1-1. DESIGN OF MAIN BRIDGE

(2) SUBSTRUCTURE

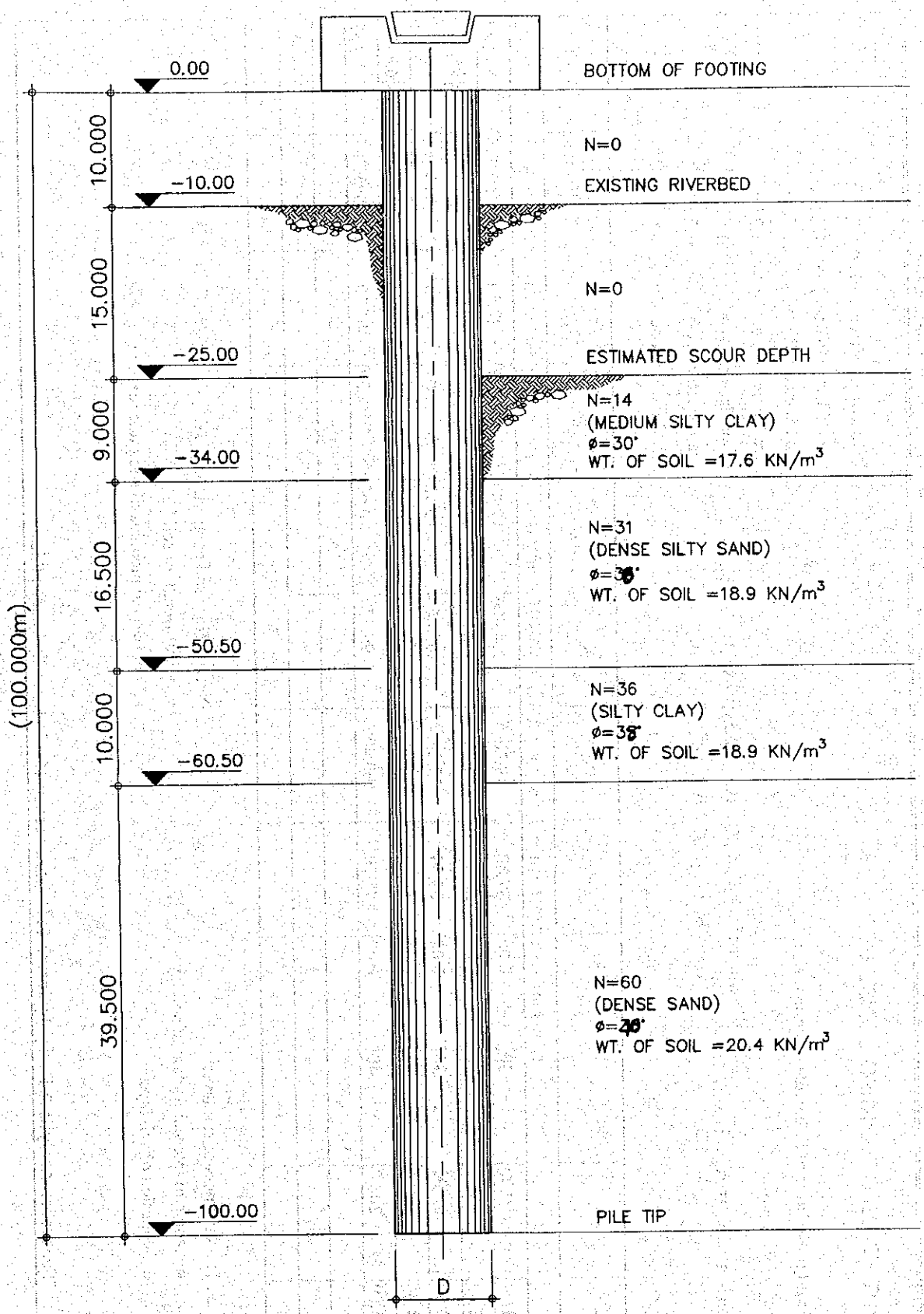
MAIN PIER-1 ANALYSIS

OF COPING, FOOTING AND PILES

STAAD ANALYSIS

SOIL SPRING CONSTANTS

FOR THE BORED PILES



1 / –

SOIL STRATIFICATION

SCALE 1:50

Job No.	Date : January 18, 2000	Designed by	Checked by :

COMPUTATION OF SPRING CONSTANTS

A. Horizontal Modulus of Subgrade Reaction, K_s :

Equation : $K_s = A_s + B_s x Z^n$

where : $A_s = F_{w1} C_m C (cxN_c + 0.5x\gamma xBxN_\gamma)$

$B_s = F_{w2} C_m C (\gamma xN_q)xZ^n$ $\quad C = 40$

Pile Input Parameter :

Pile (C-Circ., R-Rect.) =	C
Pile Diameter, B =	2.50 m.
Size Factor, C_m =	1.25 m.
Shape Factor, F_{w1} =	1.50
Shape Factor F_{w2} =	3.20
Soil Depth Exponent, n =	0.6

Layer	H	ϕ	c	N_c	N_γ	A_s	γ_s	Z^n	N_q	B_s	k_s
Note : All units are in KN, m or SI units											
1.00	9.00	30	0.00	37.20	19.70	14,406	7.80	2.47	22.50	69,235	83,640
2.00	16.50	38	0.00	80.54	77.20	65,861	9.10	5.52	65.34	525,308	591,169
3.00	10.00	38	0.00	80.54	77.20	65,861	9.10	7.77	65.34	739,470	805,331
4.00	20.00	40	0.00	95.70	100.40	99,773	10.60	9.88	81.30	1,362,458	1,462,231
5.00	20.00	40	0.00	95.70	100.40	99,773	10.60	12.30	81.30	1,695,357	1,795,130

where : H = thickness of soil layer

ϕ = angle of internal friction of soil layer

c = cohesion of soil layer

Nc, Nγ, Nq = soil parameters

γ_w = unit weight of soil

k_s = horizontal modulus of subgrade reaction

Reference : "Foundation Analysis & Design by Joseph E. Bowles, Section 16-15 : Laterally Loaded Piles

Job No. | Date January 18, 2000 | Designed by | Checked by

B. Spring Constant, $K = K_i + K_i'$

Use average end area formula : $K_i = BH/6(2k_{s,i} + k_{s,i-1})$

$K_i' = BH/6(2k_{s,i} + k_{s,i+1})$

where : B = Diameter of the Pile

H = Thickness of Segment

Layer	Node	H (m.)	Depth (m.)	k_s	Group Action	Effective k_s	K_i	K_i'	$K=K_i+K_i'$
Layer 1	1	0.00	0.00	11,949	0.65	7,767	0	14,562	14,562
	2	1.50	1.50	11,949	0.65	7,767	14,562	14,562	29,125
	3	1.50	3.00	11,949	0.65	7,767	14,562	14,562	29,125
	4	1.50	4.50	11,949	0.65	7,767	14,562	14,562	29,125
	5	1.50	6.00	11,949	0.65	7,767	14,562	14,562	29,125
	6	1.50	7.50	11,949	0.65	7,767	14,562	23,052	37,614
	7	1.50	9.00	11,949	0.65	21,350	31,541	48,520	80,061
Layer 2	8	1.50	10.50	53,743	0.65	34,933	57,009	65,499	122,508
	9	1.50	12.00	53,743	0.65	34,933	65,499	65,499	130,998
	10	1.50	13.50	53,743	0.65	34,933	65,499	65,499	130,998
	11	1.50	15.00	53,743	0.65	34,933	65,499	65,499	130,998
	12	1.50	16.50	53,743	0.65	34,933	65,499	65,499	130,998
	13	1.50	18.00	53,743	0.65	34,933	65,499	65,499	130,998
	14	1.50	19.50	53,743	0.65	34,933	65,499	65,499	130,998
	15	1.50	21.00	53,743	0.65	34,933	65,499	65,499	130,998
	16	1.50	22.50	53,743	0.65	34,933	65,499	65,499	130,998
	17	1.50	24.00	53,743	0.65	34,933	65,499	87,299	152,798
	18	1.50	25.50	53,743	0.65	69,813	109,099	87,266	196,365

Layer	Node	H (m.)	Depth (m.)	k_s	Group Action	Effective k_s	K_i	K_i'	$K=K_i+K_j'$
Layer 3	19	2.00	27.50	161,066	0.65	104,693	232,666	261,733	494,398
	20	2.00	29.50	161,066	0.65	104,693	261,733	261,733	523,465
	21	2.00	31.50	161,066	0.65	104,693	261,733	261,733	523,465
	22	2.00	33.50	161,066	0.65	104,693	261,733	257,713	519,445
	23	2.00	35.50	161,066	0.65	99,869	253,693	245,653	499,345
Layer 4	24	2.00	37.50	146,223	0.65	95,045	241,633	237,613	479,245
	25	2.00	39.50	146,223	0.65	95,045	237,613	237,613	475,225
	26	2.00	41.50	146,223	0.65	95,045	237,613	237,613	475,225
	27	2.00	43.50	146,223	0.65	95,045	237,613	237,613	475,225
	28	2.00	45.50	146,223	0.65	95,045	237,613	237,613	475,225
	29	2.00	47.50	146,223	0.65	95,045	237,613	237,613	475,225
	30	2.00	49.50	146,223	0.65	95,045	237,613	237,613	475,225
	31	2.00	51.50	146,223	0.65	95,045	237,613	237,613	475,225
	32	2.00	53.50	146,223	0.65	95,045	237,613	246,629	484,241
	33	2.00	55.50	146,223	0.65	105,864	255,645	176,440	432,085

Layer 5	34	2.00	57.50	179,513	0.65	116,683	282,693	291,709	574,401
	35	2.00	59.50	179,513	0.65	116,683	291,709	291,709	583,417
	36	2.00	61.50	179,513	0.65	116,683	291,709	291,709	583,417
	37	2.00	63.50	179,513	0.65	116,683	291,709	291,709	583,417
	38	2.00	65.50	179,513	0.65	116,683	291,709	291,709	583,417
	39	2.00	67.50	179,513	0.65	116,683	291,709	291,709	583,417
	40	2.00	69.50	179,513	0.65	116,683	291,709	291,709	583,417
	41	2.00	71.50	179,513	0.65	116,683	291,709	291,709	583,417
	42	2.00	73.50	179,513	0.65	116,683	291,709	291,709	583,417
	43	2.00	75.50	179,513	0.65	116,683	291,709	291,709	583,417

SPRING CONSTANTS

THE STUDY ON THE CONSTRUCTION OF THE BRIDGE
OVER THE RIVER RUPSA IN KHULNA - PHASE 2

Job No. :	Date : January 11, 2000	Designed by :	Checked by :

COMPUTATION OF SPRING CONSTANTS

A. Horizontal Modulus of Subgrade Reaction, K_s :

Equation : $K_s = A_s + B_s x Z^n$

where : $A_s = F_{w1} C_m C (cxN_c + 0.5x\gamma xBxN_\gamma)$

$B_s = F_{w2} C_m C (\gamma xN_q)xZ^n$ C = 40

Pile Input Parameter :

