Chapter 4

DESIGN SUMMARY OF APPROACH VIADUCT (PC I GIRDER)

4. Design Summary of Approach Viaduct (PC -I Girder)

4.1 Geometry of Bridge

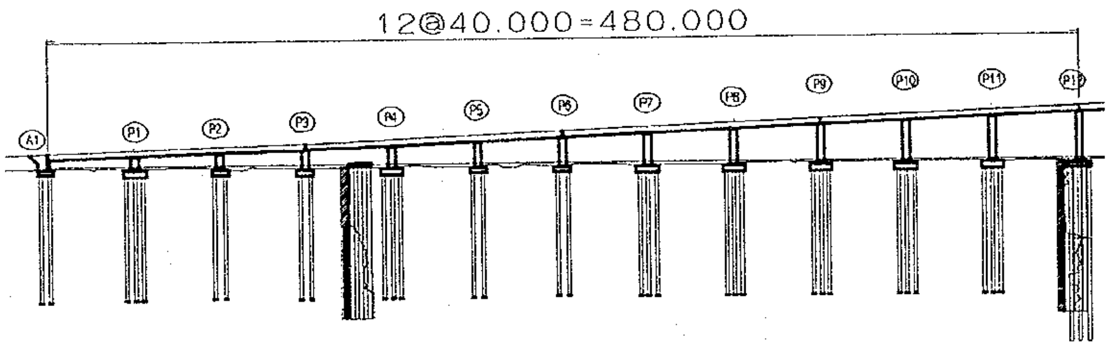
Vinh Long side

Bridge Length : L=480 m

Bridge Type : 3-spans Continuous Connection I Girder

Type of Substructure : 2-Column Pier

Type of Foundation : Cast in Place Concrete Pile Φ1.5m



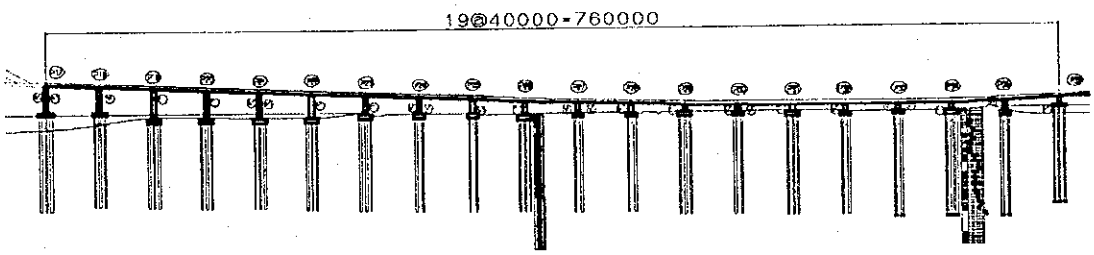
Can Tho side

Bridge Length : L=760 m

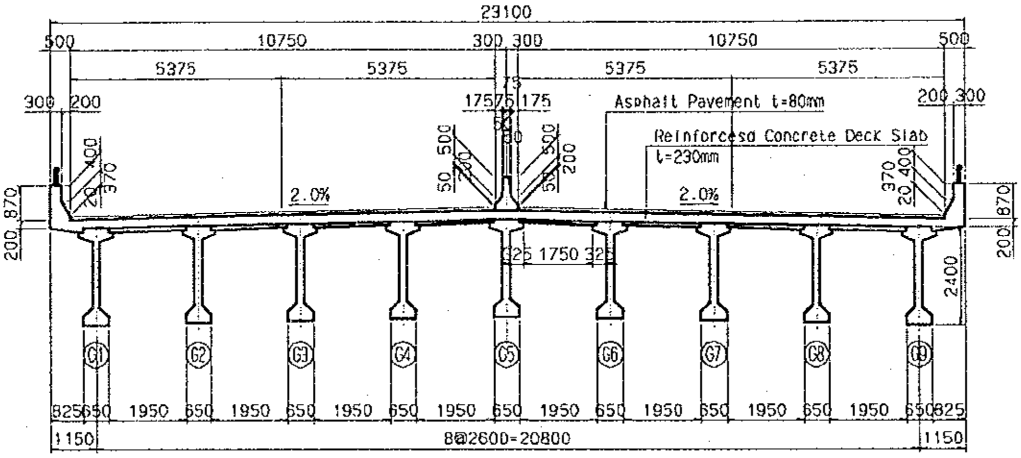
Bridge Type : 3-4 spans Continuous Connection I Girder

Type of Substructure : 2-Column Pier

Type of Foundation : Cast in Place Concrete Pile Φ1.5m



Typical Cross Section



4.2 Design of Superstructure

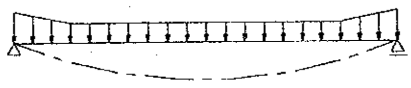
4.2.1 Calculation Model of Section Force for Girder

As for design of girder, superstructure is consider as simple girder during erection. After set up deck slab and connect girders, superstructure is consider as continuous girder. For calculation of force effect due to surfacing and live load, that are calculated in Grid Analysis. Then bearing condition is consider as elastomeric bearing. Also, the software that used it for the analysis is [APOLLO] of Japan.

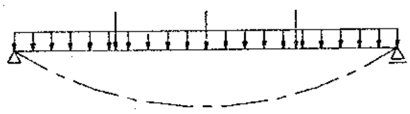
In the approach bridges, it has three structural type.(2 Continuous Span , 3 Continuous Span , 4 Continuous Span) Each type of Grid Model for calculation, which is shown below.

CALCULATION MODEL

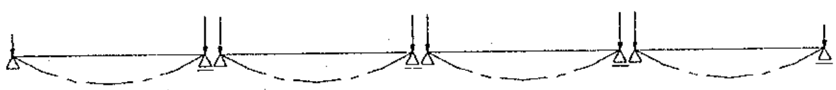
STEP-1 : MAIN GIRDERS
LOAD : GIRDER OWN WEIGHT , PRESTRESSING
STRUCTURE : SIMPLE BEAM



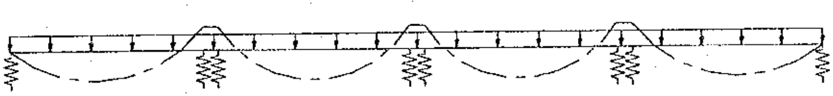
STEP-2 : INTERMEDIATE DIAPHRAGM AND DECK SLAB
LOAD : DEAD LOAD OF DIAPHRAGM AND DECK SLAB
STRUCTURE : SIMPLE BEAM



STEP-3 : CONNECTION DIAPHRAGM AND END DECK SLAB
LOAD : DEAD LOAD OF CONNECTION DIAPHRAGM AND END DECK
STRUCTURE : SIMPLE BEAM



STEP-4 : FORMING CONNECTION GIRDER THROUGH TRANSVERSE PRESTRESSING
LOAD : EFFECT OF CREEP DUE TO CHANGING STRUCTURAL SYSTEM
STRUCTURE : CONNECTION BEAM ON ELASTMERIC SUPPORT

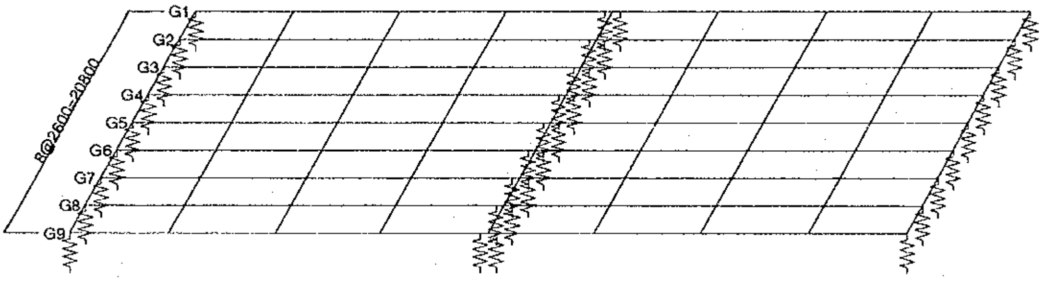


GRID MODEL FOR SUPERSTRUCTURE

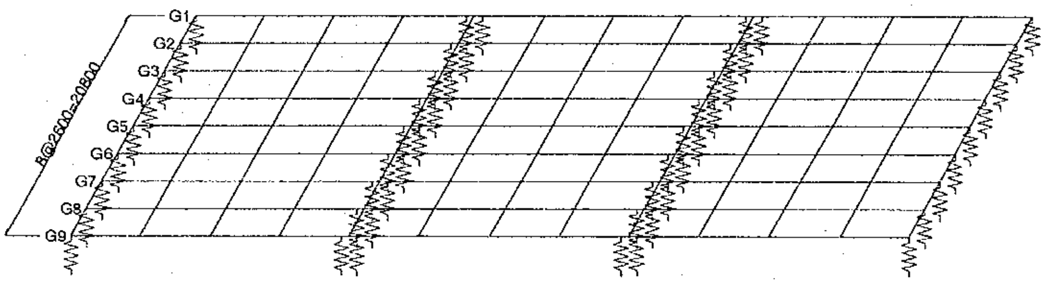
LOAD : DEAD LOAD OF SURFACING , LIVE LOAD

STRUCTURE : CONTINUOUS GRID STRUCTURE ON ELASTMERIC SUPPORT

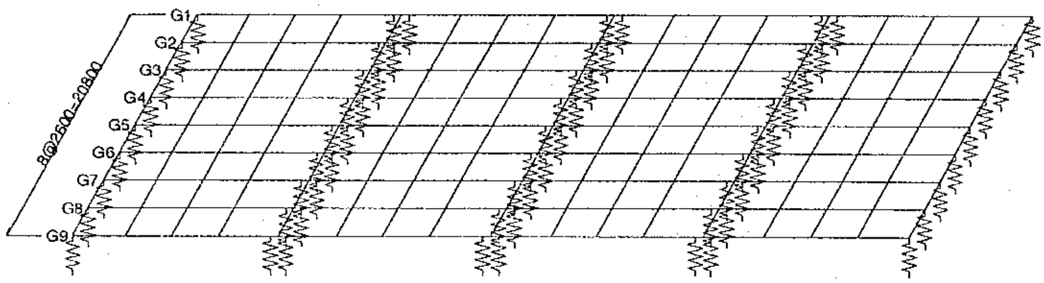
Type-1 : 2 CONTINUOUS SPAN



Type-2 : 3 CONTINUOUS SPAN



Type-3 : 4 CONTINUOUS SPAN



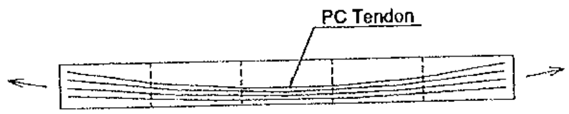
4.2.2 Construction Sequence

3- Span Continuous I Girder

Construction Sequence for 3 Continuous Span

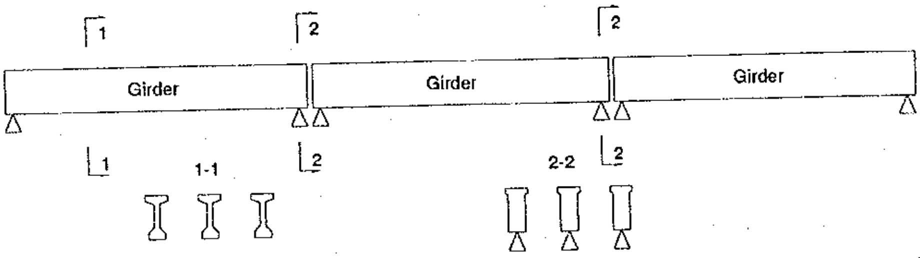
Step-1

Girder Precast Segment Connection and Posttensioning



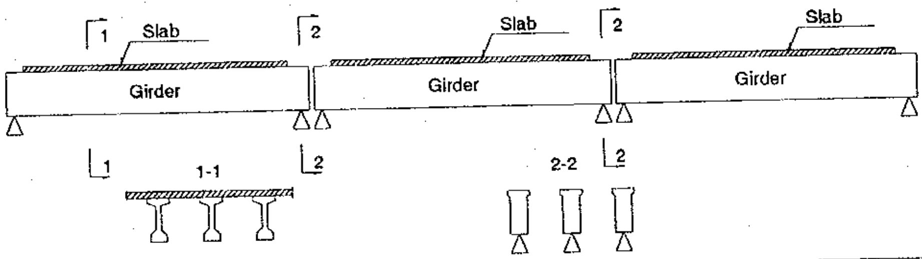
Step-2

Girder Erection



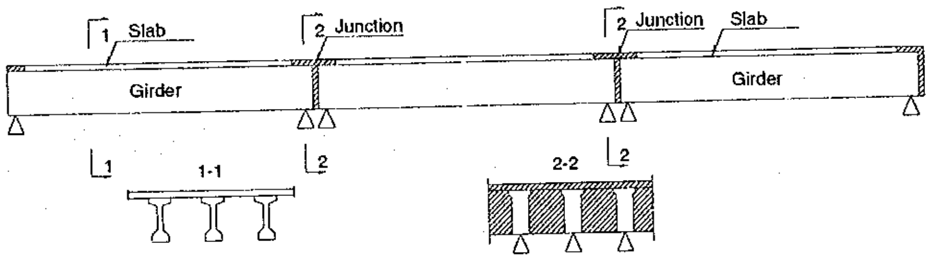
Step-3

Deck Slab , Diaphragm Cast



Step-4

Girders Connection

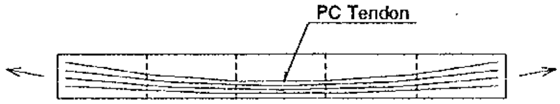


4 - Span Continuous I Girder

Construction Sequence for 4 Continuous Span

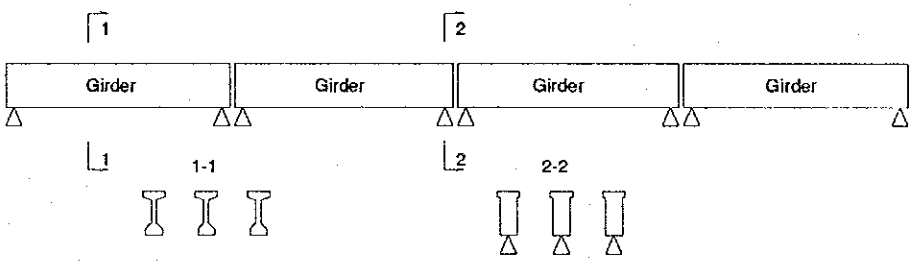
Step-1

Girder
Precast Segment
Connection
and
Posttensioning



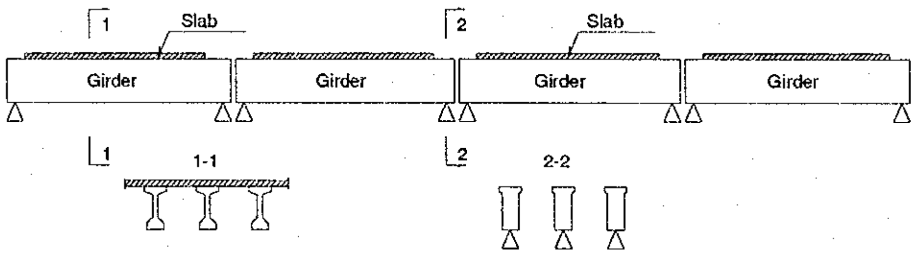
Step-2

Girder
Erection



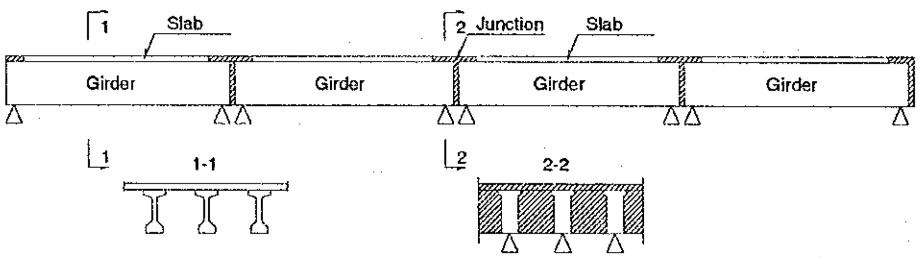
Step-3

Deck Slab ,
Diaphragm
Cast



Step-4

Girders
Connection



4.2.3 Calculation Result of Sectional Force

The calculation result of section force of main girder is shown to the next page.

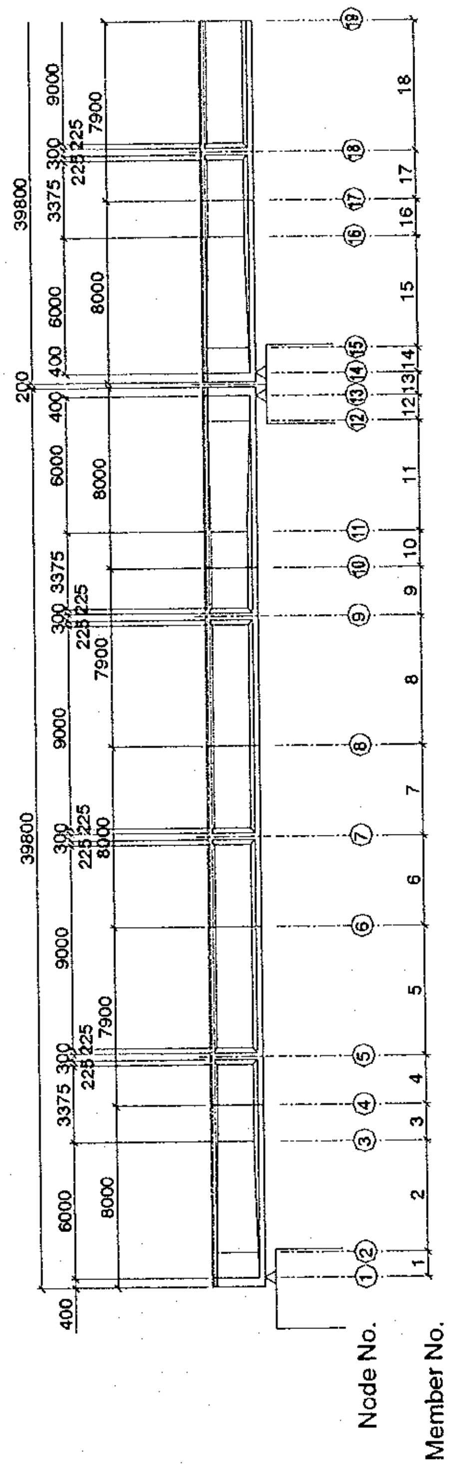
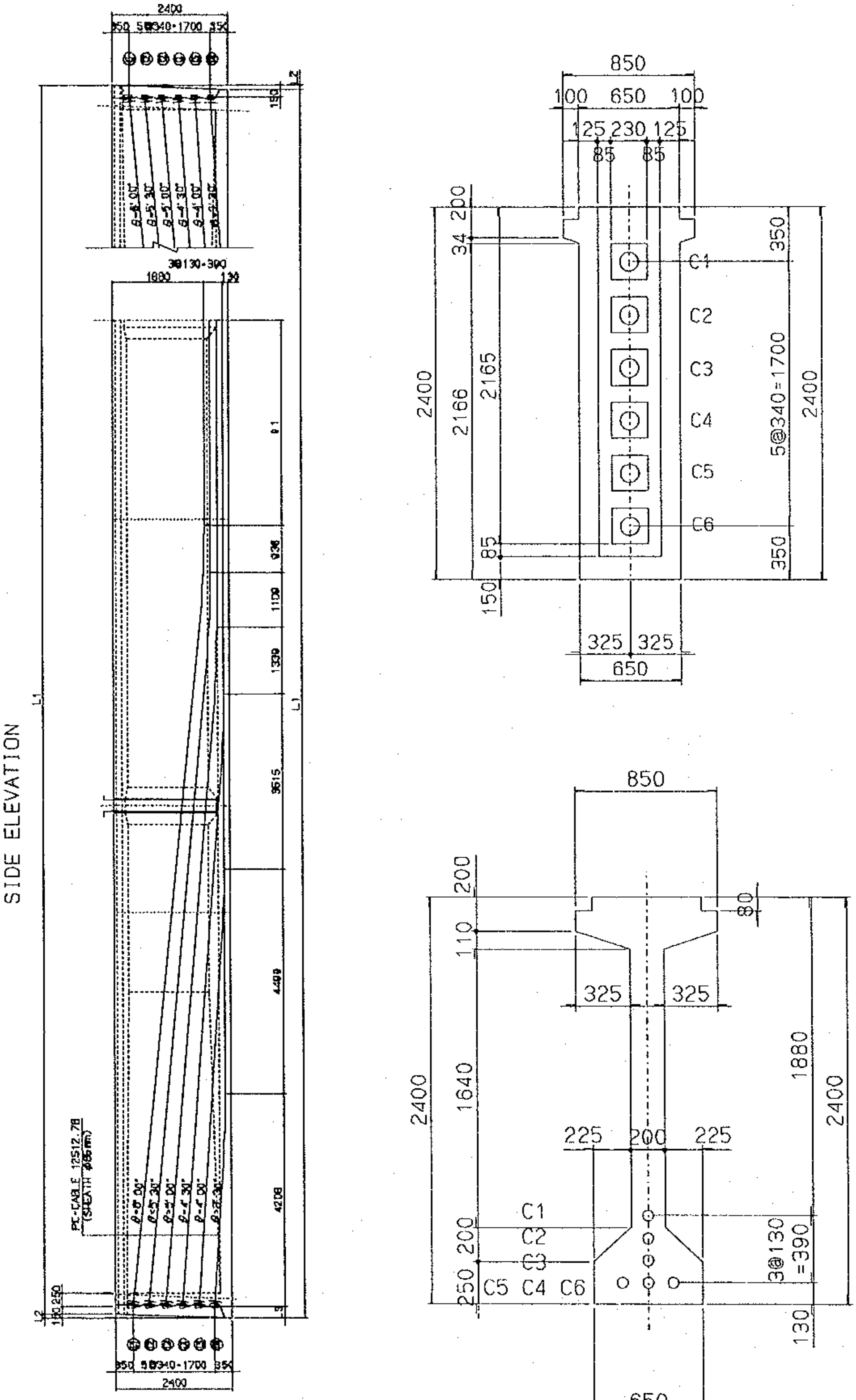


Figure Summary of Section for Calculation of Sectional Force

PC Steel Arrangement of Girder



3 Continuous Span Type

(1) Unfactored Section Force

P6-P9		Mem-1 i	Mem-1 j	Mem-2 i	Mem-2 j	Mem-3 i	Mem-3 j	Mem-4 i	Mem-4 j	Mem-5 i	Mem-5 j	Mem-6 i	Mem-6 j	Mem-7 i	Mem-7 j	Mem-8 i	Mem-8 j	Mem-9 i	Mem-9 j
Dc	M	0.0	732.7	732.7	3300.4	3300.4	3928.8	3928.8	4624.8	4624.8	5436.7	5436.7	5283.9	5283.9	4393.5	4393.5	2081.9	2081.9	825.1
	S	695.4	637.5	637.5	422.2	422.2	363.3	363.3	284.2	247.0	35.4	35.4	-111.8	-149.0	-296.2	-296.2	-507.8	-545.0	-624.1
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dw	M	0.9	212.6	212.6	1049.6	1049.6	1280.6	1280.6	1561.9	1561.9	1719.8	1719.7	1683.7	1683.7	1254.5	1254.5	426.9	426.9	-91.8
	S	196.5	188.5	188.5	153.1	150.2	138.6	138.6	123.0	48.2	6.7	5.4	-23.5	-92.8	-121.7	-123.1	-164.7	-233.5	-249.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L.L max (with IM)	M	1.9	451.7	451.7	1980.2	1980.2	2327.1	2327.1	2695.9	2695.9	3315.9	3315.9	3205.6	3205.6	2881.6	2881.6	1762.1	1762.1	1304.1
	S	508.9	454.1	454.1	351.5	351.8	318.3	318.3	290.6	335.1	205.8	207.3	146.6	261.3	153.8	158.6	67.0	225.6	140.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L.L min (with IM)	M	-2.9	-54.0	-54.0	-291.9	-291.8	-368.4	-368.4	-471.4	-471.3	-698.8	-698.8	-856.8	-856.8	-961.8	-961.8	-1112.9	-1112.9	-1188.4
	S	-52.9	-52.4	-52.4	-127.0	-120.1	-169.0	-169.0	-263.3	-114.9	-215.8	-211.9	-321.5	-256.7	-320.7	-319.9	-442.8	-408.9	-435.3
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR	M	0.0	216.7	216.7	1134.0	1134.0	1431.4	1431.4	1828.4	1828.4	2943.5	2943.5	3748.7	3748.7	4517.0	4517.0	5639.1	5639.1	6103.0
	S	198.0	197.0	197.0	189.0	189.0	188.3	188.3	187.5	187.5	189.9	189.9	192.2	192.2	192.2	192.2	192.8	192.8	194.4
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SH	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TU(+)	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TU(-)	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

