Table 7 - 1 GIRDER STRESS AND DEFLECTION

BRIDGE	M (kN-m)		SECTION (GRADE 350)	MAX STRESS (MPa)	DEFL (LL + I) (mm)
	NON COMP	COMP			
TAIENA	574	1163	910 x 304 x 224 kg UB	182	16
AGOBINO	805	1436	927 x 308 x 289 kg UB	201	26
UNGONGO	805	1436	"	201	26
MIARU	1518	1400	350 x 16 1100 x 12 350 x 40	193	34
KAPURI	756	926	927 x 308 x 289 kg UB	164	19
LAKEKAMU	-3839 2078	-3473 2730	500 x 28/14 1800 x 14 600 x 36/16	182 166	53
TAURI	3839 2078	-3473 2730	"	182 166	53
MAKARA	756	926	927 x 308 x 289 kg UB	164	16
SAPPAHARO	756	926	"	164	16

Table 7 - 2 PRINCIPAL FEATURES OF SUBSTRUCTURE

	SUPERSTRUCTURE		PILE DETAILS				HEADSTOCK (m)		
	SPAN (m)	WIDTH (m)	N x D x T	L (m)	b (m)	l(m)	L	B	H
Taiena	17.0	9.2	6/500 x 14	26.3	1.2	2 @ 3.270	9.2	2.5	1.925 1.825
Agobino	20.0	9.2	6/500 x 14	19.2	1.2	2 @ 3.270	9.2	2.5	1.925
Ungongo	20.0	9.2	6/500 x 14	28.5	1.2	2 @ 3.270	9.79	2.5	2.125 2.025
Miaru	3 x 30	5.3	6/600 x 14 4/800 x 12	26.0 38.8	1.5 2.0	2 @ 1.650 3.3	5.3 5.3	3.0 3.5	2.975 1.4
Kapuri	3 x 21.5	5.0	6/500 x 14 4/800 x 12	22.3 36.1	1.5 2.0	2 @ 1.650 3.3	5.3 5.3	3.0 3.5	2.125 1.4
Lakekamu	37 + 46 + 37	5.3	6/800 x 12 4/1000 x 12	6 x 9.3 6 x 5.3 13.5	1.6 2.0	2 @ 1.65 2.7	5.3 5.3	3.5 4.0	4.035 1.4
Tauri	37 + 46 + 37	5.3	6/800 x 12 4/1000 x 12	6 x 5.4 6 x 6.9 13.5	1.6 2.0	2 @ 1.65 2.7	5.3 5.3	3.5 4.0	4.035 1.4
Makara	2 x 20	5.3	6/500 x 14 4/800 x 12	29.4 34.6	1.5 2.0	2 @ 1.65 3.3	5.3 5.3	3.0 3.5	2.125 1.4
Sappaharo	2 x 20	5.3	6/500 x 14 4/800 x 12	6 x 32.1 6 x 27.9 41.7	1.5 2.0	2 @ 1.650 3.3	5.3 5.3	3.0 3.5	2.53 3.76 1.4

Table 7 -3 PILE LOADS AND STRESSES

	PILE SECTION				TOTAL LOAD ON PILE GROUP (kN)			PILE LOADS (kn. m)				PILE ULT CAPACITY	MAX PILE STRESS	PILE LAT DEFL
								DEAD + T44(V)	DEAD + EQ					
	No.	Dia (mm)	T (mm)	L (m)	DEAD	DEAD+T44	EQ		V (COMP)	V (TENS)	M	(MPa)	(MPa)	(mm)
TAIENA	6	500	14	26.3	566	1008	1087	170	920	390	155	2,300	104	51
AGOBINO	6	500	14	19.2	666	1121	1188	190	1140	570	168	2,850	122	65
UNGONGO	6	500	14	29.5	666	1121	1188	190	1140	570	168	2,850	122	65
MIARU	6	600	14	26.0	546	1017	1050	170	900	350	304	2,250	117	70
	4	800	12	38.8	1742	2389	800	600	1900	1020	1354	4,750	R.C	121
KAPURI	6	500	14	22.3	378	836	900	140	700	275	193	1,750	109	90
	4	800	12	36.1	1406	2113	710	530	1400	700	1004	3,500	R.C.	79
LAKEKAMU	6	800	12	9.3 5.3	2070	2540	1044	425	1500	710	154	3,750	R.C.	26
	4	1000	12	13.5	2850	3770	1760	950	4500	3000	3875	11,250	R.C.	145
TAURI	6	800	12	5.4 6.9	2070	2540	1044	425	1500	710	154	3,750	R.C.	26
	4	1000	12	13.5	2850	3770	1760	950	4500	3000	3875	11,250	R.C.	145
MAKARA	6	500	14	29.4	378	836	900	140	700	275	193	1,750	109	90
	4	800	12	34.6	1406	2113	710	530	1400	700	1004	3,500	R.C.	79
SAPPAHARO	6	500	14	32.1 27.9	378	836	900	140	700	275	193	1,750	109	90
	4	800	12	41.7	1406	2113	710	530	1400	700	1004	3,500	R.C.	79

Table 7 -4 REACTION AND BEARING TYPE

		Reaction (kN)			Bearing Type (kN)	Remarks
		Dead Load	Live Load	Total		
Taiena Creek	External Internal	121 132	381 357	502 489	BP-B103 (Fix) BP-B104 (Mov)	
Agobino Creek	External Internal	147 164	393 369	540 533	" "	
Ungongo Creek	External Internal	147 164	393 369	540 533	" "	
Miaru River	External Internal	182 182	246 223	428 405	BP-B101 (Fix) BP-B102 (Mov)	
Kapuri River	External Internal	126 126	234 212	360 338	" "	
Lakekamu River	Abutment Pier	347 1165	365 737	712 1902	BP-B104 (Mov) BP-B117 (Fix)	Mov on abutment Fix on pier
Tauri River	Abutment Pier	347 1165	365 737	712 1902	" "	" "
Makara River	External Internal	126 126	234 212	360 338	BP-B101 (Fix) BP-B101 (Mov)	
Sappaharo River	External Internal	126 126	234 212	360 338	" "	

DRILLING LOG

LOCATION: MIARU RIVER — HOLE NO.B 6
GROUND ELEVATION 4.30 m — DEPTH : 20.00 m

GWL: 1.40 m

DEPTH m	ELEVATION m	THICKNESS m	CLASSIFICATION
1.0	3.3	1.0	Top soil
4.0	0.3	3.0	Sandy silt
4.5		0.5	Sand
7.0	-2.7	2.5	Sand
7.5	-3.2	0.5	Sand & gravel
8.0		0.5	Sand
9.0		1.0	Sand
9.5		0.5	Sand
12.0	-7.7	2.5	Sand
14.0	-9.7	2.0	Sand
14.5		0.5	Sand
20.0	-15.7	5.5	Sand

Depth (m)	N-VALUE	SAMPLING	D50 TEST DATA	D50 DESIGN VALUE	F_L	D_R
1	3/30	1.0			2.48	1.00
2	4/30	2.0	0.032		1.87	"
3	5/30	3.0	0.053		1.70	"
4		4.0	0.06			
5	8/30				1.68	"
6	9/30				1.69	"
7	13/30				1.82	"
8	14/30				1.86	"
9	11/30			0.10	1.67	"
10	12/30				1.71	"
11	20/30				2.00	"
12	6/30				1.37	"
13	17/30				1.87	"
14	19/30				1.94	"
15	26/30				2.17	"
16	22/30				2.05	"
17	20/30				1.95	"
18	17/30				1.85	"
19	20/30				1.99	"
20	20/30				2.00	"

DRILLING LOG

LOCATION: MIARU RIVER — HOLE NO.B 7
GROUND ELEVATION : 4.30 m — DEPTH : 40.00 m

GWL: 0.2 m, 0.7 m

DEPTH m	ELEVATION m	THICKNESS m	CLASSIFICATION
			Top soil
3.4	0.9	3.4	Silty sand
4.5	-0.2	1.1	Silty clay
30.0	-25.7		Silty sand

Depth (m)	N-VALUE	SAMPLING	D50 TEST DATA	D50 DESIGN VALUE	F_L	D_R
1	3/30	1.0			1.19	1.0
2	3/30	2.0	0.120		1.08	"
3	4/30	3.0	0.130 0.065		1.13	"
4		4.0	0.009			
5	6/30				1.22	"
6	7/30			0.12	1.28	"
7	6/30				1.20	"
8	8/30				1.31	"
9	10/30				1.41	"
10	11/30				1.44	"
11	7/30				1.24	"
12	3/30				0.99	"
13	13/30				1.51	"
14	14/30				1.56	"
15	9/30				1.36	"
16	9/30				1.36	"
17	10/30				1.42	"
18	17/30				1.70	"
19	9/30				1.39	"
20	7/30				1.32	"
21	6/30					
22	18/30					
23	10/30					
24	7/30					
25	4/30					
26	5/30					
27	17/30					
28	10/30					
29	10/30					
30	8/30					

Fig 7-4 LIQUEFACTION ANALYSIS ON MIARU BRIDGE

DRILLING LOG

LOCATION: KAPURI RIVER — HOLE NO.B 9
GROUND ELEVATION : 0.20 m — DEPTH : 20.00 m

DEPTH m	ELEVATION m	THICKNESS m	CLASSIFICATION	GWL m
1.2	-1.0	1.2	Silty clay	0.36 to 0.70
2.6	-2.4	1.4	Silty clay	
10.2	-10.0	7.6	Clayey sand	
20.0	-19.8	9.8	Silty sand	

N-VALUE	SAMPLING	D50 TEST DATA	D50 DESIGN VALUE	F_L	D_E
3/30	1.0	0.065		1.37	1.0
3/30	2.0	0.015		1.16	〃
8/30	3.0	0.057		1.49	〃
3/30				1.06	〃
7/30			0.10	1.34	〃
13/30				1.59	〃
〃					
13/30				1.57	〃
12/30				1.51	〃
18/30				1.75	〃
30/30				2.10	〃
34/30				2.?9	〃
41/30					
34/30					
39/30					
35/30					

