 3 \times \delta_w$	=	2 x 2.5 + 3 x 0.3	=	5.60
	Calculating hight of the box **h_{tt}** (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	2 + 0.25/2 + 0.3 / 2	=	2.275
	The self weight of the box **P_b** (T)	$P_b = \gamma_c \times (H_c \times 3 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (2 x 3 x 0.3 + 5.9 x (0.25 + 0.3))	=	12.61
	Horizontal pressure coefficient μ	$\mu = tg^2 (45° - \varphi_H / 2)$	=	tg^2 (45° - 30°)	=	0.333
	Coefficient **A**	$A = H / D$	=	0.5 / 5.9	=	0.085
	Coefficient **C**	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.085 x 0.333 x tg 30°	=	1.016
	a_1 (m)	$a_1 = 0.2 + 2 \times H \times tg\ \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
	b_1 (m)	$b_1 = 0.8 + 2 \times H \times tg\ \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
	Total width of "HK80" uniform load **W** (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38
B	**DEAD LOADS (without load factors)**					
	The load of above filling layer **q_{dd}** (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.016 x 1.8 x 0.5	=	0.915
	The max value of horizontal pressure **E_A** (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 2.55 - 0.3 / 2	=	1.665
	The min value of horizontal pressure **e_A** (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.25 / 2)	=	0.375
	The self weight uniform load of top slab **q_{bt}** (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.3	=	0.625
	The self weight uniform load of bottom slab **q_{bd}** (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.30	=	0.750
	Basement reaction of self weight loads **R_{d1}** (T/m)	$R_{d1} = P_b / D$	=	(12.6125 / 5.9	=	2.138
	Basement reaction of ground loads **R_{d2}** (T/m)	$R_{d2} = q_{dd}$	=		=	0.915
	Basement reaction of dead loads **R_d** (T/m)	$R_d = R_{d1} + R_{d2}$	=	2.138 + 0.915	=	3.052
C	**WATER LOADS (without load factors)**					
	The self weight uniform load of water **q_w** (T/m)	$q_w = H_1 \times \gamma_w$	=	1 x 1	=	1.000
	Basement reaction of water load **R_w** (T/m)	$R_w = q_w \times 2 \times B_c / D$	=	1 x 2 x 2.5 / 5.9	=	0.847
D	**LIVE LOADS (without load factors)**					
	The uniform load of "HK80" axle **q_{hk}** (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
	Basement reaction of "HK80" load **R_{hk}** (T/m)	$R_{hk} = 4 \times q_{hk} \times a_1 / D$	=	4 x 9.34 x 0.78 / 5.9	=	4.922

12.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	forcers	load factor	forcers	load factor	forcers
	DEAD LOADS						
1	The load of outside filling layer q_{dd} (T/m)	1.0	**0.915**	1.25	**1.143**	1.25	**1.143**
2	The max value of horizontal pressure E_A (T/m)	1.0	**1.665**	1.25	**2.081**	1.25	**2.081**
3	The min value of horizontal pressure e_A (T/m)	1.0	**0.375**	1.25	**0.469**	1.25	**0.469**
4	The self weight uniform load of top slab q_{bt} (T/m)	1.0	**0.625**	1.25	**0.781**	1.50	**0.938**
5	The self weight uniform load of bottom slab q_{bd} (T/m)	1.0	**0.750**	1.25	**0.938**	1.50	**1.125**
6	Basement reaction of self weight loads R_{d1} (T/m)	1.0	**2.138**	1.25	**2.672**	1.50	**3.207**
7	Basement reaction of ground loads R_{d2} (T/m)	1.0	**0.915**	1.25	**1.143**	1.25	**1.143**
8	Basement reaction of dead loads R_d (T/m)		**3.052**		**3.815**		**4.350**
	WATER LOADS						
9	The self weight uniform load of water q_w (T/m)	1.0	**1.000**	1	**1.000**	1.25	**1.250**
10	Basement reaction of water load R_w (T/m)	1.0	**0.847**	1	**0.847**	1.25	**1.059**
	LIVE LOADS						
11	The uniform load of "HK80" axle q_{hk} (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
12	Basement reaction of "HK80" load R_{hk} (T/m)	1.0	**4.922**	1.75	**8.614**	0	**0**

12.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6	Sec.7-7	Sec.9-9
	Case of loading		case 1	case 2	case 2	case 2	case 1	case 1	case 1	case 1
H	Depth of slab	(mm)	250	250	300	300	300	300	250	300
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	2036	2036	2036	2036	1822	1608	2275	2275
A's	Area of Compression Reinforcement	(mm2)	2036	905	905	905	1608	905	905	905
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24	24	24
β1	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	125.0	125.0	150.0	150.0	150.0	150.0	125.0	150.0
a	Depth of the Equivalent Stress Block	(mm)	109.8	109.8	131.8	131.8	131.8	131.8	109.8	131.8
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	200	200	250	250	250	250	200	250
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	12	12	15	15	14	12	13	17
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	11	11	14	14	13	11	12	15
	Factored Bending Moment Max.	(Tfm)	5.011	5.293	3.030	5.143	5.011	3.218	9.563	9.909
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK	OK	OK

12.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5	Sec.7-7	Sec.9-9
Case of loading		case 1	case 2	case 1	case 1	case 1
Section	Effective web bv (mm)	1000	1000	1000	1000	1000
Properties	Depth (mm)	250	300	300	250	300
	Effective depth dv (mm)	180	216	216	180	216
Factored Bending Moment Max Mu (Tfm)		5.011	3.030	5.011	9.563	9.909
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00	0.00	0.00
Factored Axial Force Nu (Tf)		15.84	0.93	2.05	2.05	1.41
Factored Shear Force Vu (Tf)		2.05	13.63	15.84	18.31	18.41
Design Shear Force Vu-f*Vp(Tf)		2.05	13.63	15.84	18.31	18.41
Shear Stress v (Mpa)		0.124	0.688	0.799	1.109	0.929
Concrete Strength f'c (Mpa)		24	24	24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000	390.000	390.000
Ratio of v/f'c		5E-03	3E-02	3E-02	5E-02	4E-02
As (mm2)		4072	2941	3431	3179	3179
Ac (m2)		0.400	0.450	0.450	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Angle θ		28.9	28.8	29.7	36.3	35.1
Cot(θ)		1.812	1.821	1.753	1.362	1.424
εx (Max)		4.53E-04	4.49E-04	5.45E-04	1.03E-03	9.21E-04
εx (Min)		1.18E-04	2.15E-04	2.13E-04	2.08E-04	2.13E-04
Value of θ		28.9	28.9	29.7	36.3	35.1
		27	28	28	28	28
Value of β		2.6937	2.7108	2.4849	2.2144	2.2743
		4.0415	3.6309	3.6374	3.6573	3.6376
Component of Shear Resistance Vc (Tf)		20	24	22	17	20
Spacing of Stirrups s (mm)		250	250	250	250	250
Stirrup Diameter (mm)		0	0	0	12	0
Area of Stirrups Av (mm2)		0	0	0	452	0
Angle of Inclination α		90	90	90	90	90
Component of Shear Resistance Vs (Tf)		0	0	0	18	0
Nominal Shear Resistance						
Vn1 = Vc + Vs + Vp (Tf)		20	24	22	34	20
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		110	132	132	110	132
Check (Min. Vn1,2 > Vu)		OK	OK	OK	OK	OK

DESIGN CALCULATION OF CULVERTS

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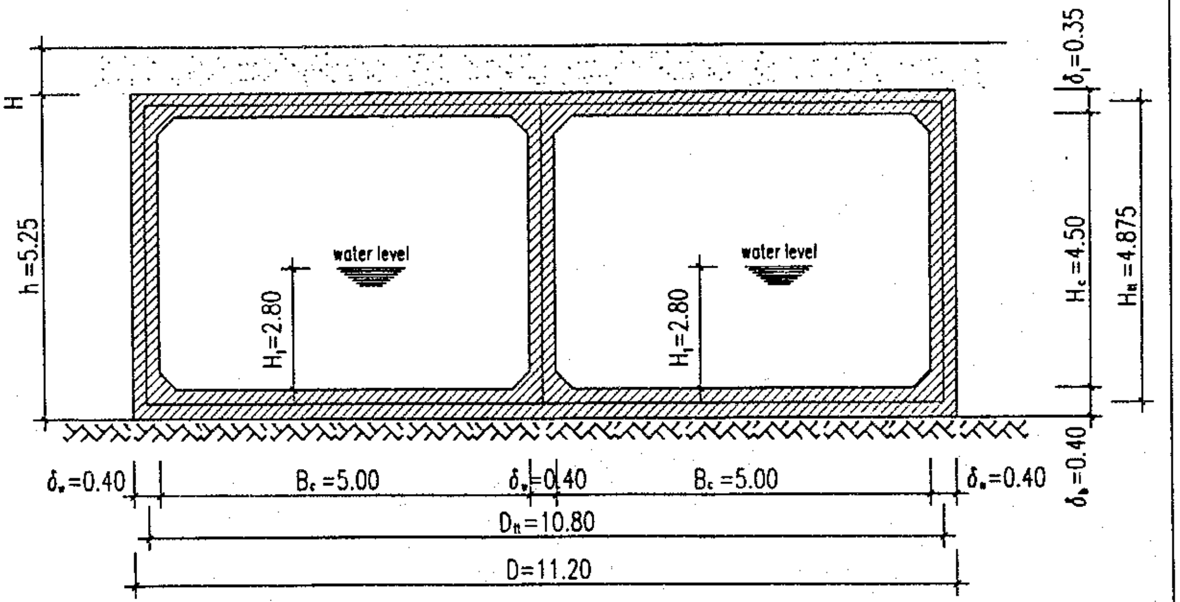
CULVERT TYPE B14

DOUBLE BOX CULVERT DIMENSION 2x5.0x4.5 M.

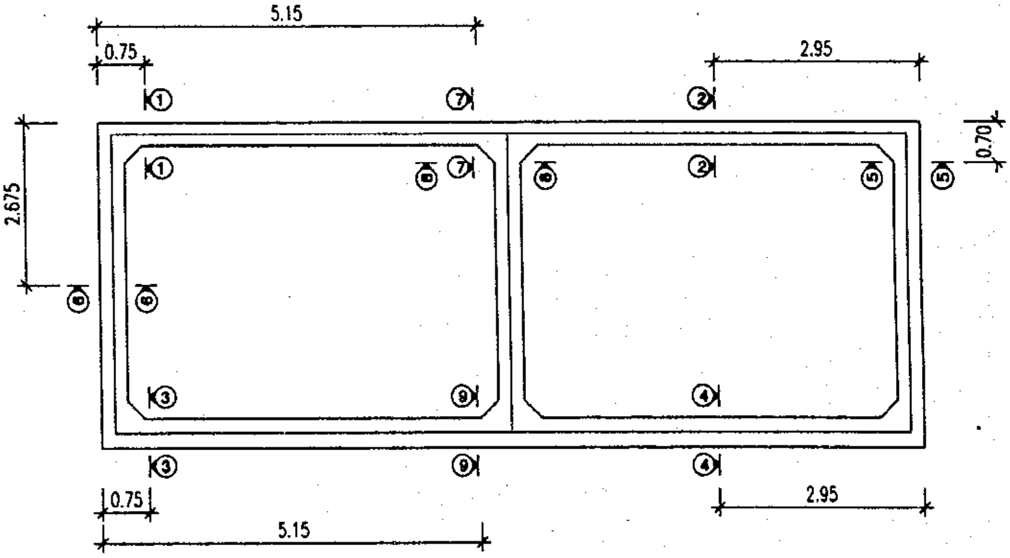
STATION KM 4+318

DOUBLE BOX CULVERT TYPE B14
(AT STATION 4+318)