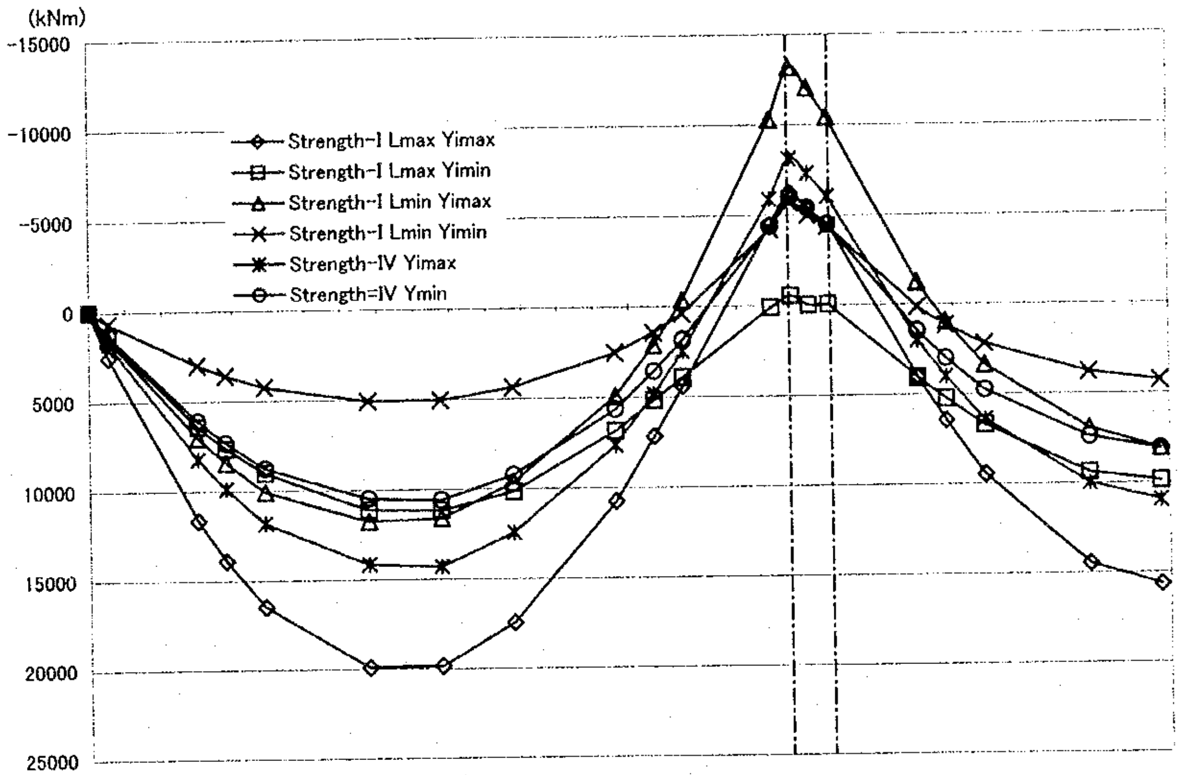
P6-P9		Mem-10 i	Mem-10 j	Mem-11 i	Mem-11 j	Mem-12 i	Mem-12 j	Mem-13 i	Mem-13 j	Mem-14 i	Mem-14 j	Mem-15 i	Mem-15 j	Mem-16 i	Mem-16 j	Mem-17 i	Mem-17 j	Mem-18 i	Mem-18 j
Dc	M	825.1	-220.6	-220.6	-4066.2	-4066.2	-5085.8	-4848.2	-3972.0	-3972.0	-765.4	-765.4	71.6	71.6	1048.0	1048.0	2609.8	2609.8	2978.5
	S	-624.1	-683.0	-683.0	-898.3	-898.3	-956.2	825.8	767.9	767.9	552.6	552.6	493.7	493.7	414.6	377.4	165.8	165.8	18.6
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dw	M	-91.8	-499.6	-499.6	-1873.5	-1873.5	-2205.8	-2105.4	-1834.2	-1834.2	-732.4	-732.4	-413.6	-413.6	-14.3	-14.3	489.9	489.9	694.1
	S	-249.0	-260.6	-262.7	-298.1	-298.1	-306.1	250.5	242.6	242.6	207.1	205.0	193.5	193.5	177.9	108.5	66.9	65.5	36.6
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L.L max (with IM)	M	1304.1	1003.3	1003.3	462.6	462.6	574.7	662.5	477.3	477.3	1018.6	1018.6	1274.0	1274.0	1649.3	1649.3	2504.2	2504.2	2613.7
	S	140.0	99.3	105.6	45.7	45.7	48.6	557.5	530.8	530.8	432.4	433.2	400.4	400.4	371.5	409.9	281.2	282.3	217.2
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L.L min (with IM)	M	-1188.4	-1334.0	-1334.0	-2418.4	-2418.4	-2839.0	-2662.5	-2411.4	-2411.4	-1581.9	-1581.9	-1441.0	-1441.0	-1356.1	-1356.2	-1211.3	-1211.3	-1110.6
	S	-435.3	-463.9	-463.3	-554.8	-554.8	-579.8	-84.2	-84.5	-84.5	-127.4	-121.2	-163.8	-163.8	-252.0	-103.4	-200.0	-195.6	-305.9
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR	M	6103.0	6447.7	6447.7	7614.7	7614.7	7843.6	8246.8	6978.3	6978.3	7855.2	7944.3	7966.8	7966.8	7964.2	7964.2	7923.6	7923.6	7865.3
	S	194.4	195.4	195.4	200.9	200.9	201.1	-385.6	-334.1	-334.1	-385.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	-2881.0	-2496.2	-2496.2	-2878.8	-6183.2	-6200.8	-6200.8	-6198.8	-6198.8	-6167.1	-6167.1	-6121.8
SH	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	-33.6	-33.6	-33.6	-33.6	-33.6	-33.6	-33.6	-33.6	-33.6	-33.6	-33.6	-33.6
TU(+)	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	103.2	103.2	103.2	103.2	103.2	103.2	103.2	103.2	103.2	103.2	103.2	103.2
TU(-)	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	-103.2	-103.2	-103.2	-103.2	-103.2	-103.2	-103.2	-103.2	-103.2	-103.2	-103.2	-103.2

(2) Factored Force Effect

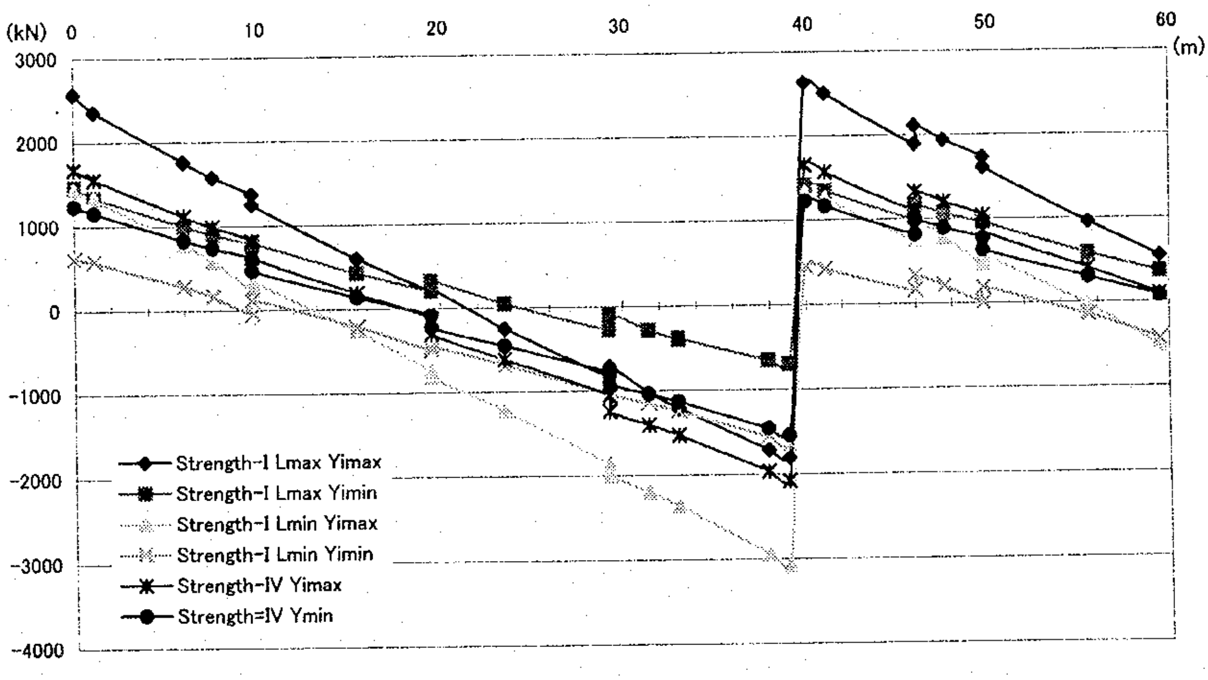
P6-P9			Mem-1		Mem-2		Mem-3		Mem-4		Mem-5		Mem-6		Mem-7		Mem-8		Mem-9	
			i	j	i	j	i	j	i	j	i	j	i	j	i	j	i	j	i	j
STRENGTH-I Lmax TU(+)	Yi= max	M	6	2549	2549	11655	11655	13925	13925	16500	16500	19913	19913	19859	19859	17459	17459	10758	10758	7192
		S	2566	2354	2354	1755	1749	1572	1572	1368	1248	593	594	198	232	-260	-253	-833	-708	-1028
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-I Lmax TU(-)		M	6	2549	2549	11655	11655	13925	13925	16500	16500	19913	19913	19859	19859	17459	17459	10758	10758	7192
		S	2566	2354	2354	1755	1749	1572	1572	1368	1248	593	594	198	232	-260	-253	-833	-708	-1028
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-I Lmax TU(+)	Yi= min	M	3	1422	1422	6428	6429	7654	7654	9028	9028	11130	11130	11178	11178	10165	10165	6853	6853	5190
		S	1465	1334	1334	996	996	895	895	786	795	421	423	208	325	38	44	-273	-90	-285
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-I Lmax TU(-)		M	3	1422	1422	6428	6429	7654	7654	9028	9028	11130	11130	11178	11178	10165	10165	6853	6853	5190
		S	1465	1334	1334	996	996	895	895	786	795	421	423	208	325	38	44	-273	-90	-285
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-I Lmin TU(+)	Yi= max	M	-4	1522	1522	7042	7042	8453	8453	10071	10071	11763	11763	11612	11612	9657	9657	4922	4922	2132
		S	1426	1326	1326	784	792	582	582	243	334	-263	-257	-752	-820	-1223	-1224	-1867	-1996	-2196
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-I Lmin TU(-)		M	-4	1522	1522	7042	7042	8453	8453	10071	10071	11763	11763	11612	11612	9657	9657	4922	4922	2132
		S	1426	1326	1326	784	792	582	582	243	334	-263	-257	-752	-820	-1223	-1224	-1867	-1996	-2196
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-I Lmin TU(+)	Yi= min	M	-4	661	661	3009	3009	3597	3597	4261	4261	5088	5088	5064	5064	4381	4381	2527	2527	1439
		S	620	572	572	276	285	162	162	-48	118	-213	-208	-497	-455	-676	-676	-1040	-1045	-1151
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-I Lmin TU(-)		M	-4	661	661	3009	3009	3597	3597	4261	4261	5088	5088	5064	5064	4381	4381	2527	2527	1439
		S	620	572	572	276	285	162	162	-48	118	-213	-208	-497	-455	-676	-676	-1040	-1045	-1151
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-IV TU(+)	Yi= max	M	2	1771	1771	8227	8227	9895	9895	11825	11825	14159	14159	14298	14298	12447	12447	7636	7636	4816
		S	1667	1551	1551	1111	1106	983	983	817	623	183	181	-124	-309	-616	-618	-1058	-1243	-1407
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-IV TU(-)		M	2	1771	1771	8227	8227	9895	9895	11825	11825	14159	14159	14298	14298	12447	12447	7636	7636	4816
		S	1667	1551	1551	1111	1106	983	983	817	623	183	181	-124	-309	-616	-618	-1058	-1243	-1407
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-IV TU(+)	Yi= min	M	1	1313	1313	6099	6099	7336	7336	8767	8767	10498	10498	10600	10600	9228	9228	5661	5661	3570
		S	1236	1150	1150	823	820	728	728	606	462	136	134	-92	-229	-457	-458	-785	-921	-1043
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STRENGTH-IV TU(-)		M	1	1313	1313	6099	6099	7336	7336	8767	8767	10498	10498	10600	10600	9228	9228	5661	5661	3570
		S	1236	1150	1150	823	820	728	728	606	462	136	134	-92	-229	-457	-458	-785	-921	-1043
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

P6-P9			Mem-10		Mem-11		Mem-12		Mem-13		Mem-14		Mem-15		Mem-16		Mem-17		Mem-18	
			i	j	i	j	i	j	i	j	i	j	i	j	i	j	i	j	i	j
STRENGTH-I Lmax TU(+)	Yi= max	M	7192	4414	4413	-4452	-4452	-6264	-5298	-4573	-4573	3985	4036	6447	6447	9457	9457	14486	14486	15636
		S	-1028	-1220	-1211	-1716	-1716	-1810	2629	2504	2504	1888	2109	1933	1933	1727	1606	951	950	544
		N	0	0	0	0	0	0	-1651	-1427	-1427	-1649	-3566	-3576	-3576	-3575	-3575	-3557	-3557	-3530
STRENGTH-I Lmax TU(-)		M	7192	4414	4413	-4452	-4452	-6264	-5298	-4573	-4573	3985	4036	6447	6447	9457	9457	14486	14486	15636
		S	-1028	-1220	-1211	-1716	-1716	-1810	2629	2504	2504	1888	2109	1933	1933	1727	1606	951	950	544
		N	0	0	0	0	0	0	-1730	-1507	-1507	-1729	-3646	-3656	-3656	-3655	-3655	-3636	-3636	-3610
STRENGTH-I Lmax TU(+)	Yi= min	M	5190	3918	3918	98	98	-552	-24	-65	-65	4035	4073	5238	5238	6712	6713	9385	9386	9890
		S	-285	-396	-387	-656	-656	-699	1409	1343	1343	993	1159	1060	1060	949	951	577	579	355
		N	0	0	0	0	0	0	-1224	-1058	-1058	-1223	-2644	-2651	-2651	-2650	-2650	-2637	-2637	-2617
STRENGTH-I Lmax TU(-)		M	5190	3918	3918	98	98	-552	-24	-65	-65	4035	4073	5238	5238	6712	6713	9385	9386	9890
		S	-285	-396	-387	-656	-656	-699	1409	1343	1343	993	1159	1060	1060	949	951	577	579	355
		N	0	0	0	0	0	0	-1283	-1117	-1117	-1282	-2703	-2710	-2710	-2710	-2710	-2696	-2696	-2676
STRENGTH-I Lmin TU(+)	Yi= max	M	2132	-331	-331	-10301	-10301	-13194	-12048	-10437	-10437	-1294	-1243	936	936	3356	3356	6944	6944	8076
		S	-2196	-2363	-2366	-2935	-2935	-3086	1326	1255	1255	752	983	787	787	461	564	-26	-20	-518
		N	0	0	0	0	0	0	-1651	-1427	-1427	-1649	-3566	-3576	-3576	-3575	-3575	-3557	-3557	-3530
STRENGTH-I Lmin TU(-)		M	2132	-331	-331	-10301	-10301	-13194	-12048	-10437	-10437	-1294	-1243	936	936	3356	3356	6944	6944	8076
		S	-2196	-2363	-2366	-2935	-2935	-3086	1326	1255	1255	752	983	787	787	461	564	-26	-20	-518
		N	0	0	0	0	0	0	-1730	-1507	-1507	-1729	-3646	-3656	-3656	-3655	-3655	-3636	-3636	-3610
STRENGTH-I Lmin TU(+)	Yi= min	M	1439	401	401	-4238	-4238	-5690	-5028	-4413	-4413	121	159	1152	1152	2189	2189	3794	3794	4285
		S	-1151	-1244	-1244	-1559	-1559	-1645	444	417	417	150	325	211	211	10	178	-147	-141	-432
		N	0	0	0	0	0	0	-1224	-1058	-1058	-1223	-2644	-2651	-2651	-2650	-2650	-2637	-2637	-2617
STRENGTH-I Lmin TU(-)		M	1439	401	401	-4238	-4238	-5690	-5028	-4413	-4413	121	159	1152	1152	2189	2189	3794	3794	4285
		S	-1151	-1244	-1244	-1559	-1559	-1645	444	417	417	150	325	211	211	10	178	-147	-141	-432
		N	0	0	0	0	0	0	-1283	-1117	-1117	-1282	-2703	-2710	-2710	-2710	-2710	-2696	-2696	-2676
STRENGTH-IV TU(+)	Yi= max	M	4816	2487	2487	-5919	-5919	-8138	-7316	-6055	-6055	1950	2002	4026	4026	6418	6418	9989	9989	10952
		S	-1407	-1529	-1532	-1965	-1965	-2080	1649	1564	1564	1098	1318	1196	1196	1031	845	405	402	96
		N	0	0	0	0	0	0	-1651	-1427	-1427	-1649	-3566	-3576	-3576	-3575	-3575	-3557	-3557	-3530
STRENGTH-IV TU(-)		M	4816	2487	2487	-5919	-5919	-8138	-7316	-6055	-6055	1950	2002	4026	4026	6418	6418	9989	9989	10952
		S	-1407	-1529	-1532	-1965	-1965	-2080	1649	1564	1564	1098	1318	1196	1196	1031	845	405	402	96
		N	0	0	0	0	0	0	-1730	-1507	-1507	-1729	-3646	-3656	-3656	-3655	-3655	-3636	-3636	-3610
STRENGTH-IV TU(+)	Yi= min	M	3570	1844	1843	-4388	-4388	-6033	-5424	-4489	-4489	1446	1484	2985	2985	4758	4758	7406	7406	8120
		S	-1043	-1133	-1136	-1457	-1457	-1542	1223	1160	1160	814	977	886	886	764	627	300	298	71
		N	0	0	0	0	0	0	-1224	-1058	-1058	-1223	-2644	-2651	-2651	-2650	-2650	-2637	-2637	-2617
STRENGTH-IV TU(-)		M	3570	1844	1843	-4388	-4388	-6033	-5424	-4489	-4489	1446	1484	2985	2985	4758	4758	7406	7406	8120
		S	-1043	-1133	-1136	-1457	-1457	-1542	1223	1160	1160	814	977	886	886	764	627	300	298	71
		N	0	0	0	0	0	0	-1283	-1117	-1117	-1282	-2703	-2710	-2710	-2710	-2710	-2696	-2696	-2676

Bending moment



Shearing force



4.2.4 Check from Load and Resistance Factor Design

		Mem-1		Mem-2		Mem-3		Mem-4		Mem-5	
		i	j	i	j	i	j	i	j	i	j
	Pt	6817.7	6823.9	6823.9	6574.4	6574.4	6586.3	6586.3	6575.8	6575.8	6518.7
	k	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
	Aps	7107	7107	7107	7107	7107	7107	7107	7107	7107	7107
	As	-	-	-	-	-	-	-	-	-	-
	fy	345	345	345	345	345	345	345	345	345	345
	fpu	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	fps	1762.45	1768.32	1768.32	1786.7	1786.7	1790.77	1790.77	1795.02	1795.02	1798.05
	f'c	40	40	40	40	40	40	40	40	40	40
	yu	1003.1	982.7	982.7	853.8	853.8	856.1	856.1	858.8	858.8	860.9
	yl	-1426.9	-1447.3	-1447.3	-1576.2	-1576.2	-1573.9	-1573.9	-1571.2	-1571.2	-1569.1
	ep	-347.7	-459.5	-459.5	-968.6	-968.6	-1077.8	-1077.8	-1206.6	-1206.6	-1309.1
	dp	1350.8	1442.2	1442.2	1822.4	1822.4	1933.9	1933.9	2065.4	2065.4	2170
	ds	-	-	-	-	-	-	-	-	-	-
Strength-I L max Yi max	M	6	2549	2549	11655	11655	13925	13925	16500	16500	19913
	N(TU+)	0	0	0	0	0	0	0	0	0	0
	N(TU-)	0	0	0	0	0	0	0	0	0	0
	Meff	6	2549	2549	11655	11655	13925	13925	16500	16500	19913
	N(TU+)	0	0	0	0	0	0	0	0	0	0
	N(TU-)	0	0	0	0	0	0	0	0	0	0
	Mn	16032.3	17231.5	17231.5	22228.9	22228.9	23696.5	23696.5	25428.2	25428.2	26806.2
	Mr	14429.1	15508.3	15508.3	20006	20006	21326.9	21326.9	22885.4	22885.4	24125.6
	Fs	2492.07	6.084	6.084	1.717	1.717	1.532	1.532	1.387	1.387	1.212
		O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
Strength-I L min Yi max	M	-4	1522	1522	7042	7042	8453	8453	10071	10071	11763
	N(TU+)	0	0	0	0	0	0	0	0	0	0
	N(TU-)	0	0	0	0	0	0	0	0	0	0
	Meff	-2375	1522	1522	7042	7042	8453	8453	10071	10071	11763
	N(TU+)	6818	0	0	0	0	0	0	0	0	0
	N(TU-)	6818	0	0	0	0	0	0	0	0	0
	Mn	-20383	17231	17231	22229	22229	23697	23697	25428	25428	26806
	Mr	-18345	15508	15508	20006	20006	21327	21327	22885	22885	24126
	Fs	7.726	10.187	10.187	2.841	2.841	2.523	2.523	2.272	2.272	2.051
		O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

		Mem-6		Mem-7		Mem-8		Mem-9		Mem-10	
		i	j	i	j	i	j	i	j	i	j
	Pt	6518.7	6388.3	6388.3	6518.7	6518.7	6575.8	6575.8	6586.3	6586.3	6574.4
	k	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
	Aps	7107	7107	7107	7107	7107	7107	7107	7107	7107	7107
	As	-	-	-	-	-	-	-	-	-	-
	fy	345	345	345	345	345	345	345	345	345	345
	fpu	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	fps	1798.05	1798.05	1798.05	1798.05	1798.05	1795.02	1795.02	1790.77	1790.77	1786.7
	f'c	40	40	40	40	40	40	40	40	40	40
	yu	860.9	860.9	860.9	860.9	860.9	858.8	858.8	856.1	856.1	853.8
	yl	-1569.1	-1569.1	-1569.1	-1569.1	-1569.1	-1571.2	-1571.2	-1573.9	-1573.9	-1576.2
	ep	-1309.1	-1309.1	-1309.1	-1309.1	-1309.1	-1206.6	-1206.6	-1077.8	-1077.8	-968.6
	dp	2170	2170	2170	2170	2170	2065.4	2065.4	1933.9	1933.9	1822.4
	ds	-	-	-	-	-	-	-	-	-	-
Strength-I L max Yi max	M	19913	19859	19859	17459	17459	10758	10758	7192	7192	4414
	N(TU+)	0	0	0	0	0	0	0	0	0	0
	N(TU-)	0	0	0	0	0	0	0	0	0	0
	Meff	19913	19859	19859	17459	17459	10758	10758	7192	7192	4414
	N(TU+)	0	0	0	0	0	0	0	0	0	0
	N(TU-)	0	0	0	0	0	0	0	0	0	0
	Mn	26806.2	26806.2	26806.2	26806.2	25428.2	25428.2	23696.5	23696.5	22228.9	22228.9
	Mr	24125.6	24125.6	24125.6	24125.6	22885.4	22885.4	21326.9	21326.9	20006	20006
	Fs	1.212	1.215	1.215	1.382	1.311	2.127	1.982	2.966	2.782	4.533
		O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
Strength-I L min Yi max	M	11763	11612	11612	9657	9657	4922	4922	2132	2132	-331
	N(TU+)	0	0	0	0	0	0	0	0	0	0
	N(TU-)	0	0	0	0	0	0	0	0	0	0
	Meff	11763	11612	11612	9657	9657	4922	4922	2132	2132	-6699
	N(TU+)	0	0	0	0	0	0	0	0	0	6574
	N(TU-)	0	0	0	0	0	0	0	0	0	6574
	Mn	26806	26806	26806	26806	25428	25428	23697	23697	23697	-14211
	Mr	24126	24126	24126	24126	22885	22885	21327	21327	21327	-12790
	Fs	2.051	2.078	2.078	2.498	2.370	4.650	4.333	10.003	10.003	1.909
		O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

		Mem-11		Mem-12		Mem-13		Mem-14		Mem-15	
		i	j	i	j	i	j	i	j	i	j
	Pt	6574.4	6823.9	6823.9	0.0	0.0	6823.9	6823.9	6574.4	6574.4	6586.3
	k	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
	Aps	7107	7107	7107	7107	7107	7107	7107	7107	7107	7107
	As	-	20421.4	20421.4	20421.4	20421.4	20421.4	20421.4	-	-	-
	fy	345	345	345	345	345	345	345	345	345	345
	fpu	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	fps	1786.7	1721	1721	1749.13	1762.45	1730.9	1730.9	1795.84	1806.47	1809.5
	f'c	40	40	40	40	40	40	40	40	40	40
	yu	853.8	982.7	982.7	831.9	1003.1	982.7	982.7	853.8	853.8	856.1
	yl	-1576.2	-1447.3	-1447.3	-1598.1	-1426.9	-1447.3	-1447.3	-1576.2	-1576.2	-1573.9
	ep	-968.6	-459.5	-459.5	-347.7	-347.7	-459.5	-459.5	-968.6	-968.6	-1077.8
	dp	1822.4	1442.2	1442.2	1179.6	1350.8	1442.2	1442.2	1822.4	1822.4	1933.9
	ds	-	125.5	125.5	125.5	125.5	125.5	125.5	-	-	-
Strength-I L max Yi max	M	4413	-4452	-4452	-6264	-5298	-4573	-4573	3985	4036	6447
	N(TU+)	0	0	0	0	0	-1427	-1427	-1649	-3566	-3576
	N(TU-)	0	0	0	0	0	-1507	-1507	-1729	-3646	-3656
	Meff	4413	-7588	-7588	-6264	-5298	-7708	-7708	3985	4036	6447
	N(TU+)	0	6824	6824	0	0	5396	5396	-1649	-3566	-3576
	N(TU-)	0	6824	6824	0	0	5317	5317	-1729	-3646	-3656
	Mn	22228.9	-21447.4	-21447.4	-15894	-15740.2	-20229.1	-20229.1	19866.1	19808.7	21263.4
	Mr	20006	-19302.6	-19302.6	-14304.6	-14166.1	-18206.2	-18206.2	17879.5	17827.8	19137.1
	Fs	4.533	2.544	2.544	2.284	2.674	2.362	2.362	4.487	4.417	2.968
		O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
Strength-I L min Yi max	M	-331	-10301	-10301	-13194	-12048	-10437	-10437	-1294	-1243	936
	N(TU+)	0	0	0	0	0	-1427	-1427	-1649	-3566	-3576
	N(TU-)	0	0	0	0	0	-1507	-1507	-1729	-3646	-3656
	Meff	-6699	-13436	-13436	-13194	-12048	-13572	-13572	-7662	-7611	936
	N(TU+)	6574	6824	6824	0	0	5396	5396	4925	3009	-3576
	N(TU-)	6574	6824	6824	0	0	5317	5317	4845	2929	-3656
	Mn	-14211	-21447	-21447	-15894	-15740	-20229	-20229	-13518	-12666	21263
	Mr	-12790	-19303	-19303	-14305	-14166	-18206	-18206	-12166	-11399	19137
	Fs	1.909	1.437	1.437	1.084	1.176	1.341	1.341	1.588	1.498	20.449
		O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

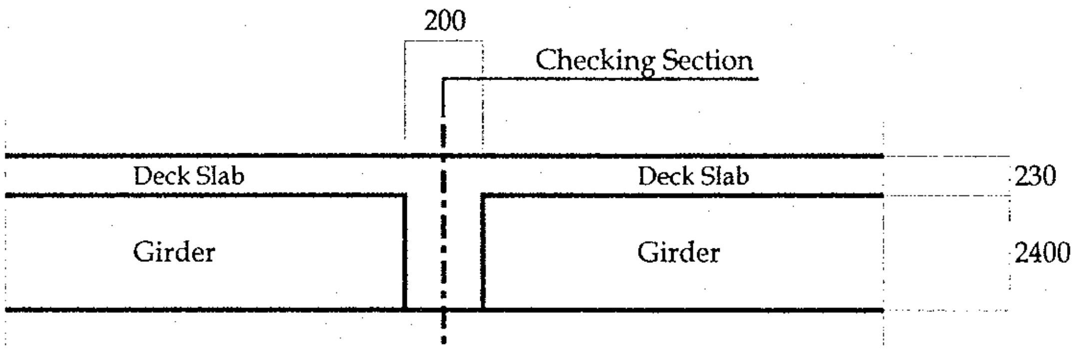
		Mem-16		Mem-17		Mem-18	
		i	j	i	j	i	j
Pt		6586.3	6575.8	6575.8	6518.7	6518.7	6388.3
k		0.38	0.38	0.38	0.38	0.38	0.38
Aps		7107	7107	7107	7107	7107	7107
As		-	-	-	-	-	-
fy		345	345	345	345	345	345
fpu		1860	1860	1860	1860	1860	1860
fps		1809.5	1812.59	1812.59	1814.72	1814.72	1814.59
f'c		40	40	40	40	40	40
yu		856.1	858.8	858.8	860.9	860.9	860.9
yl		-1573.9	-1571.2	-1571.2	-1569.1	-1569.1	-1569.1
ep		-1077.8	-1206.6	-1206.6	-1309.1	-1309.1	-1309.1
dp		1933.9	2065.4	2065.4	2170	2170	2170
ds		-	-	-	-	-	-
Strength-I L max Yi max	M	6447	9457	9457	14486	14486	15636
	N(TU+)	-3576	-3575	-3575	-3557	-3557	-3530
	N(TU-)	-3656	-3655	-3655	-3636	-3636	-3610
	Meff	6447	9457	9457	14486	14486	15636
	N(TU+)	-3576	-3575	-3575	-3557	-3557	-3530
	N(TU-)	-3656	-3655	-3655	-3636	-3636	-3610
	Mn	21263.4	22988.5	22988.5	24373.3	24373.3	24391.4
	Mr	19137.1	20689.7	20689.7	21936	21936	21952.2
	Fs	2.968	2.188	2.188	1.514	1.514	1.404
		O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
Strength-I L min Yi max	M	936	3356	3356	6944	6944	8076
	N(TU+)	-3576	-3575	-3575	-3557	-3557	-3530
	N(TU-)	-3656	-3655	-3655	-3636	-3636	-3610
	Meff	936	3356	3356	6944	6944	8076
	N(TU+)	-3576	-3575	-3575	-3557	-3557	-3530
	N(TU-)	-3656	-3655	-3655	-3636	-3636	-3610
	Mn	21263	22989	22989	24373	24373	24391
	Mr	19137	20690	20690	21936	21936	21952
	Fs	20.449	6.165	6.165	3.159	3.159	2.718
		O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

4.2.5 Calculation of Connection Reinforcement

Connection of girder is calculated as R.C. structure.
Procedure of calculation is mentioned as follows.