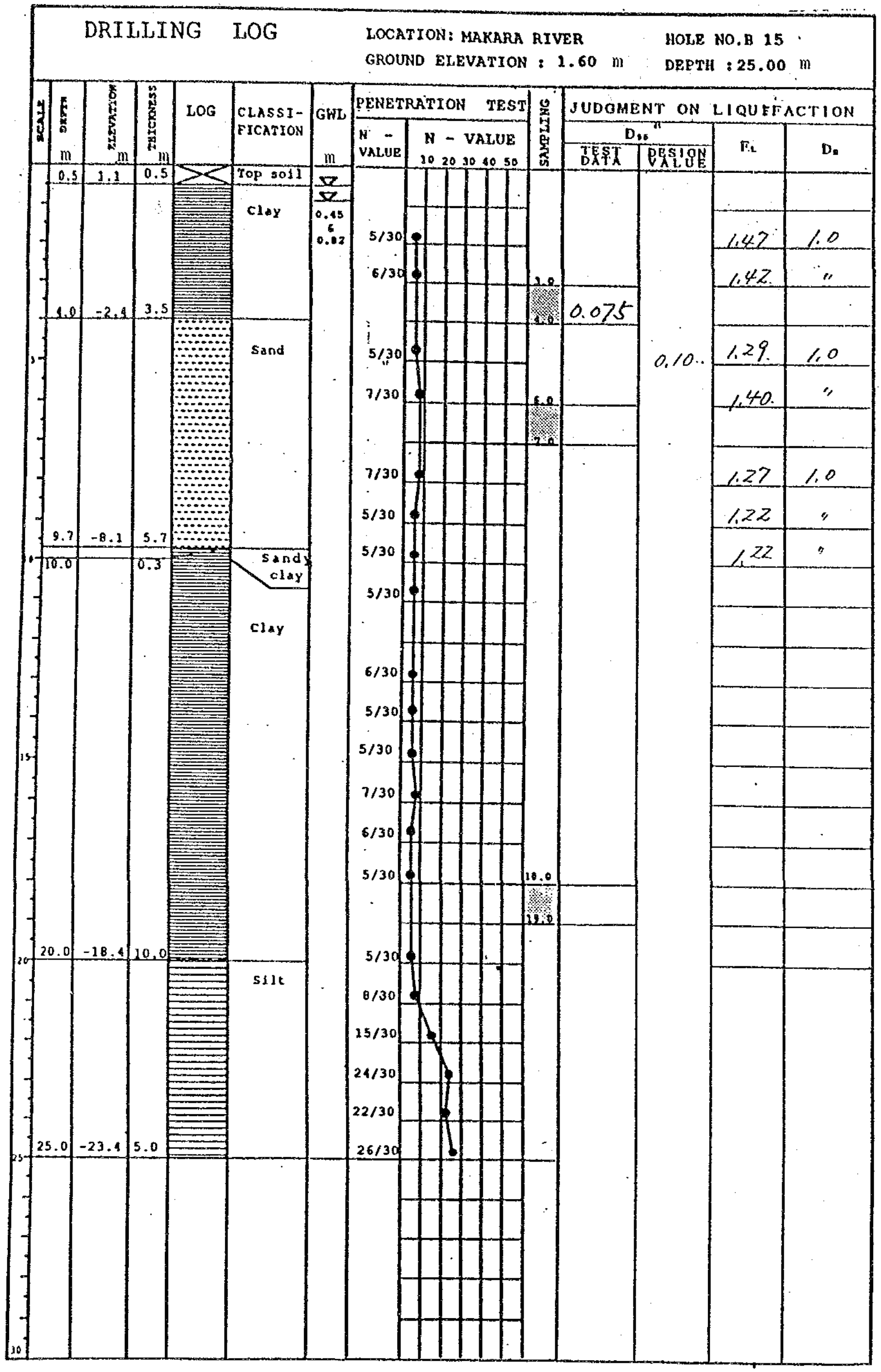
DRILLING LOG

LOCATION: KAPURI RIVER — HOLE NO.B 10
GROUND ELEVATION : 0.20 m — DEPTH : 50.00 m

DEPTH m	ELEVATION m	THICKNESS m	CLASSIFICATION	GWL m
0.5	-0.3	0.5	Top soil	
1.5	-1.3	1.0	Clay	
3.5	-3.3	2.0	Peat	2.1, 3.1
18.0	-17.8	14.5	Silty sand	
30.0	-29.8		Silty clay	

N-VALUE	SAMPLING	D50 TEST DATA	D50 DESIGN VALUE	F_L	D_E
3/30				3.05	1.0
3/30				1.93	〃
0/30				0.99	2/3
7/30	4.0–5.0			1.96	1.0
20/30	6.0–7.0	0.120	0.12	2.35	1.0
13/30	8.0–9.0	0.031		1.86	1.0
12/30				1.73	1.0
17/30					
15/30					
19/30					
22/30					
26/30					
27/30					
23/30					
13/30					
6/30					
8/30					
7/30					
8/30					
10/30					
9/30					
14/30					
16/30					
17/30					
19/30					
20/30					

Fig 7-5 LIQUEFACTION ANALYSIS ON KAPURI BRIDGE



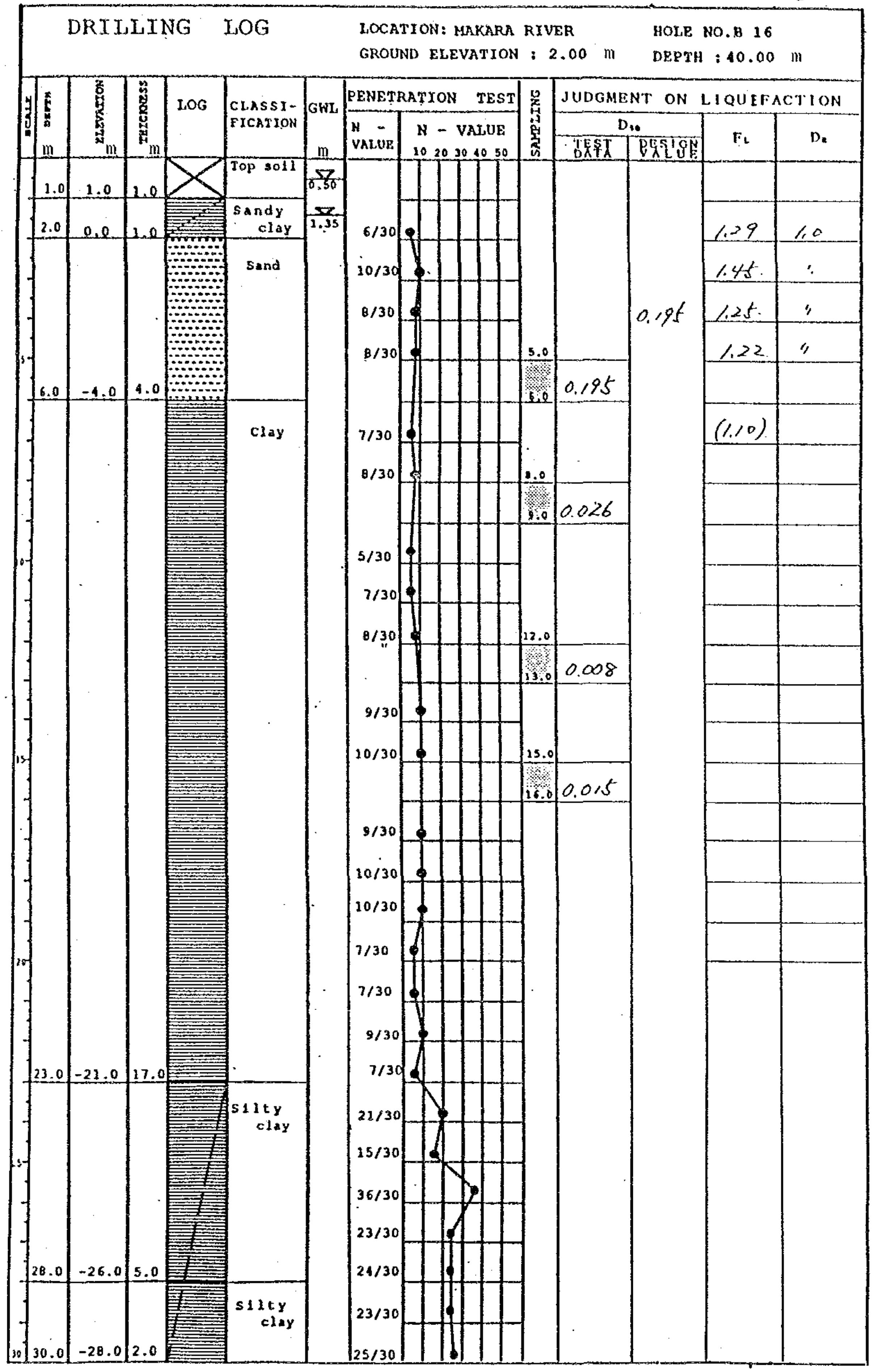


Fig 7-6 LIQUEFACTION ANALYSIS ON MAKARA BRIDGE

DRILLING LOG

LOCATION: SAPPAHARO CREEK HOLE NO.B 18
GROUND ELEVATION : 3.20 m DEPTH : 23.00 m

DEPTH m	ELEVATION m	THICKNESS m	CLASSIFICATION	GWL m
1.0	2.2	1.0	Top soil	0.59
6.0	-2.8	5.0	Clayey sand	1.47
20.0	-16.8	14.0	Clay	
20.5		0.5	Clayey sand	
22.0	-18.8	1.5	Sand	
23.0	-19.8	1.0	Silt	

Depth (m)	PENETRATION TEST N-VALUE	SAMPLING	JUDGMENT ON LIQUEFACTION D50 TEST DATA	D50 DESIGN VALUE	FL	Dz
1	3/30				1.57	1.0
2	9/30				1.80	〃
3	11/30				1.76	〃
4	7/30			0.12	1.41	〃
5	4/30			(B19)	1.14	〃
6	3/30				1.04	〃
7	3/30				(1.01)	
7.0–8.0		7.0–8.0	0.0069			
9	3/30	9.0–10.0	0.020			
11	3/30					
12	3/30					
13	3/30					
14	6/30	14.0–15.0	0.0035			
16	4/30					
17	5/30					
18	6/30					
19	7/30	19.0–20.0	0.01			
21	9/30					
22	11/30					
23	11/30					

DRILLING LOG

LOCATION: SAPPAHARO CREEK HOLE NO.B 19
GROUND ELEVATION : 3.00 m DEPTH : 23.00 m

DEPTH m	ELEVATION m	THICKNESS m	CLASSIFICATION	GWL m
1.8	1.2	1.8	Embankment	
3.0	0.0	1.2	Sandy clay	2.50
5.0	-2.0	2.0	Clayey sand	
8.0	-5.0	3.0	Clayey sand	
10.0	-8.0	2.0	Sandy clay	
21.5	-18.5	11.5	Clay	
23.0	-20.0	1.5	Silty sand	

Depth (m)	PENETRATION TEST N-VALUE	SAMPLING	JUDGMENT ON LIQUEFACTION D50 TEST DATA	D50 DESIGN VALUE	FL	Dz
1	7/30				4.49	1.0
2	4/30	2.0–3.0	0.070 / 0.004		2.29	〃
4	11/30	4.0–5.0	0.120	0.12	2.24	1.0
6	7/30				1.66	1.0
7	5/30				1.40	〃
8	4/30				1.27	〃
9	7/30				(1.48)	
10	5/30					
11	3/30					
12	5/30					
13	3/30					
14	3/30					
15	4/30					
16	3/30					
17	5/30	17.0–18.0	0.0023			
18.0–19.0		18.0–19.0	—			
20	5/30					
21	6/30					
22	24/30					
23	58/30					

Fig 7-7 LIQUEFACTION ANALYSIS ON SAPPAHARO BRIDGE

Table 7-6 LIQUEFACTION CALCULATION PAPER (1)

MIARU RIVER No. B6

(ks = 0.14
hw = 1.4 m

x (m)	N 値	D50	γt1	γt2	γt'	rd	σv	σv'	L	R1	R2	R	FL	
1.0	3		1.7	1.8	0.9	0.985	0.166	0.202	0.113	0.158	0.123	0.281	2.48	
2.0	4	0.035 }				0.970	0.346	0.292	0.161	0.178	0.123	0.301	1.87	
3.0	5	0.055 } 0.10				0.955	0.521	0.382	0.184	0.19	0.123	0.313	1.70	35/360
5.0	8	0.06 }				0.925	0.886	0.562	0.204	0.22	〃	0.343	1.68	
6.0	9					0.910	1.066	0.652	0.208	0.23	〃	0.353	1.69	
7.0	13					0.895	1.246	0.742	0.210	0.26	〃	0.383	1.82	
8.0	14					0.88	1.426	0.832	0.211	0.27	〃	0.393	1.86	
9.0	11					0.865	1.606	0.922	0.211	0.23	〃	0.353	1.67	
10.0	12					0.85	1.786	1.012	0.210	0.235	〃	0.358	1.71	
11.0	20					0.835	1.966	1.102	0.208	0.295	〃	0.418	2.00	
12.0	6					0.82	2.146	1.192	0.207	0.16	〃	0.283	1.37	
13.0	17					0.805	2.326	1.282	0.204	0.26	〃	0.383	1.87	
14.0	19					0.790	2.506	1.372	0.202	0.268	〃	0.391	1.94	
15.0	26					0.775	2.686	1.462	0.199	0.31	〃	0.433	2.17	
16.0	22					1.76	2.866	1.552	0.196	0.28	〃	0.403	2.05	
17.0	20					0.745	3.046	1.642	0.193	0.255	〃	0.378	1.95	
18.0	17					0.73	3.226	1.732	0.190	0.23	〃	0.353	1.85	
19.0	20					0.715	3.406	1.822	0.187	0.25	〃	0.373	1.99	
20.0	20					0.70	3.586	1.912	0.184	0.245	〃	0.368	2.00	