Pile (C-Circ., R-Rect.) =	C
Pile Diameter, B =	2.00 m.
Size Factor, C_m =	1.25 m.
Shape Factor, F_{w1} =	1.50
Shape Factor F_{w2} =	3.20
Soil Depth Exponent, n =	0.6

Layer	H	ϕ	c	N_c	N_γ	A_s	γ_s	Z^n	N_q	B_s	k_s
Note : All units are in KN, m or SI units											
1.00	9.00	30	0.00	37.20	19.70	11,525	7.80	2.47	22.50	69,235	80,759
2.00	16.50	35	0.00	57.80	42.40	28,938	9.10	5.52	41.40	332,840	361,778
3.00	10.00	35	0.00	57.80	42.40	28,938	9.10	7.77	41.40	468,535	497,473
4.00	20.00	38	0.00	80.54	77.20	61,374	10.60	9.88	65.34	1,094,994	1,156,368
5.00	20.00	38	0.00	80.54	77.20	61,374	10.60	12.30	65.34	1,362,542	1,423,916

where : H = thickness of soil layer

ϕ = angle of internal friction of soil layer

c = cohesion of soil layer

Nc, Nγ, Nq = soil parameters

γ_w = unit weight of soil

k_s = horizontal modulus of subgrade reaction

Reference : . "Foundation Analysis & Design by Joseph E. Bowles, Section 16-15 : Laterally Loaded Piles

B. Spring Constant, $K = K_i + K_i'$

Use average end area formula : $K_i = BH/6(2k_{s,i} + k_{s,i-1})$

$K_i' = BH/6(2k_{s,i} + k_{s,i+1})$

where : B = Diameter of the Pile

H = Thickness of Segment

Layer	Node	H (m.)	Depth (m.)	k_s	Group Action	Effective k_s	K_i	K_i'	$K=K_i+K_i'$
Layer 1	1	0.00	0.00	11,537	0.25	2,884	0	4,326	4,326
	2	1.50	1.50	11,537	0.25	2,884	4,326	4,326	8,653
	3	1.50	3.00	11,537	0.25	2,884	4,326	4,326	8,653
	4	1.50	4.50	11,537	0.25	2,884	4,326	4,326	8,653
	5	1.50	6.00	11,537	0.25	2,884	4,326	4,326	8,653
	6	1.50	7.50	11,537	0.25	2,884	4,326	5,661	9,987
	7	1.50	9.00	11,537	0.25	5,553	6,995	9,664	16,660
Layer 2	8	1.50	10.50	32,889	0.25	8,222	10,999	12,333	23,332
	9	1.50	12.00	32,889	0.25	8,222	12,333	12,333	24,667
	10	1.50	13.50	32,889	0.25	8,222	12,333	12,333	24,667
	11	1.50	15.00	32,889	0.25	8,222	12,333	12,333	24,667
	12	1.50	16.50	32,889	0.25	8,222	12,333	12,333	24,667
	13	1.50	18.00	32,889	0.25	8,222	12,333	12,333	24,667
	14	1.50	19.50	32,889	0.25	8,222	12,333	12,333	24,667
	15	1.50	21.00	32,889	0.25	8,222	12,333	12,333	24,667
	16	1.50	22.50	32,889	0.25	8,222	12,333	12,333	24,667
	17	1.50	24.00	32,889	0.25	8,222	12,333	16,496	28,830
	18	1.50	25.50	32,889	0.25	16,548	20,659	16,548	37,207

Job No. :	Date : January 11, 2000	Designed by :	Checked by :

Layer	Node	H (m.)	Depth (m.)	k_s	Group Action	Effective k_s	K_i	K_i'	$K = K_i + K_i'$
Layer 3	19	2.00	27.50	99,495	0.25	24,874	44,197	49,747	93,944
	20	2.00	29.50	99,495	0.25	24,874	49,747	49,747	99,495
	21	2.00	31.50	99,495	0.25	24,874	49,747	49,747	99,495
	22	2.00	33.50	99,495	0.25	24,874	49,747	51,092	100,840
	23	2.00	35.50	99,495	0.25	26,891	52,438	55,128	107,566
Layer 4	24	2.00	37.50	115,637	0.25	28,909	56,473	57,818	114,292
	25	2.00	39.50	115,637	0.25	28,909	57,818	57,818	115,637
	26	2.00	41.50	115,637	0.25	28,909	57,818	57,818	115,637
	27	2.00	43.50	115,637	0.25	28,909	57,818	57,818	115,637
	28	2.00	45.50	115,637	0.25	28,909	57,818	57,818	115,637
	29	2.00	47.50	115,637	0.25	28,909	57,818	57,818	115,637
	30	2.00	49.50	115,637	0.25	28,909	57,818	57,818	115,637
	31	2.00	51.50	115,637	0.25	28,909	57,818	57,818	115,637
	32	2.00	53.50	115,637	0.25	28,909	57,818	60,048	117,866
	33	2.00	55.50	115,637	0.25	32,254	62,278	43,005	105,282

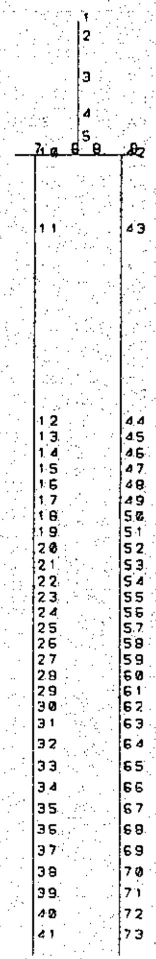
Layer 5	34	2.00	57.50	142,392	0.25	35,598	68,966	71,196	140,162
	35	2.00	59.50	142,392	0.25	35,598	71,196	71,196	142,392
	36	2.00	61.50	142,392	0.25	35,598	71,196	71,196	142,392
	37	2.00	63.50	142,392	0.25	35,598	71,196	71,196	142,392
	38	2.00	65.50	142,392	0.25	35,598	71,196	71,196	142,392
	39	2.00	67.50	142,392	0.25	35,598	71,196	71,196	142,392
	40	2.00	69.50	142,392	0.25	35,598	71,196	71,196	142,392
	41	2.00	71.50	142,392	0.25	35,598	71,196	71,196	142,392
	42	2.00	73.50	142,392	0.25	35,598	71,196	71,196	142,392
	43	2.00	75.50	142,392	0.25	35,598	71,196	71,196	142,392

MN/ELEM

STRUCTURE DATA

TYPE = PLANE

NJ =	74
NM =	73
NE =	0
NS =	0
NRJ=	62
NL =	7
XMAX=	11.0
YMAX=	88.6
ZMAX=	.0



SHOWING MEMBERS

J=74,M=73

UNIT MET KNS

S T A A D P O S T - P L O T (REV: 22.3)

DATE: FEB 8, 2000

TITLE: TRANSVERSE ANALYSIS ON MP1

(680 NOT USED)

User ID: Pacific Consultants Inter

MN/ELEM

STRUCTURE DATA

TYPE = PLANE

NJ = 74

NM = 73

NE = 0

NS = 0

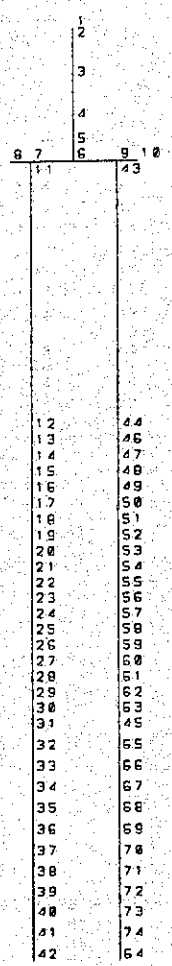
NRJ= 62

NL = 7

XMAX= 11.0

YMAX= 88.6

ZMAX= .0



SHOWING NODES

J=74,M=73

UNIT MET KNS

S T A A D P O S T - P L O T (REV: 22.3)

DATE: FEB 8, 2000

TITLE: TRANSVERSE ANALYSIS ON MP1

MAIN PIER-1 TRANSVERSE ANALYSIS

MEMB	LOAD	NODE	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
1	5	1	7,510.37	2,172.33	0.00	0.00	0.00	-11,282.03
		2	-8,394.89	-2,172.33	0.00	0.00	0.00	13,443.52
	6	1	10,931.21	2,172.33	0.00	0.00	0.00	-11,282.03
		2	-12,110.57	-2,172.33	0.00	0.00	0.00	13,443.52
	7	1	12,857.72	985.26	0.00	0.00	0.00	-4,485.16
		2	-14,037.08	-985.26	0.00	0.00	0.00	5,472.25
2	5	2	8,394.32	1,987.35	0.00	0.00	0.00	-13,355.76
		3	-9,461.36	-2,088.62	0.00	0.00	0.00	21,090.25
	6	2	12,109.80	1,987.35	0.00	0.00	0.00	-13,355.76
		3	-13,532.52	-2,088.62	0.00	0.00	0.00	21,090.25
	7	2	14,036.27	927.68	0.00	0.00	0.00	-5,442.10
		3	-15,458.99	-958.06	0.00	0.00	0.00	9,021.88
3	5	3	9,461.26	2,089.51	0.00	0.00	0.00	-21,093.38
		4	-10,570.42	-2,194.78	0.00	0.00	0.00	29,546.88
	6	3	13,532.40	2,089.51	0.00	0.00	0.00	-21,093.37
		4	-15,011.28	-2,194.78	0.00	0.00	0.00	29,546.88
	7	3	15,458.93	958.47	0.00	0.00	0.00	-9,022.49
		4	-16,937.81	-990.05	0.00	0.00	0.00	12,868.67
4	5	4	10,570.49	2,198.53	0.00	0.00	0.00	-29,541.77
		5	-11,216.33	-2,259.83	0.00	0.00	0.00	34,664.06
	6	4	15,011.35	2,198.54	0.00	0.00	0.00	-29,541.77
		5	-15,872.47	-2,259.83	0.00	0.00	0.00	34,664.06
	7	4	16,937.78	990.32	0.00	0.00	0.00	-12,867.25
		5	-17,798.90	-1,008.71	0.00	0.00	0.00	15,165.95
5	5	5	11,216.26	2,243.93	0.00	0.00	0.00	-34,673.28
		6	-11,637.46	-2,243.93	0.00	0.00	0.00	38,041.10
	6	5	15,872.40	2,243.92	0.00	0.00	0.00	-34,673.28
		6	-16,434.00	-2,243.92	0.00	0.00	0.00	38,041.09
	7	5	17,798.89	1,005.67	0.00	0.00	0.00	-15,168.27
		6	-18,360.49	-1,005.67	0.00	0.00	0.00	16,677.87
6	5	6	-1,042.26	4,431.62	0.00	0.00	0.00	-6,231.54
		7	1,042.26	-1,535.87	0.00	0.00	0.00	17,423.33
	6	6	-1,028.62	2,033.34	0.00	0.00	0.00	-16,320.67
		7	1,028.62	1,827.66	0.00	0.00	0.00	16,709.01
	7	6	-389.56	-4,331.65	0.00	0.00	0.00	-30,513.60
		7	389.56	8,192.65	0.00	0.00	0.00	7,031.28
7	5	7	-1.55	1,350.80	0.00	0.00	0.00	1,182.21
		8	1.55	0.55	0.00	0.00	0.00	-0.54
	6	7	-1.55	1,801.23	0.00	0.00	0.00	1,576.38
		8	1.55	0.57	0.00	0.00	0.00	-0.56
	7	7	-0.61	1,801.54	0.00	0.00	0.00	1,576.50
		8	0.61	0.26	0.00	0.00	0.00	-0.27
8	5	6	1,214.63	-16,069.04	0.00	0.00	0.00	-44,275.10
		9	-1,214.63	18,964.79	0.00	0.00	0.00	-21,410.36
	6	6	1,228.26	-18,467.31	0.00	0.00	0.00	-54,364.18
		9	-1,228.26	22,328.31	0.00	0.00	0.00	-22,124.65
	7	6	618.99	-14,028.85	0.00	0.00	0.00	-47,190.53
		9	-618.99	17,889.85	0.00	0.00	0.00	-12,656.16