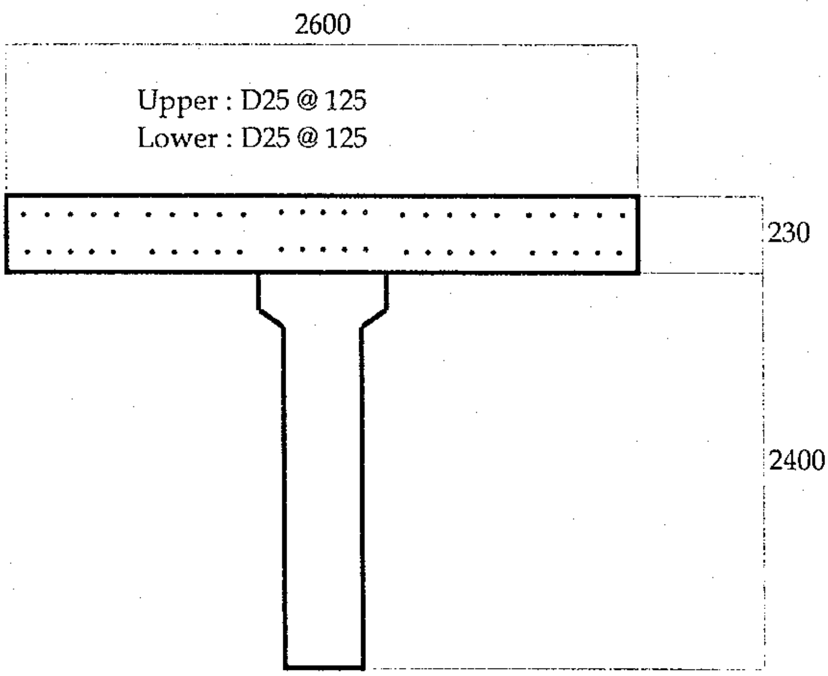
1) Location of Calculated Section

Outline of Profile



2) Figure of Section and Bar Arrangement

Figure of Seciton and Bar Arrangement of Deck Slab



3) Bending Moment

Dc	-5086	(kNm)	
Dw	-2206	(kNm)	
LL max	575	(kNm)	---- include IM
LL min	-2839	(kNm)	---- include IM
CR	7844	(kNm)	

4) Strength Design

k		0.38
As (mm2)		20421
fy (MPa)		345
fps (MPa)		1762
f'c (MPa)		30
yu (mm)		1003
yl (mm)		-1426
dp		1351
ds		126
Strength-I L max Yi max	M(kNm)	-5298
	Meff(kNm)	-5298
	Mn(kNm)	-15740
	Mr(kNm)	-14166
	Fs	2.67
		O.K.
Strength-I L min Yi max	M(kNm)	-12048
	Meff(kNm)	-12048
	Mn(kNm)	-15740
	Mr(kNm)	-14166
	Fs	1.176
		O.K.

4.3 Design of Substructure

4.3.1 Design Condition

(1) Type of Substructure

	Type of Substructure	Type of Foundation	bearing support
P10	2 Column Type	12 Cast in situ Concrete Pile, dia. 1500mm	Fix
P18	2 Column Type	12 Cast in situ Concrete Pile, dia. 1500mm	Mov

- Bearing Support Condition:
  - Move : Free for the longitudinal direction movement
  - Fix : Fix for the longitudinal direction movement

(2) Materials

1) Concrete

Grade	fc'	Typical use
D	30 MPa	In situ concrete : Bored pile
E	24 MPa	In situ concrete : Pier, Abut, Pile cap
F	20 MPa	In situ concrete : Base concrete
G	15 MPa	In situ concrete : Lean concrete, Plain concrete

fc' : Compressive strength of concrete at 28 days

Grade	fc'	Ec (MPa)	EXP
D	30 MPa	29440	10.8 x 1.0E-6 (/deg)
E	24 MPa	26330	

Ec : Elastic Modulus

EXP : Coefficient of thermal expansion and contraction

2) Reinforcement Steel

- Specified Yield Strength

  Plain Round : 240 MPa

  High Yield Deformed : 390 MPa

- Modulus of elasticity of reinforcement steel

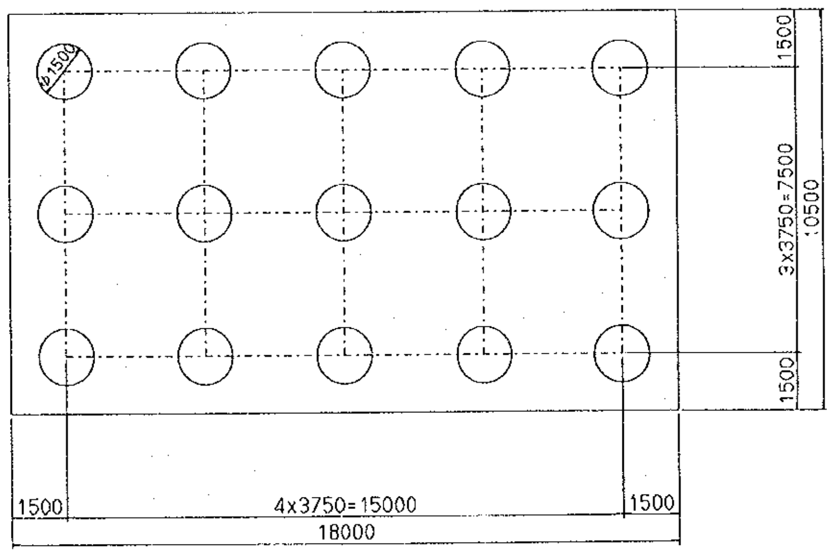
  Es = 200000 MPa

4.3.2 Calculation Result

(1) P10 - Pier

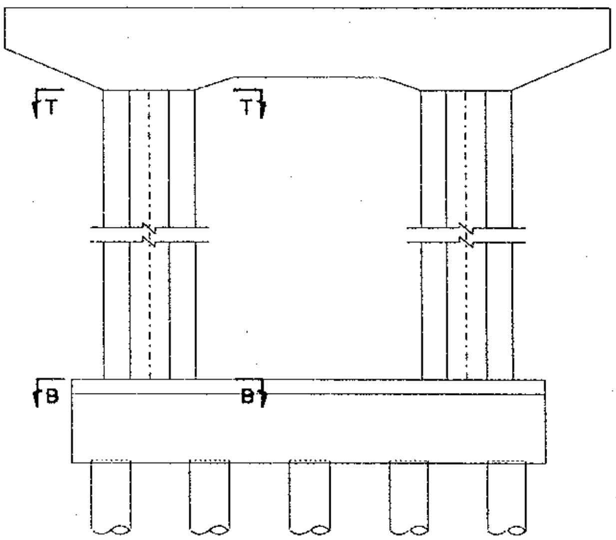
1) Stability Calculation

P10-Pier		Unit	Longtudinal Derection	Transverse Derection	Remarks
Size of Pilecap		m	10.500 × 18.000		
Diameter, Length		m	ϕ1.500, L=57.000		
Number of Piles		nos.	3 * 5 = 15		
reinforcement		cm2	28 − D28		
Load Case		−	D + ET	D + ET	
i) Stability Calculation					
Displacement	δ	mm	9.9 <OK 15.0	9.2 <OK 15.0	
Bearing Capacity	P Nmax	kN	6663.1 <OK 6800.0	6601.0 <OK 6800.0	
Uplift Capacity	P Nmin	kN	-453.2 >OK -5900.0	-391.2 >OK -5900.0	
ii) Pile Section					
concrete	σc	N/mm2	5.1 <OK 12.0	7.1 <OK 12.0	
reinforcement	σs	N/mm2	184.5 <OK 300.0	240.7 <OK 300.0	
shear stress	τ	N/mm2	0.29 <OK 0.42	0.35 <OK 0.42	

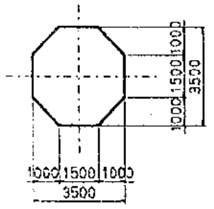


b) Column

P10-Pier		Unit	Bottom Section	Top Section	Remarks
Section	b	cm	350.0	350.0	
	h	cm	350.0	350.0	
Area	As1	cm2	(60+5) - D32	(60+5) - D32	
Load Case			D + EL	D + ET	
i)Factored Loads					
Moment	M	kN·m	-52,381	22,146.0	
Axial Force	N	kN	18,447	20,835.0	
Shear Force	S	kN	2,617	-	
ii)Result of Stress Check					
Stress of concrete	σc	N/mm2	11.5 OK	5.2 OK	Actual
	σca	N/mm2	12.0	12.0	Allowable
Stress of reinforcement	σs	N/mm2	200.8 OK	331.0 OK	Actual
	σsa	N/mm2	300.0	300.0	Allowable
Shear Stress	τ	N/mm2	0.37	-	Actual
	τa	N/mm2	0.47	-	Allowable



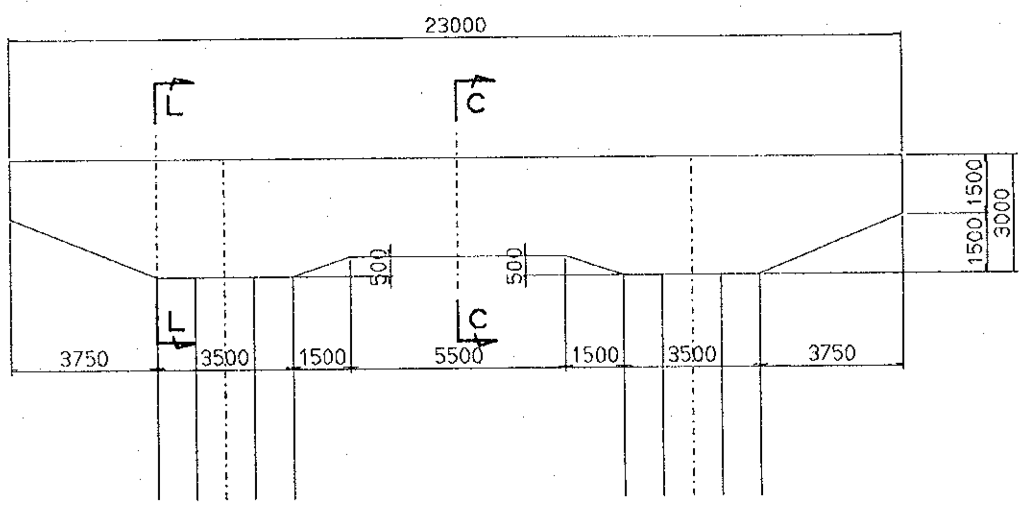
T - T
B - B

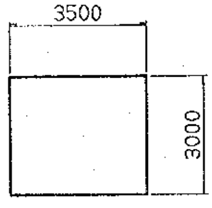


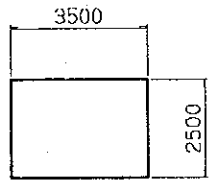
2) Design of Section

a) Beam

P10-Pier		Unit	Left Section		Center Section		Remarks
Section	b	cm	350.0		350.0		
	h	cm	300.0		250.0		
Area	As1	cm2	29 - D32		29 - D32		
Load Case			D + L		D + ET		
i)Factored Loads							
Moment	M	kN·m	-15,904		2,359.0		
Axial Force	N	kN	0		-647.0		
Shear Force	S	kN	3,548		11,079		
ii)Result of Stress Check							
Stress of concrete	σc	N/mm2	3.9	OK	5.6	OK	Actual
	σca	N/mm2	8.0		12.0		Allowable
Stress of reinforcement	σs	N/mm2	137.6	OK	233.6	OK	Actual
	σsa	N/mm2	180.0		300.0		Allowable
Shear Stress	τ	N/mm2	0.42		1.26		Actual
	τa	N/mm2	0.22		0.26		Allowable

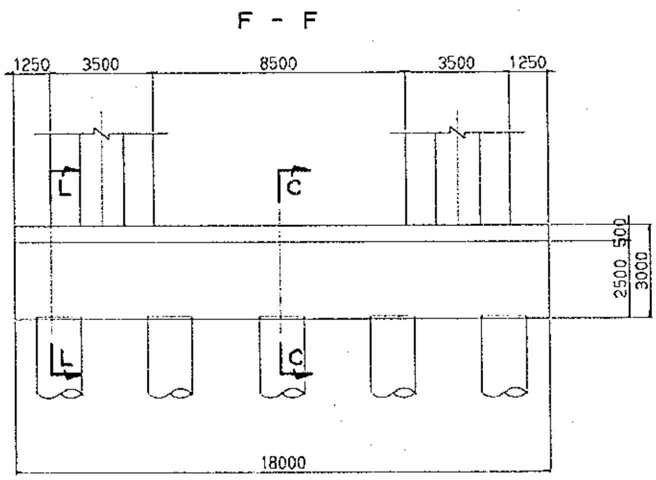


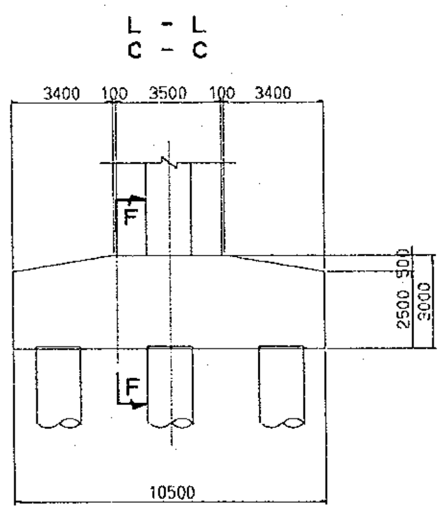




c) Base

P10-Pier		Unit	Section			Remarks
			Left	Center	Front	
Section	b	cm	1,050.0	1,050.0	1,800.0	
	h	cm	300.0	300.0	300.0	
Area	As1	cm2	83 - D32	83 - D32	143 - D32	
Load Case			D + EL	D + L	D + ET	
i)Factored Loads						
Moment	M	kN·m	1,281	-27,516	32,666.0	
Axial Force	N	kN	0	0	0.0	
Shear Force	S	kN	55	12,622	5,842	
ii)Result of Stress Check						
Stress of concrete	σc	N/mm2	0.2 OK	3.8 OK	2.4 OK	Actual
	σca	N/mm2	12.0	8.0	8.0	Allowable
Stress of reinforcement	σs	N/mm2	8.5 OK	168.3 OK	129.4 OK	Actual
	σsa	N/mm2	300.0	180.0	180.0	Allowable
Shear Stress	τ	N/mm2	0.00	0.47	0.11	Actual
	τa	N/mm2	0.22	0.22	0.17	Allowable

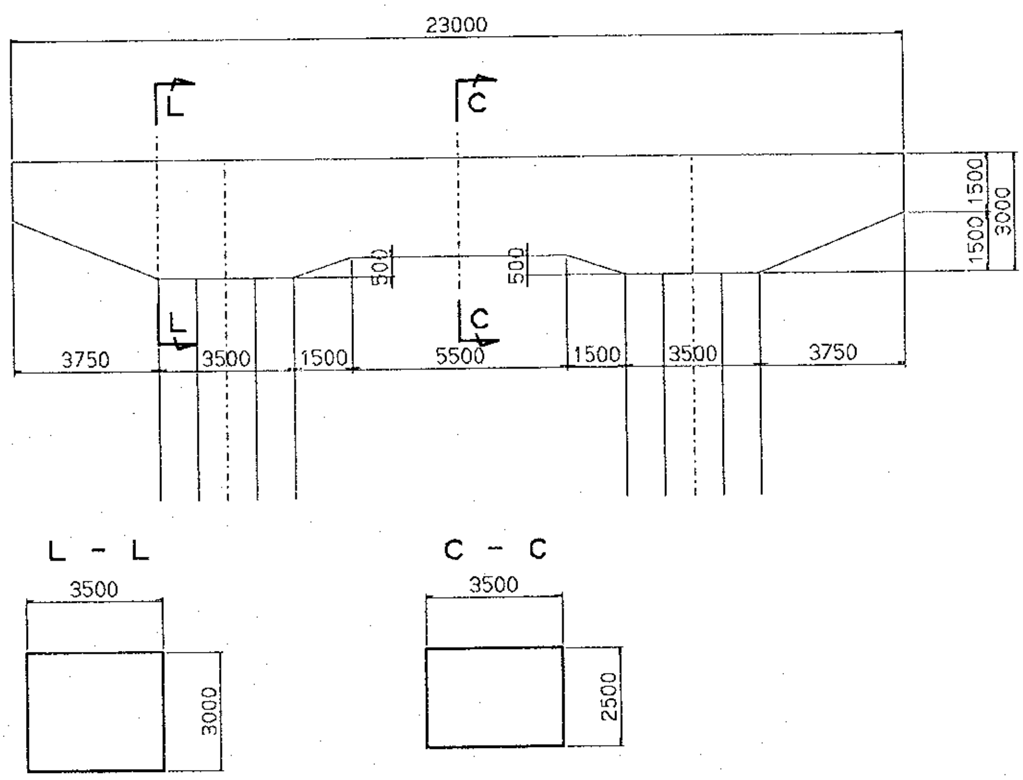




2) Design of Section

a) Beam

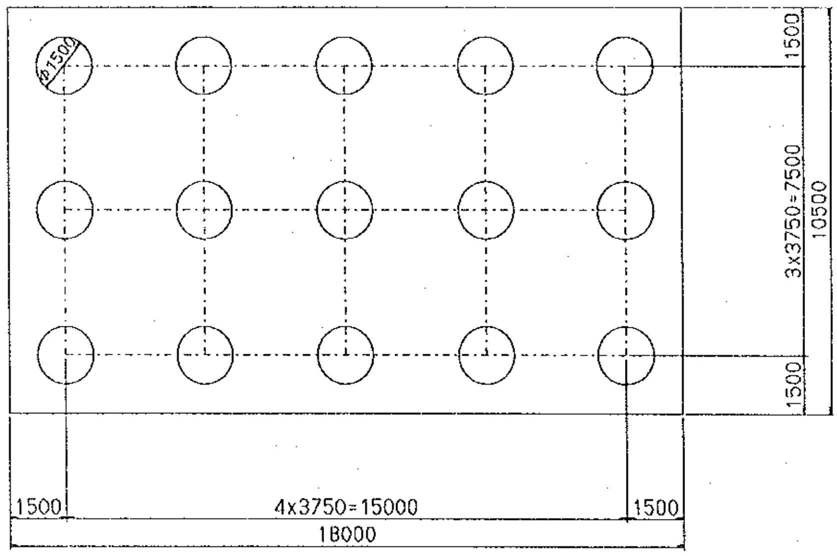
P18-Pier		Unit	Left Section		Center Section		Remarks
Section	b	cm	350.0		350.0		
	h	cm	300.0		250.0		
Area	As1	cm2	23 - D32		29 - D32		
Load Case			D + L		D + L		
i)Factored Loads							
Moment	M	kN·m	-18,897		7,364.0		
Axial Force	N	kN	0		-523.0		
Shear Force	S	kN	3,544		6,464		
ii)Result of Stress Check							
Stress of concrete	σc	N/mm2	4.3	OK	2.8	OK	Actual
	σca	N/mm2	8.0		8.0		Allowable
Stress of reinforcement	σs	N/mm2	171.7	OK	151.2	OK	Actual
	σsa	N/mm2	180.0		180.0		Allowable
Shear Stress	τ	N/mm2	0.42		0.73		Actual
	τa	N/mm2	0.21		0.16		Allowable



(2) P18 - Pier

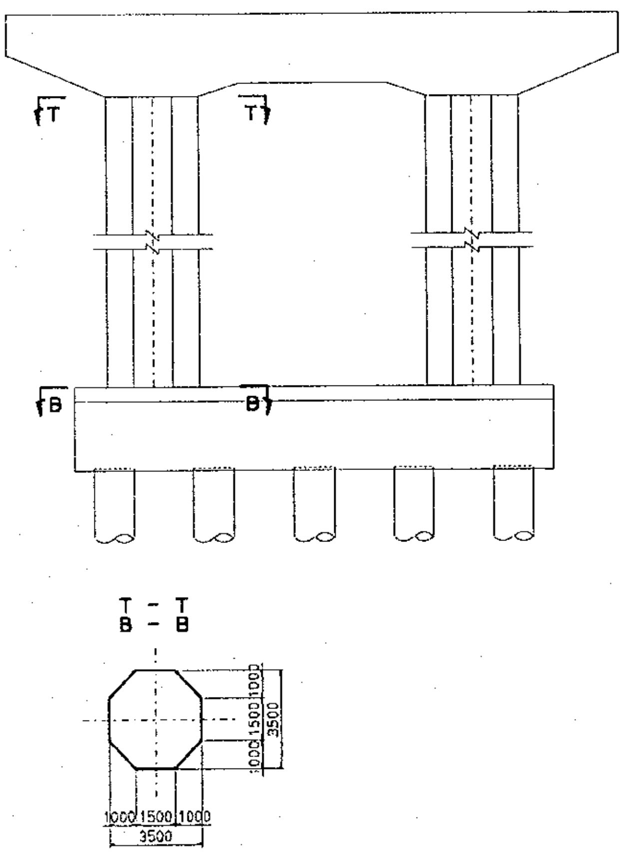
1) Stability Calculation

P18-Pier		Unit	Longtudinal Derection	Transverse Derection	Remarks
Size of Pilecap		m	10.500 × 18.000		
Diameter, Length		m	ϕ1.500, L =50.000		
Number of Piles		nos.	3 * 5 = 15		
reinforcement		cm2	28 − D28		
Load Case		−	D + ET	D + ET	
i) Stability Calculation					
Displacement	δ	mm	11.1 <OK 15.0	9.5 <OK 15.0	
Bearing Capacity	P Nmax	kN	6264.7 <OK 7300.0	5263.4 <OK 7300.0	
Uplift Capacity	P Nmin	kN	-	-	
ii) Pile Section					
concrete	σc	N/mm2	11.4 <OK 12.0	10.9 <OK 12.0	
reinforcement	σs	N/mm2	280.3 <OK 300.0	229.2 <OK 300.0	
shear stress	τ	N/mm2	0.23 <OK 0.51	0.22 <OK 0.55	



b) Column

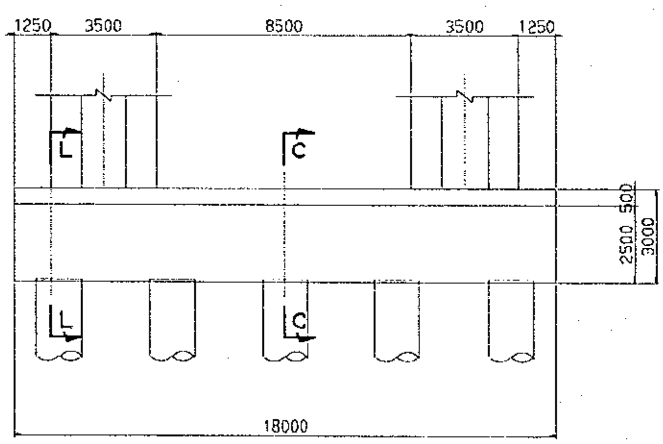
P18-Pier		Unit	Bottom Section	Top Section	Remarks
Section	b	cm	350.0	350.0	
	h	cm	350.0	350.0	
Area	As1	cm2	(60+5) - D29	44 - D29	
Load Case			D + EL	D + ET	
i)Factored Loads					
Moment	M	kN·m	-34,353	8,726.0	
Axial Force	N	kN	18,000	17,312.0	
Shear Force	S	kN	2,229	-	
ii)Result of Stress Check					
Stress of concrete	σc	N/mm2	11.9 OK	3.2 OK	Actual
	σca	N/mm2	12.0	12.0	Allowable
Stress of reinforcement	σs	N/mm2	248.8 OK	0.0 OK	Actual
	σsa	N/mm2	300.0	300.0	Allowable
Shear Stress	τ	N/mm2	0.22	-	Actual
	τa	N/mm2	0.29	-	Allowable