14.1 GENERAL VIEW

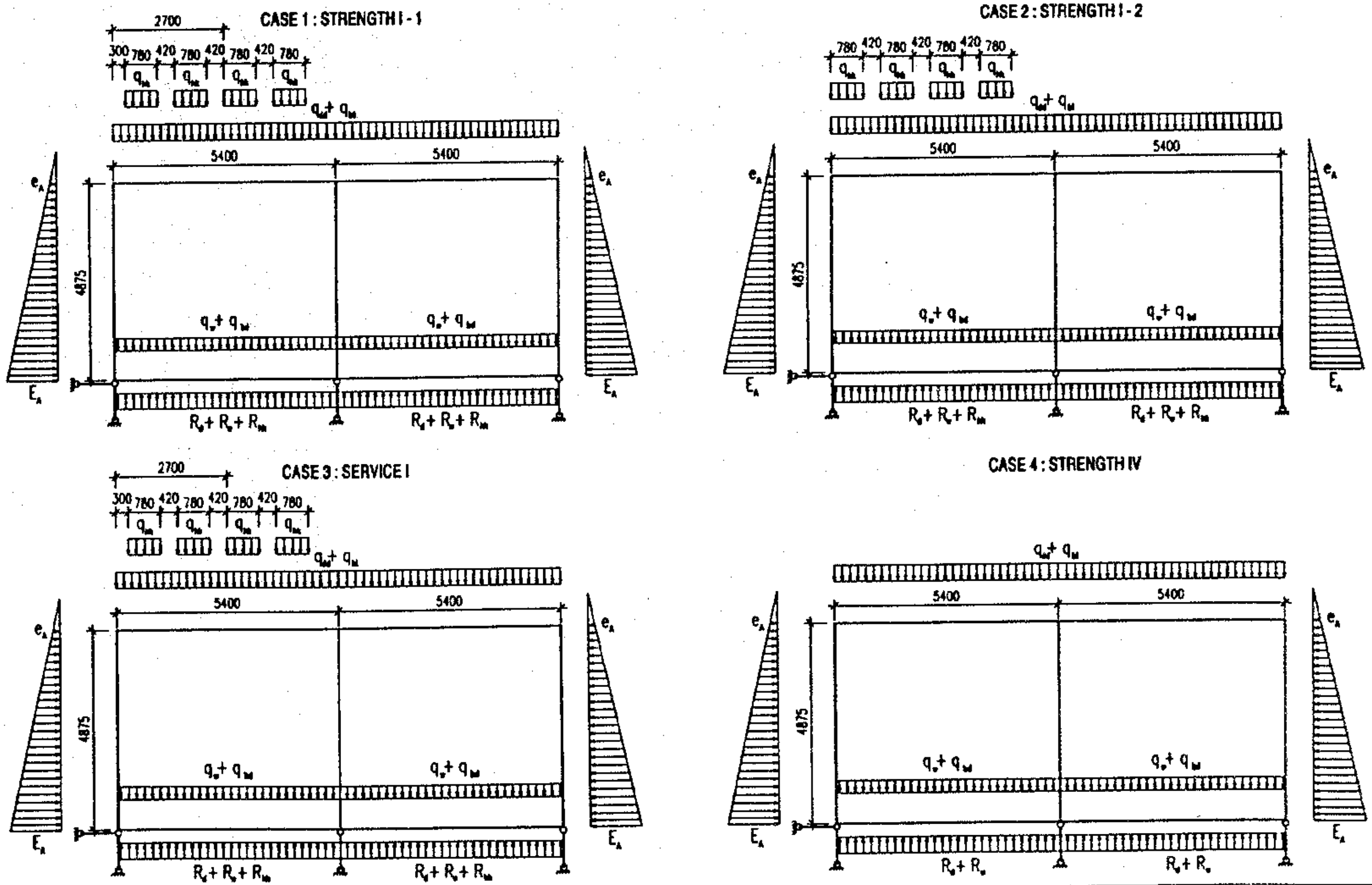


14.2 SECTIONS FOR CHEKING



DOUBLE BOX CULVERT TYPE B14
(AT STATION 4+318)

14.3 CASES OF LOADINGS



14.4 Loading formulas

A	**DIMENSION OF BOX AND COEFFICIENTS**					
	The typical of box culvert	double				
	Thickness of filling layer above the top of box **H** (m)	0.50		Density of filling ground γ_H (T)		1.8
	Inside width of box B_c (m)	5.00		Density of water γ_w (T/m^3)		1
	Inside hight of box H_c (m)	4.50		Density of concrete γ_c (T/m^3)		2.5
	Thickness of top slab δ_t (m)	0.35		Internal friction angle φ_H		30
	Thickness of walls δ_w (m)	0.40		The coefficient of basement **S**		10
	Thickness of bottom slab δ_b (m)	0.40		The angle of "HK80" axle load (with **H** < 1m) φ_t		30
	Thickness of water level H_1 (m)	2.80		Half of single "HK80" axle load P_{hk} (T)		10
	Outside width of the box **D** (m)	$D = 2 \times B_c + 3 \times \delta_w$	=	2 x 5 + 3 x 0.4	=	11.20
	Outside hight of the box **h** (m)	$h = H_c + \delta_t + \delta_b$	=	4.5 + 0.35 + 0.4	=	5.25
	Calculating width of the box D_{tt} (m)	$D_{tt} = 2 \times B_c + 3 \times \delta_w$	=	2 x 5 + 3 x 0.4	=	10.80
	Calculating hight of the box h_{tt} (m)	$h_{tt} = H_c + \delta_t / 2 + \delta_b / 2$	=	4.5 + 0.35/2 + 0.4 / 2	=	4.875
	The self weight of the box P_b (T)	$P_b = \gamma_c \times (H_c \times 3 \times \delta_w + D \times (\delta_t + \delta_b))$	=	2.5 x (4.5 x 3 x 0.4 + 11.2 x(0.35 + 0.4))	=	34.50
	Horizontal pressure coefficient μ	$\mu = tg^2 (45° - \varphi_H / 2)$	=	tg^2 (45° - 30°)	=	0.333
	Coefficient **A**	$A = H / D$	=	0.5 / 11.2	=	0.045
	Coefficient **C**	$C = 1 + A \times \mu \times tg\varphi_H$	=	1 + 0.045 x 0.333 x tg 30°	=	1.009
	a_1 (m)	$a_1 = 0.2 + 2 \times H \times tg\, \varphi_t$	=	0.2 + 2 x 0.5 x tg 30°	=	0.78
	b_1 (m)	$b_1 = 0.8 + 2 \times H \times tg\, \varphi_t$	=	0.8 + 2 x 0.5 x tg 30°	=	1.38
	Total width of "HK80" uniform load **W** (m)	$W = 3 \times 1.2 + a_1$	=	3 x 1.2 + 0.78	=	4.38
B	**DEAD LOADS (without load factors)**					
	The load of above filling layer q_{dd} (T/m)	$q_{dd} = C \times \gamma_H \times H$	=	1.009 x 1.8 x 0.5	=	0.908
	The max value of horizontal pressure E_A (T/m)	$E_A = \mu \times \gamma_H \times (H + h - \delta_b / 2)$	=	0.333 x 1.8 x (0.5 + 5.25 - 0.4 / 2	=	3.225
	The min value of horizontal pressure e_A (T/m)	$e_A = \mu \times \gamma_H \times (H + \delta_t / 2)$	=	0.333 x 1.8 x (0.5 + 0.35 / 2)	=	0.405
	The self weight uniform load of top slab q_{bt} (T/m)	$q_{bt} = \gamma_b \times \delta_t$	=	2.5 x 0.4	=	0.875
	The self weight uniform load of bottom slab q_{bd} (T/m)	$q_{bd} = \gamma_b \times \delta_b$	=	2.5 x 0.40	=	1.000
	Basement reaction of self weight loads R_{d1} (T/m)	$R_{d1} = P_b / D$	=	(34.5 / 11.2	=	3.080
	Basement reaction of ground loads R_{d2} (T/m)	$R_{d2} = q_{dd}$	=		=	0.908
	Basement reaction of dead loads R_d (T/m)	$R_d = R_{d1} + R_{d2}$	=	3.08 + 0.908	=	3.988
C	**WATER LOADS (without load factors)**					
	The self weight uniform load of water q_w (T/m)	$q_w = H_1 \times \gamma_w$	=	2.8 x 1	=	2.800
	Basement reaction of water load R_w (T/m)	$R_w = q_w \times 2 \times B_c / D$	=	2.8 x 2 x 5 / 11.2	=	2.500
D	**LIVE LOADS (without load factors)**					
	The uniform load of "HK80" axle q_{hk} (T/m^2)	$q_{hk} = P_{hk} / (a_1 \times b_1)$	=	10 / (0.78 x 1.38)	=	9.340
	Basement reaction of "HK80" load R_{hk} (T/m)	$R_{hk} = 4 \times q_{hk} \times a_1 / D$	=	4 x 9.34 x 0.78 / 11.2	=	2.593

14.5 Loading combinations

STT	TYPE OF LOADINGS	SERVICE I		STRENGTH I		STRENGTH IV	
		load factor	forcers	load factor	forcers	load factor	forcers
	DEAD LOADS						
1	The load of outside filling layer $\mathbf{q_{dd}}$ (T/m)	1.0	**0.908**	1.25	**1.135**	1.25	**1.135**
3	The max value of horizontal pressure $\mathbf{E_A}$ (T/m)	1.0	**3.225**	1.25	**4.031**	1.25	**4.031**
4	The min value of horizontal pressure $\mathbf{e_A}$ (T/m)	1.0	**0.405**	1.25	**0.506**	1.25	**0.506**
6	The self weight uniform load of top slab $\mathbf{q_{bt}}$ (T/m)	1.0	**0.875**	1.25	**1.094**	1.50	**1.313**
7	The self weight uniform load of bottom slab $\mathbf{q_{bd}}$ (T/m)	1.0	**1.000**	1.25	**1.250**	1.50	**1.500**
8	Basement reaction of self weight loads $\mathbf{R_{d1}}$ (T/m)	1.0	3.080	1.25	3.850	1.50	4.621
9	Basement reaction of ground loads $\mathbf{R_{d2}}$ (T/m)	1.0	0.908	1.25	1.135	1.25	1.135
10	Basement reaction of dead loads $\mathbf{R_d}$ (T/m)		**3.988**		**4.985**		**5.755**
	WATER LOADS						
11	The self weight uniform load of water $\mathbf{q_w}$ (T/m)	1.0	**2.800**	1	**2.800**	1.25	**3.500**
12	Basement reaction of water load $\mathbf{R_w}$ (T/m)	1.0	**2.500**	1	**2.500**	1.25	**3.125**
	LIVE LOADS						
13	The uniform load of "HK80" axle $\mathbf{q_{hk}}$ (T/m^2)	1.0	**9.340**	1.75	**16.345**	0	**0**
16	Basement reaction of "HK80" load $\mathbf{R_{hk}}$ (T/m)	1.0	**2.593**	1.75	**4.538**	0	**0**

14.6 Checking for Nominal Moment resistance

		Unit	Sec. 1-1	Sec. 2-2	Sec.3-3	Sec.4-4	Sec.5-5	Sec.6-6	Sec.7-7	Sec.9-9
	Case of loading		case 1	case 2	case 1	case 1	case 1	case 1	case 1	case 1
H	Depth of slab	(mm)	350	350	400	400	400	400	350	400
b	Width of slab	(mm)	1000	1000	1000	1000	1000	1000	1000	1000
As	Area of Tensile Reinforcement	(mm2)	2827	2827	2827	2827	2827	2827	4072	4072
A's	Area of Compression Reinforcement	(mm2)	2513	905	2513	905	1608	1608	2513	2513
fy	Yeild Strength of Tensile Rein.	(Mpa)	390	390	390	390	390	390	390	390
f'y	Yeild Strength of Compression Rein.	(Mpa)	390	390	390	390	390	390	390	390
f'c	Strength of Concrete	(Mpa)	24	24	24	24	24	24	24	24
β_1	Stress block factor		0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
c	Distance between the neutral axis and the compression face	(mm)	175.0	175.0	200.0	200.0	200.0	200.0	175.0	200.0
a	Depth of the Equivalent Stress Block	(mm)	153.8	153.8	175.7	175.7	175.7	175.7	153.8	175.7
ds	Distance from extreme compression fiber to the centroid of tensile rein.	(mm)	300	300	350	350	350	350	300	350
d's	Distance from extreme compression fiber to the centroid of compression rein.	(mm)	50	50	50	50	50	50	50	50
Mn	Nominal Resistance	(Tfm)	28	26	33	31	32	32	39	46
ϕ	Resistance factor		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Mr	Factored Resistance	(Tfm)	25	23	30	28	29	29	35	42
	Factored Bending Moment Max.	(Tfm)	20.344	21.769	10.555	14.259	20.344	8.172	29.021	26.902
	Check Mr > [Mu]		OK	OK	OK	OK	OK	OK	OK	OK