Table 7-6 LIQUEFACTION CALCULATION PAPER (2)

MIARU RIVER No. B7

(ks = 0.14
hw = 0.2 m

x (m)	N 値	D50	γt1	γt2	γt'	rd	σv	σv'	L	R1	R2	R	FL	
1.0	3		1.7	1.8	0.9	0.985	0.178	0.106	0.232	0.17	0.105	0.275	1.19	[illegible]
2.0	3	0.15				0.970	0.358	0.196	0.248	0.162	〃	0.267	1.08	[illegible]
3.0	4	0.12 0.07	0.12			0.955	0.538	0.286	0.252	0.18	〃	0.285	1.13	[illegible]
5.0	5	0.09				0.925	0.898	0.466	0.250	0.20	〃	0.305	1.22	
6.0	7					0.91	1.078	0.556	0.247	0.21	〃	0.315	1.28	
7.0	6					0.895	1.258	0.646	0.244	0.188	〃	0.293	1.20	
8.0	8					0.88	1.438	0.736	0.241	0.21	〃	0.315	1.31	
9.0	10					0.865	1.618	0.826	0.237	0.228	〃	0.333	1.41	
10.0	11					0.85	1.798	0.916	0.234	0.23	〃	0.335	1.44	
11.0	7					0.835	1.978	1.006	0.230	0.18	〃	0.285	1.24	
12.0	3					0.82	2.158	1.096	0.226	0.118	〃	0.223	0.99	DE=1.0
13.0	13					0.805	2.338	1.186	0.222	0.23	〃	0.335	1.51	
14.0	14					0.790	2.518	1.276	0.218	0.235	〃	0.340	1.56	
15.0	9					0.775	2.698	1.366	0.214	0.186	〃	0.291	1.36	
16.0	9					0.76	2.878	1.456	0.210	0.18	〃	0.285	1.36	
17.0	10					0.745	3.058	1.546	0.206	0.188	〃	0.293	1.42	
18.0	17					0.73	3.238	1.636	0.202	0.238	〃	0.343	1.70	
19.0	9					0.715	3.418	1.726	0.198	0.17	〃	0.275	1.39	
20.0	7					0.70	3.598	1.816	0.194	0.15	〃	0.255	1.22	

Table 7-6 LIQUEFACTION CALCULATION PAPER (3)

KAPURI RIVER No. B9

ks = 0.14
hw = 0.36 m

x (m)	N 値	D_{50}	γ_{t1}	γ_{t2}	γ_t'	r_d	σ_v	σ_v'	L	R_1	R_2	R	F_L	
1.0	3	0.065	1.5	1.7	0.8	0.985	0.163	0.105	0.213	0.17	0.123 ~~0.084~~	0.293 ~~0.244~~	1.37 ~~1.19~~	
2.0	3	0.015	(0.15)			0.97	0.333	0.185	0.244	0.161	〃	0.284 ~~0.246~~	1.16 ~~1.09~~	
3.0	8	0.059	0.10			0.955	0.503	0.265	0.263	0.255	〃	0.378 ~~0.339~~	1.49 ~~1.34~~	
4.0	3					0.94	0.673	0.345	0.256	0.15	〃	0.273 ~~0.234~~	1.06 ~~0.91~~	Dz = 2/3
5.0	7					0.925	0.843	0.425	0.257	0.22	〃	0.343 ~~0.304~~	1.34 ~~1.18~~	
7.0	13					0.895	1.183	0.585	0.253	0.28	〃	0.400 ~~0.344~~	1.59 ~~1.44~~	
9.0	13					0.865	1.523	0.745	0.247	0.25	〃	0.388 ~~0.349~~	1.57 ~~1.41~~	
12.0	12					0.82	2.033	0.985	0.237	0.235	〃	0.358 ~~0.319~~	1.51 ~~1.35~~	
13.0	18					0.805	2.203	1.065	0.231	0.285	〃	0.408 ~~0.369~~	1.75 ~~1.60~~	
15.0	30					0.775	2.543	1.225	0.225	0.35	〃	0.473 ~~0.434~~	2.10 ~~1.93~~	
16.0	34					0.76	2.713	1.305	0.221	0.34	〃	0.463 ~~0.424~~	2.09 ~~1.92~~	
17.0	41													
18.0	34													
19.0	39													
20.0	35													

Table 7-6 LIQUEFACTION CALCULATION PAPER (4)

KAPURI RIVER No. B10

ks = 0.14
hw = 2.1 m

	x (m)	N 値	D_{50}	γ_{t1}	γ_{t2}	γ_t'	r_d	σ_v	σ_v'	L	R_1	R_2	R	F_L
	1.0	3		1.8	1.9	1.0	0.985	0.169	0.268	0.087	0.16	0.105	0.265	3.05
	2.0	3					0.970	0.359	0.368	0.132	0.15	〃	0.255	1.93
	3.0	0					0.955	0.549	0.468	0.157	0.05	〃	0.155	0.99
	4.0	7					0.940	0.739	0.568	0.171	0.23	〃	0.335	1.96
	6.0	20					0.910	1.119	0.768	0.186	0.33	〃	0.435	2.35
	8.0	13	0.12	0.12			0.880	1.499	0.968	0.191	0.25	〃	0.355	1.86
	10.0	12	0.031	(B1)			0.850	1.879	1.168	0.191	0.225	〃	0.330	1.73
	12.0	17												
	13.0	15												
	14.0	19												
	15.0	22												
	16.0	26												
	17.0	27												
	18.0	23												
e	19.0	13												
c	20.0	6												

Table 7-6 LIQUEFACTION CALCULATION PAPER (5)

MAKARA RIVER No. B15

k_s = 0.14
h_w = 0.45 m

	x (m)	N 値	D_{50}	γ_{t1}	γ_{t2}	γ_t'	r_d	σ_v	σ_v'	L	R_1	R_2	R	F_L
c	2.0	5		1.7	1.8	0.9	0.970	0.356	0.216	0.224	0.205	0.123	0.328	1.47
c	3.0	6	0.075~0.01				0.955	0.536	0.306	0.234	0.210	〃	0.333	1.42
	5.0	5					0.925	0.896	0.486	0.239	0.185	〃	0.308	1.29
	6.0	7					0.910	1.076	0.576	0.238	0.210	〃	0.333	1.40
	8.0	7					0.880	1.436	0.756	0.234	0.175	〃	0.298	1.27
	9.0	5					0.865	1.616	0.846	0.231	0.160	〃	0.283	1.22
c	10.0	5					0.850	1.796	0.936	0.228	0.155	〃	0.278	1.22
c	11.0	5												
c	13.0	6												
c	14.0	5												
c	15.0	5												
c	16.0	7												
c	17.0	6												
c	18.0	5												
c	20.0	5												

Table 7-6 LIQUEFACTION CALCULATION PAPER (6)

MAKARA RIVER No. B16

k_s = 0.14
h_w = 0.50 m

	x (m)	N 値	D_{50}	γ_{t1}	γ_{t2}	γ_t'	r_d	σ_v	σ_v'	L	R_1	R_2	R	F_L
	2.0	6	(0.115 [illegible])	1.7	1.8	0.9	0.970	0.355	0.220	0.219	0.225	0.059	0.284	1.29
	3.0	10					0.955	0.535	0.310	0.231	0.275	〃	0.334	1.45
	4.0	8					0.940	0.715	0.400	0.235	0.235	〃	0.294	1.25
	5.0	8					0.925	0.895	0.490	0.227	0.230	〃	0.289	1.22
c	7.0	7					0.895	1.255	0.670	0.235	0.200	〃	0.259	(1.10)
c	8.0	8					0.880	1.435	0.760	0.233	0.210	〃	0.269	(1.15)
c	10.0	5					0.850	1.795	0.940	0.227	0.155	〃	0.214	(0.94)
c	11.0	7												
c	12.0	8	0.008											
c	14.0	9												
c	15.0	10	0.015											
c	17.0	9												
c	18.0	10												
c	19.0	10												
c	20.0	7												

Table 7-6 LIQUEFACTION CALCULATION PAPER (7)

SAPPAHARO CREEK NO. B18

$k_s = 0.14$
$h_w = 0.59$ m

	x (m)	N 値	D_{50}	γ_{t1}	γ_{t2}	γ_t'	r_d	σ_v	σ_v'	L	R_1	R_2	R	F_L
	1.0	3	(0.12)	1.7	1.8	0.9	0.985	0.174	0.137	0.175	0.17	0.105	0.275	1.57
	2.0	9					0.970	0.354	0.227	0.212	0.275	"	0.380	1.80
	3.0	11	(B18)				0.955	0.534	0.317	0.225	0.290	"	0.395	1.76
	4.0	7					0.940	0.714	0.407	0.231	0.220	"	0.325	1.41
	5.0	4					0.925	0.894	0.497	0.233	0.160	"	0.265	1.14
	6.0	3					0.910	1.074	0.587	0.233	0.138	"	0.243	1.04
c	7.0	3	0.007				0.895	1.254	0.677	0.232	0.130	"	(0.33) 0.235	(1.38) 1.01
c	9.0	3	0.02											
c	11.0	3												"
c	12.0	3												"
c	13.0	3												"
c	14.0	6	0.004											"
c	16.0	4												"
c	17.0	5												"
c	18.0	6												"
c	19.0	7	0.01											"

Table 7-6 LIQUEFACTION CALCULATION PAPER (8)