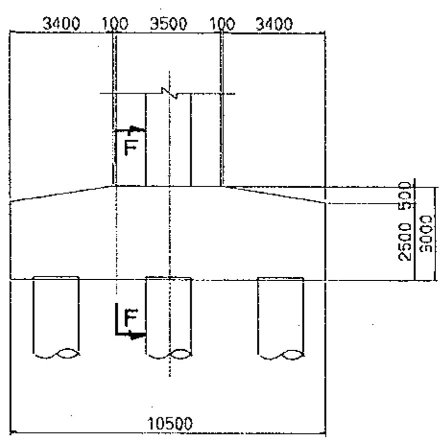
c) Base

P18-Pier		Unit	Section			Remarks
			Left	Center	Front	
Section	b	cm	1,050.0	1,050.0	1,800.0	
	h	cm	300.0	300.0	300.0	
Area	As1	cm2	83 - D28	83 - D25	143 - D32	
Load Case			D + EL	D + L	D + ET	
i)Factored Loads						
Moment	M	kN·m	776	-26,438	32,595.0	
Axial Force	N	kN	0	0	0.0	
Shear Force	S	kN	63	12,462	3,838	
ii)Result of Stress Check						
Stress of concrete	σc	N/mm2	0.0 OK	3.7 OK	2.4 OK	Actual
	σca	N/mm2	12.0	8.0	8.0	Allowable
Stress of reinforcement	σs	N/mm2	8.0 OK	151.7 OK	129.1 OK	Actual
	σsa	N/mm2	300.0	180.0	180.0	Allowable
Shear Stress	τ	N/mm2	0.00	0.47	0.10	Actual
	τa	N/mm2	0.24	0.24	0.17	Allowable

F - F



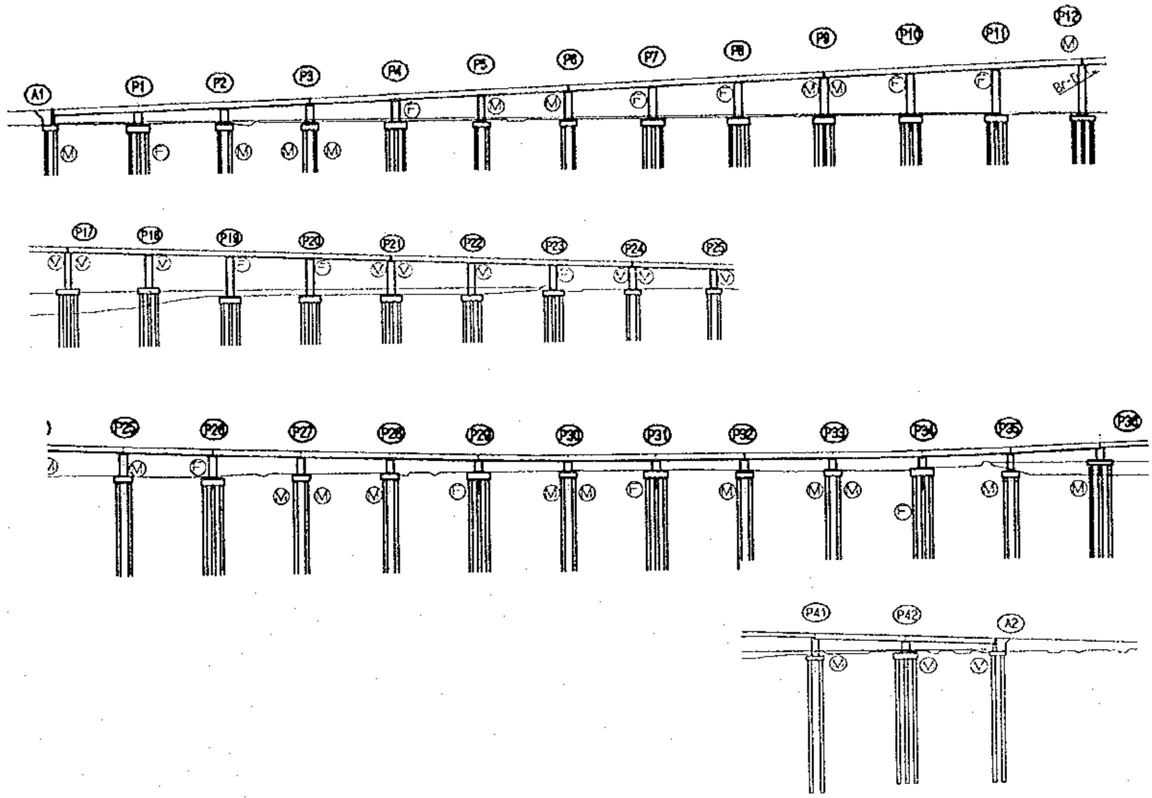
L - L
C - C



4.4 Design of Accessories

4.4.1 Design of Bearing

Bearing Condition



(1) Design Condition

1) Virtical Load

	Movable Support	Fixed Support
DC	255.34	469.37
DW	807.54	835.08
CR	96.95	-233.88
LL Max	375.36	683.85
LL Min	-65.67	-248.99
IM max	123.88	225.69
IM min	-21.67	-82.17
Rmax	1659.07	1980.11
Rmin	1072.49	739.41

2) Displacement

Cause		Type I		Type II		Type III
		2-Mov	1-Mov	1-Mov	1-Mov	
Creep (at the end)		-4.13	3.66	-3.66	3.66	3.66
Thermal Effect	+15 deg	11.99	-5.99	5.99	-5.99	-5.99
	-15 deg	-11.99	5.99	-5.99	5.99	5.99
Sub-Total CR+T(+)	+15 deg	7.86	-2.33	2.33	-2.33	-
CR+T(-)	-15 deg	-16.122	9.65	-9.65	9.65	-
Total		10.19		4.66		-2.33
		25.77		19.30		9.65

3) Dimension

Table Dimension of Bearing

		Sign	Unit	Mov	Fix
Width of Bearing					
	Longitusinal	b	mm	550	550
	Transverse	a	mm	550	550
Rubber					
	Thickness of each Rubber Layer	te	mm	22	22
	Numbers of Rubber Layer	n		5	5
	Total Thickness	Σte	mm	110	110
	Reinforce Parts	ts	mm	2.0	2.0

4.4.2 Calculate Result

Rotation Angle at Girder End		Σαe	1/300	1/300	
Maximum Reaction Force		Rmax	1659070	1980110	N
Minimum Reaction Force		Rmin	1072490	739410	N
Static Shear Module of Rigidity of Rubber		Go	0.80	0.80	N/mm2
Reduced Shear Module of Rigidity of Rubber		Gt	0.62	0.62	N/mm2
Allowable	Bearing Stress	σmax,a	8.00	8.00	N/mm2
	Minimum Compressive Stress	σmin,a	1.50	1.50	N/mm2
		⊿σa	5.00	5.00	N/mm2
Requirement Area of Bearing		Rmax/σmax,a	207384	247514	mm2
Width of Bearing at Transverse Direction		b	550	550	mm
Width of Bearing at Longitudinal Direction		a	550	550	mm
Requirement Area		A	302500	302500	mm2

(each Bearing)

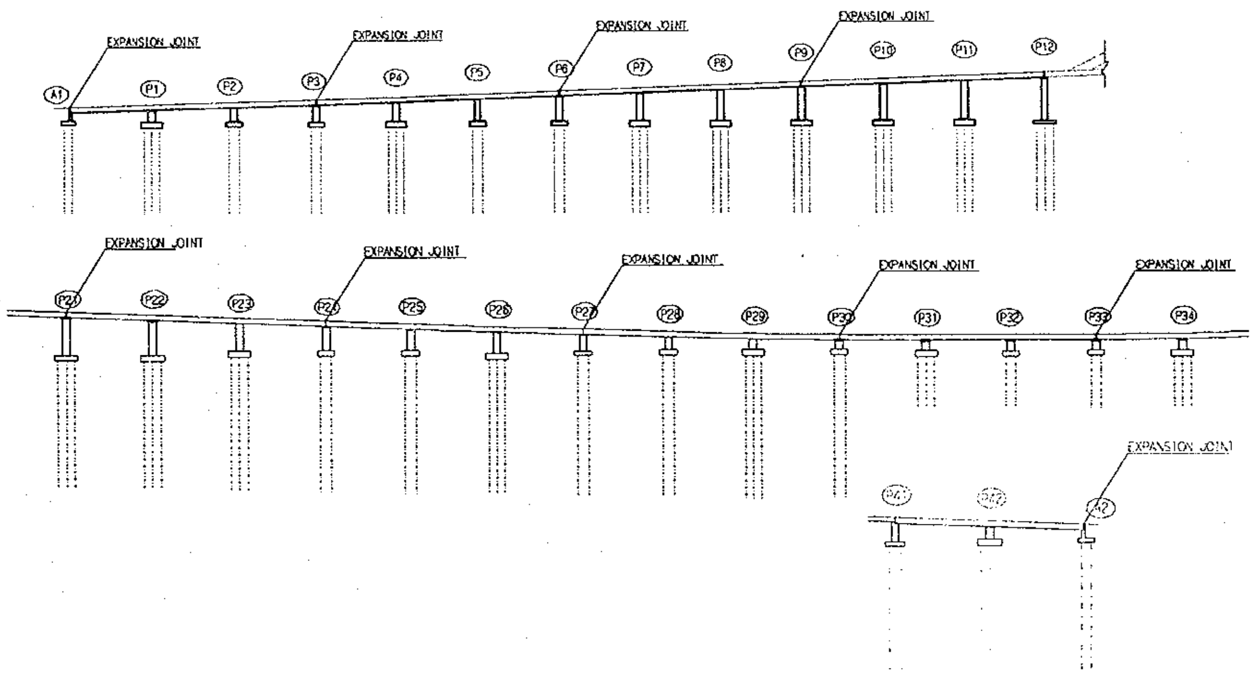
4.4.2 Design of Expansion Joint

(1) Design Conditions

Type	Pier No. , Abut No.	Expansion Girder Length
I	P3,P6,P21,P24,P27,P33,P41	79.9m+39.9m
II	P9,P30	39.9m+39.9m
III	A1,A2	39.9m

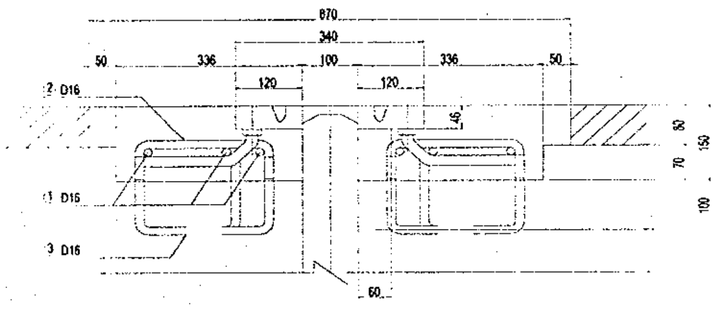
Displacement Unit : mm

Cause		Type I		Type II		Type III
		2-Mov	1-Mov	1-Mov	1-Mov	
Creep (at the end)		-4.13	3.66	-3.66	3.66	3.66
Thermal Effect	+15 deg	11.99	-5.99	5.99	-5.99	-5.99
	-15 deg	-11.99	5.99	-5.99	5.99	5.99
Sub-Total CR+T(+)	+15 deg	7.86	-2.33	2.33	-2.33	-
CR+T(-)	-15 deg	-16.12	9.65	-9.65	9.65	-
Total		10.19		4.66		-2.33
		25.77		19.30		9.65



(2) Detail of Expansion Joint

Cross Section



Chapter 5

DESIGN SUMMARY OF BRUNCH STREAM BRIDGE (PC BOX GIRDER)

5. Design Summary of Branch Steam Bridge (PC –Box Girder)

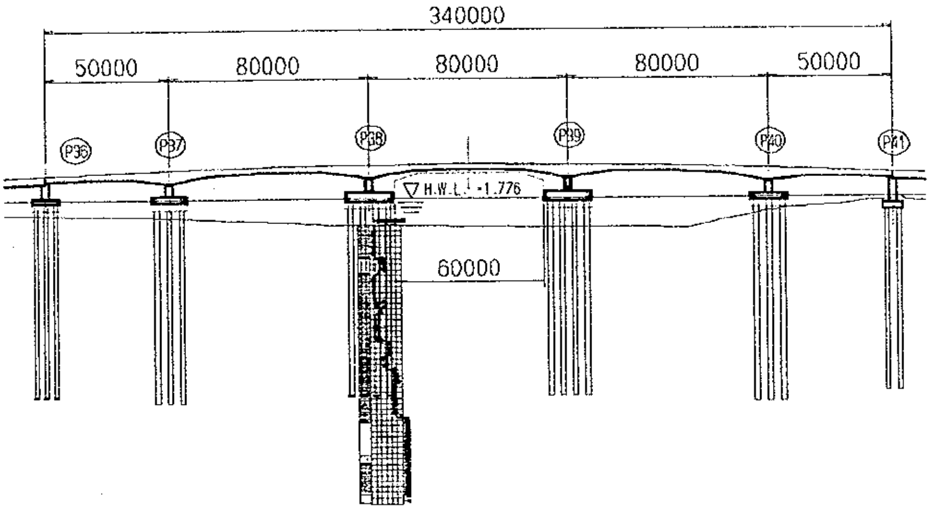
5.1 Geometry of Bridge

Bridge Length : L=340 m

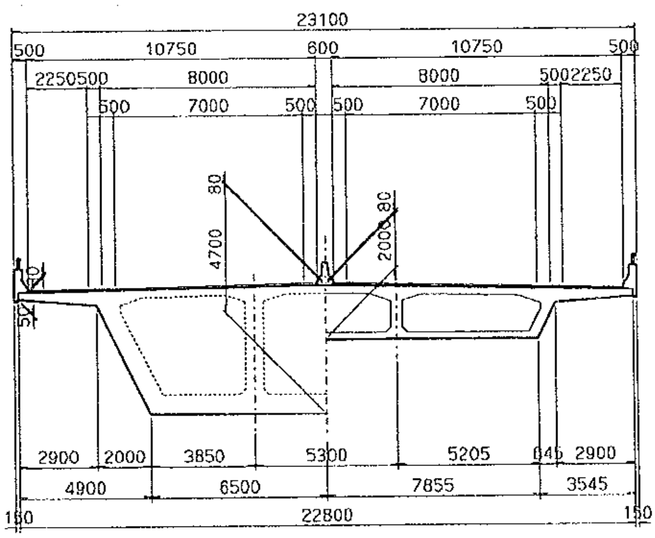
Bridge Type : 5-spans Continuous Box Girder

Type of Substructure : Wall type Pier

Type of Foundation : Cast in Place Concrete Pile Φ2.0m



General View



Typical Cross Section

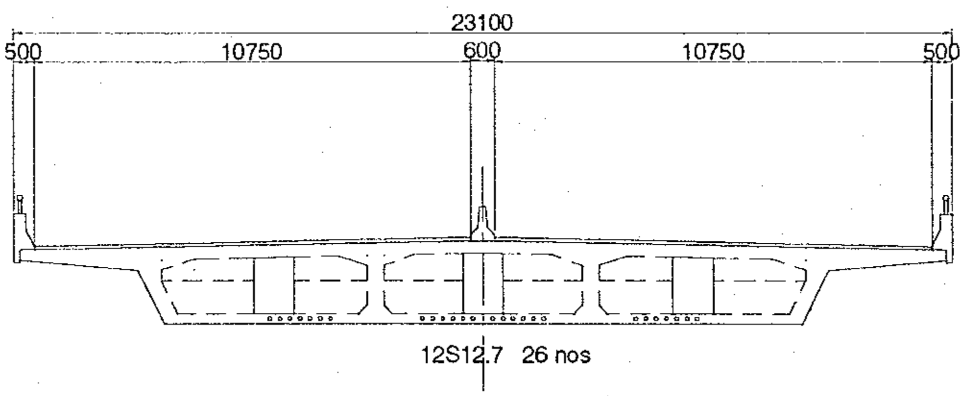
Longitudinal PC Steel : Internal PC Tendon (12S12.7)

and External PC Tendon (19S15.2)

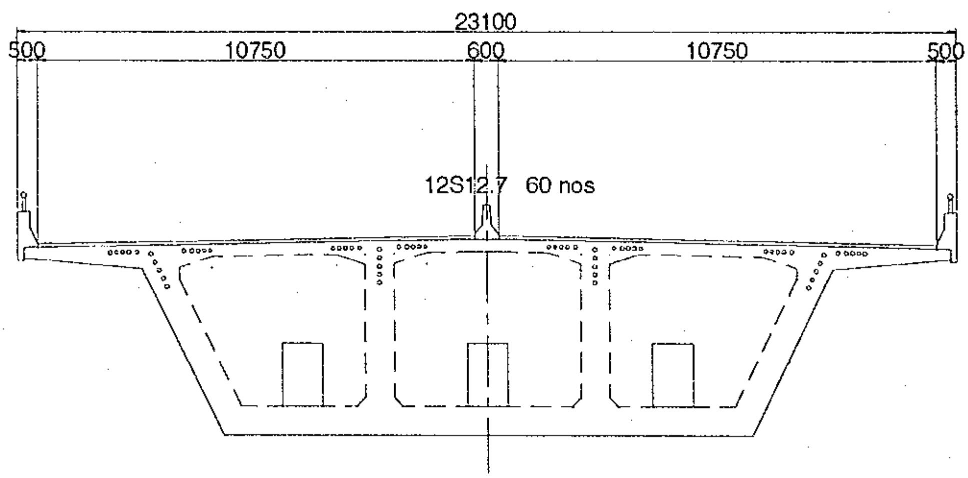
Transverse PC Steel : 1S21.8 (ctc.700)

Internal PC Tendon Arrangement

At Middle of Span

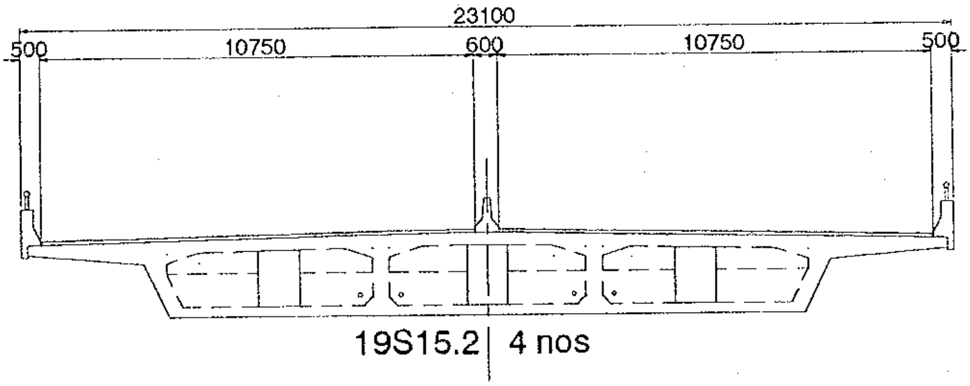


At Piers

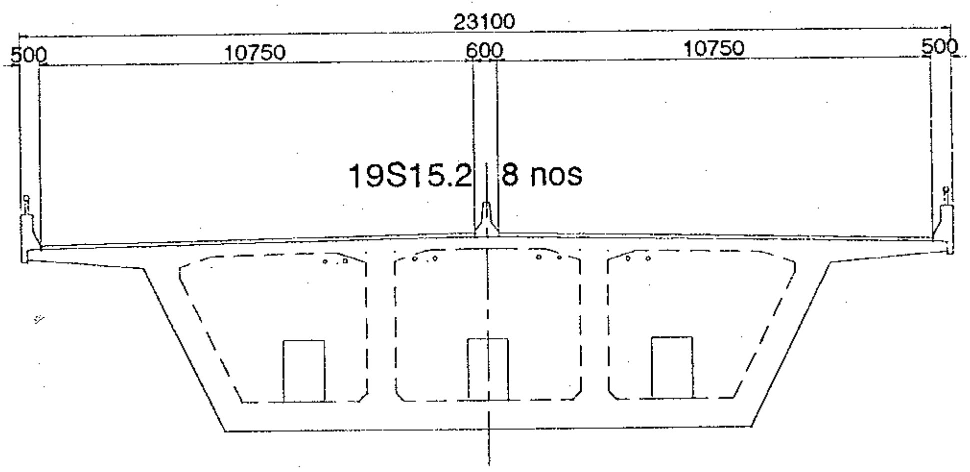


External PC Tendon Arrangement

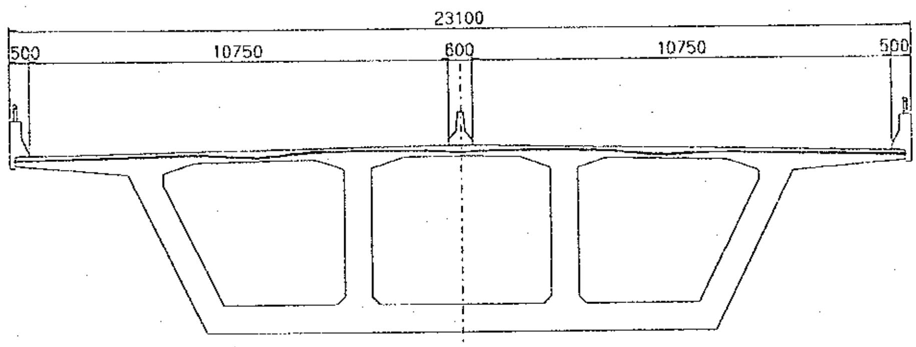
At Middle of Span



At Piers



Transverse PC Tendon (1S21.8)



5.2 Design of Superstructure

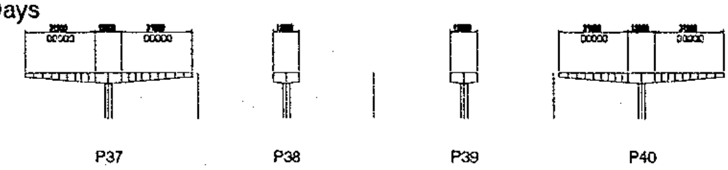
5.2.1 Construction Sequence

Erection method ; Balanced Cantilever Method

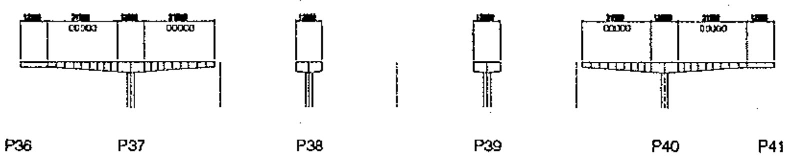
Construction Schedule of 5 Continuous Span PC Box Girder Bridge

STAGE-1; Erect Basic Segments
Passing Days ; 0 Days

STAGE-2 ; Balanced Cantilever Election
P38,P39 Erect Basic Segment
Passing Days ; 184 Days

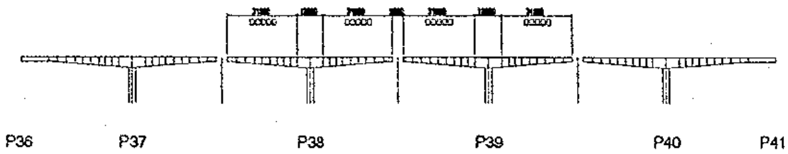


STAGE-3; Erect Closure Segment of Side Span
Passing Days ; 229 Days



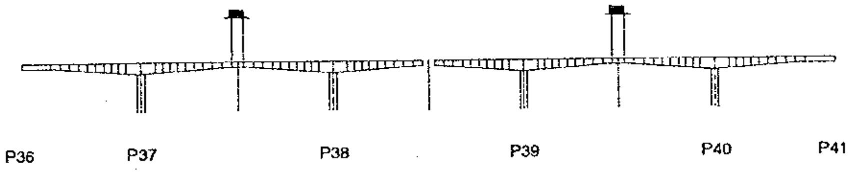
STAGE-4;P37,P39 Temporarily Fixed Free
Passing Days ; 234 Days

STAGE-5;P38,P39 Balanced Cantilever Erection
Passing Days ; 308 Days



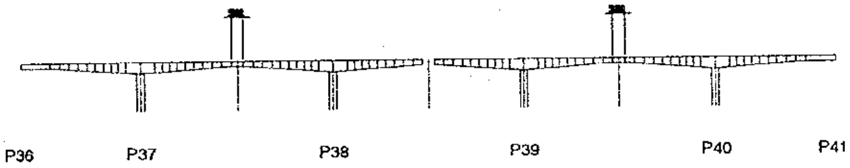
STAGE-6; Erect Closure Segment of Mid Span at P37-P38,P39-P40

Passing Days ; 338 Days



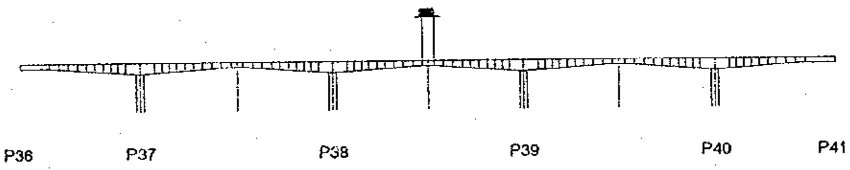
STAGE-7 ; P38,P39 Temporarily Fixed Free

Passing Days ; 343 Days



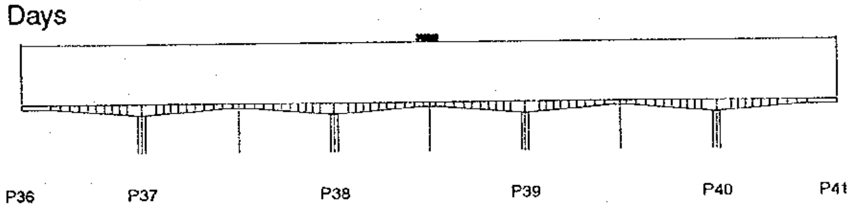
STAGE-8 ; Erect Closure Segment of Center Span