14.7 Checking for Nominal Shear resistance

Section No		Sec. 1-1	Sec.3-3	Sec.5-5
Case of loading		case 1	case 1	case 1
Section	Effective web bv (mm)	1000	1000	1000
Properties	Depth (mm)	350	400	400
	Effective depth dv (mm)	252	288	288
Factored Bending Moment Max Mu (Tfm)		20.344	10.555	20.344
Factored Bending Moment Min Mu (Tfm)		0.00	0.00	0.00
Factored Axial Force Nu (Tf)		6.48	8.77	31.89
Factored Shear Force Vu (Tf)		31.89	18.50	6.48
Design Shear Force Vu-f*Vp(Tf)		31.89	18.50	6.48
Shear Stress v (Mpa)		1.379	0.700	0.245
Concrete Strength f'c (Mpa)		24	24	24
Yeild Strength of Transverse Bars(Mpa)		390.000	390.000	390.000
Ratio of v/f'c		6E-02	3E-02	1E-02
As (mm2)		5341	5341	4436
Ac (m2)		0.400	0.450	0.450
Ec (Mpa)		2.94E+04	2.94E+04	2.94E+04
Es (Mpa)		2.00E+05	2.00E+05	2.00E+05
Fe		1.00E+00	1.00E+00	1.00E+00
Angle θ		35.7	29.4	36.1
Cot(θ)		1.390	1.772	1.373
εx (Max)		9.75E-04	5.27E-04	1.01E-03
εx (Min)		2.33E-04	1.91E-04	2.26E-04
Value of θ		35.7	29.4	36.1
		28	28	28
Value of β		2.2241	2.4946	2.2263
		3.4188	3.7267	3.5880
Component of Shear Resistance Vc (Tf)		23	30	27
Spacing of Stirrups s (mm)		250	250	250
Stirrup Diameter (mm)		12	0	0
Area of Stirrups Av (mm2)		452	0	0
Angle of Inclination α		90	90	90
Component of Shear Resistance Vs (Tf)		25	0	0
Nominal Shear Resistance				
Vn1 = Vc + Vs + Vp (Tf)		48	30	27
Vn2 = 0.25*f'c* bv* dv + Vp (Tf)		154	176	176
Check (Min. Vn1,2 > Vu)		OK	OK	OK

4.2 *WING WALL*

(1) *WING WALL, TYPE W1*

DESIGN CALCULATION OF CULVERTS

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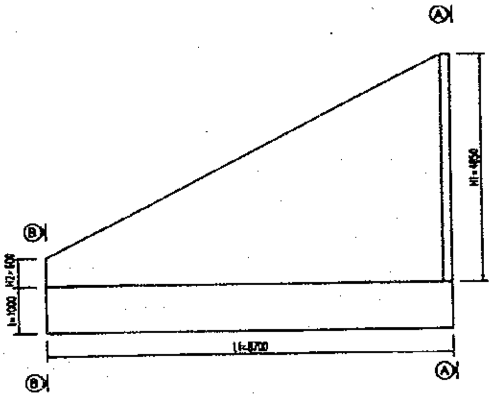
WING WALL TYPE W1

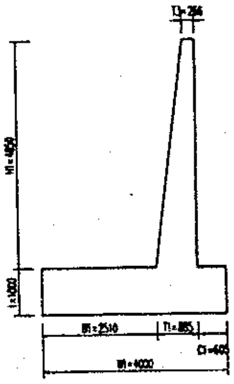
AT STATION 4+318

GENERAL VIEW OF WING WALL TYPE W1
(STATION 4+318)

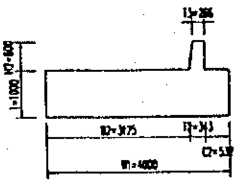
ELEVATION



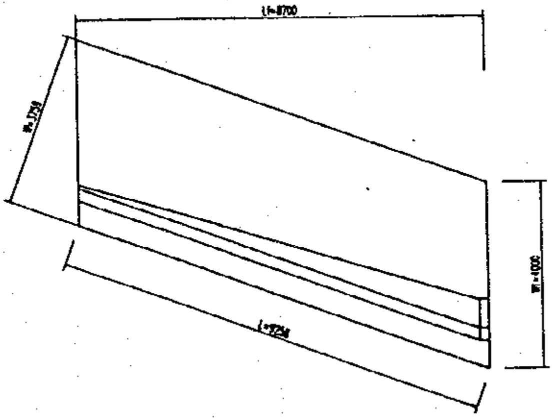
A - A



B - B



PLAN



NOTES :

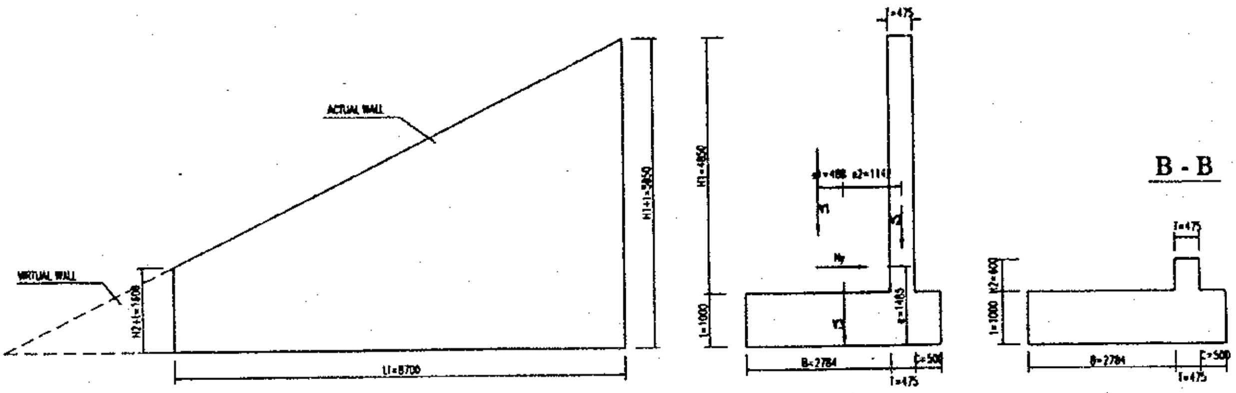
1- ALL DIMENSIONS ARE IN MILIMETER.

WING WALL TYPE W1
(STATION 4+318)
MODELLING FOR CALCULATION

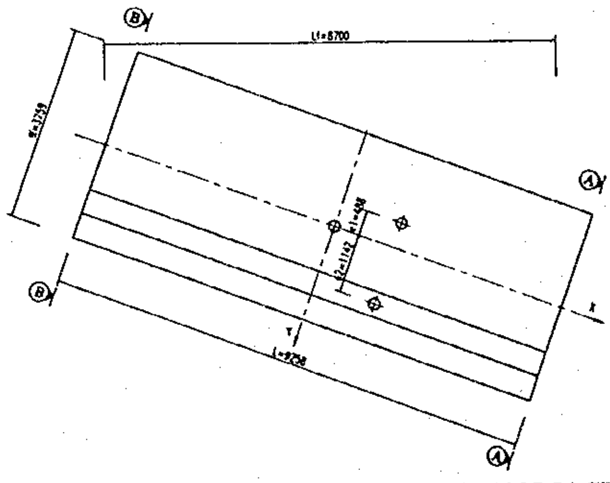
ELEVATION

A - A

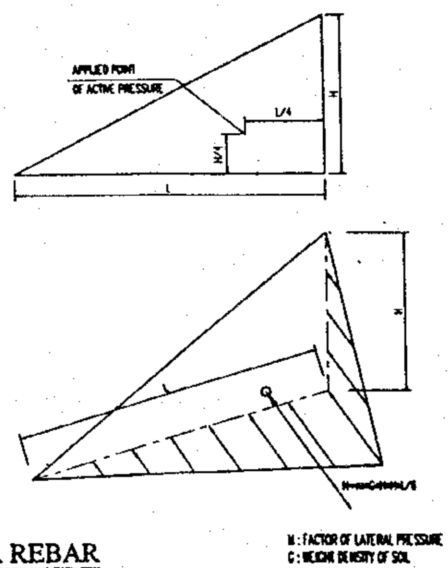
B - B



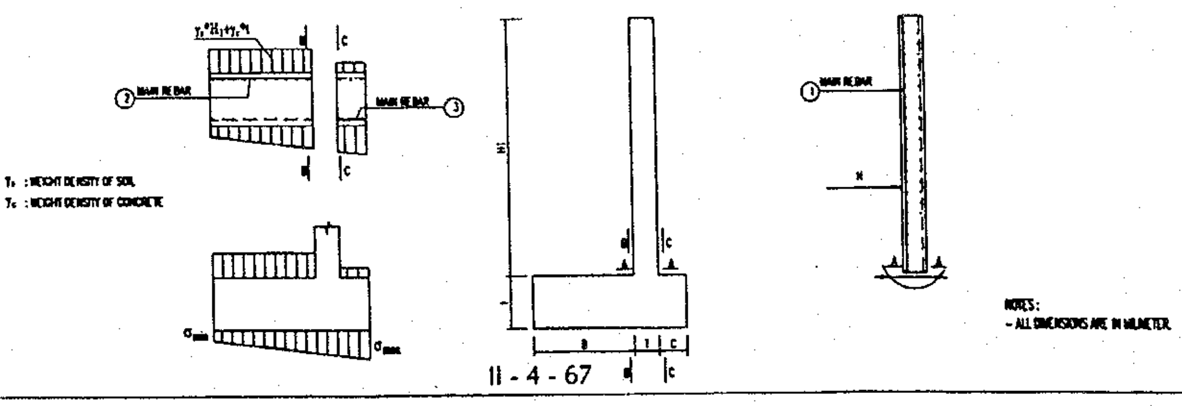
PLAN



VALUE & POSITION OF ACTIVE PRESS.



CALCULATION DIAGRAM FOR REBAR



WING WALL TYPE W1 - STATION KM 4+318

(Unit : T,m)

FORCE COMPONENTS		V	H_y		M_x
Active pressure					
Maxixmum height of wall, H_1	4.850		H_y	e	$M_{x0}=H_y e$
Minimum height of wall, H_2	0.600	Entire wall	43.57	1.463	63.72
Length of actual wall, L	9.258	Virtual wall	0.89	0.400	0.36
Factor for lateral pressure, μ	0.333	Actual wall	42.68	1.485	63.36
Weight density of soil, γ	1.800				
Footing thickness, t	1.000				
Length of virtual wall, $X=L*(H_2+t)/(H_1-H_2)$	3.485				
Length of entire wall, $L_e=X+L$	12.743				
Weight of soil		V_1		e_1	$M_{x1}=V_1 e_1$
Equivalent width of heel, B	2.784	126.41		-0.488	-61.64
Weight of wall		V_2		e_2	$M_{x2}=V_2 e_2$
Equivalent thickness of wall, T	0.475	29.97		1.142	34.22
Weight of footing		V_3		e_3	$M_{x3}=V_3 e_3$
Equivalent width of footing, W	3.759	87.00		0.000	0.00

LOAD COMBINATIONS	Load factor	V	H_y		M_x
Combination 1					
Active pressure	1.250		42.68		63.36
Weight of soil	1.250	126.41			-61.64
Weight of wall	1.000	29.97			34.22
Weight of footing	1.000	87.00			0.00
Total		**274.98**	**53.35**		**36.38**
Combination 2					
Active pressure	1.250		42.68		63.36
Weight of soil	1.250	126.41			-61.64
Weight of wall	1.500	29.97			34.22
Weight of footing	1.500	87.00			0.00
Total		**333.47**	**53.35**		**53.49**

CHECKING STABILITY & SOIL STRESSES			
Area of footing, F=W*L	34.80		
Moment of inertia about X-axis, $I_x=L*W^3/12$	40.98		
Soil friction coefficient, f	0.4		
Allowable soil pressure, {σ}	13		
	Load combination 1	Load combination 2	
Factor of safety (sliding), $k=V*f/H_y$	**2.06**	**2.50**	O.K!
Factor of safety (overturning), $k=(V*W/2)/M_x$	**14.21**	**11.72**	O.K!
Maximum soil stress, $\sigma max=V/F+M_x/(I_x/(W/2))$	**9.57**	**12.04**	O.K!
Minimum soil stress, $\sigma min=V/F-M_x/(I_x/(W/2))$	**6.23**	**7.13**	O.K!

CHECKING FLEXURAL RESISTANCE (for more details, see next page)	Mmax (Tm/m)	Designed flexural resistance, M_r (Tm/m)	
For wing wall (Section A-A)	14.25	**20.94**	O.K!
For footing heel (Section B-B)	9.81	**21.28**	O.K!