9	5	9	0.42	1,350.91	0.00	0.00	0.00	1,182.61
		10	-0.42	0.44	0.00	0.00	0.00	-0.45
	6	9	0.42	1,801.26	0.00	0.00	0.00	1,576.78
		10	-0.42	0.54	0.00	0.00	0.00	-0.54
	7	9	-0.01	1,801.44	0.00	0.00	0.00	1,576.70
		10	0.01	0.36	0.00	0.00	0.00	-0.43
10	5	7	-184.54	1,176.84	0.00	0.00	0.00	18,604.88
		11	-19.40	-1,184.80	0.00	0.00	0.00	-16,848.29
	6	7	3,629.43	1,163.21	0.00	0.00	0.00	18,284.73
		11	-3,901.35	-1,171.17	0.00	0.00	0.00	-16,548.05
	7	7	9,994.42	524.04	0.00	0.00	0.00	8,607.59
		11	-10,266.34	-532.00	0.00	0.00	0.00	-7,818.78
11	5	11	19.40	1,184.15	0.00	0.00	0.00	16,847.66
		12	-3,282.39	-1,311.45	0.00	0.00	0.00	12,649.93
	6	11	3,901.35	1,170.52	0.00	0.00	0.00	16,547.42
		12	-8,252.00	-1,297.81	0.00	0.00	0.00	12,623.34
	7	11	10,266.35	531.68	0.00	0.00	0.00	7,818.61
		12	-14,617.00	-658.98	0.00	0.00	0.00	6,325.69
12	5	12	3,282.34	924.71	0.00	0.00	0.00	-12,650.21
		13	-3,486.28	-924.71	0.00	0.00	0.00	14,014.08
	6	12	8,251.95	913.46	0.00	0.00	0.00	-12,623.62
		13	-8,523.86	-913.46	0.00	0.00	0.00	13,970.38
	7	12	14,616.96	465.01	0.00	0.00	0.00	-6,325.77
		13	-14,888.88	-465.01	0.00	0.00	0.00	7,015.12
13	5	13	3,486.30	323.36	0.00	0.00	0.00	-14,014.35
		14	-3,690.23	-323.36	0.00	0.00	0.00	14,478.92
	6	13	8,523.88	316.00	0.00	0.00	0.00	-13,970.65
		14	-8,795.80	-316.00	0.00	0.00	0.00	14,423.96
	7	13	14,888.90	163.14	0.00	0.00	0.00	-7,015.18
		14	-15,160.81	-163.14	0.00	0.00	0.00	7,252.64
14	5	14	3,690.26	-129.04	0.00	0.00	0.00	-14,478.94
		15	-3,894.20	129.04	0.00	0.00	0.00	14,268.09
	6	14	8,795.84	-133.33	0.00	0.00	0.00	-14,423.98
		15	-9,067.75	133.33	0.00	0.00	0.00	14,206.49
	7	14	15,160.84	-63.94	0.00	0.00	0.00	-7,252.65
		15	-15,432.76	63.94	0.00	0.00	0.00	7,150.57
15	5	15	3,894.22	-454.65	0.00	0.00	0.00	-14,268.03
		16	-4,098.16	454.65	0.00	0.00	0.00	13,571.75
	6	15	9,067.78	-456.59	0.00	0.00	0.00	-14,206.44
		16	-9,339.69	456.59	0.00	0.00	0.00	13,507.06
	7	15	15,432.77	-227.41	0.00	0.00	0.00	-7,150.56
		16	-15,704.69	227.41	0.00	0.00	0.00	6,804.33
16	5	16	4,098.15	-675.55	0.00	0.00	0.00	-13,571.69
		17	-4,302.08	675.55	0.00	0.00	0.00	12,547.06
	6	16	9,339.68	-675.79	0.00	0.00	0.00	-13,507.00
		17	-9,611.60	675.79	0.00	0.00	0.00	12,481.87
	7	16	15,704.69	-338.31	0.00	0.00	0.00	-6,804.31
		17	-15,976.60	338.31	0.00	0.00	0.00	6,292.75
17	5	17	4,302.11	-940.16	0.00	0.00	0.00	-12,546.99
		18	-4,506.05	940.16	0.00	0.00	0.00	11,128.00
	6	17	9,611.63	-938.13	0.00	0.00	0.00	-12,481.80
		18	-9,883.54	938.13	0.00	0.00	0.00	11,065.73

	7	17	15,976.62	-471.22	0.00	0.00	0.00	-6,292.73
		18	-16,248.54	471.22	0.00	0.00	0.00	5,582.70
18	5	18	4,506.05	-1,081.71	0.00	0.00	0.00	-11,128.01
		19	-4,709.99	1,081.71	0.00	0.00	0.00	9,499.04
	6	18	9,883.55	-1,078.25	0.00	0.00	0.00	-11,065.74
		19	-10,155.46	1,078.25	0.00	0.00	0.00	9,441.87
	7	18	16,248.54	-542.37	0.00	0.00	0.00	-5,582.70
		19	-16,520.45	542.37	0.00	0.00	0.00	4,766.78
19	5	19	4,709.95	-1,203.39	0.00	0.00	0.00	-9,499.05
		20	-4,913.89	1,203.39	0.00	0.00	0.00	7,689.63
	6	19	10,155.42	-1,198.08	0.00	0.00	0.00	-9,441.88
		20	-10,427.33	1,198.08	0.00	0.00	0.00	7,640.35
	7	19	16,520.42	-603.64	0.00	0.00	0.00	-4,766.79
		20	-16,792.33	603.64	0.00	0.00	0.00	3,859.70
20	5	20	4,913.89	-1,182.30	0.00	0.00	0.00	-7,689.62
		21	-5,117.83	1,182.30	0.00	0.00	0.00	5,913.49
	6	20	10,427.34	-1,176.25	0.00	0.00	0.00	-7,640.34
		21	-10,699.25	1,176.25	0.00	0.00	0.00	5,873.24
	7	20	16,792.33	-593.21	0.00	0.00	0.00	-3,859.70
		21	-17,064.24	593.21	0.00	0.00	0.00	2,968.86
21	5	21	5,117.84	-1,072.73	0.00	0.00	0.00	-5,913.48
		22	-5,321.78	1,072.73	0.00	0.00	0.00	4,302.96
	6	21	10,699.27	-1,066.69	0.00	0.00	0.00	-5,873.24
		22	-10,971.19	1,066.69	0.00	0.00	0.00	4,271.73
	7	21	17,064.27	-538.33	0.00	0.00	0.00	-2,968.86
		22	-17,336.19	538.33	0.00	0.00	0.00	2,160.81
22	5	22	5,321.73	-916.54	0.00	0.00	0.00	-4,302.97
		23	-5,525.66	916.54	0.00	0.00	0.00	2,927.68
	6	22	10,971.13	-911.00	0.00	0.00	0.00	-4,271.74
		23	-11,243.04	911.00	0.00	0.00	0.00	2,904.73
	7	22	17,336.13	-460.01	0.00	0.00	0.00	-2,160.81
		23	-17,608.05	460.01	0.00	0.00	0.00	1,470.59
23	5	23	5,525.69	-744.35	0.00	0.00	0.00	-2,927.70
		24	-5,729.63	744.35	0.00	0.00	0.00	1,811.31
	6	23	11,243.08	-739.57	0.00	0.00	0.00	-2,904.75
		24	-11,514.99	739.57	0.00	0.00	0.00	1,795.52
	7	23	17,608.08	-373.63	0.00	0.00	0.00	-1,470.60
		24	-17,879.99	373.63	0.00	0.00	0.00	910.18
24	5	24	5,729.62	-577.11	0.00	0.00	0.00	-1,811.34
		25	-5,933.55	577.11	0.00	0.00	0.00	946.22
	6	24	11,514.97	-573.19	0.00	0.00	0.00	-1,795.55
		25	-11,786.89	573.19	0.00	0.00	0.00	936.32
	7	24	17,879.97	-289.71	0.00	0.00	0.00	-910.19
		25	-18,151.88	289.71	0.00	0.00	0.00	475.80
25	5	25	5,933.52	-427.86	0.00	0.00	0.00	-946.22
		26	-6,137.46	427.86	0.00	0.00	0.00	305.20
	6	25	11,786.85	-424.76	0.00	0.00	0.00	-936.32
		26	-12,058.76	424.76	0.00	0.00	0.00	299.96
	7	25	18,151.85	-214.81	0.00	0.00	0.00	-475.80
		26	-18,423.76	214.81	0.00	0.00	0.00	153.86
42	5	9	20,316.36	1,214.08	0.00	0.00	0.00	20,228.73
		43	-20,520.29	-1,222.04	0.00	0.00	0.00	-18,391.10