SAPPAHARO CREEK NO B19

$k_s = 0.14$
$h_w = 2.50$ m

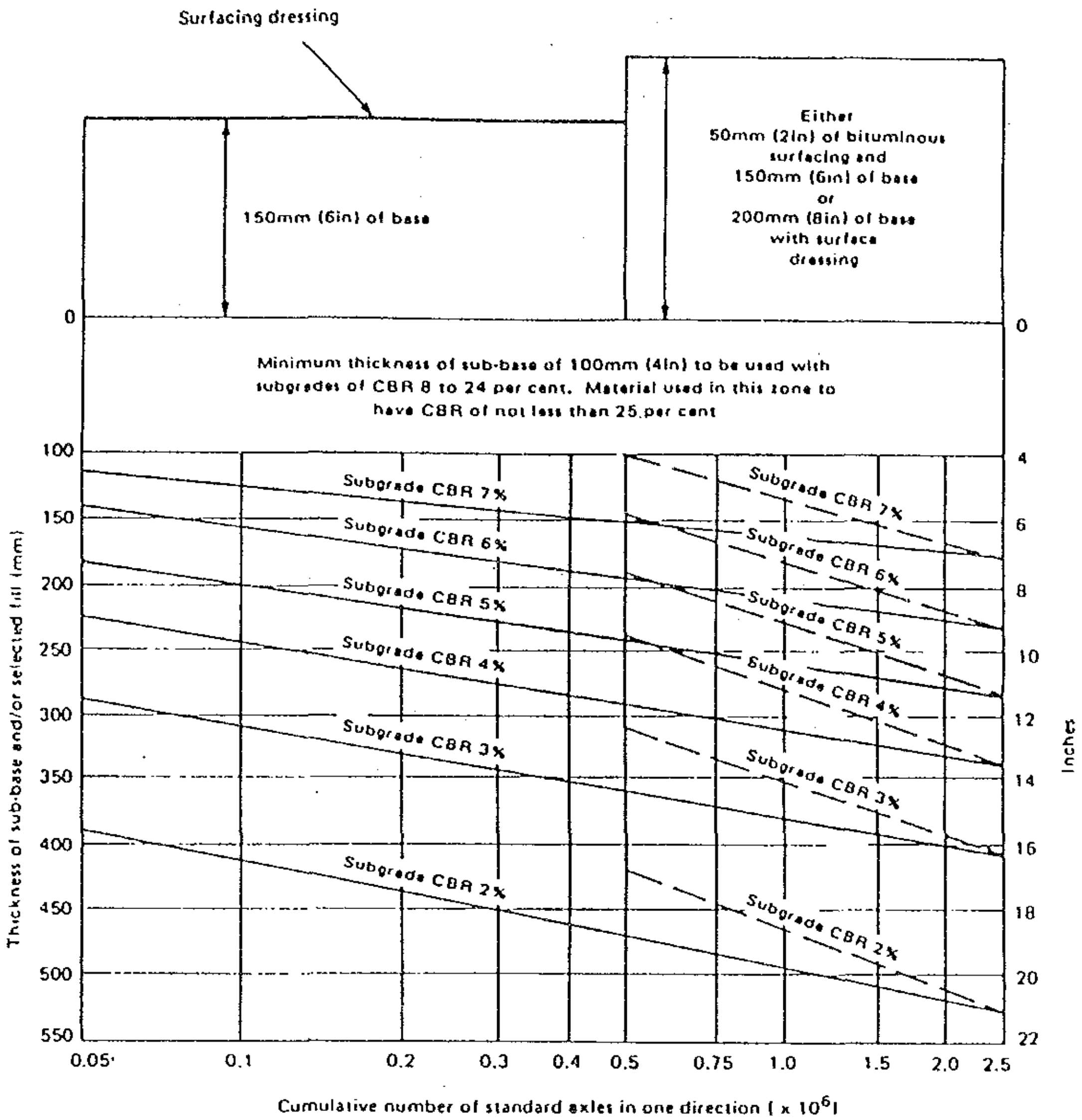
	x (m)	N 値	D_{50}	γ_{t1}	γ_{t2}	γ_t'	r_d	σ_v	σ_v'	L	R_1	R_2	R	F_L
	1.0	7	(0.12)	1.8	1.9	1.0	0.985	0.165	0.300	0.079	0.235	0.105	0.340	4.49
	2.0	4	0.07, 0.04				0.970	0.355	0.400	0.121	0.170	"	0.275	2.29
	4.0	11	0.12	0.12			0.940	0.735	0.600	0.161	0.255	"	0.360	2.24
	6.0	7					0.910	1.115	0.800	0.178	0.190	"	0.295	1.66
	8.0	5					0.880	1.495	1.000	0.184	0.152	"	0.257	1.40
	9.0	4					0.865	1.685	1.100	0.186	0.130	"	0.235	1.27
c	10.0	7					0.850	1.875	1.200	0.186	0.170	"	0.275	1.48
c	11.0	5												
c	12.0	3												"
c	13.0	5												"
c	14.0	3												"
c	15.0	3												"
c	16.0	4												"
c	17.0	3	0.004											"
c	18.0	5	—											"

Table 8-1 . CBR OF EMBANKMENT MATERIAL FOR LOT I

Location	Soil Type	Sieve Analysis ; Passing Percent				Atterberg Limits		Compaction		CBR
		2.36 mm	0.425	0.151	0.075	LL	PI	MC %	DD t/m³	Soaked %
343	clayey Silt		99	63	48	28	12	16.7	1.74	5.3
350	clayey Silt		87	61	53	35	16			
355	clay		98	71	60	42	23			
358	clay		99	82	74	52	31	18.6	1.30	4.9
366	clayey silt		91	67	57	32	13			
367	clay	99	92	70	59	39	19			
369	clay		89	67	61	37	15	20.1	1.60	7.0
371	clayey silt	99	99	60	38	31	15			
373	clayey silt		95	74	63	29	11	19.5	1.69	3.4
376	clay		93	70	60	43	26			
378	clayey silt		89	69	63	34	12			
380	clay		92	68	61	44	26			
383	clay		99	81	71	37	18			
386	clay		95	78	65	40	22	19.8	1.60	9.0
389	clay		98	91	84	56	19			
391	clay		98	75	63	37	19			
409	clay		97	97	88	76	49	22.3	1.28	1.8

Table 8-3 CBR OF EMBANKMENT MATERIALS FOR LOT II

Section of Route for Pavement Design		Miaru River to Kapuri River	Kapuri River to Tauri River	Tauri River to Malalaua
Fill Material Source and Soil Type		Palipala hill	Ilavala hill	Malalaua exist. Borrow pit
		Clayey Silt	Silty Sand	Clayey Silt
Sieve Analysis Percent by wt.passing	9.5 mm			
	4.75 mm		100	100
	2.36 mm	100	74	99
	425 um	80	25	98
	150 um	31	13	98
	75 um	25	10	45
Atterberg Limits	LL	29	39	44
	PL	17	22	29
	PI	13	17	32
Std Compaction MDD (t/m³)		1.743	1.770	1.20
	OMC %	16.7	15.8	36.0
Std Soaked CBR %		3.3 6.8 9.4	8.2 5.3	3.7
	x	6.5	6.8	
	s	3.0	2.1	
	x - s	3.5	4.7	



If it is desired to provide at the time of construction a pavement capable of carrying more than 0.5 million standard axles, the designer may choose either a 150mm (6in) base with a 50mm (2in) bituminous surfacing or a 200mm (8in) base with a double surface dressing. For both of these alternatives, the recommended sub-base thickness is indicated by the broken line.

Alternatively, a base 150mm (6in) thick with a double surface dressing may be laid initially and the thickness increased when 0.5 million standard axles have been carried. The extra thickness may consist of 50mm (2in) of bituminous surfacing or at least 75mm (3in) of crushed stone with a double surface dressing. The largest aggregate size in the crushed stone must not exceed 19mm (¾in) and the old surface must be prepared by scarifying to a depth of 50mm (2in). For this stage construction procedure, the recommended thickness of sub-base is indicated by the solid line.

Fig. 8-1 PAVEMENT DESIGN CHART (ROAD NOTE 31)

Table 8-2 SUMMARIZED TEST RESULTS OF SUBBASE FOR LOT I

(Subbase Material Test Results
Material : Pit-run Silty Sandy gravel from Inaipi hills)

	Location & Sample No.		Sieve Analysis : Percent by wt. passing								Atterberg Limits		Soaked CBR
			75	37.5	19	9.5	4.75	2.36	0.425	0.075	LL	PI	%
Cardono & Davies Report	Inaipi	S 1	100	87	66	49	39	32	13	6	49*	31*	8*
		S 2	100	86	65	49	37	32	10	2	39*	21*	18*
		S 3	100	71	55	43	35	30	7	2	35*	4	-
		S 4		100	91*	85*	74	62*	17	2	Non	Plastic	-
		S 5	100	76	61	48	40	34	12	3	34*	12*	50
		S 6	100	79	64	48	38	28	8	4	37*	10	-
		S 7	100	85	68	55*	44	37*	15	6	39*	14*	18*
		S 8	100	98	94*	82	68*	53*	22	13*	35*	13*	20*
													-
JICA Study	Inaipi	No.1	100	87	80	57	43	37*	21	14*	37*	16*	35
		No.2	100	88	80	68*	55	46*	24*	15*	41*	22*	30
		No.3	100	82	69	55	42	36*	18	11	38*	20*	30
		No.4	100	91	80	60	44	36*	15	9	39*	14*	15*
		No.5		100	82	59	41	34	17	9	40*	14*	15*
		No.6	100	97	79	55	40	34	18	11	41*	15*	15*
Mean Value		x	100	87	73	56	43	36	15	8	39*	16*	23*
Standard Deviation		s		8	10	10	9	6	5	5	4	6	12
		x + s	100	95	83	66	52	42	20	13	43	22	35
		x - s		79	63	46	34	30	10	3	35	10	11
DOW Specificaiton Type B (75 mm)			100	100 ~60	80 ~40	60 ~30	45 ~20	35 ~15	22 ~8	12 ~3	≤30	≤10	≥25
Preferred Specification	Upper Subbase (Cement treated)		100	100	85	70	55	45	23	15		≤10	≥25
	Lower Subbase (Non treated)			~70	~55	~40	~30	~20	~5	~3			≥ 8

Sample No.1, No.2, No.3 Near Bereina existing borrow pit

Sample No.4, No.5, No.6 Near Babanongo existing borrow pit

S 4 is excluded for computation of x and s

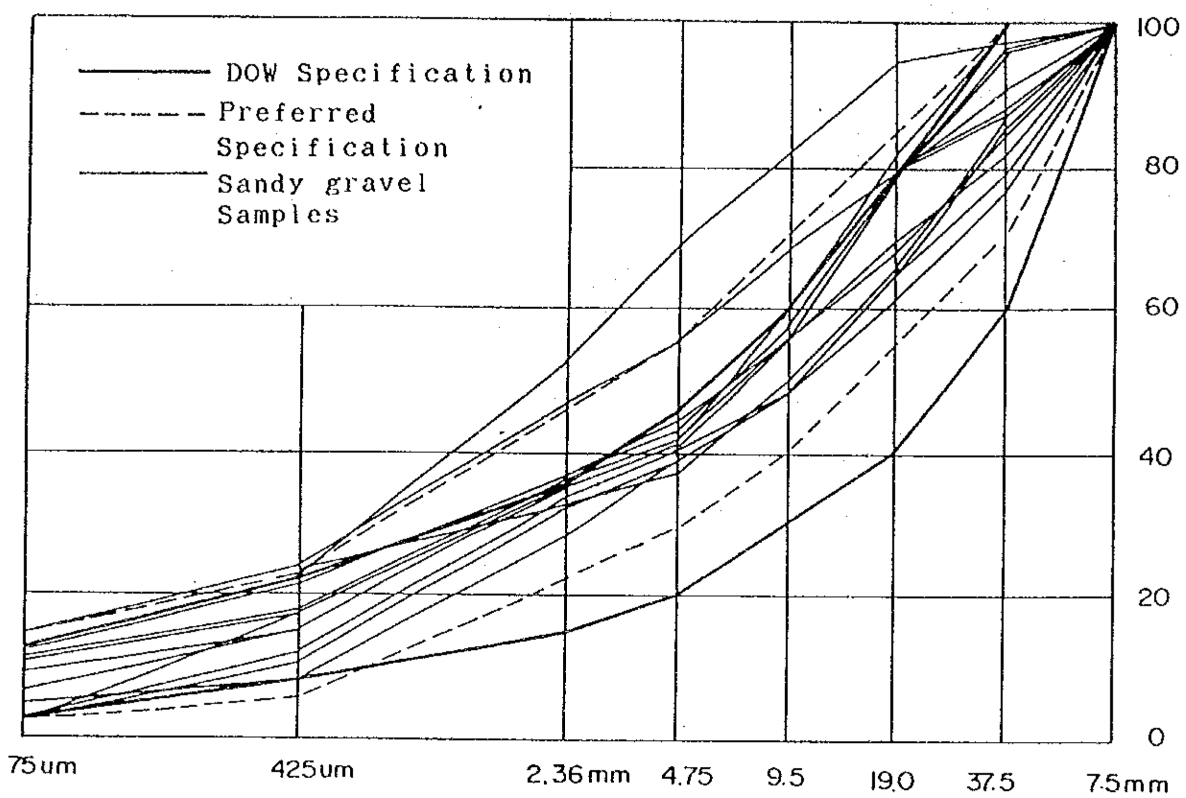
* out of DOW Specification limits

Table 8-4 SUMMARIZED TEST RESULTS OF SUBBASE FOR LOT II

(Subbase Material Test Results
Material : Pit-run Silty Sandy gravel from Malalaua hills)