CHECKING FLEXURAL RESISTANCE (for 1m-long wall) - TYPE W1					
				(Unit : T,m)	
		V	H_y	e	M_x=H_ye
Force components					
Height of wall, H	4.850				
Length of wall, L	1.000		7.05	1.617	11.40
Factor for lateral pressure, μ	0.333				
Weight density of soil, γ	1.800				
Wall thickness, T	0.475				
Width of heel, B	2.784				
Width of footing, W	3.759				
Footing thickness, t	1.000				
Load factor for concrete, n_C	1.5				
Load factor for soil, n_S	1.25				
Weight of soil		24.30		-0.488	-11.85
Weight of wall		5.762		1.142	6.58
Weight of footing		9.397		0.000	0.00
Total (factored)		**53.12**	**8.81**		**9.30**
Soil stresses					
Maximum soil stress, σ_{max}		18.08			
Minimum soil stress, σ_{min}		10.18			
Maximum moments					
At section A-A of wall, M_{A-A}		14.25			
At section B-B of footing, $M_{B-B}=M_w-M_s$		**9.81**			
Moment due to soil and footing weight, M_w		56.81			
Moment due to soil reaction, M_s		47.00			
Calculation of flexural resistance		Section A-A	Section B-B	Unit	
Rebar area in tension	A_s	1527	678.6	mm2	
Yield strength of rebar	f_y	390	390	MPa	
28-day compressive strength of concrete	f'_c	24	24	MPa	
Width of section	b	1000	1000	mm	
Coefficient	β	0.85	0.85	none	
Distance from extreme compression fiber to the centroid of tensile rebar	d_s	405	900	mm	
Distance between the neutral axis and the compression face	c	34.34	15.26	mm	
Depth of the equivalent stress block	a	29.19	12.97	mm	
Nominal resistance	M_n	232629087	236471891	Nmm	
Factored resistance	M_r	**209366178**	**212824702**	Nmm	

DESIGN CALCULATION OF CULVERTS

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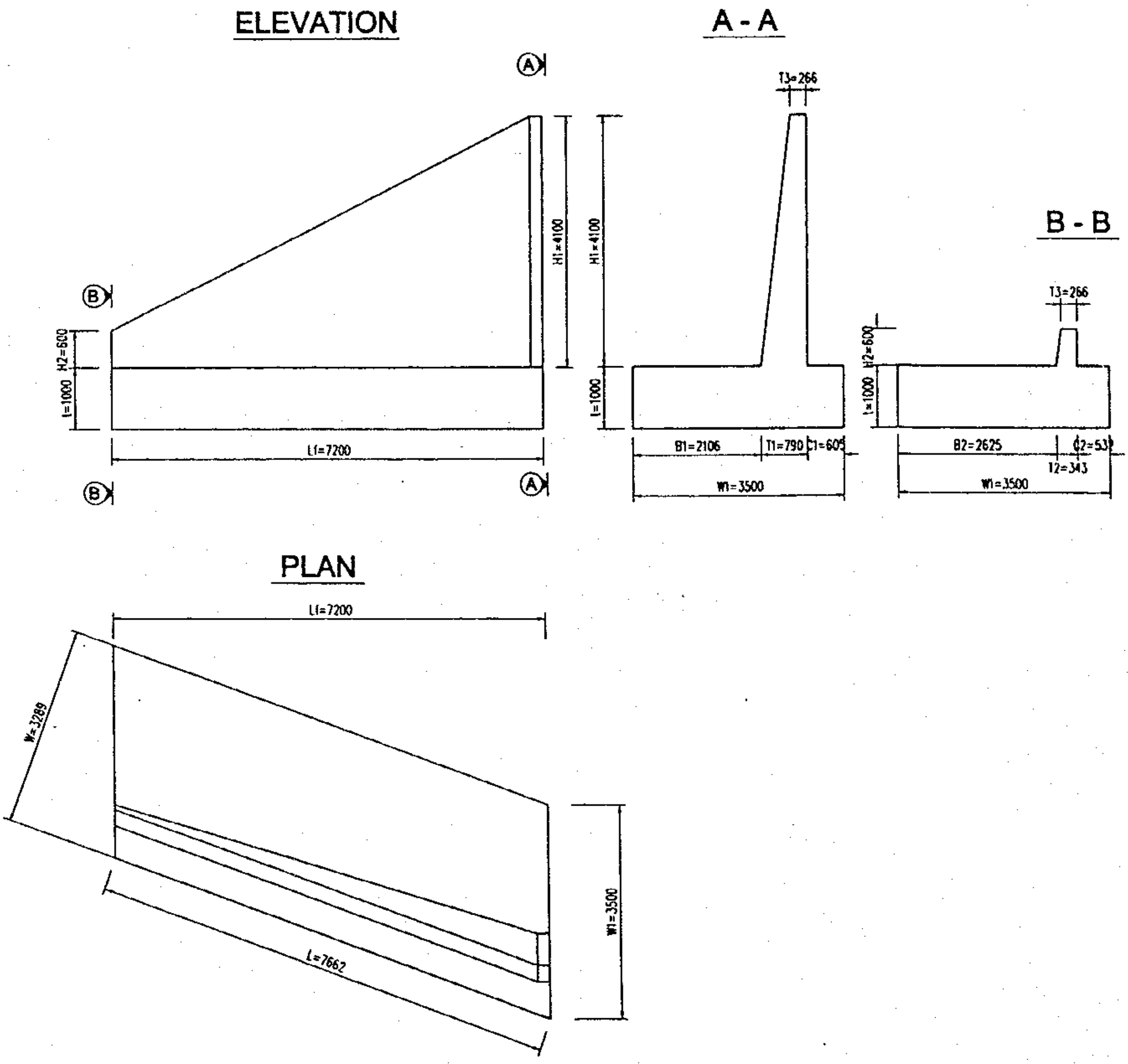
WING WALL TYPE W2

AT STATION 7+820

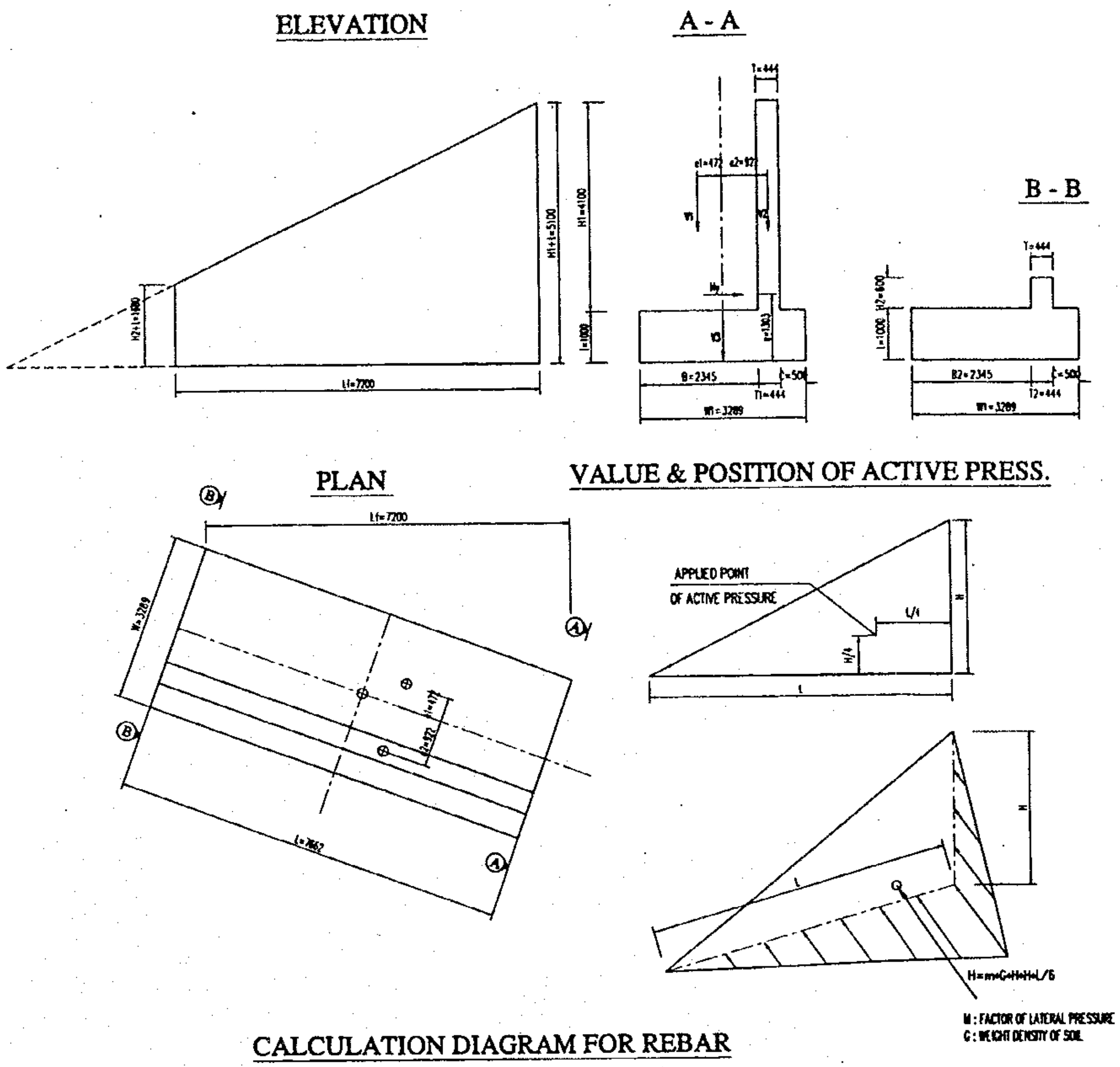
GENERAL VIEW OF WING WALL TYPE W2
(STATION 7+820)



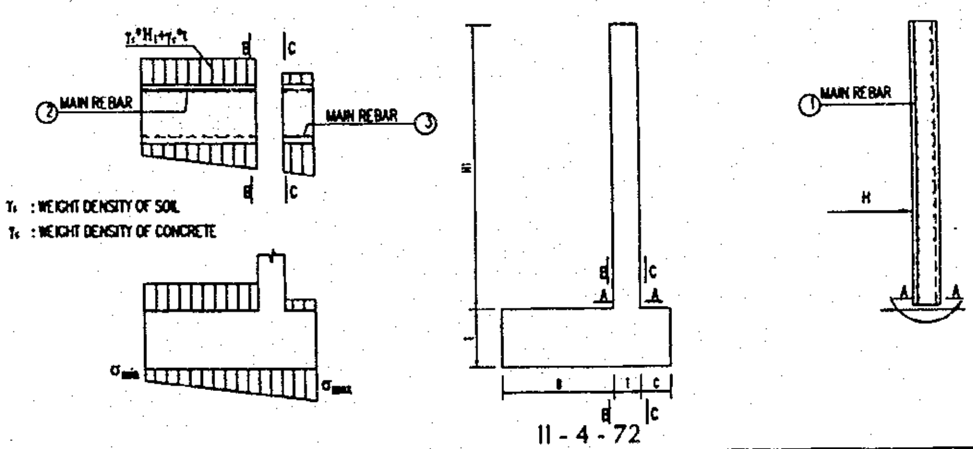
NOTES :

- ALL DIMENSIONS ARE IN MILIMETER.

WING WALL TYPE W2
(STATION 7+820)
MODELLING FOR CALCULATION



CALCULATION DIAGRAM FOR REBAR



NOTES :
- ALL DIMENSIONS ARE IN MILIMETER.

WING WALL TYPE W2 - STATION KM 7+820

(Unit : T,m)

FORCE COMPONENTS		V	H_y		M_x
Active pressure					
Maxixmum height of wall, H_1	4.100		H_y	e	$M_{x0}=H_y e$
Minimum height of wall, H_2	0.600	Entire wall	29.01	1.275	36.99
Length of actual wall, L	7.662	Virtual wall	0.90	0.400	0.36
Factor for lateral pressure, μ	0.333	Actual wall	28.11	1.303	36.63
Weight density of soil, γ	1.800				
Footing thickness, t	1.000				
Length of virtual wall, $X=L*(H_2+t)/(H_1-H_2)$	3.503				
Length of entire wall, $L_e=X+L$	11.165				
Weight of soil		V_1		e_1	$M_{x1}=V_1 e_1$
Equivalent width of heel, B	2.345	76.00		-0.472	-35.87
Weight of wall		V_2		e_2	$M_{x2}=V_2 e_2$
Equivalent thickness of wall, T	0.444	19.99		0.922	18.44
Weight of footing		V_3		e_3	$M_{x3}=V_3 e_3$
Equivalent width of footing, W	3.289	63.00		0.000	0.00
LOAD COMBINATIONS					
	Load factor	V	H_y		M_x
Combination 1					
Active pressure	1.250		28.11		36.63
Weight of soil	1.250	76.00			-35.87
Weight of wall	1.000	19.99			18.44
Weight of footing	1.000	63.00			0.00
Total		**177.99**	**35.14**		**19.38**
Combination 2					
Active pressure	1.250		28.11		36.63
Weight of soil	1.250	76.00			-35.87
Weight of wall	1.500	19.99			18.44
Weight of footing	1.500	63.00			0.00
Total		**219.48**	**35.14**		**28.60**
CHECKING STABILITY & SOIL STRESSES					
Area of footing, F=W*L	25.20				
Moment of inertia about X-axis, $I_x=L*W^3/12$	22.72				
Soil friction coefficient, f	0.4				
Allowable soil pressure, [σ]	13				
	Load combination 1		Load combination 2		
Factor of safety (sliding), $k=V*f/H_y$	**2.03**		**2.50**		O.K!
Factor of safety (overturning), $k=(V*W/2)/M_x$	**15.10**		**12.62**		O.K!
Maximum soil stress, $\sigma max=V/F+M_x/(I_x/(W/2))$	**8.47**		**10.78**		O.K!
Minimum soil stress, $\sigma min=V/F-M_x/(I_x/(W/2))$	**5.66**		**6.64**		O.K!
CHECKING FLEXURAL RESISTANCE	Mmax	Designed flexural resistance, M_r			
(for more details, see next page)	(Tm/m)	(Tm/m)			
For wing wall (Section A-A)	8.61	**15.34**	O.K!		
For footing heel (Section B-B)	5.33	**21.28**	O.K!		