Passing Days ; 373 Days



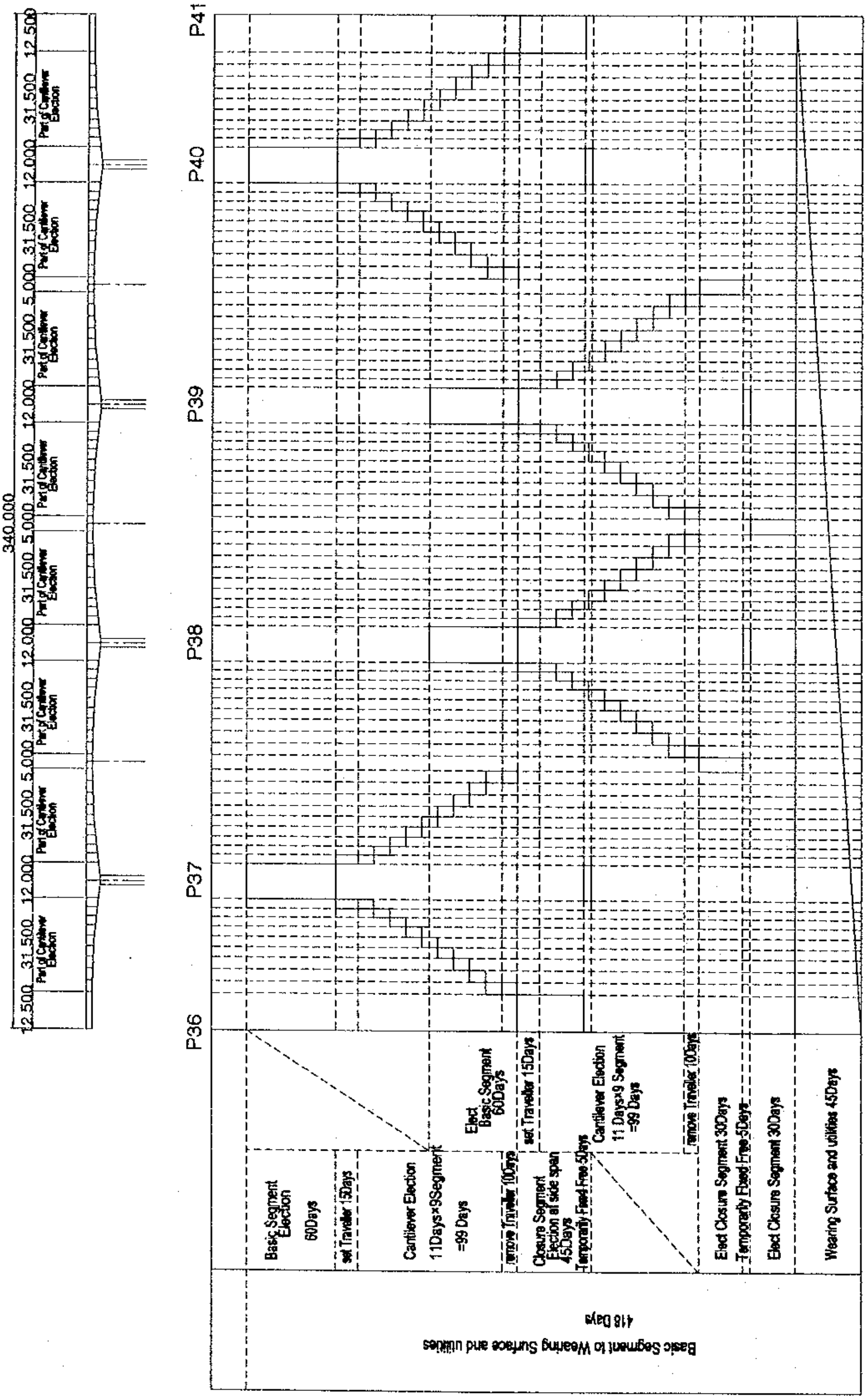
STAGE-9 ; Wearing Surface and Utilities

Passing Days ; 418 Days

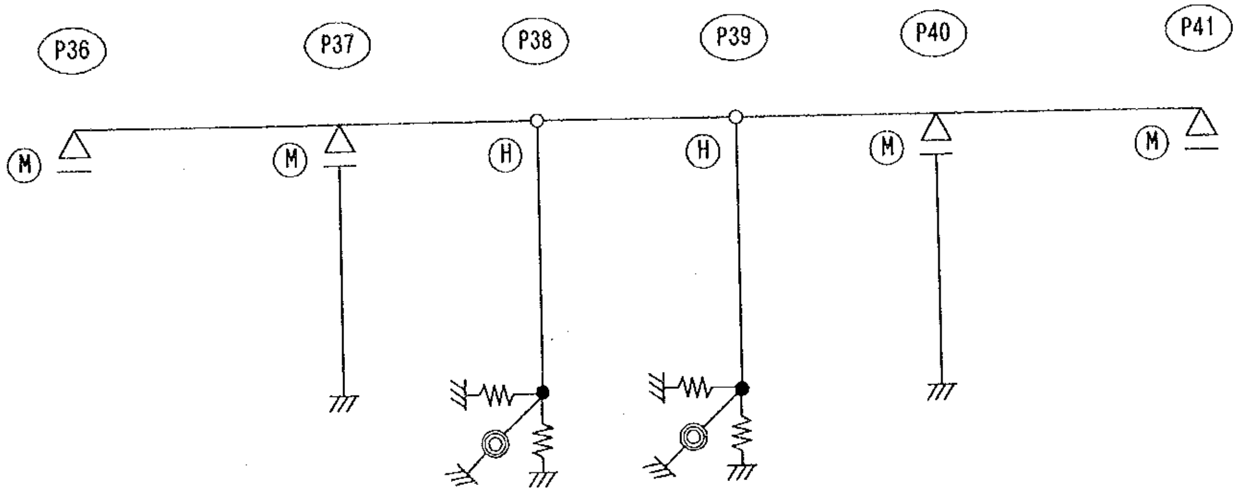


5.2.2 Construction Schedule

Construction Schedule of 5 Continuous Span PC Box Girder



5.2.3 Calculation Model



Note
M ; Movable Support
H ; Hinge

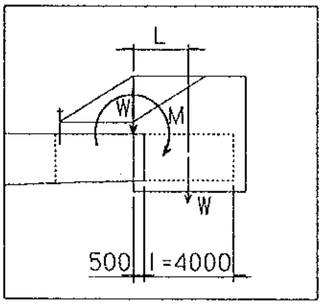
Spring Constant at Bottom of P38,P39

Kv	16094000 KN/m
Kh	457060 KN/m
Kr	559440000 KNm/rad

5.2.4 Loadings

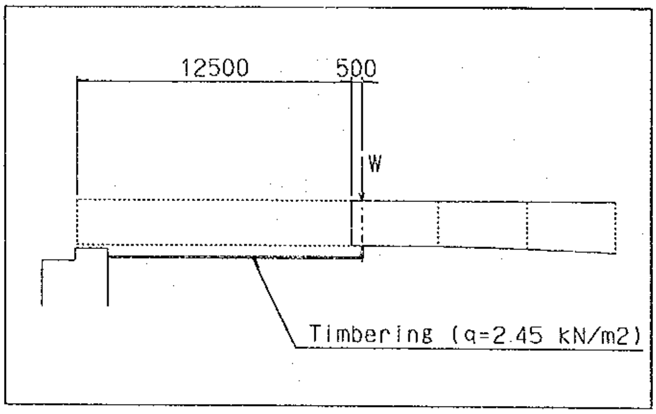
(1) Construction Load

1) Moving Traveller
Self Weoght of Traveller ; W = 1422 kN
Bending Moment due to Segment Weight;
L = 1/2 * 4.0 + 0.5 = 2.5 m
M = W*L = 1422*2.5 =3555 kNm

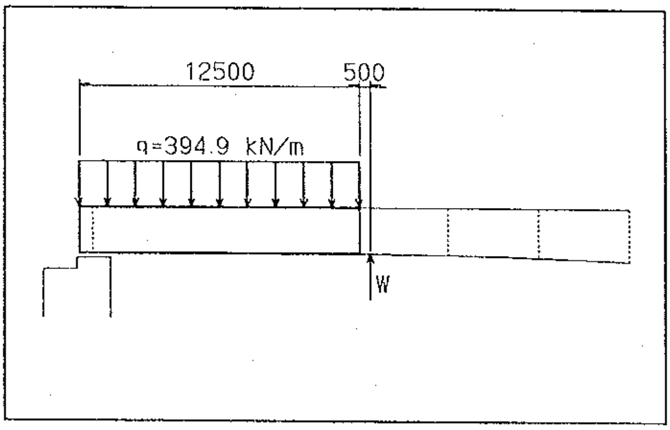


2) During Erection of Closure Segment

a) Closure Segment of Side Span
i). During Erection
Girder Width ; 22.8 m
Self weight of Timbering ; 22.8*13.0*2.45 = 726.2 kN
W = 726.2 / 2 = 363.1 kN



ii). Erection Completed
Self weight of Girder ; q = 394.9 kN/m
Release Timbering ; W = -363.1 kN

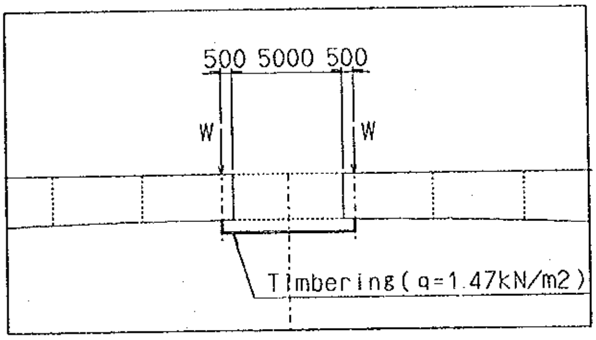


b) Closure Segment of Midspan

i) During Erection

Self weight of Timbering ; 22.8*6.0*1.47 = 201.1 kN

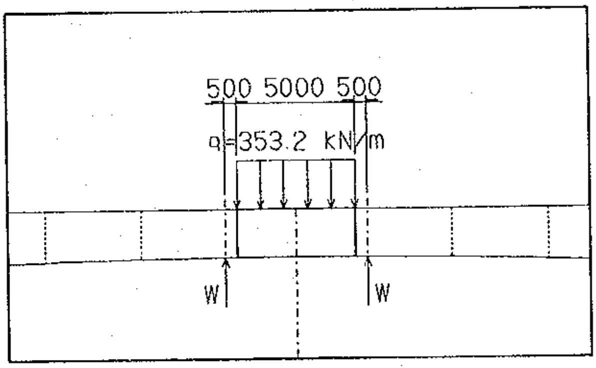
W= 201.1 / 2 = 100.6 kN



ii) Erection Completed

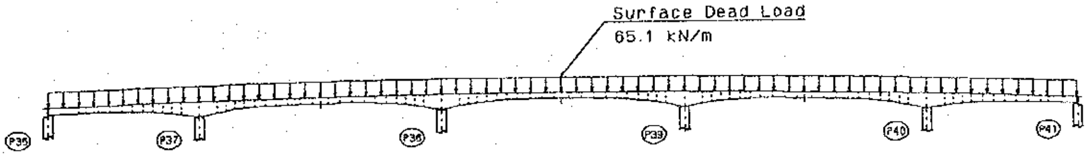
Self weight of Girder ; q = 353.2 kN/m

Release Timbering ; W = -100.6 kN



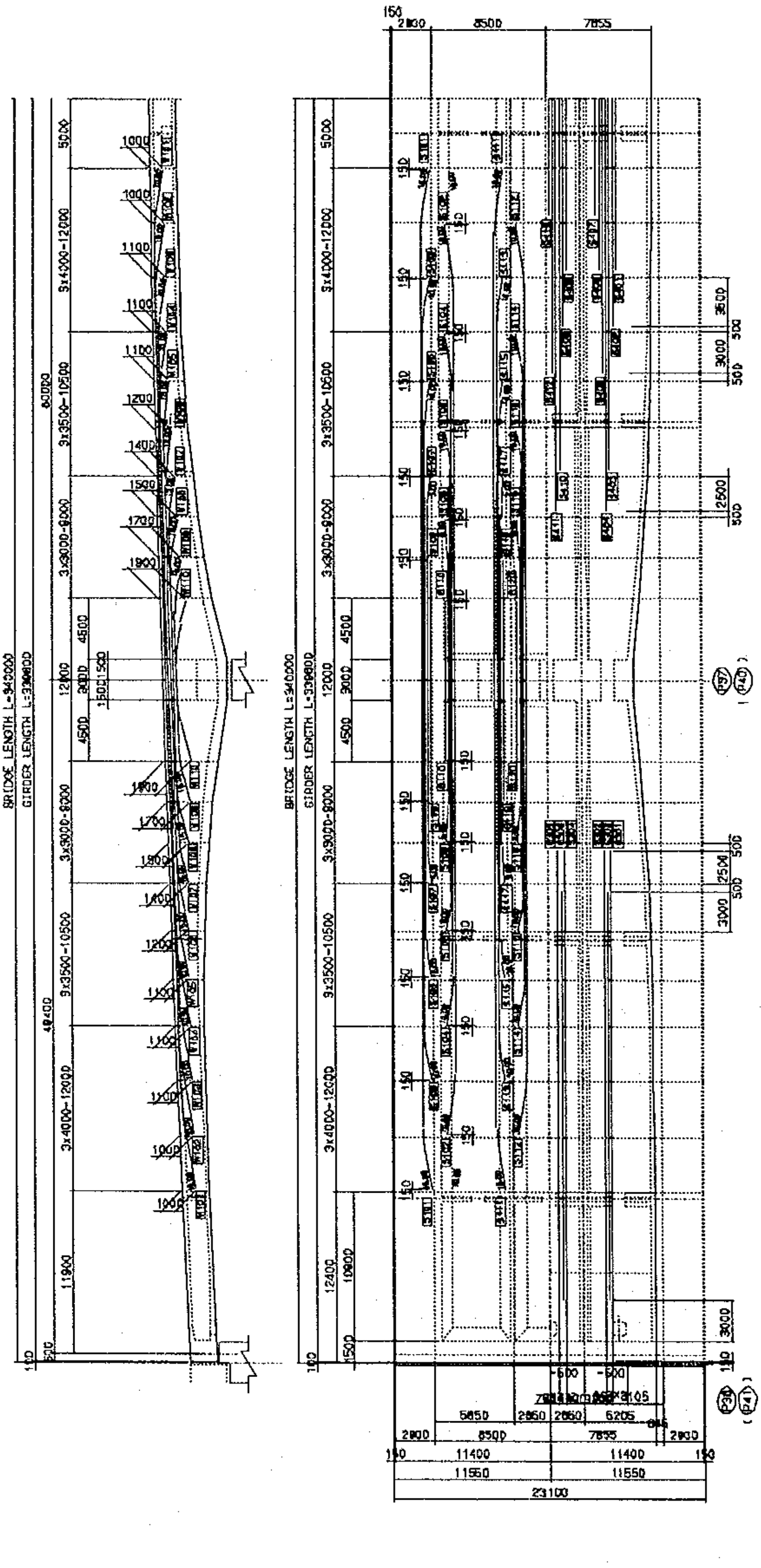
(2) Surface Dead Load

Surface Dead Load include pavement and railing. This Load Intensity distribute uniformly.

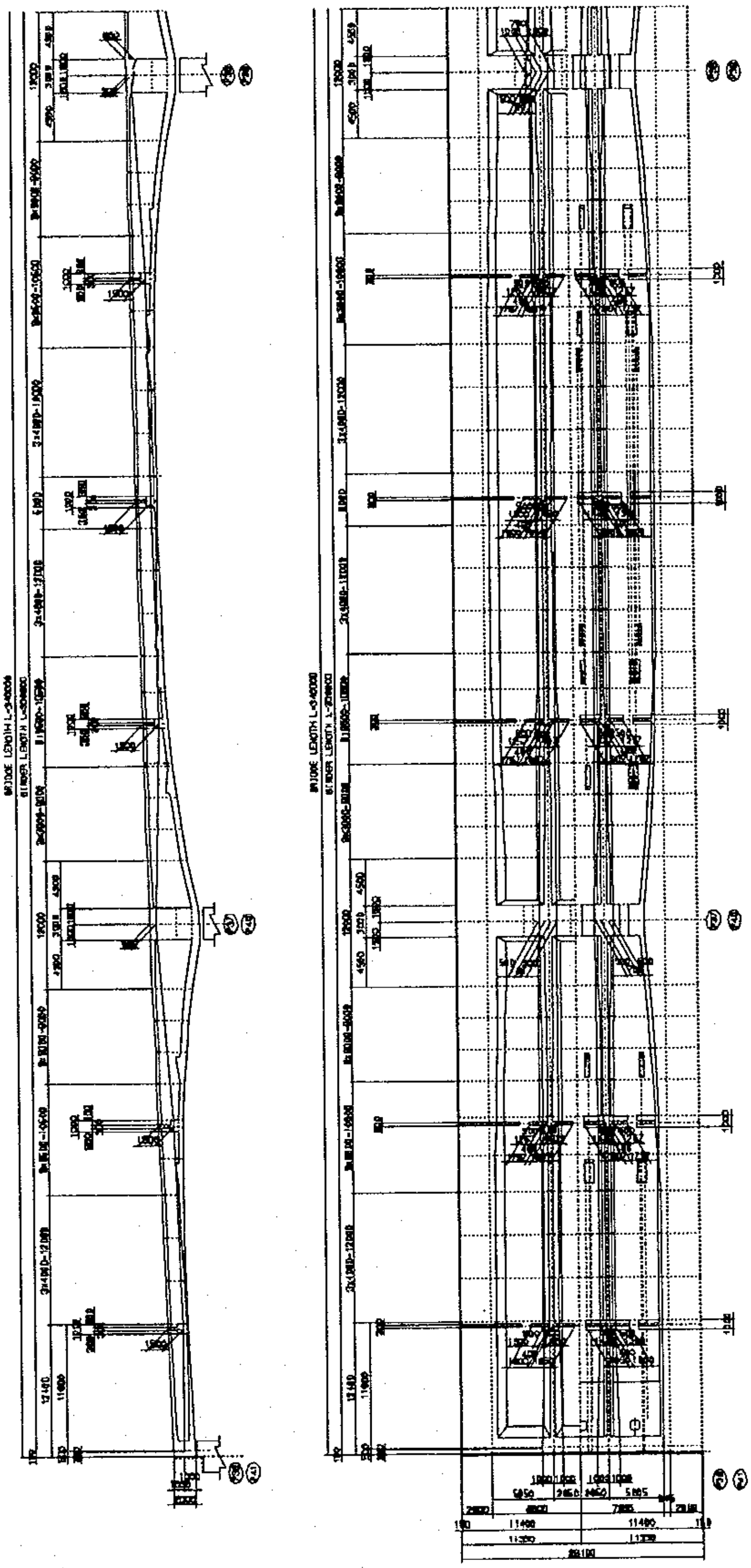


5.2.5 Arrangement of PC Tendon

(1) Internal PC Tendon

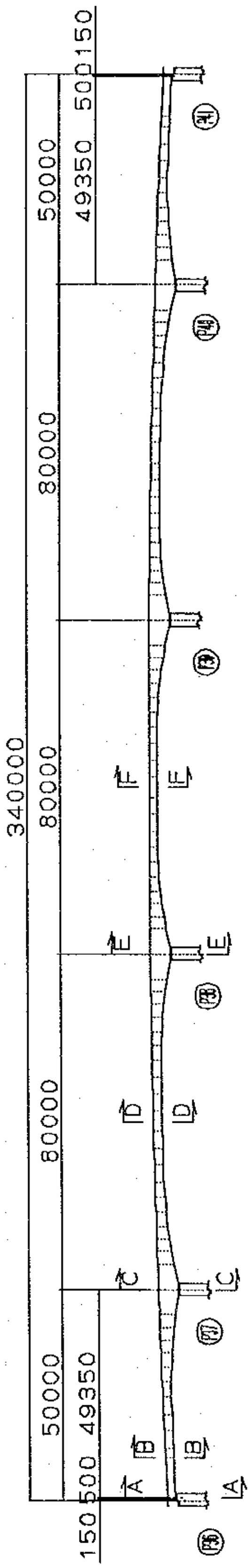


(2) External PC Tendon



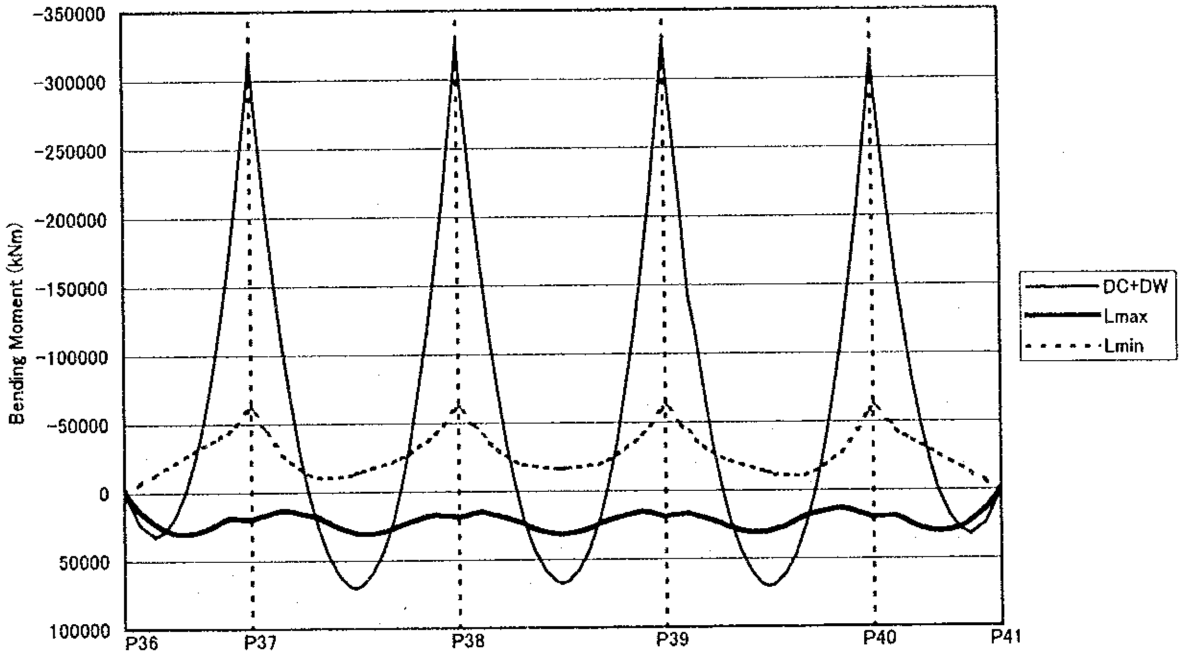
5.2.6 Summary of Calculation Result

(1) Checking Section

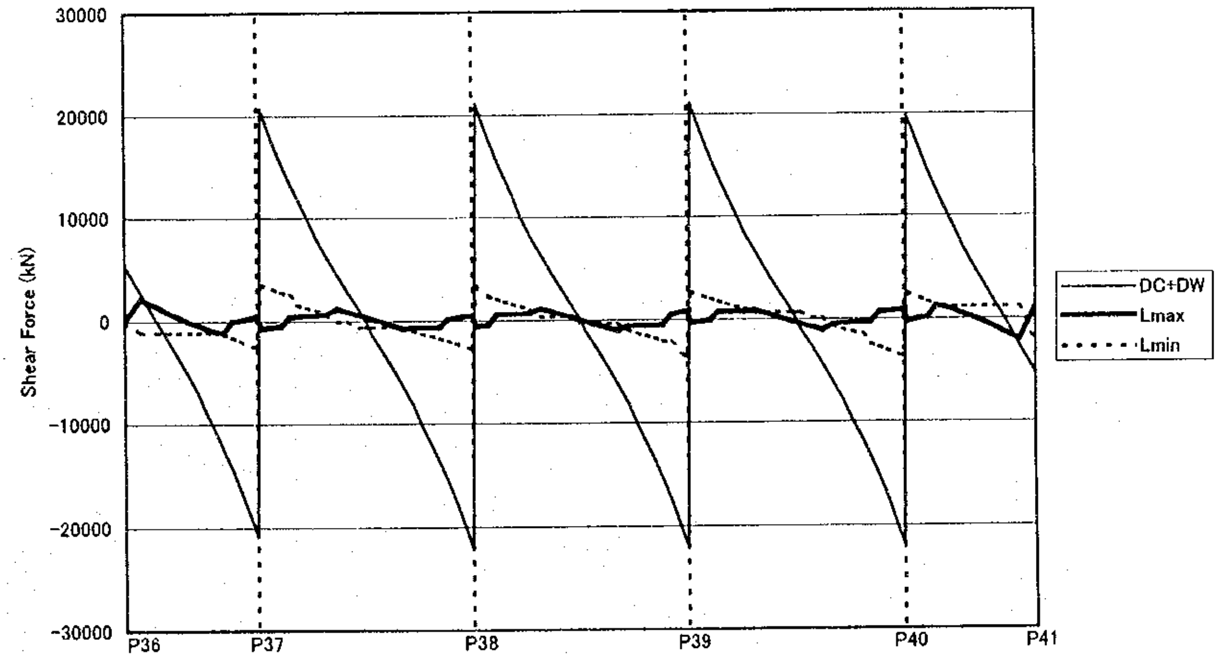


(2) Calculation Result of Sectional Force

Bending Moment Diagram



Shear Force Diagram



Section-A
Maximun

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	0	0	0	0	0	373	0	0	0		
	S (kN)	4534	748	-53	0	-23	176	0	293	125		
	N (kN)	-295	-48	3	0	1	277	0	-19	-119		
Load Combination												
Strength 1	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	5668	1122	-53	5192	-12	88	0	0	0	12005	
	N (kN)	-369	-72	3	121	1	139	0	0	0	-177	
	Factor	(1.25)	(1.50)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	5668	1122	-53	4005	-12	88	0	0	0	10818	
	N (kN)	-369	-72	3	93	1	139	0	0	0	-205	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	5668	1122	-53	0	-12	88	0	0	0	6813	
	N (kN)	-369	-72	3	0	1	139	0	0	0	-298	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	5668	1122	-53	0	-12	88	0	0	0	6813	
	N (kN)	-369	-72	3	0	1	139	0	0	0	-298	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	5668	1122	-53	4005	-12	88	0	0	0	10818	
	N (kN)	-369	-72	3	93	1	139	0	0	0	-205	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme	M (kNm)	0	0	0	0	0	0	0	0	0	0	
Event 1	S (kN)	5668	1122	-53	1484	0	0	0	0	125	8346	
	N (kN)	-369	-72	3	35	0	0	0	0	-119	-522	
	Factor	(1.25)	(1.50)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Minimum

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	0	0	0	0	0	373	0	0	0		
	S (kN)	4534	748	-53	0	-23	176	0	293	125		
	N (kN)	-295	-48	3	0	1	277	0	-19	-119		
Load Combination												
Strength 1	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	4081	486	-53	-1992	-12	88	0	0	0	2598	
	N (kN)	-266	-31	3	-264	1	139	0	0	0	-418	
	Factor	(0.90)	(0.65)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	4081	486	-53	-1536	-12	88	0	0	0	3054	
	N (kN)	-266	-31	3	-204	1	139	0	0	0	-358	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	4081	486	-53	0	-12	88	0	0	0	4590	
	N (kN)	-266	-31	3	0	1	139	0	0	0	-154	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	4081	486	-53	0	-12	88	0	0	0	4590	
	N (kN)	-266	-31	3	0	1	139	0	0	0	-154	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	0	0	0	0	0	187	0	0	0	187	
	S (kN)	4081	486	-53	-1536	-12	88	0	0	0	3054	
	N (kN)	-266	-31	3	-204	1	139	0	0	0	-358	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme	M (kNm)	0	0	0	0	0	0	0	0	0	0	
Event 1	S (kN)	4081	486	-53	-569	0	0	0	0	125	4070	
	N (kN)	-266	-31	3	-76	0	0	0	0	-119	-489	
	Factor	(0.90)	(0.65)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Section-B