	Location & Sample No.	Sieve Analysis : Percent by wt. passing								Atterberg Limits		Soaked CBR
		75	37.5	19	9.5	4.75	2.36	0.425	0.075	LL	PI	%
Cardono & Davies Report	Inaipi S 14	100	91	74	61*	50*	45*	22	6	24	4	35
	S 15		100	76	58*	46*	36*	10	3	Non	Plastic	
	S 16	100	96	79	67*	54*	40*	14	9	34*	4	
	S 17	100	93	80	62*	47*	36*	19	11	35*	11*	40
	S 18	100	94	68	55	45*	37*	19	9	34*	10	25
JICA study	Inaipi No.7	100	89	82*	66*	53*	45*	18	8	34*	11	23*
	No.8	100	94	89*	75*	60*	51*	26*	13*	28	7	18*, 15*
Mean Value	x	100	93	79	64*	52*	42*	20	9	32	7	28
Standard Deviation	s		2	7	8	5	6	4	2	4	4	10
	x + s	100	95	86	72	57	48	24	11	36	11	37
	x - s		~91	~72	~56	~48	~36	~16	~7	28	3	18
DOW Specificaiton Subbase		100	100 ~60	80 ~40	60 ~30	45 ~20	35 ~15	22 ~8	12 ~3		≤10	≥25
Preferred Specification	Upper Subbase (Cement treated)	100	100	90	80	65	50	25	15		≤10	≥25
	Lower Subbase (Non treated)		~80	~65	~50	~40	~30	~10	~3			≥ 8

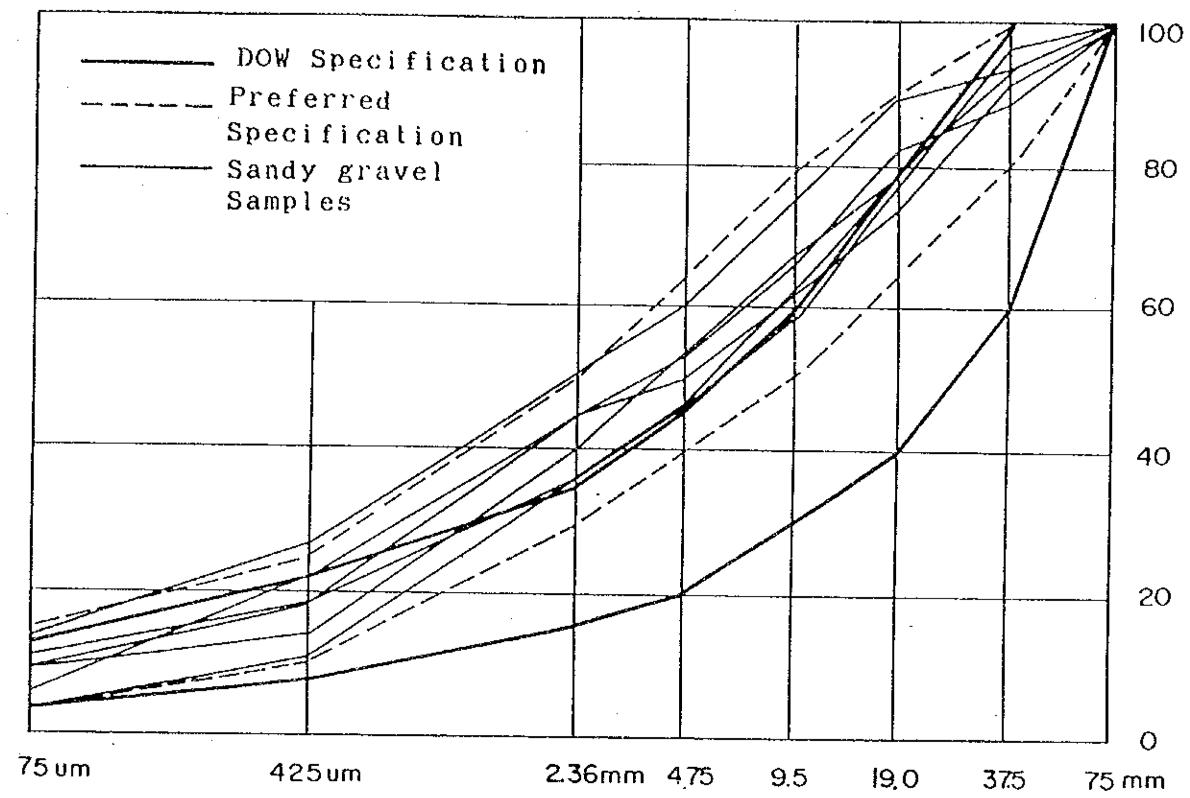
S 15 is excluded for computation of x and s



Preferred Grading Specification Range for the pit-run Sandy gravel subbase (Bereina ~ Miaru River Section)

Sieve Size	Percent by wt. passing: DOW Specification	Percent by wt. passing: Preferred Specification
75 mm	100	100
37.5 mm	60 - 100	70 - 100
19.0 mm	40 - 80	55 - 85
9.5 mm	30 - 60	40 - 70
4.75 mm	20 - 45	30 - 55
2.36 mm	15 - 35	20 - 45
425 um	8 - 22	5 - 23
75 um	3 - 12	3 - 15

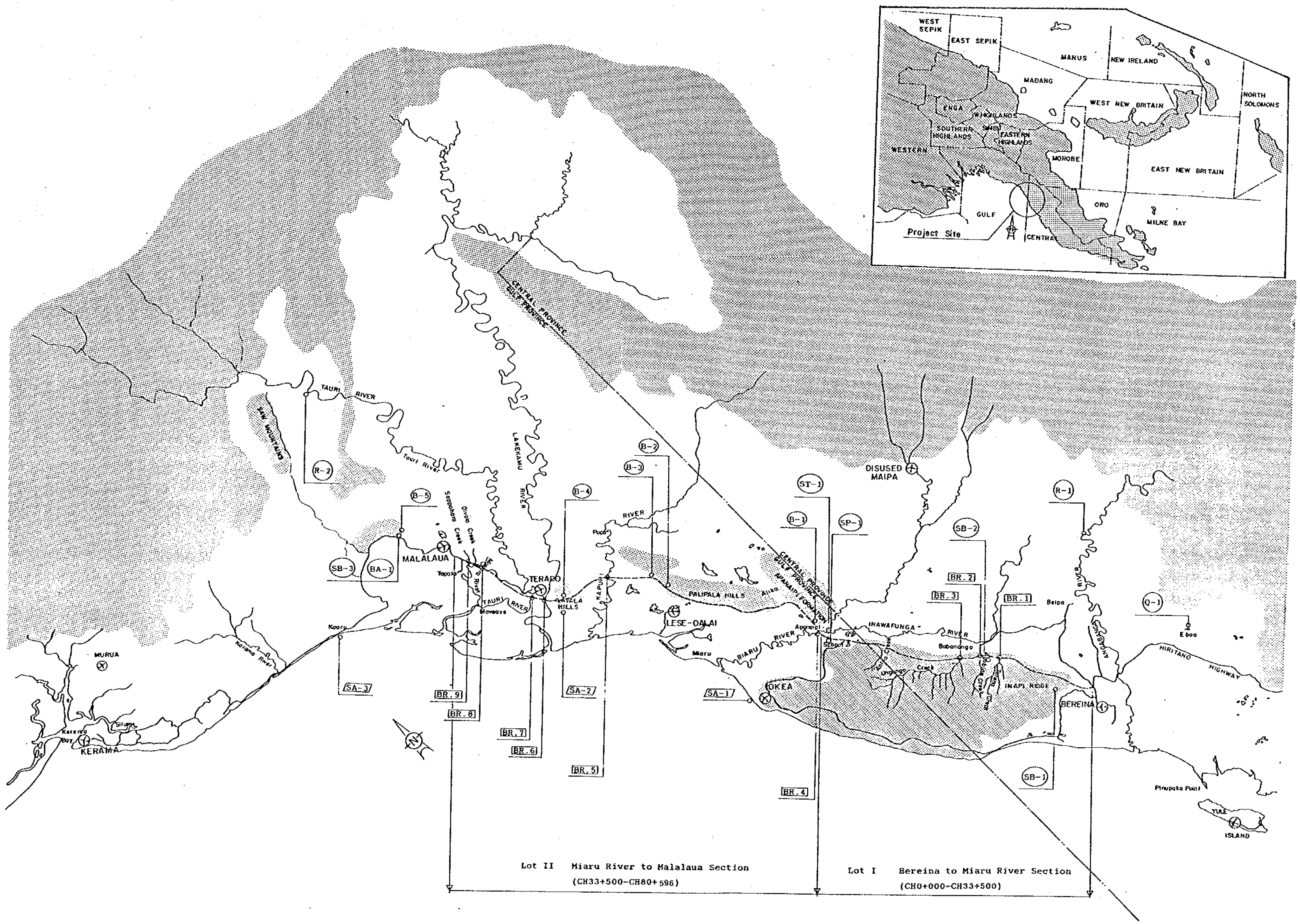
Fig. 8-3 PREFERRED GRADING OF SUBBASE FOR LOT I



Preferred Grading Specification Range for the pit-run Sandy gravel subbase (Miaru River ~ Malalaua Section)

Sieve Size	Percent by wt. passing: DOW Specification	Percent by wt. passing: Preferred Specification
75 mm	100	100
37.5 mm	60 - 100	80 - 100
19.0 mm	40 - 80	65 - 90
9.5 mm	30 - 60	50 - 80
4.75 mm	20 - 45	40 - 65
2.36 mm	15 - 35	30 - 50
425 um	8 - 22	10 - 25
75 um	3 - 12	3 - 15