CHECKING FLEXURAL RESISTANCE (for 1m-long wall) - TYPE W2					
				(Unit : T,m)	
		V	H_y	e	$M_x=H_ye$
Force components					
Height of wall, H	4.100				
Length of wall, L	1.000		5.04	1.367	6.89
Factor for lateral pressure, μ	0.333				
Weight density of soil, γ	1.800				
Wall thickness, T	0.444				
Width of heel, B	2.345				
Width of footing, W	3.289				
Footing thickness, t	1.000				
Load factor for concrete, n_C	1.5				
Load factor for soil, n_S	1.25				
Weight of soil		17.31		-0.472	-8.17
Weight of wall		4.551		0.922	4.20
Weight of footing		8.222		0.000	0.00
Total (factored)		**40.79**	**6.30**		**4.69**
Soil stresses					
Maximum soil stress, σ_{max}		15.01			
Minimum soil stress, σ_{min}		9.80			
Maximum moments					
At section A-A of wall, M_{A-A}		8.61			
At section B-B of footing, $M_{B-B}=M_w-M_s$		5.33			
Moment due to soil and footing weight, M_w		35.67			
Moment due to soil reaction, M_s		30.35			
Calculation of flexural resistance		Section A-A	Section B-B	Unit	
Rebar area in tension	A_s	1206	678.6	mm2	
Yield strength of rebar	f_y	390	390	MPa	
28-day compressive strength of concrete	f'_c	24	24	MPa	
Width of section	b	1000	1000	mm	
Coefficient	β	0.85	0.85	none	
Distance from extreme compression fiber to the centroid of tensile rebar	d_s	374	900	mm	
Distance between the neutral axis and the compression face	c	27.12	15.26	mm	
Depth of the equivalent stress block	a	23.06	12.97	mm	
Nominal resistance	M_n	170480082	236471891	Nmm	
Factored resistance	M_r	**153432074**	**212824702**	Nmm	

DESIGN CALCULATION OF CULVERTS

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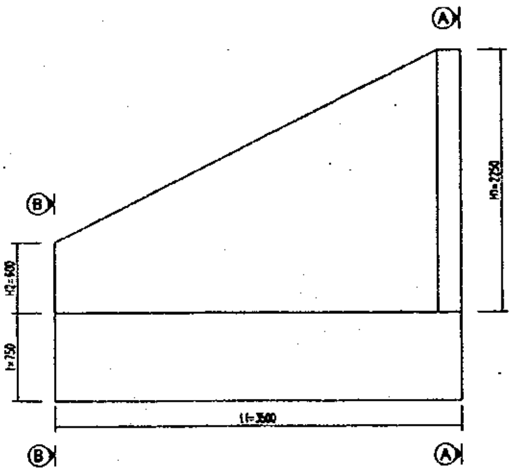
WING WALL TYPE W3

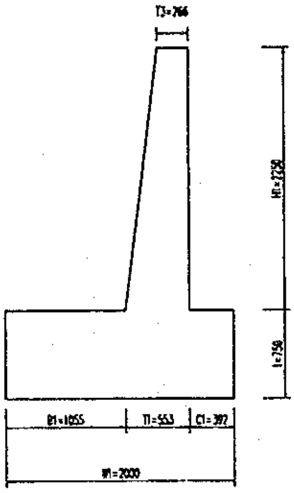
AT STATION KM 12+180

GENERAL VIEW OF WING WALL TYPE W3
(STATION 12+180)

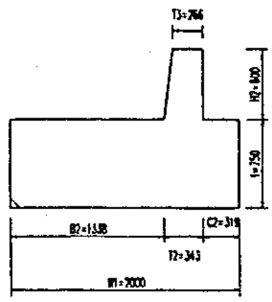
ELEVATION



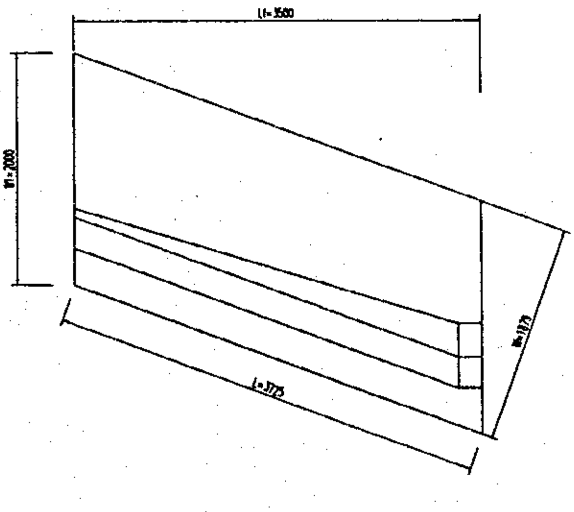
A - A



B - B



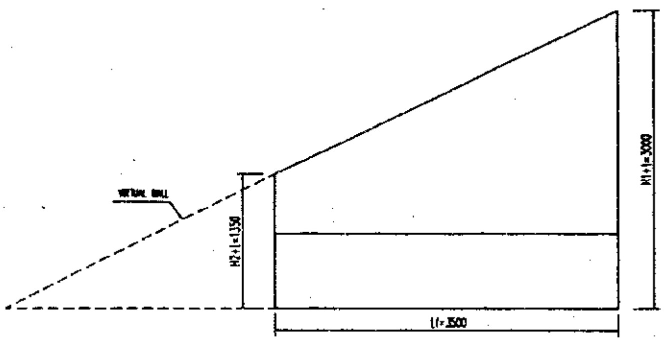
PLAN



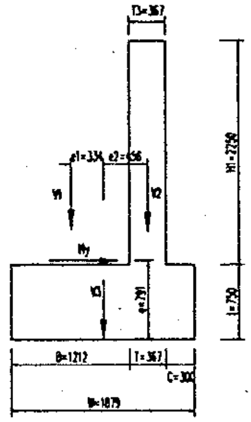
NOTES :
- ALL DIMENSIONS ARE IN MILIMETER.

WING WALL TYPE W3
(STATION 12+180)
MODELLING FOR CALCULATION

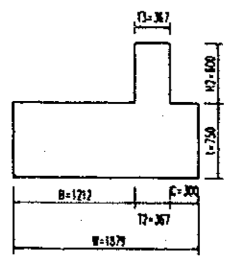
ELEVATION



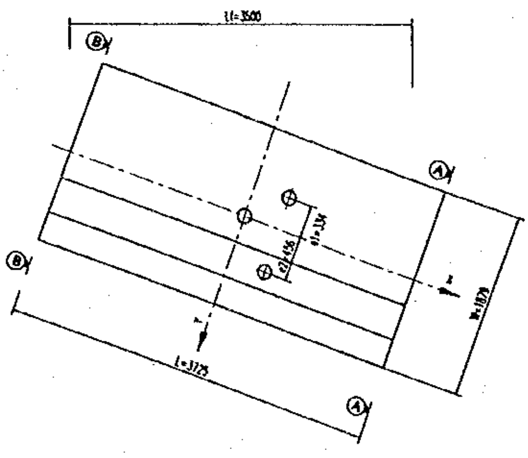
A - A



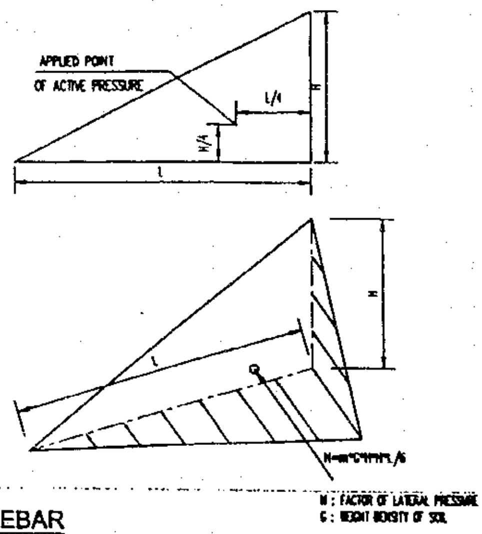
B - B



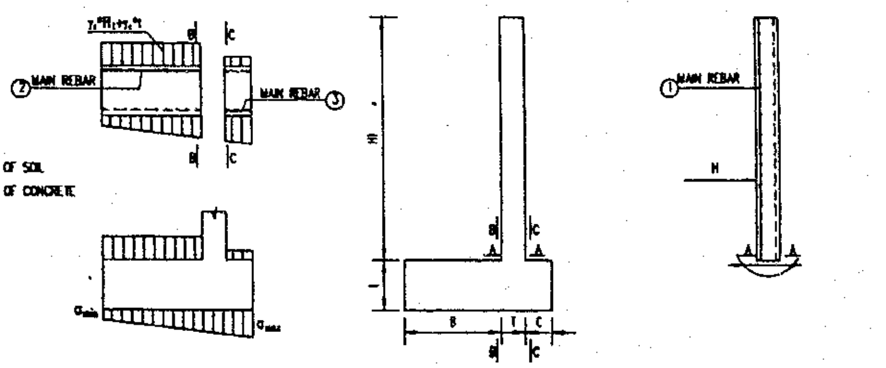
PLAN



VALUE & POSITION OF ACTIVE PRESS.



CALCULATION DIAGRAM FOR REBAR



NOTES :
- ALL DIMENSIONS ARE IN MILIMETER.

WING WALL TYPE W3 - STATION KM 12+180

(Unit : T,m)

FORCE COMPONENTS		V	H_y		M_x
Active pressure					
Maxixmum height of wall, H_1	2.250		H_y	e	$M_{x0}=H_y e$
Minimum height of wall, H_2	0.600	Entire wall	6.09	0.750	4.57
Length of actual wall, L	3.725	Virtual wall	0.55	0.338	0.19
Factor for lateral pressure, μ	0.333	Actual wall	5.53	0.791	4.38
Weight density of soil, γ	1.800				
Footing thickness, t	0.750				
Length of virtual wall, $X=L*(H_2+t)/(H_1-H_2)$	3.048				
Length of entire wall, $L_e=X+L$	6.773				
Weight of soil		V_1		e_1	$M_{x1}=V_1e_1$
Equivalent width of heel, B	1.212	11.58		-0.334	-3.86
Weight of wall		V_2		e_2	$M_{x2}=V_2e_2$
Equivalent thickness of wall, T	0.367	4.87		0.456	2.22
Weight of footing		V_3		e_3	$M_{x3}=V_3e_3$
Equivalent width of footing, W	1.879	17.50		0.000	0.00
LOAD COMBINATIONS					
	Load factor	V	H_y		M_x
Combination 1					
Active pressure	1.250		5.53		4.38
Weight of soil	1.250	11.58			-3.86
Weight of wall	1.000	4.87			2.22
Weight of footing	1.000	17.50			0.00
Total		**36.85**	**6.92**		**2.87**
Combination 2					
Active pressure	1.250		5.53		4.38
Weight of soil	1.250	11.58			-3.86
Weight of wall	1.500	4.87			2.22
Weight of footing	1.500	17.50			0.00
Total		**48.03**	**6.92**		**3.98**
CHECKING STABILITY & SOIL STRESSES					
Area of footing, F=W*L	7.00				
Moment of inertia about X-axis, $I_x=L*W^3/12$	2.06				
Soil friction coefficient, f	0.4				
Allowable soil pressure, [σ]	13				
	Load combination 1		Load combination 2		
Factor of safety (sliding),$k=V*f/H_y$	**2.13**		**2.78**		O.K!
Factor of safety (overturning),$k=(V*W/2)/M_x$	**12.07**		**11.34**		O.K!
Maximum soil stress, $σmax=V/F+M_x/(I_x/(W/2))$	**6.57**		**8.68**		O.K!
Minimum soil stress, $σmin=V/F-M_x/(I_x/(W/2))$	**3.96**		**5.05**		O.K!
CHECKING FLEXURAL RESISTANCE	Mmax	Designed flexural resistance, M_r			
(for more details, see next page)	(Tm/m)	(Tm/m)			
For wing wall (Section A-A)	1.42	**6.92**	O.K!		
For footing heel (Section B-B)	0.67	**15.33**	O.K!		