	6	9	24,130.32	1,227.72	0.00	0.00	0.00	20,548.88
		43	-24,402.24	-1,235.68	0.00	0.00	0.00	-18,691.34
	7	9	19,691.73	618.89	0.00	0.00	0.00	11,079.68
		43	-19,963.65	-626.85	0.00	0.00	0.00	-10,143.76
43	5	43	20,520.21	1,222.88	0.00	0.00	0.00	18,390.81
		44	-23,783.20	-1,350.18	0.00	0.00	0.00	12,824.45
	6	43	24,402.16	1,236.52	0.00	0.00	0.00	18,691.06
		44	-28,752.81	-1,363.81	0.00	0.00	0.00	12,851.04
	7	43	19,963.63	627.07	0.00	0.00	0.00	10,143.72
		44	-24,314.29	-754.37	0.00	0.00	0.00	6,543.80
44	5	44	23,783.16	953.02	0.00	0.00	0.00	-12,824.27
		46	-23,987.10	-953.02	0.00	0.00	0.00	14,271.79
	6	44	28,752.76	964.27	0.00	0.00	0.00	-12,850.86
		46	-29,024.67	-964.27	0.00	0.00	0.00	14,315.49
	7	44	24,314.24	542.49	0.00	0.00	0.00	-6,543.77
		46	-24,586.15	-542.49	0.00	0.00	0.00	7,364.15
45	5	46	23,987.19	333.85	0.00	0.00	0.00	-14,271.81
		47	-24,191.13	-333.85	0.00	0.00	0.00	14,788.11
	6	46	29,024.79	341.22	0.00	0.00	0.00	-14,315.50
		47	-29,296.71	-341.22	0.00	0.00	0.00	14,843.07
	7	46	24,586.26	211.31	0.00	0.00	0.00	-7,364.15
		47	-24,858.17	-211.31	0.00	0.00	0.00	7,686.89
46	5	47	24,191.04	-131.38	0.00	0.00	0.00	-14,788.31
		48	-24,394.98	131.38	0.00	0.00	0.00	14,604.46
	6	47	29,296.60	-127.09	0.00	0.00	0.00	-14,843.28
		48	-29,568.52	127.09	0.00	0.00	0.00	14,666.05
	7	47	24,858.09	-38.63	0.00	0.00	0.00	-7,686.93
		48	-25,130.01	38.63	0.00	0.00	0.00	7,633.95
47	5	48	24,394.98	-466.44	0.00	0.00	0.00	-14,604.39
		49	-24,598.92	466.44	0.00	0.00	0.00	13,915.41
	6	48	29,568.53	-464.50	0.00	0.00	0.00	-14,665.98
		49	-29,840.45	464.50	0.00	0.00	0.00	13,980.09
	7	48	25,130.03	-219.40	0.00	0.00	0.00	-7,633.94
		49	-25,401.94	219.40	0.00	0.00	0.00	7,308.88
48	5	49	24,598.97	-694.12	0.00	0.00	0.00	-13,915.39
		50	-24,802.91	694.12	0.00	0.00	0.00	12,882.80
	6	49	29,840.51	-693.88	0.00	0.00	0.00	-13,980.08
		50	-30,112.43	693.88	0.00	0.00	0.00	12,948.00
	7	49	25,401.99	-342.91	0.00	0.00	0.00	-7,308.88
		50	-25,673.90	342.91	0.00	0.00	0.00	6,797.80
49	5	50	24,802.92	-966.89	0.00	0.00	0.00	-12,882.76
		51	-25,006.86	966.89	0.00	0.00	0.00	11,439.02
	6	50	30,112.44	-968.92	0.00	0.00	0.00	-12,947.96
		51	-30,384.36	968.92	0.00	0.00	0.00	11,501.29
	7	50	25,673.93	-492.24	0.00	0.00	0.00	-6,797.79
		51	-25,945.84	492.24	0.00	0.00	0.00	6,061.98
50	5	51	25,006.79	-1,113.02	0.00	0.00	0.00	-11,439.01
		52	-25,210.72	1,113.02	0.00	0.00	0.00	9,774.28
	6	51	30,384.26	-1,116.48	0.00	0.00	0.00	-11,501.28
		52	-30,656.18	1,116.48	0.00	0.00	0.00	9,831.46
	7	51	25,945.73	-573.58	0.00	0.00	0.00	-6,061.97
		52	-26,217.64	573.58	0.00	0.00	0.00	5,203.47

51	5	52	25,210.75	-1,238.97	0.00	0.00	0.00	-9,774.29
		53	-25,414.69	1,238.97	0.00	0.00	0.00	7,919.12
	6	52	30,656.21	-1,244.28	0.00	0.00	0.00	-9,831.46
		53	-30,928.13	1,244.28	0.00	0.00	0.00	7,968.40
	7	52	26,217.69	-647.47	0.00	0.00	0.00	-5,203.47
		53	-26,489.61	647.47	0.00	0.00	0.00	4,233.57
52	5	53	25,414.69	-1,217.70	0.00	0.00	0.00	-7,919.13
		54	-25,618.63	1,217.70	0.00	0.00	0.00	6,094.63
	6	53	30,928.13	-1,223.75	0.00	0.00	0.00	-7,968.40
		54	-31,200.05	1,223.75	0.00	0.00	0.00	6,134.88
	7	53	26,489.61	-641.48	0.00	0.00	0.00	-4,233.57
		54	-26,761.53	641.48	0.00	0.00	0.00	3,272.18
53	5	54	25,618.64	-1,105.09	0.00	0.00	0.00	-6,094.63
		55	-25,822.58	1,105.09	0.00	0.00	0.00	4,438.07
	6	54	31,200.07	-1,111.12	0.00	0.00	0.00	-6,134.88
		55	-31,471.99	1,111.12	0.00	0.00	0.00	4,469.30
	7	54	26,761.55	-585.48	0.00	0.00	0.00	-3,272.18
		55	-27,033.46	585.48	0.00	0.00	0.00	2,394.41
54	5	55	25,822.59	-944.33	0.00	0.00	0.00	-4,438.07
		56	-26,026.53	944.33	0.00	0.00	0.00	3,021.96
	6	55	31,472.01	-949.86	0.00	0.00	0.00	-4,469.30
		56	-31,743.92	949.86	0.00	0.00	0.00	3,044.91
	7	55	27,033.48	-502.65	0.00	0.00	0.00	-2,394.41
		56	-27,305.40	502.65	0.00	0.00	0.00	1,640.62
55	5	56	26,026.57	-766.96	0.00	0.00	0.00	-3,021.96
		57	-26,230.51	766.96	0.00	0.00	0.00	1,871.42
	6	56	31,743.97	-771.74	0.00	0.00	0.00	-3,044.91
		57	-32,015.89	771.74	0.00	0.00	0.00	1,887.21
	7	56	27,305.45	-410.00	0.00	0.00	0.00	-1,640.62
		57	-27,577.36	410.00	0.00	0.00	0.00	1,025.61
56	5	57	26,230.41	-594.62	0.00	0.00	0.00	-1,871.43
		58	-26,434.35	594.62	0.00	0.00	0.00	979.10
	6	57	32,015.76	-598.55	0.00	0.00	0.00	-1,887.22
		58	-32,287.68	598.55	0.00	0.00	0.00	989.00
	7	57	27,577.25	-319.27	0.00	0.00	0.00	-1,025.62
		58	-27,849.16	319.27	0.00	0.00	0.00	546.59
57	5	58	26,434.38	-440.77	0.00	0.00	0.00	-979.10
		59	-26,638.31	440.77	0.00	0.00	0.00	317.38
	6	58	32,287.72	-443.87	0.00	0.00	0.00	-989.00
		59	-32,559.64	443.87	0.00	0.00	0.00	322.62
	7	58	27,849.21	-237.83	0.00	0.00	0.00	-546.58
		59	-28,121.12	237.83	0.00	0.00	0.00	189.63

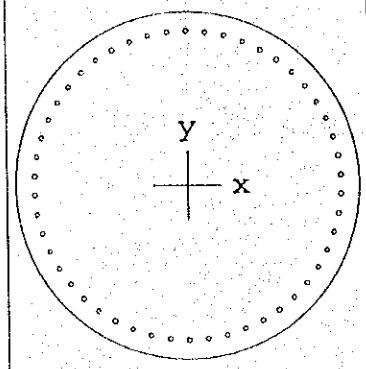
PILES

Member # 11

	Pu	Mu	Vu
Load Comb 5	9.70	8,423.83	592.11
Load Comb 6	1,950.70	8,273.71	585.30
Load Comb 7	5,133.20	3,909.40	265.80

Member # 43

	Pu	Mu	Vu
Load Comb 5	10,260.00	9,195.40	611.44
Load Comb 6	12,201.08	9,345.50	618.30
Load Comb 7	9,981.80	5,071.86	313.55



2500 mm diam.

_ c = 28 MPa

fy = 414 MPa

Confinement: Spiral

clr cover = 120 mm

spacing = 104 mm

50 N-36 at 1.04%

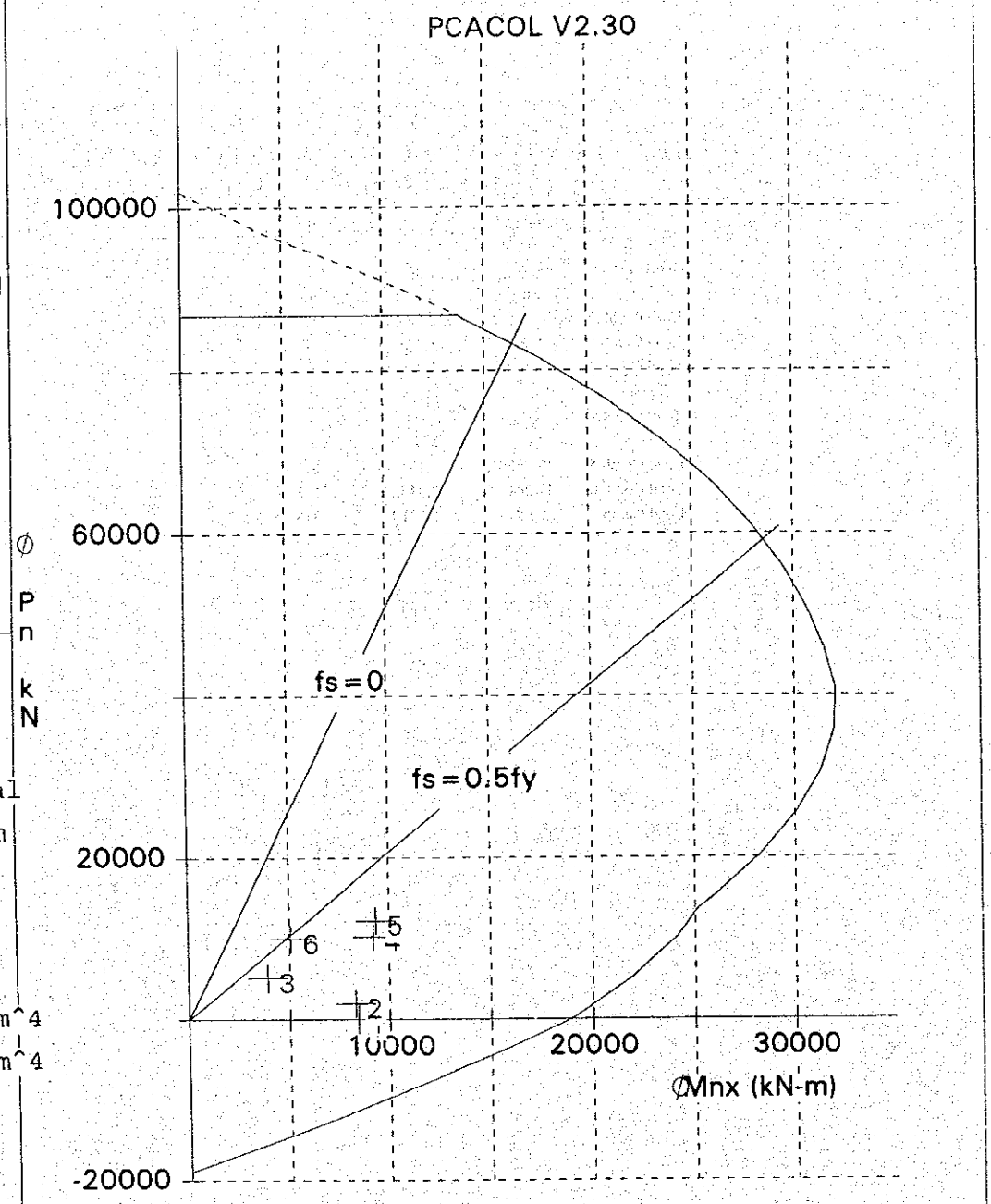
As = 50890 mm^2

Ix = 1.917e+012 mm^4

Iy = 1.917e+012 mm^4

Xo = 0 mm

Yo = 0 mm



Licensed To: Licensee name not yet specified.