Maximun

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	26411	4652	-638	23458	-281	2821	0	3505	1338		
	S (kN)	-266	31	-53	1350	-23	214	0	294	102		
	N (kN)	11	-1	2	-69	0	334	0	-11	-779		
Load Combination												
Strength 1	M (kNm)	33014	6978	-638	41052	-141	1411	0	0	0	81676	
	S (kN)	-333	47	-53	3271	-12	107	0	0	0	3027	
	N (kN)	14	-2	2	75	0	167	0	0	0	256	
	Factor	(1.25)	(1.50)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	33014	6978	-638	31668	-141	1411	0	0	0	72292	
	S (kN)	-333	47	-53	2523	-12	107	0	0	0	2279	
	N (kN)	14	-2	2	58	0	167	0	0	0	239	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	33014	6978	-638	0	-141	1411	0	0	0	40624	
	S (kN)	-333	47	-53	0	-12	107	0	0	0	-244	
	N (kN)	14	-2	2	0	0	167	0	0	0	181	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	33014	6978	-638	0	-141	1411	0	0	0	40624	
	S (kN)	-333	47	-53	0	-12	107	0	0	0	-244	
	N (kN)	14	-2	2	0	0	167	0	0	0	181	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	33014	6978	-638	31668	-141	1411	0	0	0	72292	
	S (kN)	-333	47	-53	2523	-12	107	0	0	0	2279	
	N (kN)	14	-2	2	58	0	167	0	0	0	239	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	33014	6978	-638	11729	0	0	0	0	1338	52421	
	S (kN)	-333	47	-53	935	0	0	0	0	102	698	
	N (kN)	14	-2	2	22	0	0	0	0	-779	-743	
	Factor	(1.25)	(1.50)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Minimum

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	26411	4652	-638	-12706	-281	2821	0	3505	1338		
	S (kN)	-266	31	-53	-1139	-23	214	0	294	102		
	N (kN)	11	-1	2	42	0	334	0	-11	-779		
Load Combination												
Strength 1	M (kNm)	23770	3024	-638	-22236	-141	1411	0	0	0	5190	
	S (kN)	-239	20	-53	-2177	-12	107	0	0	0	-2354	
	N (kN)	10	-1	2	-126	0	167	0	0	0	52	
	Factor	(0.90)	(0.65)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	23770	3024	-638	-17153	-141	1411	0	0	0	10273	
	S (kN)	-239	20	-53	-1679	-12	107	0	0	0	-1856	
	N (kN)	10	-1	2	-97	0	167	0	0	0	81	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	23770	3024	-638	0	-141	1411	0	0	0	27426	
	S (kN)	-239	20	-53	0	-12	107	0	0	0	-177	
	N (kN)	10	-1	2	0	0	167	0	0	0	178	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	23770	3024	-638	0	-141	1411	0	0	0	27426	
	S (kN)	-239	20	-53	0	-12	107	0	0	0	-177	
	N (kN)	10	-1	2	0	0	167	0	0	0	178	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	23770	3024	-638	-17153	-141	1411	0	0	0	10273	
	S (kN)	-239	20	-53	-1679	-12	107	0	0	0	-1856	
	N (kN)	10	-1	2	-97	0	167	0	0	0	81	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	23770	3024	-638	-6353	0	0	0	0	1338	21141	
	S (kN)	-239	20	-53	-622	0	0	0	0	102	-792	
	N (kN)	10	-1	2	-36	0	0	0	0	-779	-804	
	Factor	(0.90)	(0.65)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Section-C

Maximun

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	-287773	-36578	-2650	20383	-1170	5744	-2	14553	7441		
	S (kN)	-18816	-2230	-53	441	-23	476	0	294	34		
	N (kN)	568	67	1	-12	0	2469	1	-8	-3275		
Load Combination												
Strength 1	M (kNm)	-359716	-54867	-2650	35670	-585	2872	-1	0	0	-379277	
	S (kN)	-23520	-3345	-53	774	-12	238	0	0	0	-25918	
	N (kN)	710	101	1	189	0	1235	1	0	0	2237	
	Factor	(1.25)	(1.50)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	-359716	-54867	-2650	27517	-585	2872	-1	0	0	-387430	
	S (kN)	-23520	-3345	-53	597	-12	238	0	0	0	-26095	
	N (kN)	710	101	1	146	0	1235	1	0	0	2194	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	-359716	-54867	-2650	0	-585	2872	-1	0	0	-414947	
	S (kN)	-23520	-3345	-53	0	-12	238	0	0	0	-26692	
	N (kN)	710	101	1	0	0	1235	1	0	0	2048	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	-359716	-54867	-2650	0	-585	2872	-1	0	0	-414947	
	S (kN)	-23520	-3345	-53	0	-12	238	0	0	0	-26692	
	N (kN)	710	101	1	0	0	1235	1	0	0	2048	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	-359716	-54867	-2650	27517	-585	2872	-1	0	0	-387430	
	S (kN)	-23520	-3345	-53	597	-12	238	0	0	0	-26095	
	N (kN)	710	101	1	146	0	1235	1	0	0	2194	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	-359716	-54867	-2650	10192	0	0	-1	0	7441	-399601	
	S (kN)	-23520	-3345	-53	221	0	0	0	0	34	-26663	
	N (kN)	710	101	1	54	0	0	1	0	-3275	-2408	
	Factor	(1.25)	(1.50)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Minimum

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	-287773	-36578	-2650	-62695	-1170	5744	-2	14553	7441		
	S (kN)	-18816	-2230	-53	-2664	-23	476	0	294	34		
	N (kN)	568	67	1	77	0	2469	1	-8	-3275		
Load Combination												
Strength 1	M (kNm)	-258996	-23776	-2650	-109716	-585	2872	-1	0	0	-392852	
	S (kN)	-16934	-1450	-53	-6897	-12	238	0	0	0	-25108	
	N (kN)	511	44	1	-21	0	1235	1	0	0	1771	
	Factor	(0.90)	(0.65)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	-258996	-23776	-2650	-84638	-585	2872	-1	0	0	-367774	
	S (kN)	-16934	-1450	-53	-5320	-12	238	0	0	0	-23531	
	N (kN)	511	44	1	-16	0	1235	1	0	0	1776	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	-258996	-23776	-2650	0	-585	2872	-1	0	0	-283136	
	S (kN)	-16934	-1450	-53	0	-12	238	0	0	0	-18211	
	N (kN)	511	44	1	0	0	1235	1	0	0	1792	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	-258996	-23776	-2650	0	-585	2872	-1	0	0	-283136	
	S (kN)	-16934	-1450	-53	0	-12	238	0	0	0	-18211	
	N (kN)	511	44	1	0	0	1235	1	0	0	1792	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	-258996	-23776	-2650	-84638	-585	2872	-1	0	0	-367774	
	S (kN)	-16934	-1450	-53	-5320	-12	238	0	0	0	-23531	
	N (kN)	511	44	1	-16	0	1235	1	0	0	1776	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	-258996	-23776	-2650	-31348	0	0	-1	0	7441	-309330	
	S (kN)	-16934	-1450	-53	-1971	0	0	0	0	34	-20374	
	N (kN)	511	44	1	-6	0	0	1	0	-3275	-2724	
	Factor	(0.90)	(0.65)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Section-D
Maximun

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	55293	9385	-2244	30188	366	14035	1	11999	-3263		
	S (kN)	105	-58	10	345	38	-89	0	-63	-94		
	N (kN)	-2	1	0	-11	0	5012	1	1	-6290		
Load Combination												
Strength 1	M (kNm)	69116	14078	-2244	52829	183	7018	1	0	0	140981	
	S (kN)	131	-87	10	2882	19	-45	0	0	0	2910	
	N (kN)	-3	2	0	47	0	2506	1	0	0	2553	
	Factor	(1.25)	(1.50)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	69116	14078	-2244	40754	183	7018	1	0	0	128906	
	S (kN)	131	-87	10	2223	19	-45	0	0	0	2251	
	N (kN)	-3	2	0	36	0	2506	1	0	0	2542	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	69116	14078	-2244	0	183	7018	1	0	0	88152	
	S (kN)	131	-87	10	0	19	-45	0	0	0	28	
	N (kN)	-3	2	0	0	0	2506	1	0	0	2506	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	69116	14078	-2244	0	183	7018	1	0	0	88152	
	S (kN)	131	-87	10	0	19	-45	0	0	0	28	
	N (kN)	-3	2	0	0	0	2506	1	0	0	2506	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	69116	14078	-2244	40754	183	7018	1	0	0	128906	
	S (kN)	131	-87	10	2223	19	-45	0	0	0	2251	
	N (kN)	-3	2	0	36	0	2506	1	0	0	2542	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	69116	14078	-2244	15094	0	0	1	0	-3263	92782	
	S (kN)	131	-87	10	824	0	0	0	0	-94	784	
	N (kN)	-3	2	0	14	0	0	1	0	-6290	-6276	
	Factor	(1.25)	(1.50)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Minimum

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	55293	9385	-2244	-13077	366	14035	1	11999	-3263		
	S (kN)	105	-58	10	-642	38	-89	0	-63	-94		
	N (kN)	-2	1	0	11	0	5012	1	1	-6290		
Load Combination												
Strength 1	M (kNm)	49764	6100	-2244	-22885	183	7018	1	0	0	37937	
	S (kN)	95	-38	10	-2746	19	-45	0	0	0	-2705	
	N (kN)	-2	1	0	-54	0	2506	1	0	0	2452	
	Factor	(0.90)	(0.65)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	49764	6100	-2244	-17654	183	7018	1	0	0	43168	
	S (kN)	95	-38	10	-2118	19	-45	0	0	0	-2077	
	N (kN)	-2	1	0	-42	0	2506	1	0	0	2464	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	49764	6100	-2244	0	183	7018	1	0	0	60822	
	S (kN)	95	-38	10	0	19	-45	0	0	0	41	
	N (kN)	-2	1	0	0	0	2506	1	0	0	2506	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	49764	6100	-2244	0	183	7018	1	0	0	60822	
	S (kN)	95	-38	10	0	19	-45	0	0	0	41	
	N (kN)	-2	1	0	0	0	2506	1	0	0	2506	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	49764	6100	-2244	-17654	183	7018	1	0	0	43168	
	S (kN)	95	-38	10	-2118	19	-45	0	0	0	-2077	
	N (kN)	-2	1	0	-42	0	2506	1	0	0	2464	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	49764	6100	-2244	-6539	0	0	1	0	-3263	43819	
	S (kN)	95	-38	10	-785	0	0	0	0	-94	-812	
	N (kN)	-2	1	0	-16	0	0	1	0	-6290	-6306	
	Factor	(0.90)	(0.65)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Section-E
Maximun

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	-292457	-41229	-1838	19189	1903	6452	-4	9446	5711		
	S (kN)	-19679	-2472	10	474	38	299	0	-63	-57		
	N (kN)	200	25	0	-4	0	769	1	0	-8954		
Load Combination												
Strength 1	M (kNm)	-365571	-61844	-1838	33581	952	3226	-2	0	0	-391496	
	S (kN)	-24599	-3708	10	949	19	150	0	0	0	-27179	
	N (kN)	250	38	0	67	0	385	1	0	0	741	
	Factor	(1.25)	(1.50)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	-365571	-61844	-1838	25905	952	3226	-2	0	0	-399172	
	S (kN)	-24599	-3708	10	732	19	150	0	0	0	-27396	
	N (kN)	250	38	0	51	0	385	1	0	0	725	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	-365571	-61844	-1838	0	952	3226	-2	0	0	-425077	
	S (kN)	-24599	-3708	10	0	19	150	0	0	0	-28128	
	N (kN)	250	38	0	0	0	385	1	0	0	674	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	-365571	-61844	-1838	0	952	3226	-2	0	0	-425077	
	S (kN)	-24599	-3708	10	0	19	150	0	0	0	-28128	
	N (kN)	250	38	0	0	0	385	1	0	0	674	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	-365571	-61844	-1838	25905	952	3226	-2	0	0	-399172	
	S (kN)	-24599	-3708	10	732	19	150	0	0	0	-27396	
	N (kN)	250	38	0	51	0	385	1	0	0	725	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	-365571	-61844	-1838	9595	0	0	-2	0	5711	-413949	
	S (kN)	-24599	-3708	10	271	0	0	0	0	-57	-28083	
	N (kN)	250	38	0	19	0	0	1	0	-8954	-8646	
	Factor	(1.25)	(1.50)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Minimum

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	-292457	-41229	-1838	-63441	1903	6452	-4	9446	5711		
	S (kN)	-19679	-2472	10	-2793	38	299	0	-63	-57		
	N (kN)	200	25	0	27	0	769	1	0	-8954		
Load Combination												
Strength 1	M (kNm)	-263211	-26799	-1838	-111022	952	3226	-2	0	0	-398694	
	S (kN)	-17711	-1607	10	-7263	19	150	0	0	0	-26402	
	N (kN)	180	16	0	-9	0	385	1	0	0	573	
	Factor	(0.90)	(0.65)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	-263211	-26799	-1838	-85645	952	3226	-2	0	0	-373317	
	S (kN)	-17711	-1607	10	-5603	19	150	0	0	0	-24742	
	N (kN)	180	16	0	-7	0	385	1	0	0	575	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	-263211	-26799	-1838	0	952	3226	-2	0	0	-287672	
	S (kN)	-17711	-1607	10	0	19	150	0	0	0	-19139	
	N (kN)	180	16	0	0	0	385	1	0	0	582	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	-263211	-26799	-1838	0	952	3226	-2	0	0	-287672	
	S (kN)	-17711	-1607	10	0	19	150	0	0	0	-19139	
	N (kN)	180	16	0	0	0	385	1	0	0	582	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	-263211	-26799	-1838	-85645	952	3226	-2	0	0	-373317	
	S (kN)	-17711	-1607	10	-5603	19	150	0	0	0	-24742	
	N (kN)	180	16	0	-7	0	385	1	0	0	575	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	-263211	-26799	-1838	-31721	0	0	-2	0	5711	-317860	
	S (kN)	-17711	-1607	10	-2075	0	0	0	0	-57	-21440	
	N (kN)	180	16	0	-3	0	0	1	0	-8954	-8760	
	Factor	(0.90)	(0.65)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Section-F
Maximun

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	54020	6989	-1753	31513	-1046	13523	1	9000	-1		
	S (kN)	168	0	0	0	0	-49	0	0	-378		
	N (kN)	1087	-26	37	-845	-1305	4794	1	-197	20		
Load Combination												
Strength 1	M (kNm)	67525	10484	-1753	55148	-523	6762	1	0	0	137644	
	S (kN)	210	0	0	2928	0	-25	0	0	0	3113	
	N (kN)	1359	-39	37	1243	-653	2397	1	0	0	4345	
	Factor	(1.25)	(1.50)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	67525	10484	-1753	42543	-523	6762	1	0	0	125039	
	S (kN)	210	0	0	2259	0	-25	0	0	0	2444	
	N (kN)	1359	-39	37	959	-653	2397	1	0	0	4061	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	67525	10484	-1753	0	-523	6762	1	0	0	82496	
	S (kN)	210	0	0	0	0	-25	0	0	0	185	
	N (kN)	1359	-39	37	0	-653	2397	1	0	0	3102	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	67525	10484	-1753	0	-523	6762	1	0	0	82496	
	S (kN)	210	0	0	0	0	-25	0	0	0	185	
	N (kN)	1359	-39	37	0	-653	2397	1	0	0	3102	
	Factor	(1.25)	(1.50)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	67525	10484	-1753	42543	-523	6762	1	0	0	125039	
	S (kN)	210	0	0	2259	0	-25	0	0	0	2444	
	N (kN)	1359	-39	37	959	-653	2397	1	0	0	4061	
	Factor	(1.25)	(1.50)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	67525	10484	-1753	15757	0	0	1	0	-1	92013	
	S (kN)	210	0	0	837	0	0	0	0	-378	669	
	N (kN)	1359	-39	37	355	0	0	1	0	20	1733	
	Factor	(1.25)	(1.50)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

Minimum

		DC	DW	EL	LL	TU	CR	SH	TG	EQ	Force Effect	Remark
Sectional force												
	M (kNm)	54020	6989	-1753	-15829	-1046	13523	1	9000	-1		
	S (kN)	168	0	0	-292	0	-49	0	0	-378		
	N (kN)	1087	-26	37	710	-1305	4794	1	-197	20		
Load Combination												
Strength 1	M (kNm)	48618	4543	-1753	-27701	-523	6762	1	0	0	29947	
	S (kN)	151	0	0	-2928	0	-25	0	0	0	-2802	
	N (kN)	978	-17	37	-1479	-653	2397	1	0	0	1264	
	Factor	(0.90)	(0.65)	(1.00)	(1.75)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 2	M (kNm)	48618	4543	-1753	-21369	-523	6762	1	0	0	36279	
	S (kN)	151	0	0	-2259	0	-25	0	0	0	-2133	
	N (kN)	978	-17	37	-1141	-653	2397	1	0	0	1602	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 3	M (kNm)	48618	4543	-1753	0	-523	6762	1	0	0	57648	
	S (kN)	151	0	0	0	0	-25	0	0	0	126	
	N (kN)	978	-17	37	0	-653	2397	1	0	0	2743	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 4	M (kNm)	48618	4543	-1753	0	-523	6762	1	0	0	57648	
	S (kN)	151	0	0	0	0	-25	0	0	0	126	
	N (kN)	978	-17	37	0	-653	2397	1	0	0	2743	
	Factor	(0.90)	(0.65)	(1.00)	(0.00)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Strength 5	M (kNm)	48618	4543	-1753	-21369	-523	6762	1	0	0	36279	
	S (kN)	151	0	0	-2259	0	-25	0	0	0	-2133	
	N (kN)	978	-17	37	-1141	-653	2397	1	0	0	1602	
	Factor	(0.90)	(0.65)	(1.00)	(1.35)	(0.50)	(0.50)	(0.50)	(0.00)	(0.00)		
Extreme Event 1	M (kNm)	48618	4543	-1753	-7915	0	0	1	0	-1	43493	
	S (kN)	151	0	0	-837	0	0	0	0	-378	-1064	
	N (kN)	978	-17	37	-423	0	0	1	0	20	596	
	Factor	(0.90)	(0.65)	(1.00)	(0.50)	(0.00)	(0.00)	(0.50)	(0.00)	(1.00)		

(3) Check from Load and Rsistance Factor Design

(1) Result of Checking for Strength and Extreme event

		Section-A			Section-B			Section-C			Section-D			Section-E			Section-F		
		Force Effect		Factored Resistance	Force Effect		Factored Resistance	Force Effect		Factored Resistance	Force Effect		Factored Resistance	Force Effect		Factored Resistance	Force Effect		Factored Resistance
Strength 1	M (kNm)	187	<	718971	81676	<	289014	392852	<	4202603	140981	<	1842508	398694	<	4202603	137644	<	1842508
	S (kN)	12005	<	44183	3027	<	52949	25918	<	99860	2910	<	64678	27179	<	99594	3113	<	64678
	N (kN)	418	<	3687121	256	<	2953333	2237	<	5768367	2553	<	2954778	741	<	5768367	4345	<	2954778
Strength 2	M (kNm)	187	<	718971	72292	<	289014	387430	<	4202603	128906	<	1842508	399172	<	4202603	125039	<	1842508
	S (kN)	10818	<	44183	2279	<	52949	26095	<	99860	2251	<	64678	27396	<	99594	2444	<	64678
	N (kN)	358	<	3687121	239	<	2953333	2194	<	5768367	2542	<	2954778	725	<	5768367	4061	<	2954778
Strength 3	M (kNm)	187	<	718971	40624	<	289014	414947	<	4202603	88152	<	1842508	425077	<	4202603	82496	<	1842508
	S (kN)	6813	<	44183	244	<	52949	26692	<	99860	41	<	64678	28128	<	99594	185	<	64678
	N (kN)	298	<	3687121	181	<	2953333	2048	<	5768367	2506	<	2954778	674	<	5768367	3102	<	2954778
Strength 4	M (kNm)	187	<	718971	40624	<	289014	414947	<	4202603	88152	<	1842508	425077	<	4202603	82496	<	1842508
	S (kN)	6813	<	44183	244	<	52949	26692	<	99860	41	<	64678	28128	<	99594	185	<	64678
	N (kN)	298	<	3687121	181	<	2953333	2048	<	5768367	2506	<	2954778	674	<	5768367	3102	<	2954778
Strength 5	M (kNm)	187	<	718971	72292	<	289014	387430	<	4202603	128906	<	1842508	399172	<	4202603	125039	<	1842508
	S (kN)	10818	<	44183	2279	<	52949	26095	<	99860	2251	<	64678	27396	<	99594	2444	<	64678
	N (kN)	358	<	3687121	239	<	2953333	2194	<	5768367	2542	<	2954778	725	<	5768367	4061	<	2954778
Extreme Event (Earthquake)	M (kNm)	0	<	718971	52421	<	289014	399601	<	4202603	92782	<	1842508	413949	<	4202603	92013	<	1842508
	S (kN)	8346	<	44183	792	<	52949	26663	<	99860	812	<	64678	28083	<	99594	1064	<	64678
	N (kN)	522	<	3687121	804	<	2953333	2724	<	5768367	6306	<	2954778	8760	<	5768367	1733	<	2954778

1) Calculation of Frexural Resistance

Calculation of Flexural Resistance

	Sign	Unit	Section-A	Section-B	Section-D	Section-F	Section-H	Section-J
Factored Flexural Resistance	M_r	Nmm	7.19E+10	2.89E+10	4.203E+11	1.843E+11	4.203E+11	1.843E+11
Resistance Factor	ϕ		0.95	0.95	0.95	0.95	0.95	0.95
Nominal Resistance	M_n	Nmm	7.568E+10	3.042E+10	4.424E+11	1.939E+11	4.424E+11	1.939E+11
Area of prestressing steel	A_{ps}	mm^2	30564.8	30564.8	57956.8	51902	57956.8	51902
Average stress in prestressing steel at nominal bending resistance	f_{ps}	MPa	400	840	1466	1319	1466	1319
Yield strength of prestressing steel	f_{py}	MPa	1570	1570	1570	1570	1570	1570
Specified tensile strength of prestressing steel	f_{pu}	MPa	1860	1860	1860	1860	1860	1860
	k		0.392	0.392	0.392	0.392	0.392	0.392
Distance from extreme compression fiber to the centroid of prestressing tendons	d_p	mm	729	384	4118	2020	4118	2020
Specified yield strength of reinforcing bars	f_y	MPa	390	390	390	390	390	390
Area of nonprestressed tension reinforcement	A_s	mm^2	37516	28501	40708	28049	40708	28049
Distance from extreme compression fiber to the centroid of nonprestressed tensile reinforcement	d_s	mm	1774	1755	4471	2377	4471	2377
Area of compression reinforcement	A'_s	mm^2	28501	37516	22620	44730	22620	44730
Distance from extreme compression fiber to centroid of compression reinforcement	d'_s	mm	245	226	329	230	329	230
Specified yield strength of compression reinforcement	f'_y	MPa	390	390	390	390	390	390
Specified compressive strength of concrete at 28 days, unless another age is specified	f'_c	MPa	40	40	40	40	40	40
Width of the compression face of the member	b	mm	15710	22800	13000	22800	13000	22800
Web width or diameter of a circular section	b_w	mm	1600	1600	1600	1600	1600	1600
Stress block factor	β_1		0.76	0.76	0.76	0.76	0.76	0.76
Distance from extreme compression fiber to the nutral axis assuming the tendon prestressing steel has yielded	c	mm	1460	537	2226	1499	2226	1499
Compression flange depth of an I or T member	h_f	mm	700	300	700	300	700	300
Depth of the equivalent stress block	a (=$c\beta_1$)		1109.6	408.12	1691.76	1139.24	1691.76	1139.24

Fomula : $M_n = A_{ps}f_{ps}(d_p-a/2)+A_sf_y(d_s-a/2)-A'_sf'_y(d'_s-a/2)+0.85f'_c(b-b_w)\beta_1h_f(a/2-h_f/2)$

$f_{ps} = f_{pu}(1-kc/d_p)$

$k = 2(1.04-f_{py}/f_{pu})$

$c = (A_{ps}f_{pu}+A_sf_y-A'_sf'_y-0.85\beta_1f'_c(b-b_w)h_f)/(0.85f'_c\beta_1b_w+kA_{ps}f_{pu}/d_p)$

2) Calculation of Axial Resistance

	Sign	Unit	Section-A	Section-B	Section-D	Section-F	Section-H	Section-J
Factored Axial Resistance	P_r	N	3.69E+09	2.95E+09	5.77E+09	2.95E+09	5.77E+09	2.95E+09
Resistance Factor	ϕ		0.75	0.75	0.75	0.75	0.75	0.75
Nominal Resistance	P_n	Nmm	4.92E+09	3.94E+09	7.69E+09	3.94E+09	7.69E+09	3.94E+09
Specified strength of concrete at 28 days, unless another age is specified	f'_c	MPa	40	40	40	40	40	40
Gross area of section	A_g	mm^2	1.8E+08	1.44E+08	2.82E+08	1.44E+08	2.82E+08	1.44E+08
Total area of longitudinal reinforcement	A_{st}	mm^2	66016.9	66017.1	63328.4	72779.2	63328.4	72779.2
Specified yield strength of reinforcement	f_y	MPa	390	390	390	390	390	390

Formula : $P_n = 0.80[0.85f'_c(A_g - A_{st}) + f_y A_{st}]$

3) Calculation of Shear Resistance

Fctored forces (moment, shear force, axial force) are taken as maximam value, aimed at Shear force.