CHECKING FLEXURAL RESISTANCE (for 1m-long wall) - TYPE W3					
				(Unit : T,m)	
		V	H_y	e	M_x=H_ye
Force components					
Height of wall, H	2.250				
Length of wall, L	1.000		1.52	0.750	1.14
Factor for lateral pressure, μ	0.333				
Weight density of soil, γ	1.800				
Wall thickness, T	0.367				
Width of heel, B	1.212				
Width of footing, W	1.879				
Footing thickness, t	0.750				
Load factor for concrete, n_C	1.5				
Load factor for soil, n_S	1.25				
Weight of soil		4.91		-0.334	-1.64
Weight of wall		2.065		0.456	0.94
Weight of footing		3.523		0.000	0.00
Total (factored)		**14.52**	**1.90**		**0.79**
Soil stresses					
Maximum soil stress, σ_{max}		9.07			
Minimum soil stress, σ_{min}		6.39			
Maximum moments					
At section A-A of wall, M_{A-A}		1.42			
At section B-B of footing, M_{B-B}=M_w-M_s		0.67			
Moment due to soil and footing weight, M_w		5.78			
Moment due to soil reaction, M_s		5.11			
Calculation of flexural resistance		Section A-A	Section B-B	Unit	
Rebar area in tension	A_s	678.6	678.6	mm2	
Yield strength of rebar	f_y	390	390	MPa	
28-day compressive strength of concrete	f'_c	24	24	MPa	
Width of section	b	1000	1000	mm	
Coefficient	β	0.85	0.85	none	
Distance from extreme compression fiber to the centroid of tensile rebar	d_s	297	650	mm	
Distance between the neutral axis and the compression face	c	15.26	15.26	mm	
Depth of the equivalent stress block	a	12.97	12.97	mm	
Nominal resistance	M_n	76920327	170308391	Nmm	
Factored resistance	M_r	**69228294**	**153277552**	Nmm	

Appendices

APPENDIX - 1	*SUMMARY OF BRIDGES, PACKAGE-1 & 3*	*II-A - 2*
APPENDIX - 2	*SUMMARY OF CATEGORIES OF SUBSTRUCTURES AND FOUNDATIONS*	*II-A - 5*
APPENDIX - 3	*SUMMARY OF CATEGORIES OF CULVERTS & WING WALLS*	*II-A - 6*

Appendix - 1 Summary of Bridges, Package-1 & 3 (1/3)

Side	Bridge Name	Chainage	Direction	Bridge Length	Superstructure	Substructure		Abutment (A1)	Pier (P1)	Pier (P2)	Pier (P3)	Pier (P4)	Pier (P5)	Pier (P6)	Pier (P7)	Abutment (A2)
Vinh Long	Large Tra Va Bridge	0 + 578.55 ~ 0 + 860.15	HO CHI MINH ↓ CA MAU	281.60m	PC-I (Connect) 4@35 + 4@35 H=1.85m H=1.85m	Structural Height		9.2 m	9.4 m	8.9 m	10.4 m	9.4 m	5.8 m	5.3 m	8.9 m	9.2 m
						Fix/Mov		M	F,F	F,F	F,F	M,M	F,F	F,F	F,F	M
						Type		Reversed-T-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Reversed-T-Type
						Water inside/Land		Land	Land	Land	Land	Land	Water inside	water inside	Land	Land
						Pile	BOR No.	D-1	D-1	D-1	D-1	D-1	D-2	D-3	D-3	D-3
						Pile	Bore hole pile	ϕ1.5m*70m*17nos	ϕ1.5m*70m*12nos	ϕ1.5m*70m*12nos	ϕ1.5m*70m*12nos	ϕ1.5m*70m*12nos	ϕ1.5m*74m*12nos	ϕ1.5m*74m*12nos	ϕ1.5m*70m*12nos	ϕ1.5m*70m*17nos
						Pile	Driven pile	-	-	-	-	-	-	-	-	-
			CA MAU ↓ HO CHI MINH	281.60m	PC-I (Connect) 4@35 + 4@35 H=1.85m H=1.85m	Structural Height			9.4 m	8.9 m	10.4 m	9.4 m	5.8 m	5.3 m	8.9 m	
						Fix/Mov			F,F	F,F	F,F	M,M	F,F	F,F	F,F	
						Type			Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	
						Water inside/Land			Land	Land	Land	Land	Water inside	water inside	Land	
						Pile	BOR No.		D-1	D-1	D-1	D-1	D-2	D-3	D-3	
						Pile	Bore hole pile		ϕ1.5m*70m*12nos	ϕ1.5m*70m*12nos	ϕ1.5m*70m*12nos	ϕ1.5m*70m*12nos	ϕ1.5m*74m*12nos	ϕ1.5m*74m*12nos	ϕ1.5m*70m*12nos	
						Pile	Driven pile		-	-	-	-	-	-	-	
	Small Tra Va Bridge	1 + 866.25 ~ 1 + 953.75	HO CHI MINH ↓ CA MAU	87.50m	PC-I (Connect) 25 + 37 + 25 H=1.45m H=1.85m H=1.45m	Structural Height		8.2 m	7.4 m	7.4 m	-	-	-	-	-	8.2 m
						Fix/Mov		M	F,F	F,F	-	-	-	-	-	M
						Type		Reversed-T-Type	Multi-Column-Type	Multi-Column-Type	-	-	-	-	-	Reversed-T-Type
						Water inside/Land		Land	Land	Land	-	-	-	-	-	Land
						Pile	BOR No.	D-5	D-5	D-6	-	-	-	-	-	D-6
						Pile	Bore hole pile	ϕ1.5m*66m*10nos	ϕ1.5m*64m*8nos	ϕ1.5m*64m*8nos	-	-	-	-	-	ϕ1.5m*66m*10nos
						Pile	Driven pile	-	-	-	-	-	-	-	-	-
			CA MAU ↓ HO CHI MINH	87.50m	PC-I (Connect) 25 + 37 + 25 H=1.45m H=1.85m H=1.45m	Structural Height			7.4 m	7.4 m	-	-	-	-	-	
						Fix/Mov			F,F	F,F	-	-	-	-	-	
						Type			Multi-Column-Type	Multi-Column-Type	-	-	-	-	-	
						Water inside/Land			Land	Land	-	-	-	-	-	
						Pile	BOR No.		D-5	D-6	-	-	-	-	-	
						Pile	Bore hole pile		ϕ1.5m*64m*8nos	ϕ1.5m*64m*8nos	-	-	-	-	-	
						Pile	Driven pile		-	-	-	-	-	-	-	
	Tra On Bridge	3 + 582.00 ~ 3 + 842.00	HO CHI MINH ↓ CA MAU	260.00m	PC-I (Simple) PC-BOX PC-I (Simple) 2@36.0 +36.5+57+36.5+ 2@28.6 H=1.85m H=2.3~3.8m H=1.85m	Structural Height		9.5 m	9.5 m	9.5 m	15.0 m	15.0 m	9.5 m	9.5 m	-	9.2 m
						Fix/Mov		M	F,F	F,M	F	F	M.F	F,F	-	M
						Type		Reversed-T-Type	Wall-Type(1)	Wall-Type(1)	Wall-Type(2)	Wall-Type(2)	Wall-Type(1)	Wall-Type(1)	-	Reversed-T-Type
						Water inside/Land		Land	Land	Land	Water inside	Water inside	Land	Land	-	Land
						Pile	BOR No.	D-8	D-8	D-8	D-8	D-9	D-9	D-9	-	D-9
						Pile	Bore hole pile	ϕ1.5m*79m*17nos	ϕ1.5m*77m*6nos	ϕ1.5m*77m*6nos	ϕ1.5m*71m*9nos	ϕ1.5m*71m*9nos	ϕ1.5m*77m*6nos	ϕ1.5m*77m*6nos	-	ϕ1.5m*79m*17nos
						Pile	Driven pile	-	-	-	-	-	-	-	-	-
			CA MAU ↓ HO CHI MINH	260.00m	PC-I (Simple) PC-BOX PC-I (Simple) 2@31.6 +36.5+57+36.5+ 2@33.0 H=1.85m H=2.3~3.8m H=1.85m	Structural Height			9.5 m	9.5 m	15.0 m	15.0 m	9.5 m	9.5 m	-	
						Fix/Mov			F,F	F,M	F	F	M.F	F,F	-	
						Type			Wall-Type(1)	Wall-Type(1)	Wall-Type(2)	Wall-Type(2)	Wall-Type(1)	Wall-Type(1)	-	
						Water inside/Land			Land	Land	Water inside	Water inside	Land	Land	-	
						Pile	BOR No.		D-8	D-8	D-8	D-9	D-9	D-9	-	
						Pile	Bore hole pile		ϕ1.5m*77m*6nos	ϕ1.5m*77m*6nos	ϕ1.5m*71m*9nos	ϕ1.5m*71m*9nos	ϕ1.5m*77m*6nos	ϕ1.5m*77m*6nos	-	
						Pile	Driven pile		-	-	-	-	-	-	-	
	Interchange (NH.54) Over Bridge	3 + 129.68	CAI VON TOWN ↕ TRA ON TOWN	132.70m	PRC-Hollow Slab 2@24.5 + 34.5 + 2@24.5 H=1.25~2.00m	Structural Height		8.8 m	8.5 m	8.1 m	8.1 m	8.5 m	-	-	-	8.8 m
						Fix/Mov		M	M	R	R	M	-	-	-	M
						Type		Reversed-T-Type	Wall-Type(3)	Wall-Type(3)	Wall-Type(3)	Wall-Type(3)	-	-	-	Reversed-T-Type
						Water inside/Land		Land	Land	Land	Land	Land	-	-	-	Land
						Pile	BOR No.	D-7	D-7	D-7	D-7	D-7	-	-	-	D-7
						Pile	Bore hole pile	ϕ1.5m*71m*8nos	ϕ1.5m*75m*4nos	ϕ1.5m*75m*6nos	ϕ1.5m*75m*6nos	ϕ1.5m*75m*4nos	-	-	-	ϕ1.5m*71m*8nos
						Pile	Driven pile	-	-	-	-	-	-	-	-	-

Appendix - 1 Summary of Bridges, Package-1 & 3 (2/3)