File name: C:\BANGLA\RUPSA\MP1.COL

Project: RUPSA BRIDGE PROJECT

Column Id: MP-1 BORED PILE

Engineer: PCI-DHAKA

Date: 02/08/00 Time: 11:28:48

Code: ACI 318-89

Units: Metric

Material Properties:

Ec = 26657 MPa eu = 0.003 mm/mm

fc = 23.63 MPa Es = 199955 MPa

Beta1 = 0.85

Stress Profile: Block

phi(c) = 0.75, phi(b) = 0.90

X-axis slenderness is not considered.

THE STUDY ON THE CONSTRUCTION OF THE BRIDGE
OVER THE RIVER RUPSA IN KHULNA, PHASE - 2

Job No. :	Designed by :	Checked by :	Date :	10-Feb-00

A. MATERIALS AND DIMENSIONS :

1. Concrete Strength @ 28 days, f_c' = 30.00 MPa
2. Min. Yied Strength of Reinf. Steel, fy = 275.80 MPa for ϕ =or < 16
   = 413.70 MPa for ϕ = or > 20
3. Diameter of Pile, D = 2.50 m.
4. Minimum Concrete Cover, c = 0.10 m.

B. DESIGN FORCES :

B.1. Pile Forces

Forces	Longitudinal Direction	Transverse Direction
Mom., M_y, (KN-m.)		9,346
Mom., M_z, (KN-m.)		0
Mom., M_{des} (KN-m.)	0	9,346
Shear, V_y, (KN)		618

Forces	Longitudinal Direction	Transverse Direction
Shear, V_x, (KN)	0	0
Shear, V_{DES}, (KN)	0	618
Axial, $P_{max.}$, (KN)		12,201
Axial, $P_{min.}$, (KN)		10

FROM PCACOL :

B.2. Main Reinforcement
Required ρ_{min} = .0075 for upper 2/3 of pile length

As	Diam.	Pcs.	ρ (%)
50890	36	50	1.04

B.3. Main Reinforcement
Required, r_{min} = .0050 for lower 1/3 of pile length)

As	D36	D32	D28
24,544	25	32	41

B.4. Special Pile Requirement of, AASHTO Art. 6.4.1 Reinforcing Bars, f_y = 413,700 Mpa

1. Confinement Length, L_c = 2D : 5.00 m.
2. Anchorage: Max. Tension, $P = 1.25A_sf_y$: 526.37 KN
3. Anchorage Length : (a). $L_a = 0.60*A_bf_y/f_c'$ 1.46 m.
   (b). $L_a = 0.000058\phi_bf_y$ 0.86 m. *USE L_a = 1.46 m.*

C. TRANSVERSE REINFORCEMENT :

C.1. Transverse Reiforcement Spiral Size = 20.00 mm. Spiral, f_y = 413,700 kPa

C.1.1. Transverse Reinforcement

1. $\rho = 0.45 (A_g/A_c - 1) f_c'/f_y$ = 0.0059 A_g = 4.91 D_c = 2.30 A_c = 4.15 Ds = 2.28

Spiral Sp. : $S_P = 4A_s/\rho D_s$ = 0.093
Maximum Spacing : S_P = 0.096 *USE S_P = 0.093 m.*

C.1.2. Check Requirement from Shear Force :

Shear Stresses			
Carried by Concrete, $vc = 166(f_c')^{1/2}$	909.22 KPa	Vu=	618.30 KN
Due to Applied Load, $vu = V_u/(\phi b_w d)$	131.90 KPa	b_w =	2.50 m.
Carried by Steel, vs = vu - vc	0.00 KPa	d_v =	1.88 m.
Minimum Requirement, v_s	345.00 KPa	Use : v_s =	345.00 KPa

Spiral Spacing $Sp = A_v f_y / v_s b_w$: sp = 0.15 m. ***Adopt Sp*** = 0.09 m.

Finally adopt

20 mm. diam. spiral pitch @ 0.09 m. from pile top to 2D below ground
20 mm. diam. spiral pitch @ 0.15 m. for the rest of the pile length

200

```
OOOOOOO  OOOOO  OOOOO  OOOOO  OOOOO  OO
OO   OO OO  OO OO  OO OO  OO OO  OO OO
OO   OO OO  OO OO  OO OO  OO OO  OO OO
OO   OO OO    OO  OO OO    OO  OO OO
OO   OO OO    OOOOOOO OO    OO  OO OO
OOOOOOO  OO  OO OO  OO OO  OO OO  OO OO
OO     OO  OO OO  OO OO  OO OO  OO OO
OO      OOOOO  OO  OO  OOOOO  OOOOO  OOOOO (TM)
```

Computer program for the Strength Design of Reinforced Concrete Sections

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General Information:

File Name: C:\BANGLA\RUPSA\MP1.COL
Project: RUPSA BRIDGE PROJECT Code: ACI 318-89
Column: MP-1 BORED PILE Units: SI Metric
Engineer: PCI-DHAKA Date: 02/08/00 Time: 11:28:48

Run Option: Design Short (nonslender) column
Run Axis: X-axis Column Type: Structural

Material Properties:

fc = 27.8 MPa fy = 413.7 MPa
Ec = 26656.8 MPa Es = 199955 MPa
fc = 23.63 MPa erup = 0 mm/mm
eu = 0.003 mm/mm
Stress Profile: Block Beta1 = 0.848404

Geometry:

Circular: Diameter = 2500 mm

Gross section area, Ag = 4.90874e+006 mm^2
Ix = 1.91748e+012 mm^4 Xo = 0 mm
Iy = 1.91748e+012 mm^4 Yo = 0 mm

Reinforcement:

Rebar Database: User-defined

Size	Diam	Area	Size	Diam	Area	Size	Diam	Area
10	11	100	15	16	200	20	20	300
25	25	500	30	30	700	35	36	1000
36	36	1018	45	44	1500	55	56	2500

Confinement: Spiral; phi(c) = 0.75, phi(b) = 0.9, a = 0.85
N-10 ties with N-25 bars, N-20 with larger bars.

Layout: Circular
Pattern: All Sides Equal [Cover to transverse reinforcement (ties)]

Total steel area, As = 50890 mm^2 at 1.04%

50N-36 Cover = 100 mm

Pt.	Applied Loads P (kN)	Mx (kN-m)	Computed Strength P (kN)	Mx (kN-m)	Computed/ Applied Ray length
1	10	8424	22	19002	2.256
2	1951	8274	5157	21959	2.653
3	5133	3909	41258	32050	8.097
4	10260	9195	34345	31858	3.400
5	12201	9345	41078	32062	3.391
6	9982	5072	56630	29293	5.694

Program completed as requested!

User ID: Pacific Consultants Inter

MN/ELEM

MOMENT MZ LN= 5

STRUCTURE DATA

TYPE = PLANE

NJ = 74

NM = 73

NE = 0

NS = 0

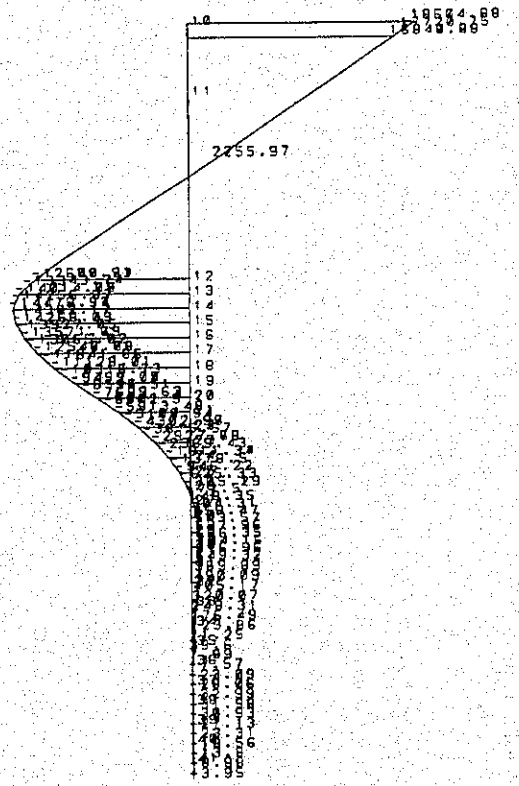
NRJ= 62

NL = 7

XMAX= 11.0

YMAX= 88.6

ZMAX= .0



1.3(0.75 D + W + SF)

Maximum= 18564.88

J=74,M=73

UNIT MET KNS

S T A A D P O S T - P L O T (REV: 22.3) DATE: FEB 8, 2000

TITLE: TRANSVERSE ANALYSIS ON MP1

969

User ID: Pacific Consultants Inter

MN/ELEM

MOMENT MZ LN= 6

STRUCTURE DATA

TYPE = PLANE

NJ = 74

NM = 73

NE = 0

NS = 0

NRJ= 62

NL = 7

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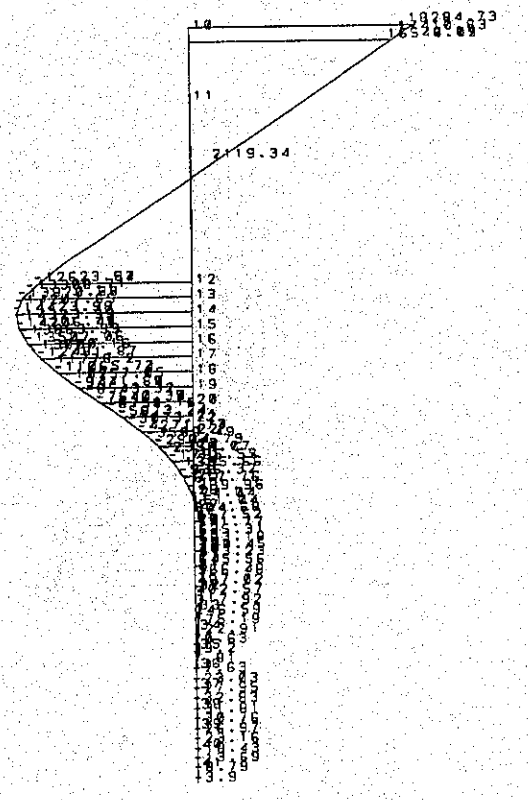
YMAX= 88.6