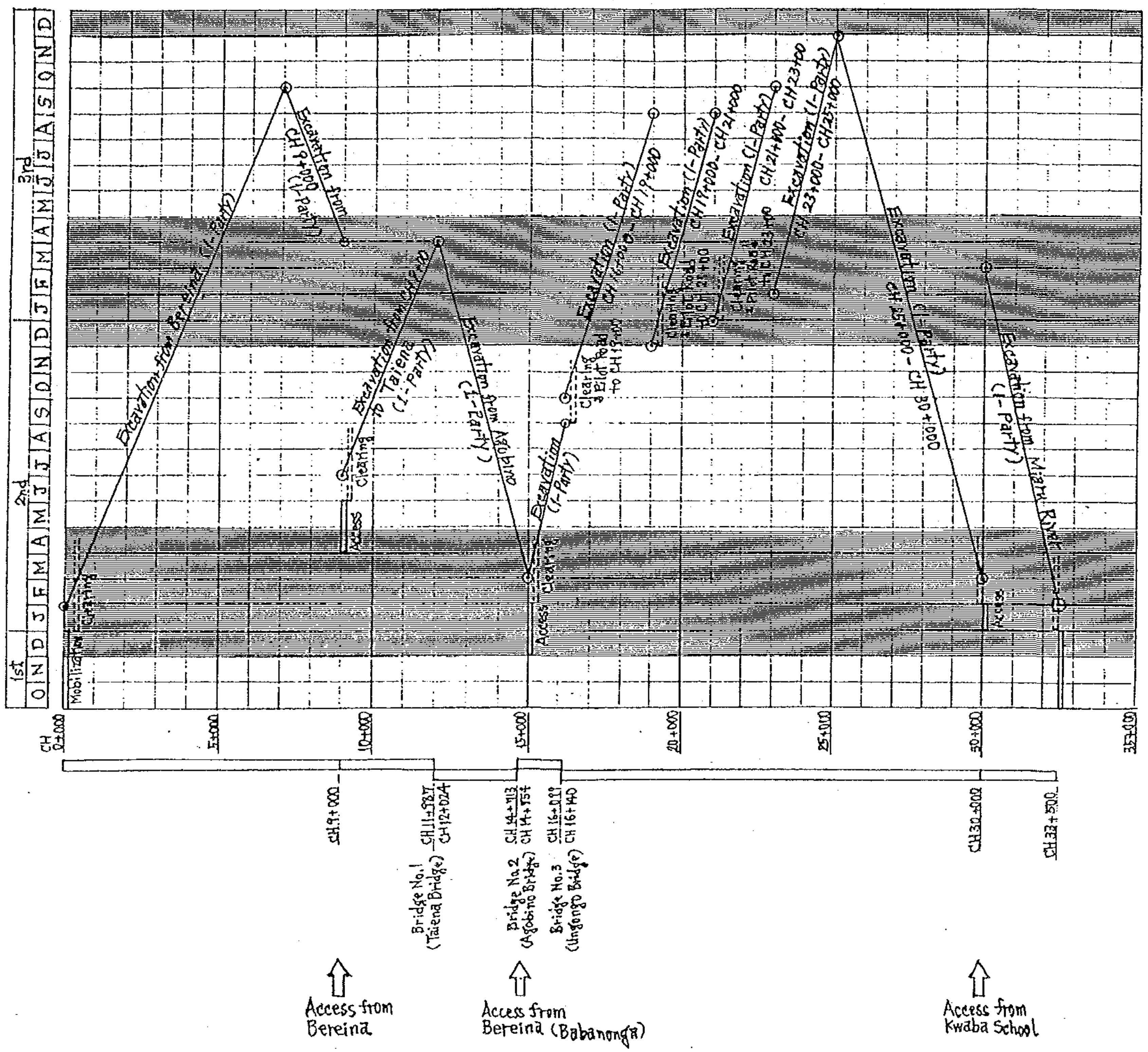
Fig. 8-5 PREFERRED GRADING OF SUBBASE FOR LOT II



Abbreviation:

BR.1	Taiena Bridge
BR.2	Agobino Bridge
BR.3	Ungongo Bridge
BR.4	Miaru Bridge
BR.5	Kapuri Bridge
BR.6	Lakekamu Bridge
BR.7	Tauri Bridge
BR.8	Makara Bridge
BR.9	Sappaharo Bridge
SP-1	Spoil Bank No.1
B-1	Borrow Pit No.1
B-2	Borrow Pit No.2
B-3	Borrow Pit No.3
B-4	Borrow Pit No.4
B-5	Borrow Pit No.5
ST-1	Stockpile No.1
SB-1	Subbase Borrow Pit No.1 (Bereina)
SB-2	Subbase Borrow Pit No.2 (Babanongo)
SB-3	Subbase Borrow Pit No.3 (Malalaua)
BA-1	Base Borrow Pit No.1 (Malalaua)
Q-1	Quarry Site No.1 (Eboa Quarry)
R-1	River Deposit No.1 (Angabanban River)
R-2	River Deposit No.2 (Tauri River)
SA-1	Sand Borrow Pit No.1 (Iokea)
SA-2	Sand Borrow Pit No.2 (Ilavala Hill)
SA-3	Sand Borrow Pit No.3 (Koaru)

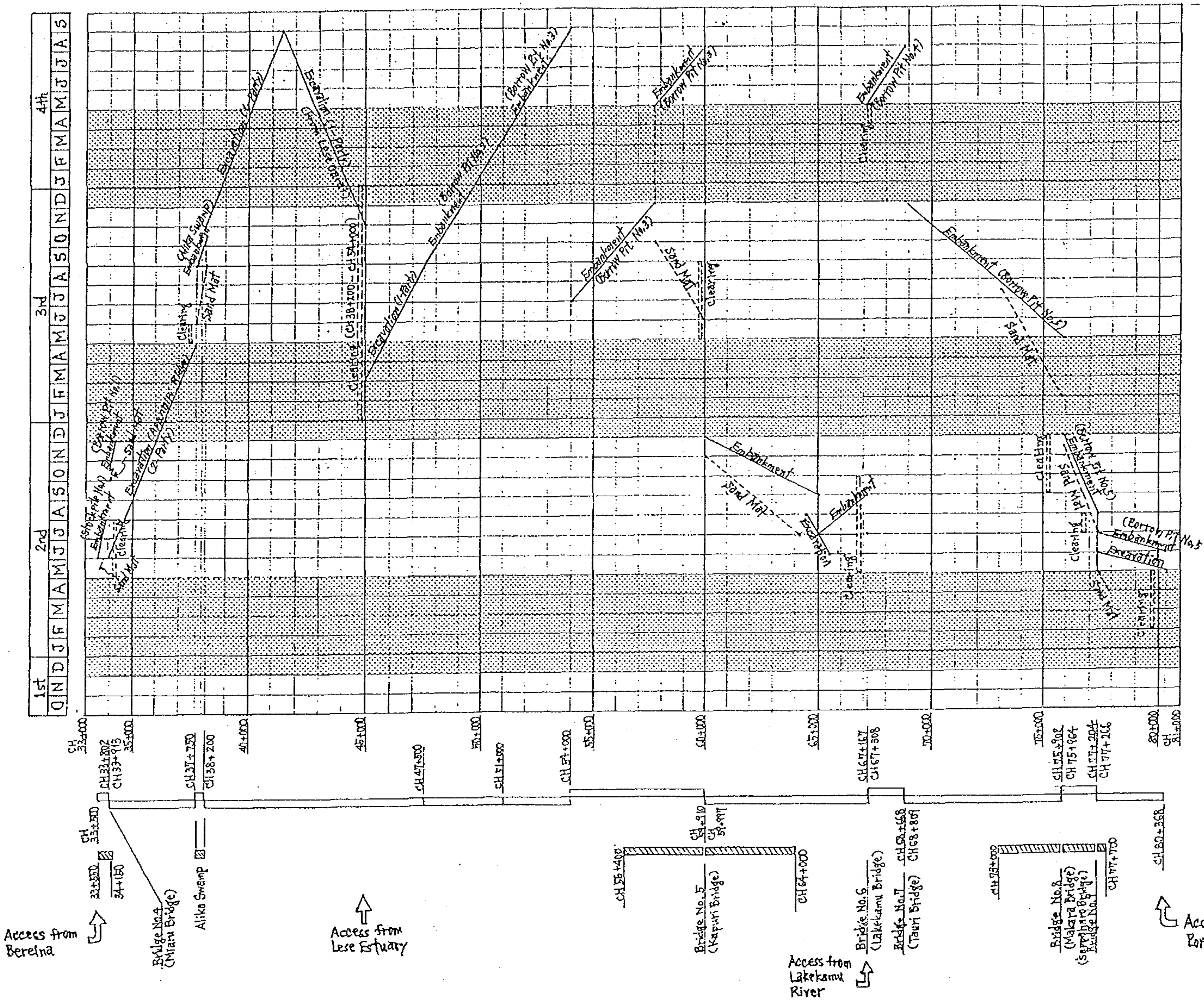
Fig. 11-1 PROJECT LOCATION & MATERIAL SITE



Earthwork procedure and schedule are planned based on the following conditions:

- Workable day 19 days/month (in whole year)
- Daily progress rade 340 m³/day
- To repeat the cutting and filling work within 2,000 m road section from mass-curve plan.
- Working width of road cutting section is narrow.
- CH16+099 to CH23+000
  In a view point of topographical conditions, the parallel work will be done after providing pilot road (temporary access).
- CH 23+000 to CH 30+000
  Working site is restricted by steep land.
- Access to the road alignment
  - Bereina
  - CH 9+000
  - Babanonga
  - CH30+000
  - End point (Miaru River)

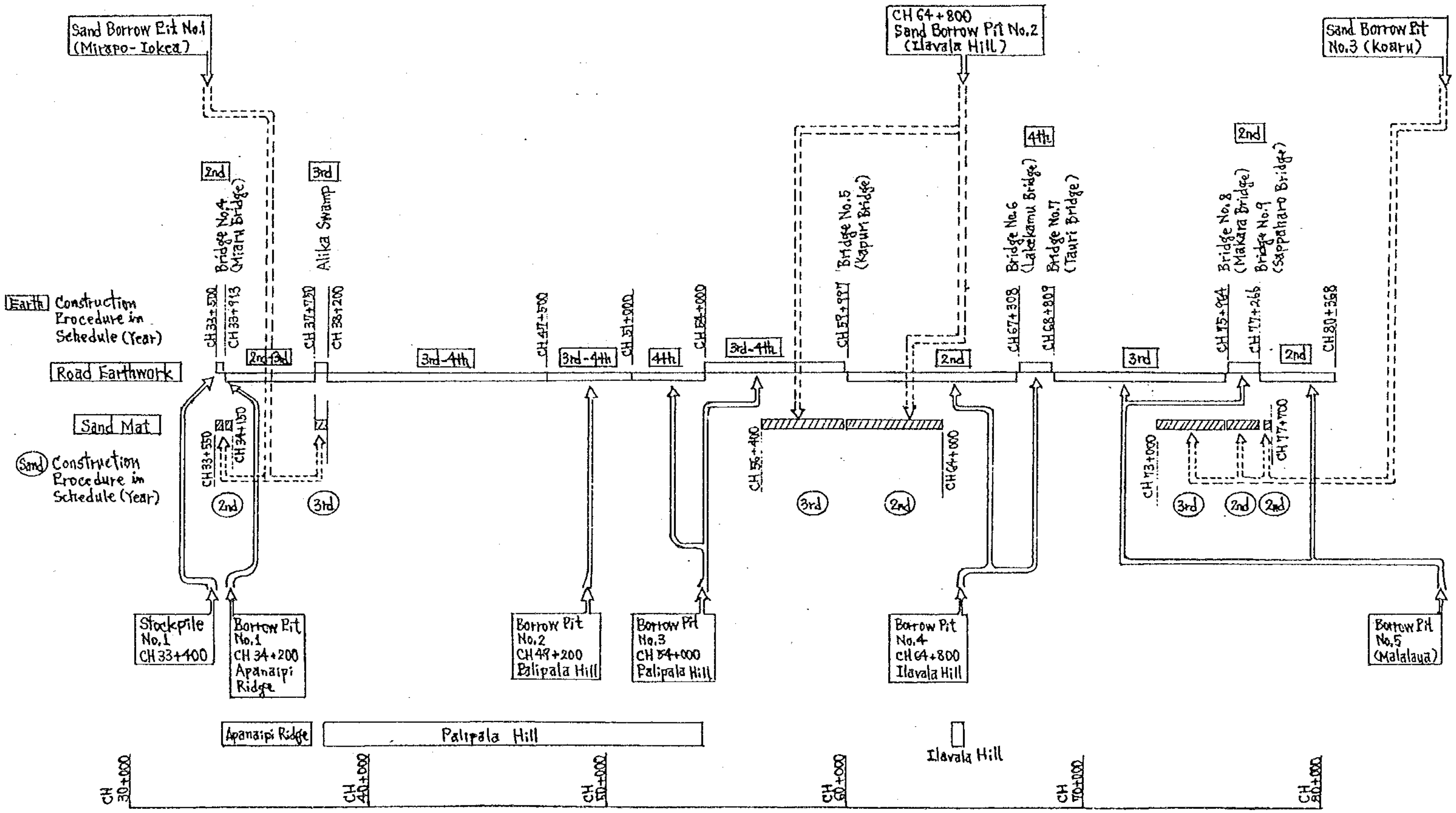
Fig 11-2 EARTHWORK ACCESS DIAGRAM FOR LOT I