	Sign	Unit	Section-A	Section-B	Section-D	Section-F	Section-H	Section-J
Factored Flexural Resistance	V_r	N	44183499	52948886	99859894	64677599	99593719	64677599
Resistance Factor	ϕ		0.9	0.9	0.9	0.9	0.9	0.9
Nominal Shear Resistance	V_n	N	49092777	58832096	110955438	71863999	110659688	71863999
Nominal Shear Resistance (upper limit)	V_n	N	24198000	23040000	54144000	28800000	54353000	28800000
Nominal shear resistance provided by tensile stresses in the concrete	V_c	N	37493178	52127612	102320093	65159515	101751648	65159515
Shear resistane provided by shear reinforcement	V_s	N	10441599	6704484	8635345	6704484	8699040	6704484
Specified minimum yield strength of reinforcing bar	f_y	MPa	390	390	390	390	390	390
Corresponding effective depth from the extreme compression fiber to the centroid of the tensile force in the tensile reinforcement	d_e	mm	1298	798	4174	2069	4174	2069
Effective web width taken as the minimum web width within the depth b_v	b_v	mm	1440	1440	3384	1800	3384	1800
Effective shear depth	d_v	mm	1600	1600	1600	1600	1600	1600
Spacing of stirrups	s	mm	250	250	250	250	250	250
Factor indicating ability of diagonally cracked concrete to transmit tension	β		2.4	1.7	1.1	1.7	1.1	1.7
Angle of inclination of diagonal compressive stress	θ	Deg	31	43.1	36	43.1	35.8	43.1
Shear stress on the concrete	v	N/mm	4.03	1.34	6.88	1.07	7.22	0.21
Strain in the reinforcement on the flexural tension side of the member	εx		5.75E-04	3.63E-03	1.31E-02	4.45E-03	1.25E-02	2.67E-03
Factored moment	M_u	Nmm	187000000	6.657E+10	3.709E+11	1.107E+11	3.507E+11	6.834E+10
Factored shear force	V_u	N	9397000	2777000	33538000	2761000	35349000	532000
Factored axial force	N_u	N	-418000	292000	2237000	2571000	2377000	1733000
Angle of inclination of transverse reinforcement to longitudinal axis	α	Deg	90	90	90	90	90	90
Area of shear reinforcement within a distance s	A_v	mm2	2513.6	2513.6	2513.6	2513.6	2513.6	2513.6
Component in the direction of the applied shear of the effective prestressing force ; positive if resisting the applied shear	V_p	N	1158000	0	0	0	209000	0

Formula : Nominal Shear Resistance

$V_n = V_c + V_s + V_p$

The upper limit of Nominal Shear Resistance

$V_n = 0.25 f'_c b_v d_v + V_p$

$V_c = 0.083 \beta f'^{1/2}_c b_v d_v$

$V_s = A_v f_y d_v (\cot\theta + \cot\alpha) \sin\alpha / s$

(2) Stress Check for Service Limit State

Unfactored stress (N/mm2)

Section	DC Upper fiber	DC Lower fiber	DW Upper fiber	DW Lower fiber	LL-MAX Upper fiber	LL-MAX Lower fiber	LL-MIN Upper fiber	LL-MIN Lower fiber	TU(+) Upper fiber	TU(+) Lower fiber	TU(-) Upper fiber	TU(-) Lower fiber	CR+SH Upper fiber	CR+SH Lower fiber	TG(+) Upper fiber	TG(+) Lower fiber	TG(-) Upper fiber	TG(-) Lower fiber	EQ(+) Upper fiber	EQ(+) Lower fiber	EQ(-) Upper fiber	EQ(-) Lower fiber
A	1.12	2.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	-0.06	0.00	0.14	-0.16	0.00	0.01	0.01	0.00	0.00
B	2.09	3.99	0.55	-0.72	2.76	-3.60	-1.50	1.95	0.04	0.06	-0.05	-0.06	0.31	-0.47	0.17	0.04	-0.03	-0.42	0.21	-0.15	-0.21	0.15
C	3.34	5.60	-1.01	1.01	0.56	-0.56	-1.73	1.73	0.06	0.04	-0.05	-0.05	0.07	-0.25	0.63	0.03	-0.03	-0.12	0.32	-0.09	-0.32	0.09
D	2.84	11.10	1.09	-1.39	3.52	-4.48	-1.52	1.94	0.06	0.07	-0.06	-0.09	1.32	-2.62	1.18	0.05	-0.04	-1.70	0.05	0.91	-0.05	-0.92
E	1.14	6.11	-1.14	1.14	0.53	-0.53	-1.75	1.75	0.09	0.07	-0.08	-0.09	0.16	-0.21	0.51	0.10	-0.05	-0.06	0.48	0.15	-0.47	-0.16
F	2.89	10.05	0.82	-1.04	3.73	-4.64	-1.89	2.31	0.05	0.38	-0.05	-0.36	1.27	-2.51	0.84	0.25	-0.03	-1.43	0.00	0.00	0.00	0.00

Factored stress (N/mm2)

	DC		DW		LL-MAX		LL-MIN		TU(+)		TU(-)		CR+SH		TG(+)		TG(-)		EQ(+)		EQ(-)		Combined Stress			
	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Upper fiber	Lower fiber	Maximum Upper	Maximum Lower	Maximum Upper	Maximum Lower
Section A																										
Service 1	1.12	2.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	-0.06	0.00	0.07	-0.08	0.00	0.00	0.00	0.00	0.00	1.15	2.97	1.07	2.90
Service 2	1.12	2.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	-0.06	0.00	0.07	-0.08	0.00	0.00	0.00	0.00	0.00	1.15	2.97	1.07	2.90
Service 3	1.12	2.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	-0.06	0.00	0.07	-0.08	0.00	0.00	0.00	0.00	0.00	1.15	2.97	1.07	2.90
Service 4	1.12	2.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	-0.06	0.00	0.14	-0.16	0.00	0.00	0.00	0.00	0.00	1.15	3.04	0.99	2.90
Section B																										
Service 1	2.09	3.99	0.55	-0.72	2.76	-3.60	-1.50	1.95	0.04	0.06	-0.05	-0.06	0.31	-0.47	0.09	0.02	-0.02	-0.21	0.00	0.00	0.00	0.00	5.84	-0.72	1.39	4.48
Service 2	2.09	3.99	0.55	-0.72	3.59	-4.68	-1.95	2.54	0.04	0.06	-0.05	-0.06	0.31	-0.47	0.09	0.02	-0.02	-0.21	0.00	0.00	0.00	0.00	6.67	-1.80	0.94	5.07
Service 3	2.09	3.99	0.55	-0.72	2.21	-2.88	-1.20	1.56	0.04	0.06	-0.05	-0.06	0.31	-0.47	0.09	0.02	-0.02	-0.21	0.00	0.00	0.00	0.00	5.29	0.00	1.69	4.09
Service 4	2.09	3.99	0.55	-0.72	0.00	0.00	0.00	0.00	0.04	0.06	-0.05	-0.06	0.31	-0.47	0.17	0.04	-0.03	-0.42	0.00	0.00	0.00	0.00	3.17	2.90	2.88	2.32
Section C																										
Service 1	3.34	5.60	-1.01	1.01	0.56	-0.56	-1.73	1.73	0.06	0.04	-0.05	-0.05	0.07	-0.25	0.32	0.01	-0.02	-0.06	0.00	0.00	0.00	0.00	3.34	5.86	0.61	7.99
Service 2	3.34	5.60	-1.01	1.01	0.73	-0.73	-2.25	2.25	0.06	0.04	-0.05	-0.05	0.07	-0.25	0.32	0.01	-0.02	-0.06	0.00	0.00	0.00	0.00	3.50	5.69	0.09	8.50
Service 3	3.34	5.60	-1.01	1.01	0.45	-0.45	-1.38	1.38	0.06	0.04	-0.05	-0.05	0.07	-0.25	0.32	0.01	-0.02	-0.06	0.00	0.00	0.00	0.00	3.22	5.97	0.96	7.64
Service 4	3.34	5.60	-1.01	1.01	0.00	0.00	0.00	0.00	0.06	0.04	-0.05	-0.05	0.07	-0.25	0.63	0.03	-0.03	-0.12	0.00	0.00	0.00	0.00	3.09	6.44	2.33	6.20
Section D																										
Service 1	2.84	11.10	1.09	-1.39	3.52	-4.48	-1.52	1.94	0.06	0.07	-0.06	-0.09	1.32	-2.62	0.59	0.02	-0.02	-0.85	0.00	0.00	0.00	0.00	9.42	2.71	3.65	8.09
Service 2	2.84	11.10	1.09	-1.39	4.58	-5.82	-1.98	2.52	0.06	0.07	-0.06	-0.09	1.32	-2.62	0.59	0.02	-0.02	-0.85	0.00	0.00	0.00	0.00	10.48	1.37	3.19	8.67
Service 3	2.84	11.10	1.09	-1.39	2.82	-3.58	-1.22	1.55	0.06	0.07	-0.06	-0.09	1.32	-2.62	0.59	0.02	-0.02	-0.85	0.00	0.00	0.00	0.00	8.72	3.61	3.95	7.70
Service 4	2.84	11.10	1.09	-1.39	0.00	0.00	0.00	0.00	0.06	0.07	-0.06	-0.09	1.32	-2.62	1.18	0.05	-0.04	-1.70	0.00	0.00	0.00	0.00	6.49	7.22	5.15	5.30
Section E																										
Service 1	1.14	6.11	-1.14	1.14	0.53	-0.53	-1.75	1.75	0.09	0.07	-0.08	-0.09	0.16	-0.21	0.26	0.05	-0.03	-0.03	0.00	0.00	0.00	0.00	1.04	6.64	-1.69	8.67
Service 2	1.14	6.11	-1.14	1.14	0.69	-0.69	-2.28	2.28	0.09	0.07	-0.08	-0.09	0.16	-0.21	0.26	0.05	-0.03	-0.03	0.00	0.00	0.00	0.00	1.19	6.48	-2.22	9.20
Service 3	1.14	6.11	-1.14	1.14	0.42	-0.42	-1.40	1.40	0.09	0.07	-0.08	-0.09	0.16	-0.21	0.26	0.05	-0.03	-0.03	0.00	0.00	0.00	0.00	0.93	6.74	-1.34	8.32
Service 4	1.14	6.11	-1.14	1.14	0.00	0.00	0.00	0.00	0.09	0.07	-0.08	-0.09	0.16	-0.21	0.51	0.10	-0.05	-0.06	0.00	0.00	0.00	0.00	0.76	7.22	0.04	6.89
Service F																										
Service 1	2.89	10.05	0.82	-1.04	3.73	-4.64	-1.89	2.31	0.05	0.38	-0.05	-0.36	1.27	-2.51	0.42	0.13	-0.02	-0.72	0.00	0.00	0.00	0.00	9.18	2.36	3.03	7.74
Service 2	2.89	10.05	0.82	-1.04	4.85	-6.03	-2.46	3.00	0.05	0.38	-0.05	-0.36	1.27	-2.51	0.42	0.13	-0.02	-0.72	0.00	0.00	0.00	0.00	10.29	0.97	2.46	8.43
Service 3	2.89	10.05	0.82	-1.04	2.98	-3.71	-1.51	1.85	0.05	0.38	-0.05	-0.36	1.27	-2.51	0.42	0.13	-0.02	-0.72	0.00	0.00	0.00	0.00	8.43	3.29	3.41	7.27
Service 4	2.89	10.05	0.82	-1.04	0.00	0.00	0.00	0.00	0.05	0.38	-0.05	-0.36	1.27	-2.51	0.84	0.25	-0.03	-1.43	0.00	0.00	0.00	0.00	5.87	7.13	4.91	4.71
Modification Factor																							Allowable Stress			
Service 1	1.00		1.00		1.00		1.00		1.00		1.00		1.00		0.50		0.50		0.00		0.00		Compressive			
Service 2	1.00		1.00		1.30		1.30		1.00		1.00		1.00		0.50		0.50		0.00		0.00			0.6f'c=	24.00 MPa	
Service 3	1.00		1.00		0.80		0.80		1.00		1.00		1.00		0.50		0.50		0.00		0.00		Tensile			
Service 4	1.00		1.00		0.00		0.00		1.00		1.00		1.00		1.00		1.00		0.00		0.00			0.5√f'c=	3.16 MPa	

5.3 Design of Substructure

5.3.1 Design Conditions

(1) Type of Substructure

	Type of Substructure	Type of Foundation	Bearing Support
P36	Wall Type Pier	9 Cast in situ Concrete Pile, dia. 1500mm	- Move
P37	Wall Type Pier	9 Cast in situ Concrete Pile, dia. 2000mm	- Move
P38	Wall Type Pier	15 Cast in situ Concrete Pile, dia. 2000mm	- Fix
P39	Wall Type Pier	15 Cast in situ Concrete Pile, dia. 2000mm	- Fix
P40	Wall Type Pier	9 Cast in situ Concrete Pile, dia. 2000mm	- Move
P41	Wall Type Pier	9 Cast in situ Concrete Pile, dia. 1500mm	- Move

- Bearing Support Condition:
  - Move: Free for the longitudinal direction movement
  - Fix: Fix for the longitudinal direction movement

(2) Materials

1) **Concrete**

Grade	fc'	Typical use
B	40 MPa	PC box girder, PC I-Girder
C	35 MPa	Hollow Slab
D	30 MPa	In situ concrete : Bored pile
E	24 MPa	In situ concrete : Pier, Abut, Pile cap
F	20 MPa	In situ concrete : Base concrete
G	15 MPa	In situ concrete : Lean Concrete, Plain Concrete

fc': Compressive strength of concrete at 28 days

Grade	fc'	Ec (MPa)	EXP
B	40MPa	33 990	10.8 x 1.0E-6 (/°C)
D	30MPa	29 440	
E	24MPa	26 330	

* Ec: Young's Modulus (AASHTO LRFD, 5.4.2.4), $Ec = 0.043\gamma_c^{1.5} \times \sqrt{fc'}$

γ_c: Density of concrete (kg/m^3)

EXP: Coefficient of thermal expansion and contraction

2) **Reinforcement Steel**

- Specified Yield Strength:
  Plain Round: 240Mpa   High Yield deformed: 390MPa
- Modulus of elasticity of reinforcement steel: Es = 200,000 Mpa

(3) Geological Conditions:

Layer Number & Type of Soil	Layer Notation	N-Value for Design	fsi (kN/m2)
(1) Lean Clay, soft	Rd	N= 0	-
(2) Clay, soft	C1	N= 2	19.6
(3) Lean Clay or Silty Sand	S/St	N= 10	98.1
(4) Lean Clay	C2	N= 20	98.1
(5) Lean Clay, stiff	St/C-1	N= 2	19.6
(6) Silty Sand, dense	S1	N= 10	98.1
(7) Lean Clay, hard	St/C-2	N= 20	98.1
(8) Silty Sand, dense	S3	N= 50	245.2

* fsi: unit friction force along pile shaft.

Geotechnical Feature for Main Bridge

Substructure		P36, P41	P37, P40	P38, P39
Existing Ground Level		-3.88 (1.56)	-4.74 (-3.21)	-7.84 (-8.88)
Level of the pile cap bottom		+0.50	0.50	0.50
Design Ground Level		-3.88	-4.74	-7.84
Layer Condition	No.	Approximated Height & Thickness (m)	Approximated Height & Thickness (m)	Approximated Height & Thickness (m)
	(1)	-3.88 ~ -14.76 (10.88m)	-4.74 ~ -14.76 (10.02m)	-7.84 ~ -14.76 (6.92m)
	(2)	-14.76 ~ -19.66 (4.9m)	-14.76 ~ -19.66 (4.9m)	-14.76 ~ -19.66 (4.9m)
	(3)	-19.66 ~ -25.26 (5.6m)	-19.66 ~ -25.26 (5.6m)	-19.66 ~ -25.26 (5.6m)
	(4)	-25.56 ~ -35.66 (10.4m)	-25.56 ~ -35.66 (10.4m)	-25.56 ~ -35.66 (10.4m)
	(5)	-35.66 ~ -49.76 (14.1m)	-35.66 ~ -49.76 (14.1m)	-35.66 ~ -49.76 (14.1m)
	(6)	-49.76 ~ -78.56 (28.8m)	-49.76 ~ -78.56 (28.8m)	-49.76 ~ -78.56 (28.8m)
	(7)	-78.56 ~ -93.46 (14.9m)	-78.56 ~ -93.46 (14.9m)	-78.56 ~ -93.46 (14.9m)
	(7)	-93.46 ~ -104.66 (11.2m)	-93.46 ~ -104.66 (11.2m)	-93.46 ~ -104.66 (11.2m)
	(8)	-104.66 ~	-104.66 ~	-104.66 ~

(4) Loading and Load Combination

1) Vessel Collision CV (AASHTO 3.14)

Design Velocity of Stream:

Items	*P38 (P39)*	*P37 (P40)*	*P36 (P41)*
Distance from pier to edge of channel (m)	130	90	10
Design Impact Velocity (m/s)	4.94	3.26	2.42

Tonnage of Design Vessel: 500MG

Application of Vessel Collision Force

- *Amplitude:* 100% of the design impact force in a direction parallel to the alignment of the centerline of the navigable channel, or 50% of the design impact force in a direction normal to the alignment of the centerline of the channel (applied separately).
- *Location:* The design impact force is applied as a concentrated force on the pier at the mean high water level of the waterway.

2) Water Loads (AASHTO 3.7)

a) Buoyancy: $P_B = 1000*g*V$ (N).

Where: V=Volume of substructure components under water surface (m^3).

g = gravity acceleration (~9.81 m/s^2).

b) Longitudinal Stream Pressure:

$p = 5.14 \times 10^{-4} C_D V^2$ (MPa)

Where: V = design velocity of water (m/s)

C_D= drag coefficient for piers

3) Load Combinations

(a) Combination of Loads (AASHTO LRFD, 3.4.1)

Load Combination Limit State	DC DD DW EH EV ES	LL IM CE BR PL LS EL	WA	WS	WL	FR	TU CR SH	TG	SE	Use one of these at a time EQ	IC	CT	CV
STRENGTH-I	γ_p	1.75	1.00			1.00	0.50	γ_{tg}	γ_{ce}	-	-	-	-
STRENGTH-II	γ_p	1.35	1.00			1.00	0.50	γ_{tg}	γ_{ce}	-	-	-	-
STRENGTH-III	γ_p	-	1.00	1.40		1.00	0.50	γ_{tg}	γ_{ce}	-	-	-	-
STRENGTH-IV:													
EH, EV, ES, DW	γ_p	-	1.00			1.00	0.50	-	-	-	-	-	-
DC ONLY	1.50												
STRENGTH-V	γ_p	1.35	1.00	0.40	1.00	1.00	0.50	γ_{tg}	γ_{ce}				
EXTREME EVENT-I	γ_p	γ_{eq}	1.00			1.00	-	-	-	1.00	-	-	-
EXTREME EVENT-II	γ_p	0.50	1.00			1.00	-	-	-	-	1.00	1.00	1.00
SERVICE-I	1.00	1.00	1.00	0.30	1.00	1.00	1.00	γ_{tg}	γ_{ce}	-	-	-	-
SERVICE-II	1.00	1.30	1.00			1.00	1.00	γ_{tg}	γ_{ce}	-	-	-	-
SERVICE-III	1.00	0.80	1.00			1.00	1.00	γ_{tg}	γ_{ce}	-	-	-	-
FATIGUE-LL,IM & CE ONLY	-	0.75	1.00			1.00	-	-	-	-	-	-	-

* Loading Denotations:

- Permanent Loads
  - DD = downdrag
  - DC = dead load of structural components and nonstructural attachments
  - DW = dead load of wearing surfaces and utilities
  - EH = horizontal earth pressure load
  - EL = accumulated locked-in effects resulting from the construction process
  - ES = earth surcharge load
  - EV = vertical pressure from dead load of earth fill
- Transient Loads
  - BR = vehicular braking force
  - CE = vehicular centrifugal force
  - CR = creep
  - CT = vehicular collision force
  - CV = vessel collision force
  - EQ = earthquake
  - FR = friction
  - IC = ice load
  - IM = vehicular dynamic load allowance
  - LL = vehicular live load
  - LS = live load surcharge
  - PL = pedestrian live load

SE = settlement
SH = shrinkage
TG = temperature gradient
TU = uniform temperature
WA = water load and stream pressure
WL = wind on live load
WS = wind load on structure

(b) Application of Load Combinations:

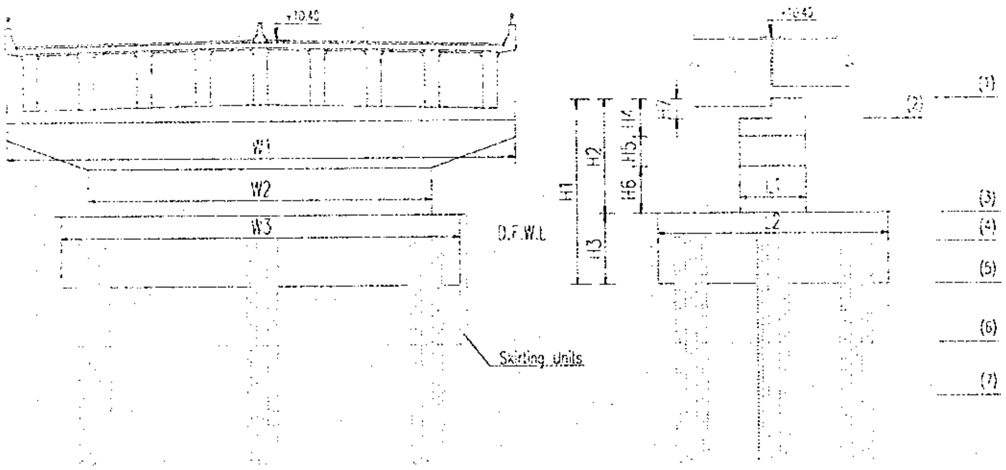
Load Items	Notation	Load Combinations										
		STRENGTH I-1	STRENGTH I-2	STRENGTH III	STRENGTH IV	STRENGTH V-1	STRENGTH V-2	EXTREME EVENT I-1	EXTREME EVENT I-2	EXTREME EVENT II	SERVICE I-1	SERVICE I-2
Deadload from superstructure	DC1	1.25	0.90	1.25	1.50	1.25	0.90	1.25	0.90	1.25	1.00	1.00
Deadload of pier	DC2	1.25	0.90	1.25	1.50	1.25	0.90	1.25	0.90	1.25	1.00	1.00
Superimposed Load of superstructure	DW	1.50	0.65	1.50	1.50	1.50	0.65	1.50	0.65	1.50	1.00	1.00
Live load max	LLmax	1.75				1.35		0.50		0.50	1.00	
Live load min	LLmin		1.75				1.35		0.50			1.00
Dynamic Allowance max	IMmax	1.75				1.35		0.50		0.50	1.00	
Dynamic Allowance min	IMmin		1.75				1.35		0.50			1.00
Braking max	BRmax	1.75				1.35		0.50		0.50	1.00	
Braking min	BRmin		1.75				1.35		0.50			1.00
Water pressure	WA	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wind pressure on vehicles	WL					1.00	1.00				1.00	1.00
Wind pressure on Superstructure	WS1			1.40		0.40	0.40				0.30	0.30
Wind pressure on Substructure	WS2			1.40		0.40	0.40				0.30	0.30
Friction load	FR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature uniform	TU	0.50	0.50	0.50	0.50	0.50	0.50				1.00	1.00
Temperature Gradient	TG										0.50	0.50
Creep	CR	0.50	0.50	0.50	0.50	0.50	0.50				1.00	1.00
Shrinkage	SH	0.50	0.50	0.50	0.50	0.50	0.50				1.00	1.00
Earthquake from Superstructure	EQ1							1.00	1.00			
Earthquake of Substructure	EQ2							1.00	1.00			
Vessel Collision	CV									1.00		

5.3.2 Design of P36(P41) pier

(1) Stability Calcalation

1) Dimension of Pier

Portion	Length	Portion	Length	Portion	Level	Portion	Level
(Figure)			(m)		(Level)		(m)
H1	7.32	H7	0.84	(1)	+7.82	(6)	-2.00
H2	4.32	W1	23.00	(2)	+6.98	(7)	-3.88
H3	3.00	W2	15.50	(3)	+3.50		
H4	1.59	L1	3.00	(4)	+1.78		
H5	1.25	W3	18.00	(5)	+0.50		
H6	1.48	L2	10.50				



2) Summray of Load Combination Force at the Botom of Pile Cap

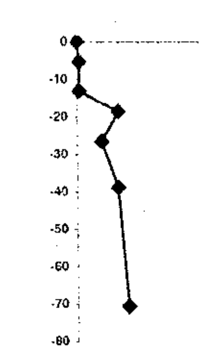
Load Combination		V (tf)	Longitudinal H (tf)	Longitudinal M (tf.m)	Transverse H (tf)	Transverse M (tf.m)
1	STRENGTH I-1	5779.4	59.7	437.2	28.9	112.9
2	STRENGTH I-2	3043.3	0.1	0.9	28.9	112.9
3	STRENGTH III	4737.3	30.2	132.3	52.4	264.4
4	STRENGTH IV	5590.9	0.1	0.9	17.7	-10.8
5	STRENGTH V-1	5541.2	54.7	375.0	38.6	194.2
6	STRENGTH V-2	3102.1	8.7	38.4	38.6	194.2
7	EXTREME EVENT I-1	5006.3	461.0	1997.0	465.1	2080.6
8	EXTREME EVENT I-2	3198.3	443.9	1872.3	465.1	2080.6
9	EXTREME EVENT II	4992.7	341.7	538.9	670.2	853.1
10	SERVICE I-1	4395.4	42.4	291.1	33.9	149.8
11	SERVICE I-2	3653.0	8.3	41.7	33.9	149.8

3) Pile Capacity

INPUT DATA

BoreHole			BRD17
Pile Diameter	D1	=	1700 mm
	D2	=	1500 mm
Factor of Safety	FS	=	3
Pile length	L	=	70.00 m
	L0	=	4.38 m
	L1	=	10.62 m
	L2	=	55.00 m
Pile Embedded Length	Le	=	65.62 m
Pile Cross-Section Circumference	P1	=	5.341 m
	P2	=	4.712 m
Pile Cross-Section Area	Ab1	=	2.270 m2
	Ab2	=	1.767 m2
Concrete Unit Weight	γc	=	2.5 t/m3
Ultmate Soil End Bearing Capacit	3qu	=	135 t/m2
Soil Type of Bearing Layer			2 (1/2 = Sand/Clay)

SKIN FRICTION CAPACITY Formula: Qs = Σ (fs * P * d) for N > 0



Layer Number	Thickness d (m)	Soil Type '1'=Sand; '2'=clay		γ'e (t/m3)	N	fs (t/m2)	Qs (t)
1-1	10.62	2	Clay	0.70	1.0	1.0	57
1-2	5.16	2	Clay	1.00	1.0	2.0	49
2	5.60	2	Clay	0.90	20.0	1.0	26
3	10.40	2	Clay	1.00	12.0	2.0	98
4	14.10	2	Clay	0.90	20.0	1.0	66
5	19.74	2	Clay	1.00	25.0	15.0	1395
Total L =	65.62	m				Total Qs =	1692