ZMAX= .0



1.3 (D + W + SF)

Maximum= 18284.73

J=74, M=73

UNIT MET KNS

S T A A D P O S T - P L O T (REV: 22.3) DATE: FEB 8, 2000

TITLE: TRANSVERSE ANALYSIS ON MP1

407

User ID: Pacific Consultants Inter

MN/ELEM

MOMENT MZ LN= 7

STRUCTURE DATA

TYPE = PLANE

NJ = 74

NM = 73

NE = 0

NS = 0

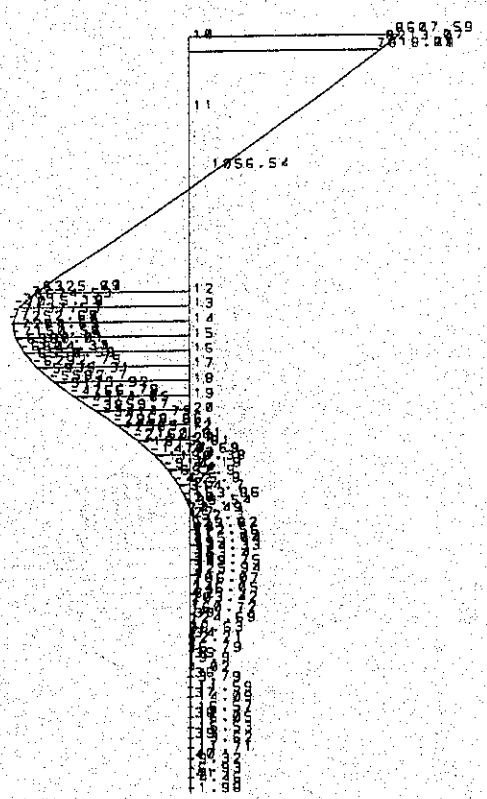
NRJ= 62

NL = 7

XMAX= 11.0

YMAX= 88.6

ZMAX= .0



1.3(D + 0.3W + WL + SF)

Maximum= 8607.59

J=74,M=73

UNIT MET KNS

S T A A D P O S T - P L O T (REV: 22.3)

DATE: FEB 8, 2000

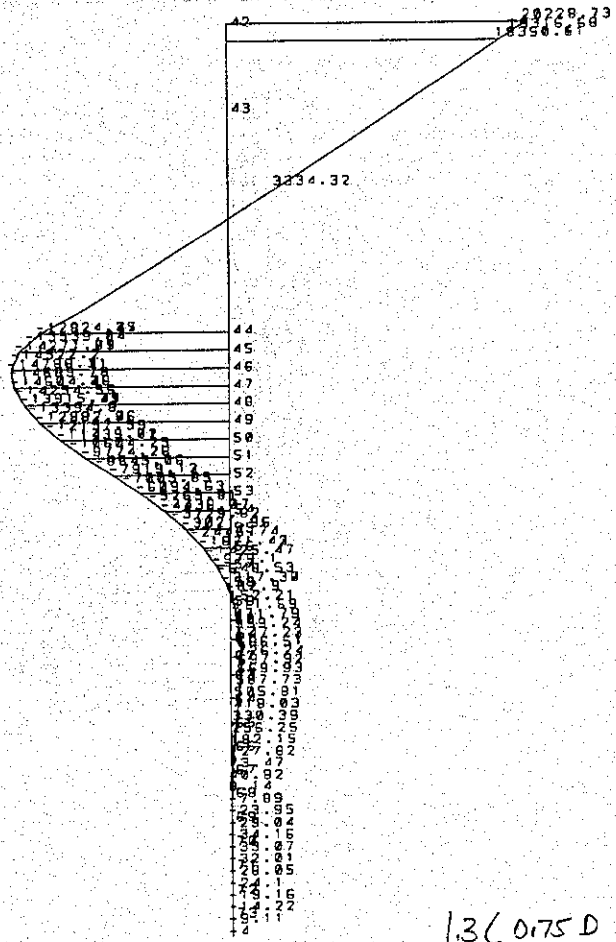
TITLE: TRANSVERSE ANALYSIS ON MP1

369

User ID: Pacific Consultants Inter

STRUCTURE DATA

TYPE = PLANE
NJ = 74
NM = 73
NE = 0
NS = 0
NRJ= 62
NL = 7
XMAX= 11.0
YMAX= 88.6
ZMAX= .0



Maximum= 20228.73
J=74,M=73

UNIT MET KNS

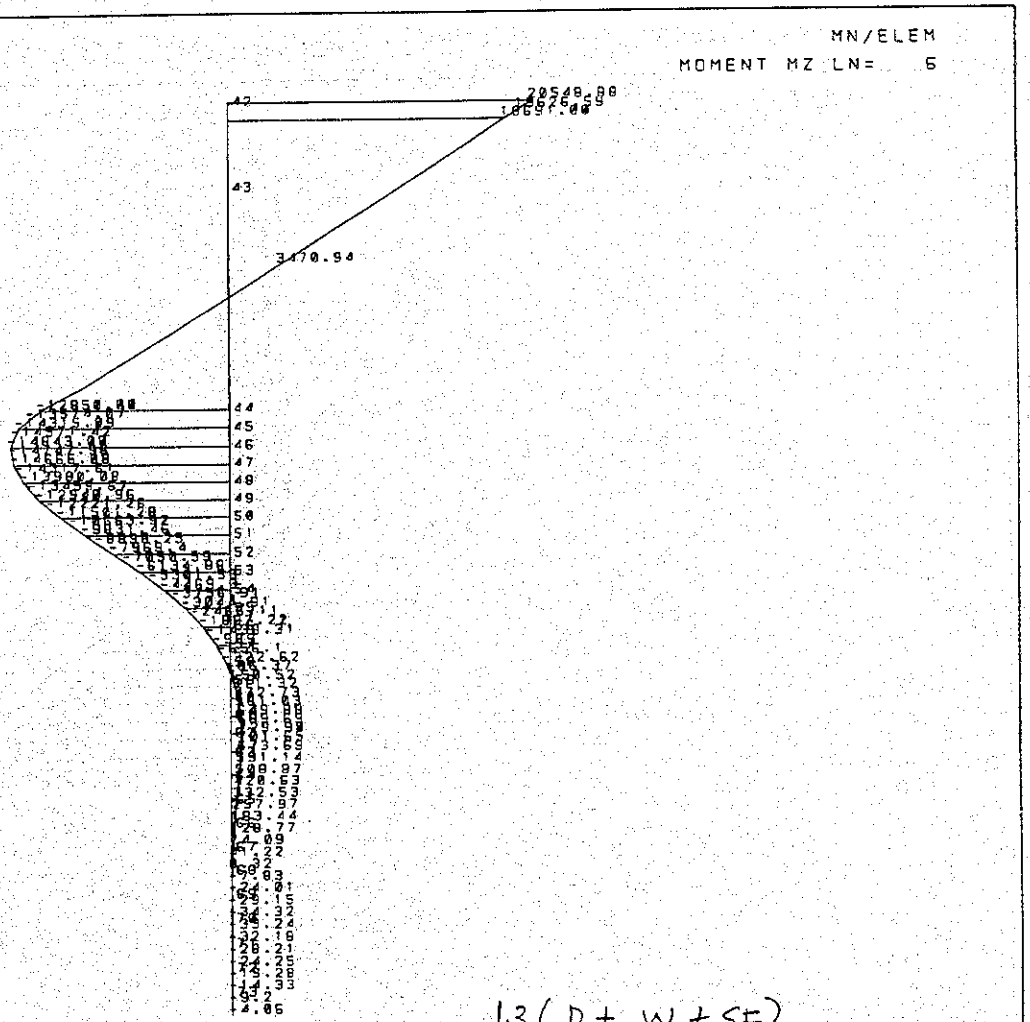
STAAD POST-PLOT (REV: 22.3) DATE: FEB 8, 2000

TITLE: TRANSVERSE ANALYSIS ON MP1

User ID: Pacific Consultants Inter

STRUCTURE DATA

TYPE = PLANE
NJ = 74
NM = 73
NE = 0
NS = 0
NRJ= 62
NL = 7
XMAX= 11.0
YMAX= 88.6
ZMAX= .0



Maximum= 20548.88
J=74,M=73

UNIT MET KNS

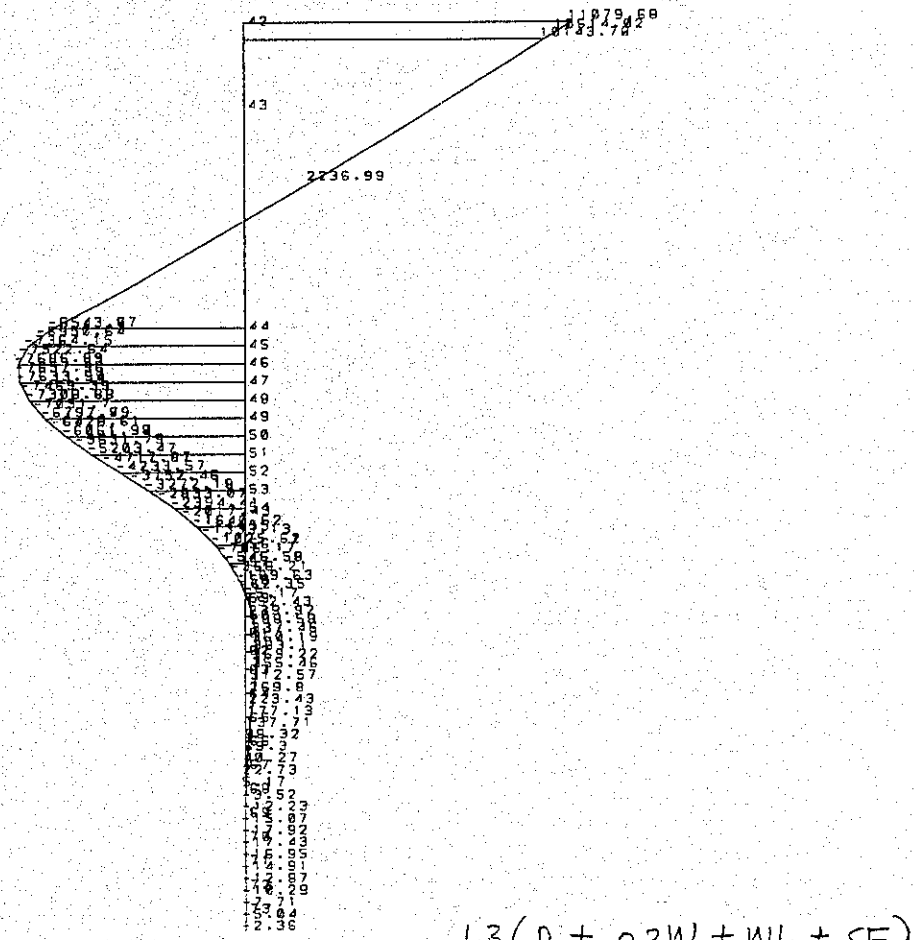
STAAD POST-PLOT (REV: 22.3) DATE: FEB 8, 2000