Earthwork procedure and schedule are planned based on the following conditions ;

- Workable day
  - Land area 19 days/month
  - Swamp area 22 days/month (Dry season)
- Cutting & filling section
  - Apanaipi Ridge
  - Palipala Hill
- Embankment section
  - Miaru Bridge
  - Alika swamp
  - CH 47+500 in Palipala Hill to CH 54+000
  - CH 54+000 to CH 80+368 Swamp area and soft ground area
- Borrow Pits No.1 to No.5
- Sand Borrow Pit No.1 to No.3
- Access to the road alignment
  - Miar River (Kwaba School)
  - Lese Oarai (Lese Estuary)
  - Lakekam Bridge Site (Lakekamu River)
  - Malalaua (From Port Kerema)

Fig.11-3 EARTHWORK ACCESS DIAGRAM FOR LOT II



Note : 2nd, 3rd, 4th means fiscal year after commencement

Fig.11-4 EARTH MATERIAL DISTRIBUTION PLAN FOR LOT II

Table 11-1 Major Construction Plant and Equipment, Lot I

Description	Spec.		Required Number
1. Bulldozer w/ripper	21	ton	10
2. Bulldozer	11	ton	7
3. Tractor shovel	2.3	m^3	10
4. Wheel loader	2.0	m^3	1
5. Wheel loader	1.6	m^3	1
6. Backhoe	0.3	m^3	2
7. Crawler drill	10	m^3/min	2
8. Air compressor	13.5	m^3/min	2
9. Dump truck	11	ton	55
10. Dump truck	8	ton	4
11. Dump truck	4	ton	1
12. Crushing plant	60	ton/hr	1
13. Crushing plant	20	ton/hr	1
14. Motor grader	3.7	m	5
15. Vibrating roller	8	ton	7
16. Vibrating roller	4	ton	2
17. Road stabilizer	1.6	m	4
18. Aggregate spreader	3.5	m	1
19. Chip spreader	2.0	m	1
20. Tire roller	15	ton	10
21. Macadam roller	10	ton	5
22. Tandem roller	10	ton	2
23. Sprinkler	5	kl	3
24. Road sweeper			3
25. Asphalt kettle	6,000	litre	2
26. Asphalt distributor	4,000	litre	3
27. Engine sprayer	600	litre	2
28. Pre-coating spray			1
29. Diesel pile driver	2.5	ton	1
30. Truck crane	10	ton	3
31. Crawler crane	35	ton	1
32. Portable mixer	0.6	m^3	1
33. Concrete dumper	0.7	m^3	2

Table 11-2 Major Construction Plant and Equipment, Lot II

Description	Spec.		Required Number
1. Bulldozer w/ripper	21	ton	7
2. Bulldozer	21	ton	2
3. Bulldozer	11	ton	4
4. Bulldozer, low pressure type	10	ton	6
5. Clamshell crane w/pontoon	0.6	m^3	1
6. Amphibious backhoe	0.4	m^3	2
7. Tractor shovel	2.3	m^3	9
8. Backhoe	0.6	m^3	3
9. Backhoe	0.2	m^3	1
10. Wheel loader	2.0	m^3	1
11. Wheel loader	1.6	m^3	1
12. Wheel loader	1.0	m^3	1
13. Dump truck	11	ton	80
14. Dump truck	8	ton	3
15. Dump truck	2	ton	1
16. Soil plant	100	ton/hr	1
17. Crushing plant	20	ton/hr	1
18. Cargo ship	10	m^3	8
19. Motor grader	3.7	m	4
20. Vibrating roller	8	ton	7
21. Vibrating roller	4	ton	2
22. Road stabilizer	1.6	m	2
23. Chip spreader	2.0	m	2
24. Tire roller	15	ton	11
25. Macadam roller	10	ton	4
26. Tandem roller	10	ton	2
27. Sprinkler	5	kl	3
28. Road sweeper			3
29. Asphalt kettle	6,000	litre	2
30. Asphalt distributor	4,000	litre	2
31. Engine sprayer	600	litre	2
32. Pre-coating spray			1
33. Diesel pile driver	2.5	ton	1
34. Diesel pile driver	3.5	ton	1
35. Vibro hammer	60	kw	1
36. Crawler crane	35	ton	2
37. Crawler crane	40	ton	2
38. Truck crane	10	ton	4
39. Bore boring machine	41	kw	1
40. Suction pump	45	kw	1
41. Sand pump	22	kw	1
42. Portable mixer	0.6	m^3	1
43. Concrete dumper	0.7	m^3	2
44. Concrete bucket	0.7	m^3	2

ATTACHMENT-1

1. ROAD CLASSIFICATION AND CROSS SECTION

2. GEOMETRIC STANDARD

1 ROAD CLASSIFICAITON AND CROSS SECTION

1-1 PROJECTED TRAFFIC VOLUME

ADT in initial year --- 200 vehicles per day

ADT after 20 years --- 360* vechicles per day

* ADT (20) = ADT(initial year) x $(1 + i)^N$
= 200 x $(1+0.03)^{20}$
= 200 x 1.806
= 360 vehicles per day
where: i= Traffic growth rate --- 3 %
N= Design life ---------- 20 years

1-2 TRAFFIC CATEGORY

Judging from the traffic volume, the traffic category is classified as "Medium" from Table2-2 DOW Design Manual, as shown below.

TABLE 2-2
TRAFFIC CATEGORY AND CROSS SECTION DETAILS

Traffic Category	Volume Range (v.p.d)**	Terrain Type ***	Design Speed (kph)	Width of Pavement (m)	Width of Formation (m)
Heavy	400	F/R	80	6.5	8.5
		H	50	6.5	8.0
		M	30	6.0	7.5
Medium	100-400	F/R	70	6.5	7.5
		H	50	6.0	7.0
		M	25	5.5	6.5
Light	< 100	F/R	60	N/A	6.5
		H	40	N/A	6.0
		M	25	N/A	5.5

** The volume range is the anticipated traffic at the end of the design life, assumed to be the same as the pavement design life, of the road.
*** The terrain types are defined as:
F/R Flat and Rolling - less than 10° cross slope
H Hilly - 10° to 30° cross slope
M Mountaiouns - greater than 30° cross slope

1-3 DESIGN SPEED

The Disign Speed adopted is 70km/h considering Flat and Rolling terrain type, refering to the same Table.

1-4 CROSS SECTION

Formation width is amended from 7.5 m to 8.5 m as described in the minutes of meeting, 12 July 1988. The components of the cross section are as follows;

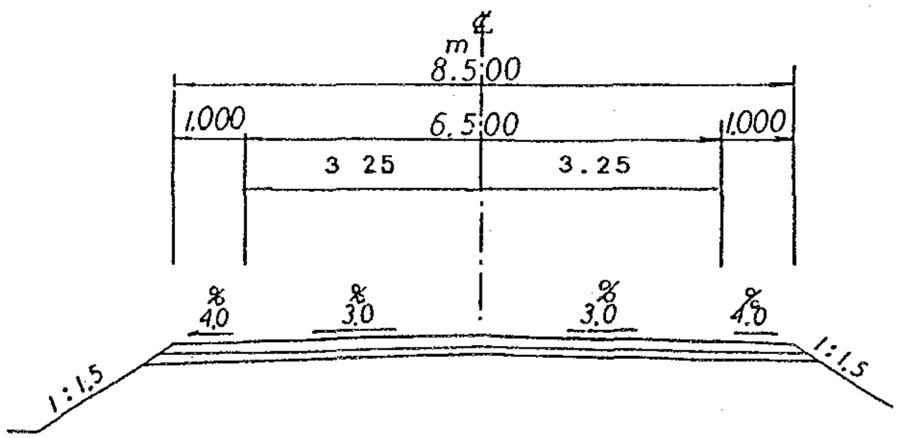
Number of Lanes--- 2
Lane Width ------- 3.25 m
Shoulder Width --- 1.00 m
Crossfall (Refer to Table 3.5.2 in DOW Design Manual)
  Pavement --- 3 %
  shoulder --- 4 %

TABLE 3.5.2

MINIMUM CROSSFALL

Type of Pavement	Crossfall
Earth or Loan	5 %
Gravel (Shoulder)	4 %
Bitumen (Pavement)	3 %

The typical cross section is shown below.



2 GEOMETRIC STANDARD

2-1 SIGHT DISTANCE

Stopping Distance -------- 90 m
Intermediate Distance ---- 180 m
Overtaking Distance ------ 350 m *
 * Intervals of 2 to 2.5 km are desired.

These values are adopted after refering to Table 4.7.1 in DOW Design Manual.

TABLE 4.7.1

SIGHT DISTANCE ON SEALED PAVEMENTS

Design Speed	f	Stopping Distance Ds	Intermediate Distance	Overtaking Distance
30	0.53	30	60	90
40	0.51	40	80	160
50	0.49	55	110	200
60	0.47	70	140	300
70	0.45	90	180	350
80	0.43	115	230	480
100	0.39	170	340	800
Height of eye		1.15	1.15	1.15
Height of object		0.2	1.15	1.15

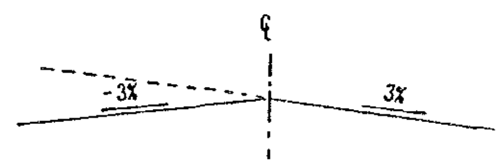
2-2 HORIZONTAL CURVE

Desirable Radius --------------- 400 m
Minimum Radius ----------------- 155 m
Minumum Length ----------------- 120 m
Minimum Deflection Angle
  Superelevation is needed ---- 4.0 Degree
  Curve is needed ------------- 1.5 do
Minimum Radius of Horizontal Curve Having Adverse Crossfall --- 1000 m *

$$* \quad R_{min.} = \frac{V^2}{127(e+f)} = \frac{70^2}{127(-0.03+0.07)}$$

$$= 964 \fallingdotseq 1000m$$

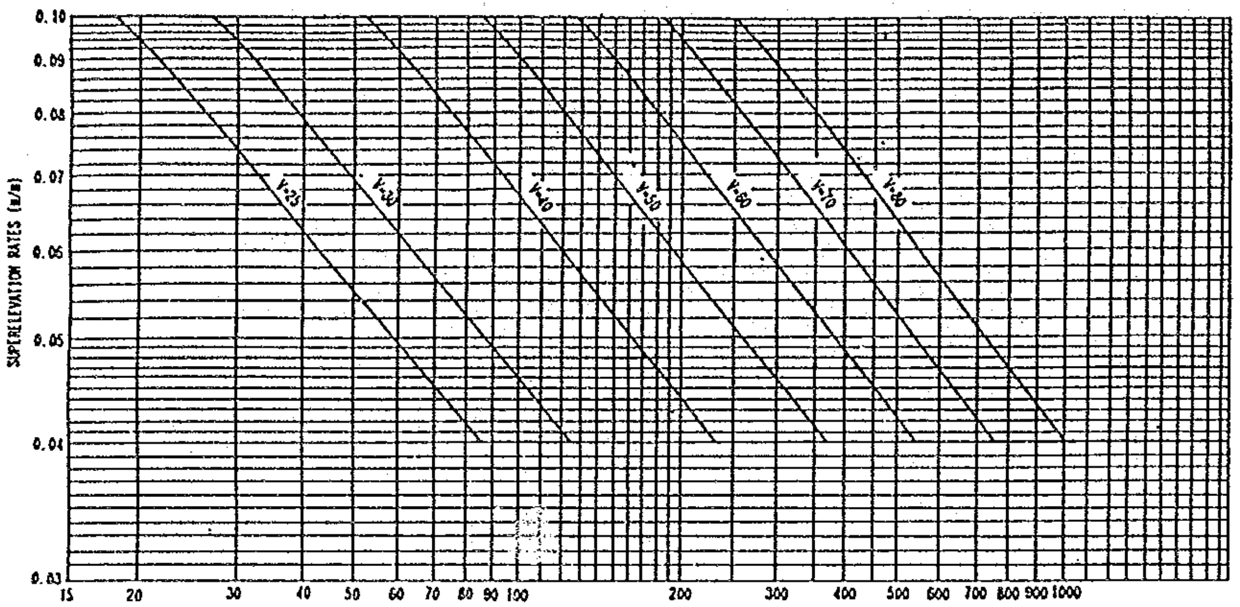
where: $e = -0.03$
$f = 0.07$



Note: f = 0.07 is also adopted in "A GUIDE TO GEOMETRIC DESIGN " OF OVERSEAS UNIT, TRANSPORT AND ROAD RESEARCH LABORATORY-CROWTHORNE, BERKSHIRE, UNITED KINGDOM"

2-3 SUPERELEVATION

Superelevations for each horizontal curve radius in the case of V=70km/h are adopted from Fig.5.2.2. in DOW Design Manual.