Side	Bridge Name	Chainage	Direction	Bridge Length	Superstructure	Substructure		Abutment (A1)	Pier (P1)	Pier (P2)	Pier (P3)	Pier (P4)	Pier (P5)	Pier (P6)	Pier (P7)	Abutment (A2)
Can Tho	Cai Tac 1 Bridge	8 + 456.85 ~ 8 + 642.75	HO CHI MINH ↓ CA MAU	185.90m	PC-I (Connect) 5 @ 37 H=1.85m	Structural Height		7.6 m	8.4 m	8.0 m	9.0 m	9.0 m	-	-	-	9.2 m
						Fix/Mov		M	M,M	F,F	F,F	M,M	-	-	-	M
						Type		Reversed-T-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	-	-	-	Reversed-T-Type
						Water inside/Land		Land	Land	Land	Water inside	Water inside	-	-	-	Land
						Pile	BOR No.	D-18	D-18	D-18	D-19	D-19	-	-	-	D-19
							Bore hole pile	φ1.5m*51m*10nos	φ1.5m*49m*10nos	φ1.5m*53m*10nos	φ1.5m*53m*10nos	φ1.5m*53m*10nos	-	-	-	φ1.5m*55m*12m
							Driven pile	-	-	-	-	-	-	-	-	-
			CA MAU ↓ HO CHI MINH	185.90m	PC-I (Connect) 5 @ 37 H=1.85m	Structural Height			8.4 m	8.0 m	9.0 m	9.0 m	-	-	-	
						Fix/Mov			M,M	F,F	F,F	M,M	-	-	-	
						Type			Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	-	-	-	
						Water inside/Land			Land	Land	Water inside	Water inside	-	-	-	
						Pile	BOR No.		D-18	D-18	D-19	D-19	-	-	-	
							Bore hole pile		φ1.5m*49m*10nos	φ1.5m*53m*10nos	φ1.5m*53m*10nos	φ1.5m*53m*10nos	-	-	-	
							Driven pile		-	-	-	-	-	-	-	
	Cai Tac 2 Bridge	9 + 431.45 ~ 9 + 468.55	HO CHI MINH ↓ CA MAU	37.10m	PC-I (Simple) 37 H=1.85m	Structural Height		7.9 m	-	-	-	-	-	-	-	7.9 m
						Fix/Mov		F	-	-	-	-	-	-	-	M
						Type		Reversed-T-Type	-	-	-	-	-	-	-	Reversed-T-Type
						Water inside/Land		Land	-	-	-	-	-	-	-	Land
						Pile	BOR No.	D-20	-	-	-	-	-	-	-	D-20
							Bore hole pile	φ1.5m*55m*14nos	-	-	-	-	-	-	-	φ1.5 m*55m*12nos
							Driven pile	-	-	-	-	-	-	-	-	-
			CA MAU ↓ HO CHI MINH	37.10m	PC-I (Simple) 37 H=1.85m (W=18.25m)	Structural Height			-	-	-	-	-	-	-	
						Fix/Mov			-	-	-	-	-	-	-	
						Type			-	-	-	-	-	-	-	
						Water inside/Land			-	-	-	-	-	-	-	
						Pile	BOR No.		-	-	-	-	-	-	-	
							Bore hole pile		-	-	-	-	-	-	-	
							Driven pile		-	-	-	-	-	-	-	
	Cai Da Bridge	10 + 416.25 ~ 10 + 509.75	HO CHI MINH ↓ CA MAU	93.50m	PC-I (Connect) 28 + 37 + 28 H=1.65m H=1.85m H=1.65m	Structural Height		7.5 m	9.1 m	9.1 m	-	-	-	-	-	7.5 m
						Fix/Mov		M	F,F	F,F	-	-	-	-	-	M
						Type		Reversed-T-Type	Multi-Column-Type	Multi-Column-Type	-	-	-	-	-	Reversed-T-Type
						Water inside/Land		Land	Water inside	Water inside	-	-	-	-	-	Land
						Pile	BOR No.	D-21	D-21	D-21	-	-	-	-	-	D-21
							Bore hole pile	φ1.5m*55m*10nos	φ1.5m*52m*4nos	φ1.5m*52m*4nos	-	-	-	-	-	φ1.5m*55m*10nos
							Driven pile	-	-	-	-	-	-	-	-	-
			CA MAU ↓ HO CHI MINH	93.50m	PC-I (Connect) 28 + 37 + 28 H=1.65m H=1.85m H=1.65m	Structural Height			9.1 m	9.1 m	-	-	-	-	-	
						Fix/Mov			F,F	F,F	-	-	-	-	-	
						Type			Multi-Column-Type	Multi-Column-Type	-	-	-	-	-	
						Water inside/Land			Water inside	Water inside	-	-	-	-	-	
						Pile	BOR No.		D-21	D-21	-	-	-	-	-	
							Bore hole pile		φ1.5m*52m*4nos	φ1.5m*52m*4nos	-	-	-	-	-	
							Driven pile		-	-	-	-	-	-	-	
	Ba Mang Bridge	11 + 202.45 ~ 11 + 227.55	HO CHI MINH ↓ CA MAU	25.10m	PC-I (Simple) 25 H=1.45m	Structural Height		7.8 m	-	-	-	-	-	-	-	7.8 m
						Fix/Mov		F	-	-	-	-	-	-	-	M
						Type		Reversed-T-Type	-	-	-	-	-	-	-	Reversed-T-Type
						Water inside/Land		Land	-	-	-	-	-	-	-	Land
						Pile	BOR No.	D-22	-	-	-	-	-	-	-	D-22
							Bore hole pile	-	-	-	-	-	-	-	-	-
							Driven pile	450*450*40m*78nos	-	-	-	-	-	-	-	450*450*40m*78nos
			CA MAU ↓ HO CHI MINH	25.10m	PC-I (Simple) 25 H=1.45m	Structural Height			-	-	-	-	-	-	-	
						Fix/Mov			-	-	-	-	-	-	-	
						Type			-	-	-	-	-	-	-	
						Water inside/Land			-	-	-	-	-	-	-	
						Pile	BOR No.		-	-	-	-	-	-	-	
							Bore hole pile		-	-	-	-	-	-	-	
							Driven pile		-	-	-	-	-	-	-	

Appendix - 1 Summary of Bridges, Package-1 & 3 (3/3)

Side	Bridge Name	Chainage	Direction	Bridge Length	Superstructure	Substructure		Abutment (A1)	Pier (P1)	Pier (P2)	Pier (P3)	Pier (P4)	Pier (P5)	Pier (P6)		Abutment (A2)
Can Tho	Cai Nai Bridge	12 + 336.25 ~ 12 + 429.75	HO CHI MINH ↓ CA MAU	93.50m	PC-I (Simple) 28 + 37 + 28 H=1.65m H=1.85m H=1.65m	Structural Height		8.2 m	10.8 m	10.8 m	-	-	-	-	-	8.2 m
						Fix/Mov		M	F,F	F,F	-	-	-	-	-	M
						Type		Reversed-T-Type	Multi-Column-Type	Multi-Column-Type	-	-	-	-	-	Reversed-T-Type
						Water inside/Land		Land	Water inside	Water inside	-	-	-	-	-	Land
						Pile	BOR No.	D-23	D-23	D-24	-	-	-	-	-	D-24
							Bore hole pile	-	-	-	-	-	-	-	-	-
							Driven pile	450*450*40m*78nos	450*450*40m*24nos	450*450*40m*24nos	-	-	-	-	-	450*450*40m*78nos
			CA MAU ↓ HO CHI MINH	93.50m	PC-I (Simple) 28 + 37 + 28 H=1.65m H=1.85m H=1.65m	Structural Height			10.8 m	10.8 m	-	-	-	-	-	
						Fix/Mov			F,F	F,F	-	-	-	-	-	
						Type			Multi-Column-Type	Multi-Column-Type	-	-	-	-	-	
						Water inside/Land			Water inside	Water inside	-	-	-	-	-	
						Pile	BOR No.		D-23	D-24	-	-	-	-	-	
							Bore hole pile		-	1.5 m	-	-	-	-	-	
							Driven pile		450*450*40m*24nos	450*450*40m*24nos	-	-	-	-	-	
	Ap My Bridge	13 + 109.55 ~ 13 + 250.45	HO CHI MINH ↓ CA MAU	140.90m	PC-I (Simple) 28 + 25 + 37 + 25 + 25 H=1.65m, 1.45m H=1.85m H=1.45m, 1.65m	Structural Height		9.2 m	7.7 m	11.5 m	11.5 m	7.7 m	-	-	-	9.2 m
						Fix/Mov		M	M,M	F,F	F,F	M,M	-	-	-	M
						Type		Reversed-T-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	-	-	-	Reversed-T-Type
						Water inside/Land		Land	Land	Water inside	Water inside	Land	-	-	-	Land
						Pile	BOR No.	D-26	D-26	D-26	D-26	D-26	-	-	-	D-26
							Bore hole pile	-	-	-	-	-	-	-	-	-
							Driven pile	450*450*40m*90nos	450*450*40m*24nos	450*450*40m*24nos	450*450*40m*24nos	450*450*40m*24nos	-	-	-	450*450*40m*90nos
			CA MAU ↓ HO CHI MINH	140.90m	PC-I (Simple) 25 + 25 + 37 + 25 + 28 H=1.65m, 1.45m H=1.85m H=1.45m, 1.65m	Structural Height			7.7 m	11.5 m	11.5 m	7.7 m	-	-	-	
						Fix/Mov			M,M	F,F	F,F	M,M	-	-	-	
						Type			Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	Multi-Column-Type	-	-	-	
						Water inside/Land			Land	Water inside	Water inside	Land	-	-	-	
						Pile	BOR No.		D-26	D-26	D-26	D-26	-	-	-	
							Bore hole pile		-	-	-	-	-	-	-	
							Driven pile		450*450*40m*24nos	450*450*40m*24nos	450*450*40m*24nos	450*450*40m*24nos	-	-	-	
	Cai Rang Bridge	13 + 806.40 ~ 14 + 64.90	HO CHI MINH ↓ CA MAU	258.50m	PC-I (Simple) 31 + PC-BOX 42+75+42 + PC-I (Simple) 37+31 H=1.85m H=2.2~4.4m H=1.85m	Structural Height		9.2 m	8.6 m	11.2 m	11.2 m	8.6 m	8.7 m	-	-	9.2 m
						Fix/Mov		M	F,M	F	F	M,F	F,F	-	-	M
						Type		Reversed-T-Type	Wall-Type(1)	Wall-Type(2)	Wall-Type(2)	Wall-Type(1)	Multi-Column-Type	-	-	Reversed-T-Type
						Water inside/Land		Land	Land	Water inside	Water inside	Land	Land	-	-	Land
						Pile	BOR No.	D-27	D-27	D-27	D-28	D-28	D-28	-	-	D-28
							Bore hole pile	-	φ1.5m*50m*4nos	φ1.5m*49m*9nos	φ1.5m*49m*9nos	φ1.5m*45m*4nos	-	-	-	-
							Driven pile	450*450*40m*90nos	-	-	-	-	450*450*40m*30nos	-	-	450*450*40m*90nos
			CA MAU ↓ HO CHI MINH	258.50m	PC-I (Simple) 37 PC-BOX 42+75+42 + PC-I (Simple) 31+31 H=1.85m H=2.2~4.4m H=1.85m	Structural Height			8.6 m	11.2 m	11.2 m	8.6 m	8.7 m	-	-	
						Fix/Mov			F,M	F	F	M,F	F,F	-	-	
						Type			Wall-Type(1)	Wall-Type(2)	Wall-Type(2)	Wall-Type(1)	Multi-Column-Type	-	-	
						Water inside/Land			Land	Water inside	Water inside	Land	Land	-	-	
						Pile	BOR No.		D-27	D-27	D-28	D-28	D-28	-	-	
							Bore hole pile		φ1.5m*50m*4nos	φ1.5m*49m*9nos	φ1.5m*49m*9nos	φ1.5m*45m*4nos	-	-	-	
							Driven pile		-	-	-	-	450*450*40m*30nos	-	-	
	Interchange (NH.91B) Over Bridge	-	CAN THO CITY ↓↑ CA CUI POT	100.10m	PRC-Hollow Slab 4 @ 25 H=1.25m	Structural Height		9.2 m	9.0 m	9.1 m	9.0 m	-	-	-	-	9.2 m
						Fix/Mov		M	R	M	R	-	-	-	-	M
						Type		Reversed-T-Type	Wall-Type(3)	Wall-Type(3)	Wall-Type(3)	-	-	-	-	Reversed-T-Type
						Water inside/Land		Land	Land	Land	Land	-	-	-	-	Land
						Pile	BOR No.	D-21	D-21	D-21	D-21	-	-	-	-	D-21
							Bore hole pile	φ1.5m*57m*20nos	φ1.5m*57m*12nos	φ1.5m*57m*10nos	φ1.5m*57m*12nos	-	-	-	-	φ1.5m*57m*20nos
							Driven pile	-	-	-	-	-	-	-	-	-
				100.10m	PRC-Hollow Slab 4 @ 25 H=1.25m	Structural Height			9.0 m	9.1 m	9.0 m	-	-	-	-	
						Fix/Mov			R	M	R	-	-	-	-	
						Type			Wall-Type(3)	Wall-Type(3)	Wall-Type(3)	-	-	-	-	
						Water inside/Land			Land	Land	Land	-	-	-	-	
						Pile	BOR No.		D-21	D-21	D-21	-	-	-	-	
							Bore hole pile		φ1.5m*57m*12nos	φ1.5m*57m*10nos	φ1.5m*57m*12nos	-	-	-	-	
							Driven pile		-	-	-	-	-	-	-	
	Interchange (NH.91B) Ramp Way Bridge	—	Rampway D	93.50m	PC-I (Simple) 28 + 37 + 28 H=1.65m H=1.85m H=1.65m	Structural Height		7.6 m	9.2 m	9.2 m	-	-	-	-	-	7.6 m
						Fix/Mov		M	F,F	F,F	-	-	-	-	-	M
						Type		Reversed-T-Type	Wall-Type(1)	Wall-Type(1)	-	-	-	-	-	Reversed-T-Type
						Water inside/Land		Land	Water inside	Water inside	-	-	-	-	-	Land
						Pile	BOR No.	D-21	D-21	D-21	-	-	-	-	-	D-21
							Bore hole pile	-	-	-	-	-	-	-	-	-
							Driven pile	450*450*40m*24nos	450*450*40m*25nos	450*450*40m*25nos	-	-	-	-	-	450*450*40m*24nos