TITLE: TRANSVERSE ANALYSIS ON MP1

User ID: Pacific Consultants Inter

STRUCTURE DATA

TYPE = PLANE
NJ = 74
NM = 73
NE = 0
NS = 0
NRJ= 62
NL = 7
XMAX= 11.0
YMAX= 88.6
ZMAX= .0



Maximum= 11079.68
J=74,M=73

UNIT MET KNS

S T A A D P O S T - P L O T (REV: 22.3)

DATE: FEB 9, 2000

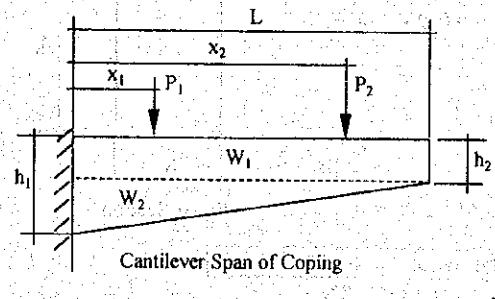
TITLE: TRANSVERSE ANALYSIS ON MP1

COPING

THE STUDY ON THE CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA, PHASE-2

Job No. :	Designed by :	Checked by :	Date : 2/9/00

1. Geometry and Material Property



Cantilever Span of Coping

Input Data :

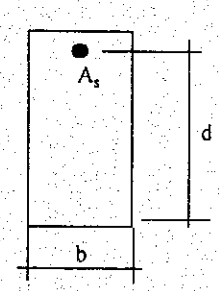
Cantilever Span Length, L =	4.32	m.
Girder Dist. from face, x_1 =	1.02	m.
x_2 =	3.42	m.
Coping Depth, h_1 (m.) =	1.80	m.
h_2 (m.) =	1.20	m.
at d distance h_d (m.) =	1.56	m.
Coping Width, B (m.) =	0.90	m.
Comp. Strength of concrete @ 28 days, fc' =	30,000	KPa
Minimum Yield Strength of Reinf. Bars, fy =	413,700	KPa

2. Loads and Forces

Item	Dist. Fr. Column Face (x)	Dead Load			Live Load + Impact			Total Ultimate Load 1.3(DL+5/3 LL+I)	
		Load	M	V	Load	M	V	M	V
W_1	2.16	111.97	241.86	111.97	0.00	0.00	0.00	314.42	145.57
W_2	1.44	27.99	40.31	27.99	0.00	0.00	0.00	52.40	36.39
P_1	1.02	615.00	627.30	615.00	150.00	153.00	150.00	1146.99	1,124.50
P_2	3.42	615.00	2,103.30	615.00	150.00	513.00	150.00	3845.79	1,124.50
Summation			3,012.78	1,369.97		666.00	300.00	5,359.61	2,430.96

3. Flexural Reinforcement

3.1. Flexural Requirement



Flexural Section

Rectangular Section with Tension Reinforcement only:

$Mu = \phi A_s f_y d(1 - 0.6\rho f_y/f_c')$ where $A_s = \rho bd$

$Mu = \phi bd^2 f_y(1 - 0.6\rho f_y/f_c')$ let $\omega = \rho f_y/f_c'$

$Mu = \phi bd^2 \omega f_c'(1-\omega)$

This is reduced to quadratic equation :

$0.60\omega^2 - \omega + Mu/(\phi bd^2 f_c') = 0$ where $\rho = \omega f_c'/f_y$

Conc. Cover, (m.) = 0.05

Bar Size, ϕ (mm) = 32.00 Bar Area= 804.25 $mm.^2$

Ult. Mom., Mu =	5,360 KN-m.	ω =	0.07998
Beam Width, b =	0.90 m.	ρ =	0.0058
Beam Depth, d =	1.70 m.	A_s =	8,884 $mm.^2$
$Mu/(\phi bd^2 f_c')$ =	0.0761	N_b =	12 bars of ϕ- 32

3.2. Minimum Flexural Requirement, $\rho_{min.}$ = (ρ based on $1.2M_{cr}$) AASHTO Art. 8.17.2

$M_{cr} = f_r I/y_t$ f_r = 3,410 KPa $1.2M_{cr}$ = 1,988

$f_r = 622 f_c'^{1/2}$ for normal I = 0.437 $m.^4$ $1.2M_{cr}$ = < Mu

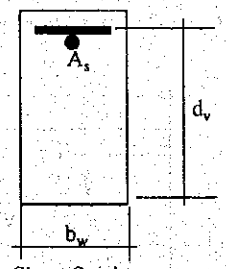
weight conc y_t = 0.90 m. $\rho_{min.} \sim$ **0.00215**

3.3. Maximum Flexural Requirement, $\rho_{max} = 0.75\rho_{bal}$, AASHTO Art. 8.16.3.1

$\rho_{bal} = 0.85\beta_1 f_c'/f_y(599865/(599865+f_y))$ $\rho_{bal} = 0.0304$

$\beta_1 = 0.832$ $\rho_{max} = \mathbf{0.0228}$

AASHTO Art. 8.16.2.7 β_1 =0.85 up to fc' = 27.58 Mpa and shall be reduced continuously at the rate of 0.05 for each in excess of 27.58 Mpa.



Shear Section

4. Shear Requirement

Ultimate Shear	@ Column Face	@ d distance	Unit
V_f or V_d	2,430.96	1,224.89	KN

$V_n = V_c + V_s$ Tie/Stirrup Size = 12.000 mm. Shear Depth

$V_n = V_u/0.85$ Area per Leg, A_{v1} = 0.000113 $m.^2$ At Face, d_f = 1.74 m.

$V_s = V_u/0.85 - V_c$ No. of Legs = 4.0000 pcs. At d dist, d_d = 1.51 m.

$V_c = 166 f_c'^{1/2} b_w d$ Tot. Shear, A_v = 0.000452 $m.^2$ Width, b_w = 0.90 m.

Spacing of Tie/Stirrup, $s = A_v f_y d/V_s$

Location	V_u	V_c	V_s	spacing - ϕ 12 Stirrups, 4 -legs
At Column Face	2,431	1,427	1,433	0.23 m. o.c. fr. col.face to d' dist
At d distance	1,225	1,233	208	1.36 m. o.c. from d dist. to rest

FOOTING

THE STUDY ON THE CONSTRUCTION OF THE BRIDGE
OVER THE RIVER RUPSA IN KHULNA, PHASE - 2

Job No. :	Designed by :	Checked by :	Authority : afh	Date : 2/10/00

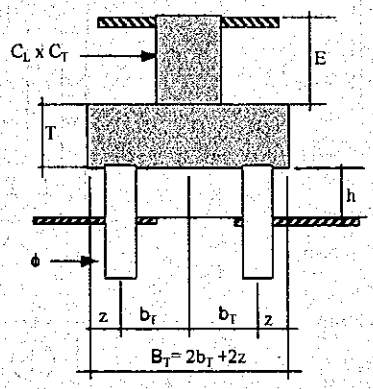
Limitations :

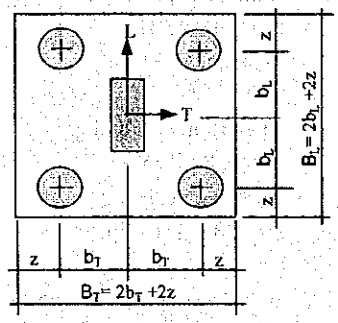
1. Applicable to footings with symmetrically arranged piles with total of four(4) piles.
2. Spring constants K_1, K_2, K_3, K_4 & K_v are the same for all the piles.
3. Applicable to piles with a minimum length of $l = \pi/\beta$ (Long Piles)
4. Method of calculations using Displacement Method.

Note :
L.D.- Longitudinal Direction
T.D.- Transverse Direction.
L = Longitudinal Axis
T = Transverse Axis

A. DIMENSIONS :

Half Spacing @ L.D., b_L =	3.75 m.
Half Spacing @ T.D., b_T =	3.75 m.
Ftng. Width @ L.D.,B_L =	11.00 m.
Ftng. Width @ T.D.,B_T =	11.00 m.
Footing Thickness, T =	3.00 m.
Footing Embedment, E =	0.00 m.
Column Dim. @ T.D., C_T =	6.00 m.
Column Dim. @ L.D., C_L =	4.00 m.
Typical Pile Diameter, ϕ =	2.50 m.
Pile Ext. above ground, h =	24.00 m.
Dist. From edge of Cap, z =	1.75 m.





B. SOIL AND PILE PARAMETERS :

1. Coefficient of Hor. Subgrade Reaction, $k = 174 * N D^{-3/4} y^{-1/2}$
   Mean value of SPT over 1/β below ground, N = 15 blows
   Standard amount of displ. at ground surface, y = 0.025 m.
   Coefficient of Horizontal Subgrade Reaction, k = 12,454 KN/m^3
   Compensating Coefficient, $\mu = 1 - 0.2(2.5 - l/\phi)$ = 1.00
   12,454 KN/m^3

2. Flexural Rigidity of Pile, EI : EI = 19,874,880 KN-m^2
   Minimum Length of Pile, $l = \pi/\beta$: l = 22.33 m.
3. Char. value of pile, $\beta = (kD/4EI)^{1/4}$: β = 0.140676 m^{-1}
4. Radial Spring and Axial Spring Constants

C. MATERIALS :

1. Concrete Strength at 28 days, fc' :
   fc' = 30,000 KPa
   Ec = 25,912,754 KPa
2. Minimum Yield Stess of Rebar, fy :
   fy = 413,700 KPa for ϕ =/> 20
   fy = 275,800 KPa for ϕ =/< 16

Total Length of pile, $l = l + h$ = 46.33 m.
$1/\beta$ = 7.11 m. $\kappa = 1/\beta + h$ = 31.11 m.

	Rigidly Connected Pile Head		Hinge- Connected Pile Head	
	h >0	h=0	h >0	h=0
K_1 =	$12EI\beta^3/((1+\beta h)^3 + 2)$	$4EI\beta^3$	$3EI\beta^3/((1+\beta h)^3 + 0.5)$	$2EI\beta^3$
K_2, K_3=	$K1*\kappa/2$	$2EI\beta^3$	0	0
K_4 =	$\frac{4EI\beta*((1+bh)^3 + 0.5)}{(1+\beta h)*((1+bh)^3 + 2.0)}$	$2EI\beta^3$	0	0
K_v =	a*Ap*Ep/l where a=0.022l/D-.05		a*Ap*Ep/l where a=0.022l/D-.05	

? Input Pile Head Connection	
Rigidly Connected Pile Head (1)	
Hinge- Connected Pile Head (2)	
Type (1 or 2) ?	1

Adopt : K_1 = 7,738 K_v = 982,084
K_2, K_3 = 120,352 K_4 = 49,690

Note : All units of Spring Constants in KN/m.