END BEARING CAPACITY Formula: Qt = qu* Ab

Type of Pile		Soil Type of B.P	End Bearing Capacity
Cast-in-situ	Friction & Bearing	Clay	239 tonne

Ultimate Bearibg Capacity (Qult)

* Qult = Qt + Qs 1930.1 tonne

Replaced Effective Weight of Soil (Ws)

113.2 tonne

Buoyant Weight of Pile (W)

206.8 tonne

Allowable Bearing Capacity for Service Load Combinations ($Qall_1$)

* $Qall_1$ = (Qult - Ws) / FS + Ws - W 512.0 tonne

Allowable Bearing Capacity for Earthquake & Strength Load Combinations($Qall_2$)

* $Qall_2$ = (Qult - Ws) / FS + Ws - W 814.8 tonne

FS= 2

Design Uplift Caacity for Service Load Combinations (Qup_1)

* Qup_1 = Qs / FS + W 488.7 tonne

FS = 6

Design Uplift Capacity fot Earthquake & Strength Load Combinations(Qup_2)

* Qup_2 = Qs / FS + W 770.6 tonne

FS= 3

4) Reaction of Pile

a) Displacement

Load Combination		Longitudinal			Transverse			δ xa(cm)	Remark
		δf x(cm)	δ y(cm)	α (rad)	δf x(cm)	δ y(cm)	α (rad)		
1	STRENGTH I-1	0.14	0.84	0.00011	0.05	0.84	0.00001	3.00	OK
2	STRENGTH I-2	0.00	0.44	0.00000	0.05	0.44	0.00001	3.00	OK
3	STRENGTH III	0.07	0.69	0.00004	0.10	0.69	0.00002	3.00	OK
4	STRENGTH IV	0.00	0.81	0.00000	0.03	0.81	0.00000	3.00	OK
5	STRENGTH V-1	0.12	0.81	0.00010	0.07	0.81	0.00002	3.00	OK
6	STRENGTH V-2	0.02	0.45	0.00001	0.07	0.45	0.00002	3.00	OK
7	EXTREME EVENT	1.00	0.73	0.00067	0.86	0.73	0.00019	2.00	OK
8	EXTREME EVENT	0.96	0.47	0.00064	0.86	0.47	0.00019	2.00	OK
9	EXTREME EVENT	0.70	0.73	0.00038	1.22	0.73	0.00020	3.00	OK
10	SERVICE I-1	0.15	0.64	0.00008	0.10	0.64	0.00002	1.50	OK
11	SERVICE I-2	0.03	0.53	0.00001	0.10	0.53	0.00002	1.50	OK

b) Bearing and Pullout forces of piles

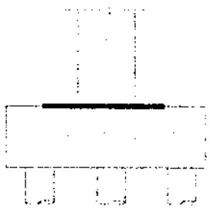
Load Combination		Longitudinal		Transverse		Allowable Capacitie		Checking	
		PNmax(tf)	PNmin(tf)	PNmax(tf)	PNmin(tf)	Bearing (tf)	Pull (tf)	Bearing	Pull
1	STRENGTH I-1	673.68	610.63	648.65	635.66	814.8	-770.6	OK	OK
2	STRENGTH I-2	338.20	338.09	344.64	331.65	814.8	-770.6	OK	OK
3	STRENGTH III	538.96	513.78	539.41	513.32	814.8	-770.6	OK	OK
4	STRENGTH IV	621.27	621.15	623.95	618.47	814.8	-770.6	OK	OK
5	STRENGTH V-1	643.61	587.77	625.29	606.09	814.8	-770.6	OK	OK
6	STRENGTH V-2	348.32	341.04	354.28	335.08	814.8	-770.6	OK	OK
7	EXTREME EVENT	747.66	364.85	666.40	446.11	814.8	-770.6	OK	OK
8	EXTREME EVENT	537.71	173.02	465.52	245.22	814.8	-770.6	OK	OK
9	EXTREME EVENT	662.71	446.78	667.81	441.68	814.8	-770.6	OK	OK
10	SERVICE I-1	512.04	464.71	497.12	479.64	512.1	-488.7	OK	OK
11	SERVICE I-2	409.93	401.84	414.63	397.15	512.1	-488.7	OK	OK

(2) Section Calculation of Pier Column

1) Sectional forces

Load Combination		V	Longitudinal		Transverse	
		(tf)	H (tf)	M (tf.m)	H (tf)	M (tf.m)
1	STRENGTH I-1	3229.5	59.7	258.0	11.2	90.0
2	STRENGTH I-2	1207.5	0.1	0.5	11.2	90.0
3	STRENGTH III	2187.4	21.5	49.1	29.5	175.7
4	STRENGTH IV	2531.1	0.1	0.5	0.0	0.0
5	STRENGTH V-1	2991.3	52.2	213.0	19.4	143.5
6	STRENGTH V-2	1266.2	6.2	14.4	19.4	143.5
7	EXTREME EVENT I-1	2456.5	461.0	1407.8	447.5	1542.7
8	EXTREME EVENT I-2	1362.4	443.9	1334.2	447.5	1542.7
9	SERVICE I-1	2355.5	40.5	165.6	15.1	112.9
10	SERVICE I-2	1613.1	6.4	18.4	15.1	112.9

2) Section Analysis



a) Section Dimensions & Material Properties

Item	Notation	Unit	Value	Remark
Section Dimension				
Width	W	mm	15500	oblong,
Height	H	mm	3000	rounded-end shape
Material Properties				
Concrete strength	fc	MPa	24	
Yield Strength of Rebars	fy	MPa	390	
Elastic modulus of Concrete	Ec	MPa	26332	
Elastic modulus of Steel	Es	MPa	200000	
Allowable Comp. Stress of Concrete	fca	MPa	10.8	
Allowable Stress of Steel	fsa	MPa	-234	

b) Envelope of Sectional Forces

Item	Notation	Unit	Value	Load Case
Maximum Flexural Moment				
for Calculating Main Reinforcement	Mu	kN.mm	13805669	EXTREME EVENT I-1
Corresponding Compressive force	Nu	kN	24090	
Maximum Shear Force				
Shear force	Vu	kN	4521	EXTREME EVENT I-1
Corresponding moment	$Mu_{corr.}$	kN.mm	13805669	

c) Bar Arrangement

Item	Notation	Unit	Value	Remark
Main Reinforcement				
Diameter	φbot.	mm	32	
Area of 1 bar	A1's	mm2	804.2	
Total numbers of Rebar	n's	nos	270	@125
Shear Reinforcement				
Diameter	φv.	mm	16	
Area of 1 bar	A1v	mm2	201.1	
Numbers of Rebar in section	nv	nos	26	
Spacing of Shear Reinf.	s	mm	500	
Total Area of Shear Reinf. within s	Av	mm2	5227.6	

d) Checking for Flexural - Axial Resistance (AASHTO 5.7.3.2)

Item	Notation	Unit	Value	Remark
Bending Moment	Mu	kN.mm	13805669	
Compressive force	Nu	kN	24090	
Depth of Compressive Area	c	mm	2342	
Flexural Resistance	Mr	kN.mm	317150720	
Compressive Resistance	Nr	kN	553402	
Checking Resistance			**OK**	
Checking Reinforcement Ratio				
Numbers of Tensile bar	n_{tens}	nos	121	
$\rho st = As_{tensile}/A_g$		%	**0.218**	
ρmin=0.03fc/fy		%	**0.185**	**OK**

Notes: Reinforcement selection is controlled by the Minimum Reinforcement Ratio Requirement.

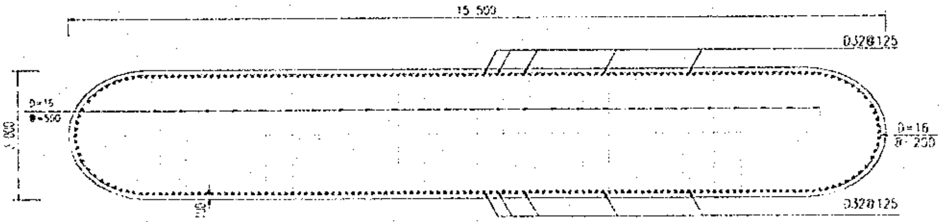
e) Checking for Shear Resistance (AASHTO 5.8.3.3)

Item	Notation	Unit	Value	Remark
Factored Shear	Vu	N	4520564.3	
Shear Resistance	Vr	N		
Effective shear Depth	d_v	mm	2160	
Effective web width	b_v	mm	14856	
Spacing of stirrups	s	mm	500	
Angle of inclination of transverse reinf.	α	degrees	90	
Factor indicating ability of diagonally cracked concrete to transmit tension	β		4.9	
Area of shear reinf. within a distance s	A_v	mm^2	5228	
Strain in the tensile reinforcement	ε_x		-0.000002	
Inclination angle of diagonal comp. stress	θ	degrees	27.00	
Shear stress on the concrete	v	MPa	0.157	
Area of Conc. on flexural tensile side	Act	mm^2	22284291.74	
Nominal Resistance of Concrete	V_c	N	63935361	
Nominal Resistance of Reinforcement	V_s	N	17285648	
Nominal Resistance	Vn	N	81,221,009	
Resistance factor for shear	φ		0.9	
Factored Resistance	Vr	N	73,098,908	
Checking			**OK**	

f) Checking for Flexural Stress

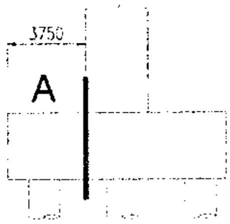
Item	Notation	Unit	Value	Remark
Factored Forces				
SERVICE I-1	Mu	kN.mm	1623662.0	
	Nu	kN	23099.3	
SERVICE I-2	Mu	kN.mm	180782.0	
	Nu	kN	15819.3	
Factored Comp. Stress of Concrete	σcu	MPa		
SERVICE I-1			0.5	
SERVICE I-2			0.34	
Checking Stress of Concrete			OK	
Factored Tensile Stress of Steel	σsu	MPa		
SERVICE I-1			-3.81	
SERVICE I-2			-2.61	
Checking Stress of Steel			OK	

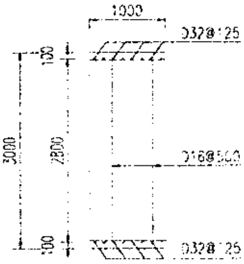
REINFORCEMENT OF COLUMN



(3) Section Calculation of Pile Cap

1) Section Analysis of "A"





Total width of section 18000 mm

Calculation width 1000 mm

a) Section Dimensions & Material Properties

Item	Notation	Unit	Value	Remark
Section Dimension				
Width	W	mm	1000	
Height	H	mm	3000	
Material Properties				
Concrete strength	fc	MPa	24	
Yield Strength of Rebars	fy	MPa	390	
Elastic modulus of Concrete	Ec	MPa	26332	
Elastic modulus of Steel	Es	MPa	200000	
Allowable Comp. Stress of Concrete	fca	MPa	10.8	
Allowable Stress of Steel	fsa	MPa	-234	

b) Envelope of Sectional Forces

Item	Notation	Unit	Value	Load Case
Maximum Flexural Moment				
for Calculating Top Reinforcement	Mu_{top}	kN.mm	-48768	EXTREME EVENT I-2
for Calculating Bottom Reinforcement	$Mu_{bot.}$	kN.mm	1883456	EXTREME EVENT I-1
Maximum Shear Force				
Shear force	Vu	kN	760	EXTREME EVENT I-1
Corresponding moment	$Mu_{corr.}$	kN.mm	1883456	

c) Bar Arrangement

Item	Notation	Unit	Value	Remark
Top Reinforcement				
Diameter	φtop	mm	32	
Area of 1 bar	A1s	mm2	804.2	
Numbers of Rebar	ns	nos	8	
Bottom Reinforcement				
Diameter	φbot.	mm	32	
Area of 1 bar	A1's	mm2	804.2	
Numbers of Rebar	n's	nos	8	
Shear Reinforcement				
Diameter	φv.	mm	16	
Area of 1 bar	A1v	mm2	201.1	
Numbers of Rebar in section	nv	nos	2	
Spacing of Shear Reinf.	s	mm	500	
Total Area of Shear Reinf. within s	Av	mm2	402.1	

d) Checking for Flexural Resistance (AASHTO 5.7.3.2)

Item	Notation	Unit	Value	Remark
Top Reinforcement				
Bending Moment	Mu_{top}	kN.mm	48768	
Depth of Compressive Area	c	mm	115.25	
Flexural Resistance	Mr_{top}	kN.mm	6415080	
Checking Resistance			OK	
Checking Reinforcement Ratio				
$\rho st = As_{tensile}/(H.W)$		%	0.214	
$\rho min=0.03fc/fy$		%	0.185	OK
Bottom Reinforcement				
Bending Moment	Mu_{bot}	kN.mm	1883456	
Depth of Compressive Area	c	mm	115.25	
Flexural Resistance	Mr_{bot}	kN.mm	6415080	
Checking Resistance			OK	
Checking Reinforcement Ratio				
$\rho st = As_{tensile}/(H.W)$		%	0.214	
$\rho min=0.03fc/fy$		%	0.185	OK

Notes: Reinforcement selection is controlled by the Minimum Reinforcement Ratio Requirement.

e) Checking for Shear Resistance (AASHTO 5.8.3.3)

Item	Notation	Unit	Value	Remark
Factored Shear	Vu	N	760109.6	
Shear Resistance	Vr	N		
Effective shear Depth	d_v	mm	2160	
Effective web width	b_v	mm	1000	
Spacing of stirrups	s	mm	500	
Angle of inclination of transverse reinf.	α	degrees	90	
Factor indicating ability of diagonally cracked concrete to transmit tension	β		2.3	
Area of shear reinf. within a distance s	A_v	mm^2	402	
Strain in the tensile reinforcement	ε_x		0.001080	
Inclination angle of diagonal comp. stress	θ	degrees	36.30	
Shear stress on the concrete	v	MPa	0.391	
Area of Conc. on flexural tensile side	Act	mm^2	1500000	
Nominal Resistance of Concrete	V_c	N	2020065	
Nominal Resistance of Reinforcement	V_s	N	922302	
Nominal Resistance	Vn	N	2,942,367	
Resistance factor for shear	φ		0.9	
Factored Resistance	Vr	N	2,648,130	
Checking			OK	

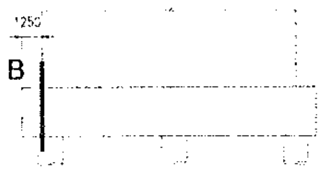
f) Checking for Flexural Stress

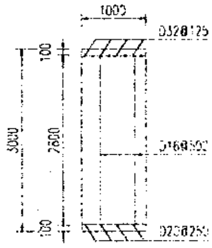
Item	Notation	Unit	Value	Remark
Factored Moments	Mu	kN.mm		
SERVICE I-1			1146255	Tensile at bottom
SERVICE I-2			770748	Tensile at bottom
Factored Comp. Stress of Concrete	σcu	MPa		
SERVICE I-1			0.7	
SERVICE I-2			0.47	
Checking Stress of Concrete			OK	
Factored Tensile Stress of Steel	σsu	MPa		
SERVICE I-1			-4.95	
SERVICE I-2			-3.3	
Checking Stress of Steel			OK	

g) Checking for Cracking $f_s=Z/(d_cA)^{(1/3)} <= fsa$

Item	Notation	Unit	Value	Remark
Nominal Concrete Cover	d_c	mm	50	
Bonding Area of Conc. around 1 b	A	mm2	12500	
Crack width parameter	Z	N/mm	17500	
Tensile Stress of Reinforcement	fs	MPa	204.7	
Checking			OK	

2) Section Analysis of "B"





Total width of section 10500 mm
Calculation width 1000 mm

a) Section Dimensions & Material Properties

Item	Notation	Unit	Value	Remark
Section Dimension				
Width	W	mm	1000	
Height	H	mm	3000	
Material Properties				
Concrete strength	fc	MPa	24	
Yield Strength of Rebars	fy	MPa	390	
Elastic modulus of Concrete	Ec	MPa	26332	
Elastic modulus of Steel	Es	MPa	200000	
Allowable Comp. Stress of Concrete	fca	MPa	10.8	
Allowable Stress of Steel	fsa	MPa	-234	

b) Envelope of Sectional Forces

Item	Notation	Unit	Value	Load Case
Maximum Flexural Moment				
for Calculating Top Reinforcemen	Mutop	kN.mm	-110592	STRENGTH IV
for Calculating Bottom Reinforcen	Mubot.	kN.mm	-76116	STRENGTH I-2
Maximum Shear Force				
Shear force	Vu	kN	177	STRENGTH IV
Corresponding moment	Mucorr.	kN.mm	110592	

c) Bar Arrangement

Item	Notation	Unit	Value	Remark
Top Reinforcement				
Diameter	ϕtop	mm	32	
Area of 1 bar	A1s	mm2	804.2	
Numbers of Rebar	ns	nos	8	
Bottom Reinforcement				
Diameter	ϕbot.	mm	20	Structural Reinf.
Area of 1 bar	A1's	mm2	314.2	
Numbers of Rebar	n's	nos	4	
Shear Reinforcement				
Diameter	ϕv.	mm	16	
Area of 1 bar	A1v	mm2	201.1	
Numbers of Rebar in section	nv	nos	2	
Spacing of Shear Reinf.	s	mm	500	
Total Area of Shear Reinf. within s	Av	mm2	402.1	

d) Checking for Flexural Resistance (AASHTO 5.7.3.2)

Item	Notation	Unit	Value	Remark
Top Reinforcement				
Bending Moment	Mu_{top}	kN.mm	110592	
Depth of Compressive Area	c	mm	133.74	
Flexural Resistance	Mr_{top}	kN.mm	6413400	
Checking Resistance			OK	
Checking Reinforcement Ratio				
$\rho st = As_{tensile}/(H.W)$		%	0.214	
$\rho min=0.03fc/fy$		%	0.185	OK
Bottom Reinforcement				
Bending Moment	Mu_{bot}	kN.mm	-76116.1	
Depth of Compressive Area	c	mm	133.74	
Flexural Resistance	Mr_{bot}	kN.mm	6413400	
Checking Resistance			OK	
Checking Reinforcement Ratio				
$\rho st = As_{tensile}/(H.W)$		%	0.042	
$\rho min=0.03fc/fy$		%	0.185	AILURE

Notes: Reinforcement selection is controlled by the Minimum Reinforcement Ratio Requirement.

e) Checking for Shear Resistance (AASHTO 5.8.3.3)

Item	Notation	Unit	Value	Remark
Factored Shear	Vu	N	176948	
Shear Resistance	Vr	N		
Effective shear Depth	d_v	mm	2160	
Effective web width	b_v	mm	1000	
Spacing of stirrups	s	mm	500	
Angle of inclination of transverse reinf.	α	degrees	90	
Factor indicating ability of diagonally cracked concrete to transmit tension	β		2.4	
Area of shear reinf. within a distance s	A_v	mm^2	402	
Strain in the tensile reinforcement	ε_x		0.000747	
Inclination angle of diagonal comp. stress	θ	degrees	32.95	
Shear stress on the concrete	v	MPa	0.091	
Area of Conc. on flexural tensile side	Act	mm^2	1500000	
Nominal Resistance of Concrete	V_c	N	2107894	
Nominal Resistance of Reinforcement	V_s	N	1045252	
Nominal Resistance	Vn	N	3,153,145	
Resistance factor for shear	φ		0.9	
Factored Resistance	Vr	N	2,837,831	
Checking			OK	

f) Checking for Flexural Stress

Item	Notation	Unit	Value	Remark
Factored Moments	Mu	kN.mm		
SERVICE I-1			-130979	Tensile at top
SERVICE I-2			-130979	Tensile at top
Factored Comp. Stress of Concrete	σcu	MPa		
SERVICE I-1			0.08	
SERVICE I-2			0.08	
Checking Stress of Concrete			OK	
Factored Tensile Stress of Steel	σsu	MPa		
SERVICE I-1			-0.58	
SERVICE I-2			-0.58	
Checking Stress of Steel			OK	

(4) Section Calculation of Pile

Dia : D1 =	1700 mm	L1 =	15.0 m
D2 =	1500 mm	L2 =	55.0 m
Length :	70.0 m		
Number :	9 nos.		

1) Sectional Forces (Extracted from the Results of Pile Group Analysis)

Load Case	Longitudinal			Transverse		
	Sectional Force		Depth	Sectional Force		Depth
	Mmax (tf.m)	Nmin (tf)	Z(m)	Mmax (tf.m)	Nmin (tf)	Z(m)
STRENGTH I-1	30.24	610.63	0.00	19.93	635.66	0.00
STRENGTH I-2	0.05	338.09	0.00	19.93	331.65	0.00
STRENGTH III	16.78	513.78	0.00	35.86	513.32	0.00
STRENGTH IV	0.05	621.15	0.00	12.48	618.47	0.00
STRENGTH V-1	28.14	587.77	0.00	26.42	606.09	0.00
STRENGTH V-2	4.83	341.04	0.00	26.42	335.08	0.00
EXTREME EVENT I-1	256.61	364.85	0.00	319.57	446.11	0.00
EXTREME EVENT I-2	247.82	173.02	0.00	319.57	245.22	0.00
EXTREME EVENT II	205.04	446.78	0.00	470.55	441.68	0.00
SERVICE I-1	26.82	464.71	0.00	27.07	479.64	0.00
SERVICE I-2	5.48	401.84	0.00	27.07	397.15	0.00

2) General Conditions

Item	Notation	Unit	Value	Remark
Diameter of pile	D	mm	1700	
Steel Casing			Yes	
Number of Reinf. layers	n_{layer}	nos	1	
Concrete cover	cv	m	250	
Diameter of Rebars	d	mm	28	
Number of Rebars	n_{st}	nos	15	
Total Area of Reinforcement	A_{st}	mm2	9236	

3) Section Calculation

a) Distribution of Axial Force and Bending Moment in Composite Section

Diameter of Pile		1.70 m
Thickness of Casing		0.014 m
Es=	20000000	
Ec=	2500000	
n=Es/Ec=	8.00	
As0=	0.074770 m2	
Ac=	2.269801 m2	
Atrans=	2.867960 m2	
Is0=	0.027685 m4	
Ic0=	0.409983 m4	
Itrans=	0.631465 m4	
* Casing:	- Axial	20.86%
	- Bending	35.07%
* RC:	- Axial	79.14%
	- Bending	64.93%

b) Checking Resistance (AASHTO 5.7.2)

i) In longitudinal Direction

Load Case	Forces	Total	RC	Allowable	Casing	Allowable	Remark
STRENGTH I-1	PN (tf)	610.63	483.27	4703.73	127.36	1460.1	OK
	M (tf.m)	30.24	19.63	191.12	10.61	121.60	OK
STRENGTH I-2	PN (tf)	338.09	267.58	5278.73	70.51	1714.6	OK
	M (tf.m)	0.05	0.03	0.81	0.02	0.43	OK
STRENGTH III	PN (tf)	513.78	406.62	4893.27	107.16	1538.1	OK
	M (tf.m)	16.78	10.89	131.27	5.89	84.48	OK
STRENGTH IV	PN (tf)	621.15	491.60	4976.32	129.55	1715.0	OK
	M (tf.m)	0.05	0.03	0.23	0.02	0.23	OK
STRENGTH V-1	PN (tf)	587.77	465.18	4735.49	122.59	1467.4	OK
	M (tf.m)	28.14	18.27	186.19	9.87	118.14	OK
STRENGTH V-2	PN (tf)	341.04	269.91	5172.47	71.13	1633.8	OK
	M (tf.m)	4.83	3.14	60.31	1.69	38.91	OK
EXTREME EVENT I-1	PN (tf)	364.85	288.75	1441.86	76.10	492.4	OK
	M (tf.m)	256.61	166.61	832.01	90.00	582.40	OK
EXTREME EVENT I-2	PN (tf)	173.02	136.93	352.49	36.09	283.2	OK
	M (tf.m)	247.82	160.90	414.21	86.92	682.04	OK
EXTREME EVENT II	PN (tf)	446.78	353.60	2482.97	93.18	654.6	OK
	M (tf.m)	205.04	133.12	934.84	71.92	505.2	OK

ii) In Transverse Direction

Load Case	Forces	Total	RC	Allowable	Casing	Allowable	Remark
STRENGTH I-1	PN (tf)	635.66	503.08	4774.51	132.58	1544.5	OK
	M (tf.m)	19.93	12.94	122.98	6.99	81.43	OK
STRENGTH I-2	PN (tf)	331.65	262.48	4924.84	69.17	1415.2	OK
	M (tf.m)	19.93	12.94	242.99	6.99	143.01	OK
STRENGTH III	PN (tf)	513.32	406.26	4689.70	107.06	1376.0	OK
	M (tf.m)	35.86	23.28	268.51	12.58	161.65	OK
STRENGTH IV	PN (tf)	618.47	489.48	4850.74	128.99	1601.4	OK
	M (tf.m)	12.48	8.10	80.06	4.38	54.34	OK
STRENGTH V-1	PN (tf)	606.09	479.68	4740.53	126.41	1486.6	OK
	M (tf.m)	26.42	17.15	169.30	9.27	108.98	OK
STRENGTH V-2	PN (tf)	335.08	265.19	4812.94	69.89	1341.8	OK
	M (tf.m)	26.42	17.15	311.35	9.27	177.92	OK
EXTREME EVENT I-1	PN (tf)	446.11	353.07	1375.13	93.04	486.0	OK
	M (tf.m)	319.57	207.48	808.04	112.09	585.46	OK
EXTREME EVENT I-2	PN (tf)	245.22	194.08	416.94	51.14	306.2	OK
	M (tf.m)	319.57	207.48	445.74	112.09	671.07	OK
EXTREME EVENT II	PN (tf)	441.68	349.56	611.87	92.12	360.2	OK
	M (tf.m)	470.55	305.51	534.79	165.04	645.4	OK

c) Checking Stress in RC portion

Load Case		Force		Tensile Steel (tf/m2)		Comp. Concrete (tf/m2)		Remark
		PN (tf)	M(tf.m)	Actual	Allowable	Actual	Allowable	
SERVICE I-1	Horizontal	367.79	17.41	910.13	-23861	193.60	1377	OK
	Transverse	379.60	17.58	943.05	-23861	199.03	1377	
SERVICE I-2	Horizontal	318.03	3.56	896.25	-23861	144.12	1377	OK
	Transverse	314.32	17.58	752.14	-23861	170.93	1377	

d) Checking Minimum Steel Ratio

Item	Notation	Unit	Value	Remark
Total Area of Reinforcement	A_{st}	mm2	9236	
Gross Area of Section	Ag	mm2	2269801	
Reinforcement Ratio	ρst	%	0.41	
Minimum Reinforcement ratio	ρmin	%	0.40	OK