Appendix - 2 Summary of Categories of Substructures & Foundations

Package	Bridge Name	Superstructure		Substructure																										
				Abutment						Pier																				
				A1			A2			P1			P2			P3			P4			P5			P6			P7		
		Type	Span Arrangement	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type	Substructure (Height) (Bearing)	Pile (Type) (Length)	Designed Type
Package-1, Vinh Long side	Large Tra Va	PC-I	4@35+4@35	9,200	1,500	Type A1	9,200	1,500	Type A1	9,400	1,500	Type P6	8,900	1,500	Type P6	10,400	1,500	Type P6	9,400	1,500	Type P6	5,800	1,500	Type P6	5,300	1,500	Type P6	8,900	1,500	Type P6
				(M)	70m		(M)	70m	Calculated	(F,F)	70m	3C Calculated	(F,F)	70m	3C	(F,F)	70m	3C	(M,M)	60 m	3C	(F)	74m	3C	(F)	74m	3C	(F)	70m	3C
	Small Tra Va	PC-I	25 + 37 + 25	8,200	1,500	Type A3	8,200	1,500	Type A3	7,400	1,500	Type P7	7,400	1,500	Type P7															
			25 + 37 + 25	(M)	66 m	Calculated	(M)	61 m		(F,F)	64 m	3C Calculated	(F,F)	59 m	3C															
	Tra On	PC-I PC-BOX	2@36+36.5+57+36.5+2@28.6	9,500	1,500	Type A1	9,200	1,500	Type A1	9,500	1,500	Type P2	9,500	1,500	Type P2	15,000	1,500	Type P4	15,000	1,500	Type P4	9,500	1,500	Type P2	9,500	1,500	Type P2			
			2@31.6+36.5+57+36.5+2@33	(M)	79 m		(M)	79 m		(F,F)	77 m	1C Calculated	(F,M)	77m	1C	(F)	71 m	W Calculated	(F)	71m	W	(M,F)	77m	1C	(F,F)	77m	1C			
	NH.54 I.C Over Bridge	PRC Hollow Slab	2@24.5+34.5+2@24.5	8,800	1,500	Type A4	8,800	1,500	Type A4	8,500	1,500	Type P14	8,100	1,500	Type P13	8,100	1,500	Type P13	8,500	1,500	Type P14									
			(B=14.0)	(M)	70 m	Calculated	(M)	70 m		(M)	69 m	W Calculated	(R)	69 m	W Calculated	(R)	69 m	W	(M)	69 m	W									
Package-3, Can Tho side	Cai Tac 1	PC-I	5@37	7,600	1,500	Type A6	9,200	1,500	Type A1	8,400	1,500	Type P11	8,000	1,500	Type P8	9,000	1,500	Type P8	9,000	1,500	Type P11									
			5@37	(M)	51m	Calculated	(M)	55 m		(M,M)	49m	3C	(F,F)	53m	3C	(F,F)	53 m	3C Calculated	(M,M)	53 m	3C Calculated									
	Cai Tac 2	PC-I	37 (B=11.75)	7,900	1,500	Type A8	7,900	1,500	Type A5																					
			37 (B=18.75)	(F)	55m	Calculated	(M)	55m	Calculated																					
	Cai Da	PC-I	28 + 37 + 28	7,500	1,500	Type A6	7,500	1,500	Type A6	9,100	1,500	Type P9	9,100	1,500	Type P9															
			28 + 37 + 28	(M)	55 m		(M)	55 m		(F,F)	52 m	3C	(F,F)	52 m	3C															
	Ba Mang	PC-I	25	7,800	450x 450	Type A9-DP	7,800	450x 450	Type A9-DP																					
			25	(F)	40m	Calculated	(M)	40m																						
	Cai Nai	PC-I	28 + 37 + 28	8,200	450x 450	Type A3-DP	8,200	450x 450	Type A3-DP	10,800	450x 450	Type P9-DP	10,800	450x 450	Type P9-DP															
			28 + 37 + 28	(M)	40m		(M)	40m		(F,F)	40m	3C	(F,F)	40m	3C Calculated															
	Ap My	PC-I	28 + 25 + 37 + 2@25	9,200	450x 450	Type A2-DP	9,200	450x 450	Type A2-DP	7,700	450x 450	Type P12-DP	11,500	450x 450	Type P9-DP	11,500	450x 450	Type P9-DP	7,700	450x 450	Type P12-DP									
			2@25 + 37 + 25 + 28	(M)	40m		(M)	40m		(M,M)	40m	3C Calculated	(F,F)	40m	3C Calculated	(F,F)	40m	3C	(M,M)	40m	3C									
	Cai Rang	PC-I PC-BOX	31+42+75+42+37+31	9,200	450x 450	Type A2-DP	9,200	450x 450	Type A2-DP	8,600	1,500	Type P2	11,200	1,500	Type P5	11,200	1,500	Type P5	8,600	1,500	Type P2	8,700	450x 450	Type P6-DP						
			37+42+75+42+31+31	(M)	40m		(M)	40m		(F,M)	50 m	1C	(F)	49m	W Calculated	(F)	49m	W	(M,F)	45 m	1C	(F,F)	40m	3C						
	NH.91B I.C Over Bridge	PRC Hollow Slab	4@25	9,200	1,500	Type A2	9,200	1,500	Type A2	9,000	1,500	Type P15	9,100	1,500	Type P16	9,000	1,500	Type P15												
			(B=2*15.5)	(M)	57 m	Calculated	(M)	57 m		(R)	57m	W Calculated	(M)	57m	W Calculated	(R)	57m	W												
	NH.91B I.C Ramp Way Bridge	PC-I	28 + 37 + 28	7,600	450x 450	Type A7-DP	7,600	450x 450	Type A7-DP	9,200	450x 450	Type P3-DP	9,200	450x 450	Type P3-DP															
			(B=7.5)	(M)	40m	Calculated	(M)	40m		(F,F)	40m	1C Calculated	(F,F)	40m	1C															

NOTES:

- Type of Substructures (Shown on "Notes" Column)
  - Type A1-A9 : Types of Abutment designed
  - Type P1-P16:Types of Pier designed
- Figure of Pier (Shown on "Notes" Column):
  - 3C:Pier with 3 Columns
  - 1C:Pier with Solid Single Column
  - W:Wall Type Pier
- Pile (Shown on "Pile" Column)
  - First row indicates the Type of Pile.
    - 1,500: Cast in Place Concrete Pile (Dia. 1,500mm)
    - 450x450: Driving Pile (450mm x 450mm, Square)
  - Second row indicates the Length of Pile.
- Type of Supporting Condition of the Bearing (Shown on "Height (Bearing)" Column)
  - (F): Fixed Support
  - (R): Rigid
  - (M): Movable Support

Appendix - 3 Summary of Categories of Culverts & Wing Walls

Side	No	Chainage	Dimension (m) W x H	Type: Box culvert		Type: Wing wall	High of filling ground above culvert	Require Calculation: Box culvert	Require Calculation: Wing wall	Thickness of Box culvert at: Top slab (m)	Thickness of Box culvert at: Wall (m)	Thickness of Box culvert at: Bottom Slab (m)	Pavement Elevation at center line (m)	Bottom elevation (m)	Angle (Deg) (Left or Right)
		MAIN ROUTE													
	1	Km 0+51.8	Φ1.5	Single		Type W1	1.84						3.19	-0.3	
	2	Km 0+183.7	3.00 x 3.20	Single	Type B3	Type W2	0.75	Calculated		0.3	0.35	0.35	3.19	-1.06	
	3	Km 0+369.5	3.00 x 3.20	Single	-	-	1.76			0.3	0.35	0.35	4.20	-1.06	
	4	Km 1+063.2 (Path)	5.00 x 4.50	Single	Type B9	Type W3	0.79	Calculated		0.35	0.4	0.4	5.58	-0.06	75 (L)
	5	Km 1+300	2.50 x 1.50	Double	Type B11	Type W1	0.75			0.25	0.3	0.3	2.62	0.12	
	6	Km 1+560	3.00 x 3.50	Single	Type B4	Type W2	0.78	Calculated		0.3	0.35	0.35	4.52	-0.06	
	7	Km 2+150	2.50 x 2.00	Double	Type B12	Type W1	0.74	Calculated		0.25	0.3	0.3	3.05	0.06	
VINH LONG	8	Km 2+620 (Path)	5.00 x 3.80	Single	Type B6	Type W2	0.78	Calculated		0.35	0.4	0.4	5.57	0.64	63 (R)
	9	Km 2+835	2.50 x 2.00	Double	Type B12	Type W1	1.84			0.25	0.3	0.3	4.23	0.14	
	10	Km 3+170	2.50 x 1.50	Double	Type B11	-	0.87			0.25	0.3	0.3	2.75	0.13	
	11	Km 4+125	2.50 x 1.50	Double	-	-	1.27			0.25	0.3	0.3	3.48	0.46	
	12	Km 4+318	5.00 x 4.50	Double	Type B14	Type W3	0.96	Calculated	Calculated	0.35	0.4	0.4	4.75	-1.06	
	13	Km 4+640 (Path)	6.50 x 4.50	Single	Type B10	-	0.91	Calculated		0.4	0.45	0.45	5.75	-0.06	65 (L)
		INTERCHANGE 2													
	1	Ramp "A" - Km 0+300	2.50 x 1.50	Single	Type B1	Type W1	0.61	Calculated		0.25	0.3	0.3	2.67	0.31	
	2	Ramp "B" - Km 0+220	2.50 x 1.50	Single	-	-	0.61			0.25	0.3	0.3	2.63	0.27	
	3	Ramp "C" - Km 0+240	2.50 x 1.50	Single	-	-	0.61			0.25	0.3	0.3	2.70	0.34	
	4	Ramp "D" - Km 0+300	2.50 x 1.50	Single	-	-	0.61			0.25	0.3	0.3	2.63	0.27	
		MAIN ROUTE													
	14	Km 7+820	3.00 x 3.80	Single	Type B5	Type W2	0.81	Calculated		0.3	0.35	0.35	4.55	-0.36	
	15	Km 7+950	2.50 x 2.00	Double	Type B12	Type W1	0.74			0.25	0.3	0.3	3.77	0.78	
	16	Km 8+820	2.50 x 2.00	Double	-	-	0.94			0.25	0.3	0.3	4.12	0.93	
	17	Km 9+326	2.50 x 2.00	Double	-	-	1.97			0.25	0.3	0.3	4.92	0.7	
	18	Km 9+760	2.50 x 1.50	Double	Type B11	-	0.83			0.25	0.3	0.3	3.36	0.78	
	19	Km 10+310	2.50 x 2.00	Double	Type B12	-	1.02			0.25	0.3	0.3	4.03	0.76	
	20	Km 10+690	2.50 x 1.50	Double	Type B11	-	0.75			0.25	0.3	0.3	2.71	0.21	
	21	Km 10+950	2.50 x 1.50	Double	-	-	0.93			0.25	0.3	0.3	2.75	0.07	
	22	Km 11+451	2.50 x 1.50	Double	-	-	0.75			0.25	0.3	0.3	2.97	0.47	
	23	Km 11+690	2.50 x 2.00	Double	Type B12	-	1.87			0.25	0.3	0.3	4.18	0.06	
	24	Km 11+976.50 (Path)	5.00 x 4.00	Single	Type B7	Type W3	0.83	Calculated		0.35	0.4	0.4	5.62	0.44	85 (R)
	25	Km 12+180	2.50 x 2.00	Double	Type B13	Type W1	3.68	Calculated	Calculated	0.25	0.3	0.3	6.33	0.4	
CAN THO	26	Km 12+592.50 (Path)	5.00 x 4.00	Single	Type B7	Type W3	0.98			0.35	0.4	0.4	5.77	0.44	75 (R)
	27	Km 12+756	3.00 x 3.80	Single	Type B5	Type W2	1.09		Calculated	0.25	0.3	0.3	4.78	-0.36	71 (R)
	28	Km 13+600	2.50 x 1.50	Double	Type B11	Type W1	0.75			0.25	0.3	0.3	2.87	0.37	
	29	Km 14+247	5.00 x 4.00	Single	Type B7	Type W3	0.93			0.35	0.4	0.4	5.72	0.44	75 (R)
	30	Km 14+450	2.50 x 1.50	Double	Type B11	Type W1	0.75			0.25	0.3	0.3	2.85	0.35	
	31	Km 14+625	2.50 x 1.50	Double	-	-	0.75			0.25	0.3	0.3	2.74	0.24	
	32	Km 14+890	2.50 x 1.50	Double	-	-	0.75			0.25	0.3	0.3	2.67	0.17	
		INTERCHANGE 3													
	1	Ramp "A" - Km 0+154	2.50 x 1.50	Double	Type B11	Type W1	0.64			0.25	0.3	0.3	3.23	0.84	
	2	Ramp "B" - Km 0+286.5	2.50 x 1.50	Double	-	-	0.61			0.25	0.3	0.3	2.80	0.44	
	3	Ramp "C" - Km 0+300	5.00 x 4.00	Single	Type B8	Type W3	0.64	Calculated		0.35	0.4	0.4	3.73	-1.26	
	4	Ramp "D" - Km 0+300	2.50 x 2.00	Single	Type B2	Type W1	0.61	Calculated		0.25	0.3	0.3	3.59	0.73	
	5	Ramp "F" - Km 0+300	5.00 x 4.00	Single	Type B8	Type W3	0.64			0.35	0.4	0.4	3.84	-1.15	45 (R)
		INTERSECTION 4													
	1	Ramp "B" - Km0+223	2.50 x 1.50	Double	Type B11	Type W1	0.61	Calculated		0.25	0.3	0.3	2.63	0.27	

JICA