D. LOADS :

D.1. Forces in the Longitudinal Direction

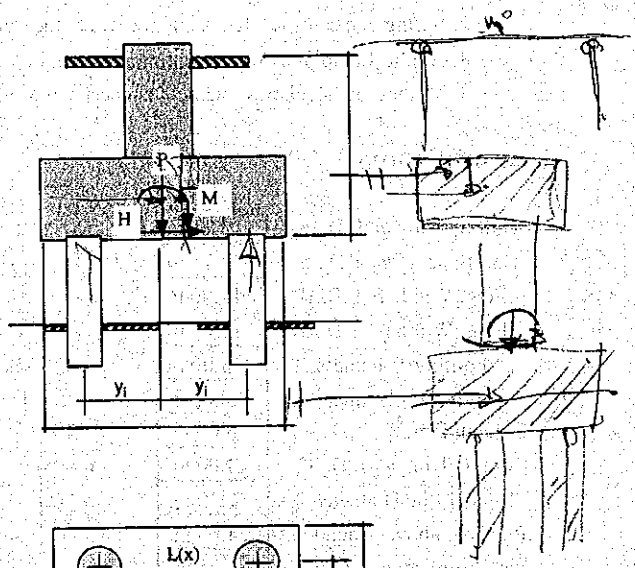
Wt. of Footing, W_f = 8712 KN
Weight of Soil, W_s = 4656 KN
Soil Press. @ Ftg. Pp = 0 0 KN

At Top of Footing :

Axial Force, P =	21,771	KN
Horiz. Force, H=	85	KN
Moment, M =	943	KN-m.

At Bottom of Footing :

Axial , P =P +W_f +W_s = 35,139 KN
Horiz. Force, H - Pp = 85 KN
Mo= M +H*T - Pp*y= 1,199 KN-m.



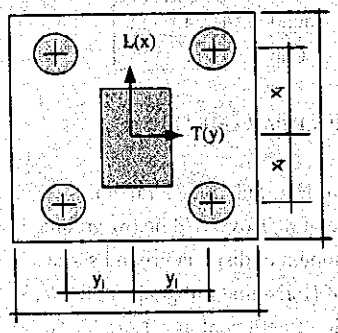
D.2. Forces in the Tranverse Direction

At Top of Footing :

Axial Force, P =	15,872	KN
Horiz. Force, H=	2,260	KN
Moment, M =	34,664	KN-m.

At Bottom of Footing :

Axial, P =P +W_f +W_s = 29,240 KN
Horiz. Force, H - Pp = 2,260 KN
Mo = M +H*T -Pp*y = 41,444 KN-m.



D.3 Formula :

D.3.1 Axial Force of the i-th pile, P_{Ni} : $$P_{Ni} = V_o/n + \frac{M_o + 1/2*\kappa*H_o}{\Sigma x_i^2 + n/K_v(K_4 - K_2^2/K_1)} * x_i$$

D.3.2 Radial Force of the i-th pile, $P_{Hi} = H_o/n$

D.3.3 Moment as an External Force which acts on the ith pile, $M_{Ii} = 1/n\,(M_o - \Sigma P_{Ni}\, x_i)$

E. REACTIONS AND DISPLACEMENTS :

$\Sigma x_i^2 = n_1x_1^2 + n_2x_2^2 + \ldots + n_nx_n^2 =$ 56.25 m^2 for long'l.(x-axis)
$\Sigma y_i^2 = n_1y_1^2 + n_2y_2^2 + \ldots + n_ny_n^2 =$ 56.25 m^2 for transv.(y-axis)

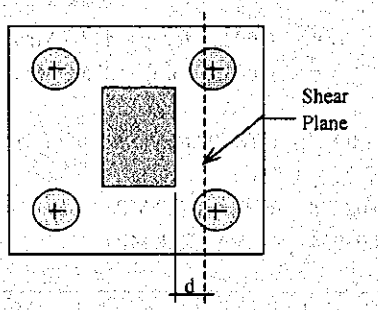
Forces	Long'l Direction	Transv. Direction	Ultimate Allowable	Unit	Remark
Axial, Max. P_{Ni} =	8,979	13,193	**27,000**	KN, Comp.	**O.K.**
Axial,Min. P_{NI} =	8,591	1,428	**-7,049**	KN, Uplift	**O.K.**
Rad. Force , P_{Hi} =	21	565	**1,264**	KN	**O.K.**
Moment , M_{Ii} =	-428	-11,698	----	KN-m.	

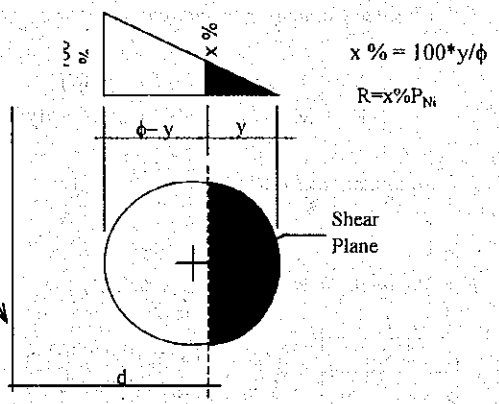
Note :
Ultimate Allow. Radial Force
H = kDδ/β for Pile Burried under the ground
H = 4EIβ^{3}δ/(1+βh) for Piles Protruding Above Ground

F. CHECK SECTIONAL ADEQUACY OF FOOTING :

E.1 Check One-way or Beam Shear

AASHTO Art. 8.16.6.6(a), the section shall be checked at a distance "d" from the face of the concentrated load or reaction area as shown in the drawing

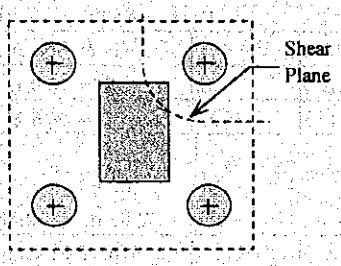


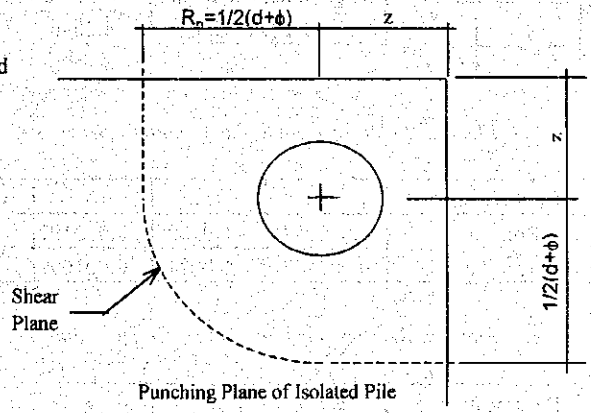


Load Direction	b	d	y	x %	Total Vu	$V_c = 166 f_c'^{1/2} bd$	Remark
Longitudinal Direction	11.00 m.	2.85 m.	0.15 m.	6.00	1,077	28,504 KN	O.K...
Transverse Direction	11.00 m.	2.85 m.	-0.85 m.	0.00	0	28,504 KN	O.K...

E.2. Check for Two-way Shear or Punching

AASHTO Art. 8.16.6.6(b) Critical section at d/2 distance to the perimeter of the concentrated load or reaction area.





Shear Plane Diam.,D_p = 5.35 m. Area Within Shear Plane, A = 18.05 m^2

Footing depth, d = 2.85 m. Wt. of Concrete, Wc = 768.72 KN

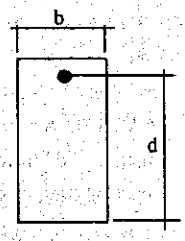
bo = $1/4*\pi D_p+2z$ = 7.70 m. Wt. of Soil above Area, Ws = 0.00 KN

Punching Load = Pmax - Wc -Ws = 12,424 KN O.K...

Allow. Punching Load, Vp = $332*fc'^{1/2}*b_o d$ = 39,915 KN

Finally Adopt : 3.00 m. x 11.00 m. x 11.00 m. Footing on 4 piles x 2.50 m. diameter

G. FLEXURAL CAPACITY OF FOOTING :



F.1. Flexural Capacity of Rectangular Footing

$$Mu = \phi\, As\, fy\, d\,(1 - 0.59\,\rho\, fy/fc')$$

$$Ku = Mu/\phi\, bd^2 = \rho\, fy - 0.59\,\rho^2\, fc'/fy$$

$$\omega = \frac{1-(1-4*0.59*Ku)^{1/2}}{2*0.59}$$

$$\rho = \omega\, fc'/fy$$

F.2. Minimum Steel Ratio , ρ_{min} :

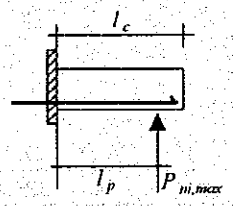
ρ_{min} =166 $fc'^{1/2}/fy$ = 0.00220 for fy = 413.7 Mpa

ρ_{min} =166 $fc'^{1/2}/fy$ = 0.00330 for fy = 275.8 Mpa

F.3. Maximum Steel Ratio , $\rho_{max} = 0.75\,\rho_{bal}$:

$\rho_{bal} = 0.85*\beta_1 fc'/fy(599{,}865/(599{,}865+fy))$

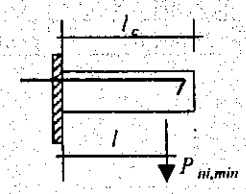
β_1 = 0.83



ρ_{bal} = 0.03036794 ρ_{max} = 0.02278 for fy = 413.7 MPa

ρ_{bal} = 0.05272543 ρ_{max} = 0.03954 for fy = 275.8 MPa

Load Direction	l_c	l_p	$P_{Ni,max}$	w_u	Mu
Longitudinal Direction	4.50 m.	2.75 m.	17,957	1,716	32,008 KN-m.
Transverse Direction	4.00 m.	2.25 m.	26,385	1,716	45,638 KN-m.



Load Direction	l_c	l_p	$P_{Ni,max}$	w_u	Mu
Longitudinal Direction	4.50 m.	2.75 m.	8,591	1,716	6,250 KN-m.
Transverse Direction	4.00 m.	2.25 m.	1,428	1,716	10,516 KN-m.

F.4 Flexural Reinforcement @ Longitudinal Direction

b= 11.00 m.

d= 2.88 m. 2.91 m.

Bar Location	Ku	ω	ρ	As(mm^2)	Bar ϕ	No. & Spacing
Bot. Bar	0.012957	0.01306	0.002197	69,705	32	**87 - @ 0.13 mm. o.c.**
Top Bar	0.002487	0.00249	0.001099	35,155	32	**44 - @ 0.25 mm. o.c.**

F.4 Flexural Reinforcement @ Transverse Direction

b= 11.00 m.

d= 2.85 m. 2.88 m.

Bar Location	Ku	ω	ρ	As	Bar ϕ	No. & Spacing
Bot. Bar	0.018475	0.01868	0.002197	68,932	32	**86 - @0.13 mm. o.c.**
Top Bar	0.004184	0.00419	0.001099	34,768	32	**44 - @0.25 mm. o.c.**