DESIGN SUPERELEVATION RATES GRAVELLED PAVEMENT

FIG. 5.2.2

The relations between the horizontal curve radius, the superelevations and the coefficient of side friction are shown in the table below.

HORIZONTAL CURVE RADIUS(m)	SUPER-EVEVATION e (%)	SIDE FRICTION f
155≤R<188	10	0.149~0.115
180≤R<220	9	0.124~0.085
220≤R<260	8	0.068~0.095
260≤R<320	7	0.078~0.051
320≤R<420	6	0.061~0.032
420≤R<580	5	0.042~0.017
580≤R<880	4	0.027~0.004
R≥880	3	0.014

$$R = \frac{V^2}{127(e + f)}$$

where:

R = Radius of Curve (m)

V = Speed of Vehicle 70 km/h

e = Superelevation

f = Coefficient of side friction

Note: Absolute Minimum Curve Radius

$$Rmin. = \frac{70^2}{127(0.10 + 0.149)} = 155 \text{ m}$$

2-4 SUPERELEVATION TRANSITION

For the maximum relative grade in the development of superelevation is adopted 0.55 from Table 5.7 in DOW Design Mannual.

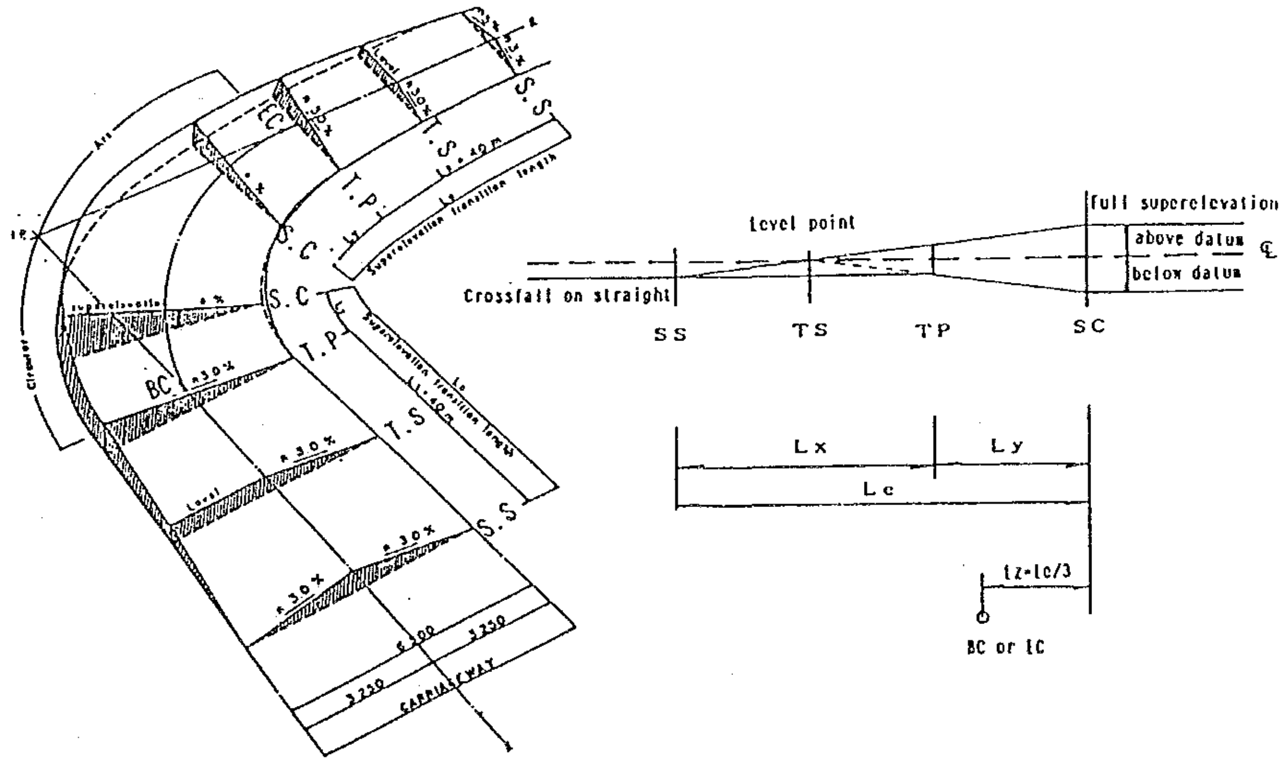
TABLE 5.7

MAXIMUM RELATIVE GRADES IN DEVELOPMENT OF SUPERELEVATION

SPEED km.hr	MAXIMUM RELATIVE GRADE %
25	1.10
30	1.05
40	0.90
50	0.75
60	0.65
70	0.55
80	0.50
100	0.45

(1) STRAIGHT-CURVE-STRAIGHT Alignment.

Considerling safe driving the beginning of the curve (B.C) is located between TP and SC (Lz = Le/3) as shown below.

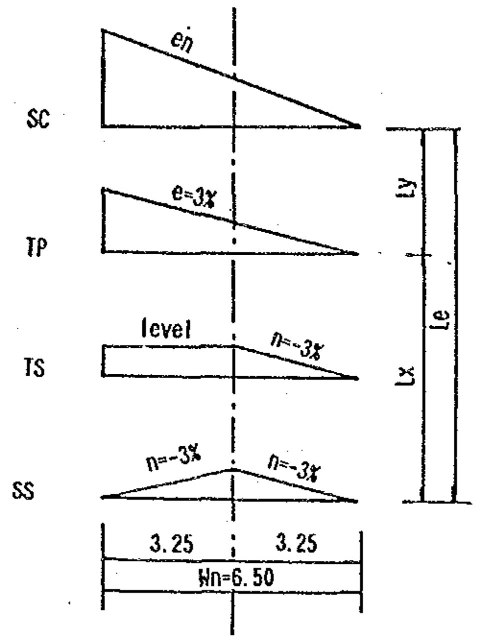


Lx (SS - TP)

$$Lx = \frac{50 \cdot Wn\ (n+e)}{Gr}$$

$$= \frac{50 \times 6.50(0.03+0.03)}{0.05}$$

$$= 35.45 = 40.00 \text{ m}$$



Where
Lx = Length of Superelevation Transition(m)
Wn = Width of Two-lane pavement on Tangent(m)
n = Normal Crossfall ------ 3.0 %
Gr = Max. relative grade --- 0.55 %
en = Superelevation Crossfall(m/m)

LY - (TP -SC)

$$LY = \frac{50 \times 6.50(e_n - 0.03)}{0.55}$$

e_n (%)	LY (m)	Gr (%)
4	10	0.3250
5	15	0.433
6	20	0.4875
7	30	0.4333
8	35	0.4643
9	40	0.4875
10	50	0.455

Le = Lx + LY

n~e-en (%)	Le (m)	Lx (m)	LY (m)	Le/3 (m)
-3~3~ 4	50	40	10	-
-3~3~ 5	55	40	15	-
-3~3~ 6	60	40	20	20
-3~3~ 7	70	40	30	23
-3~3~ 8	75	40	35	25
-3~3~ 9	80	40	40	27
-3~3~10	90	40	50	30

The development of superelevation in the case of a 200m radius curve is shown below for clarification.

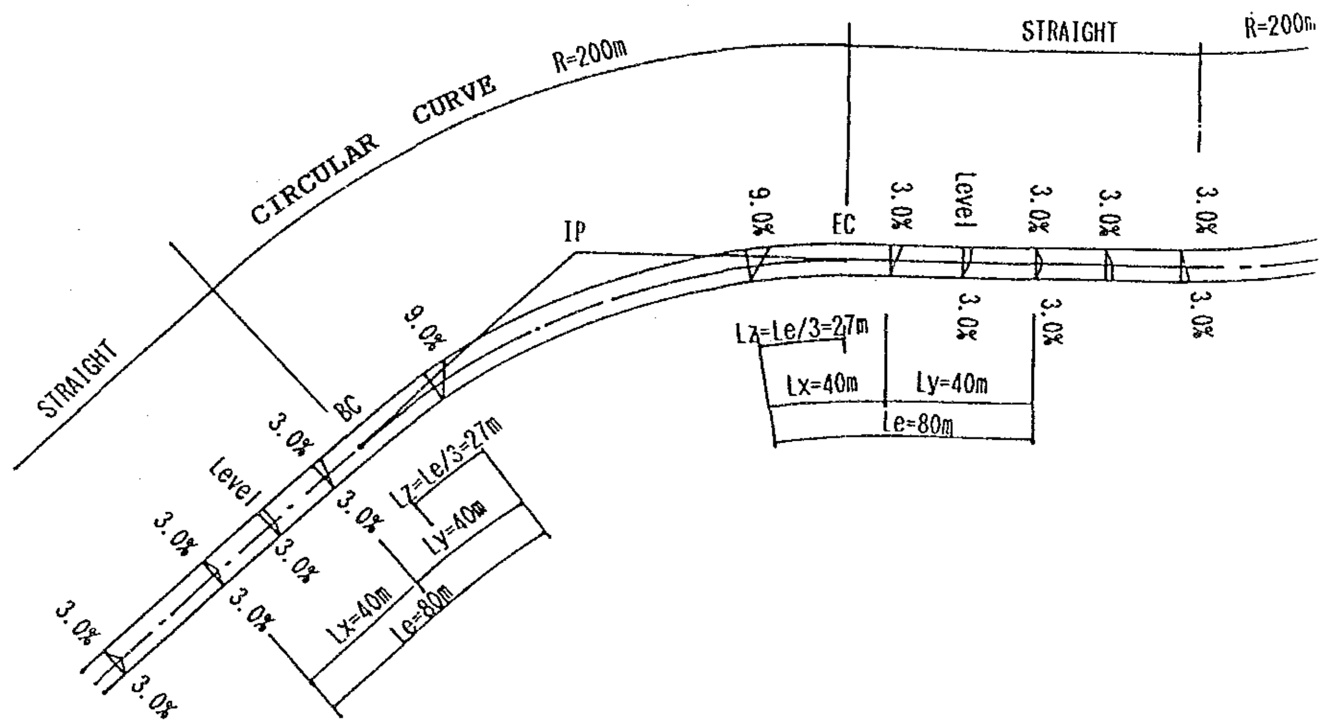
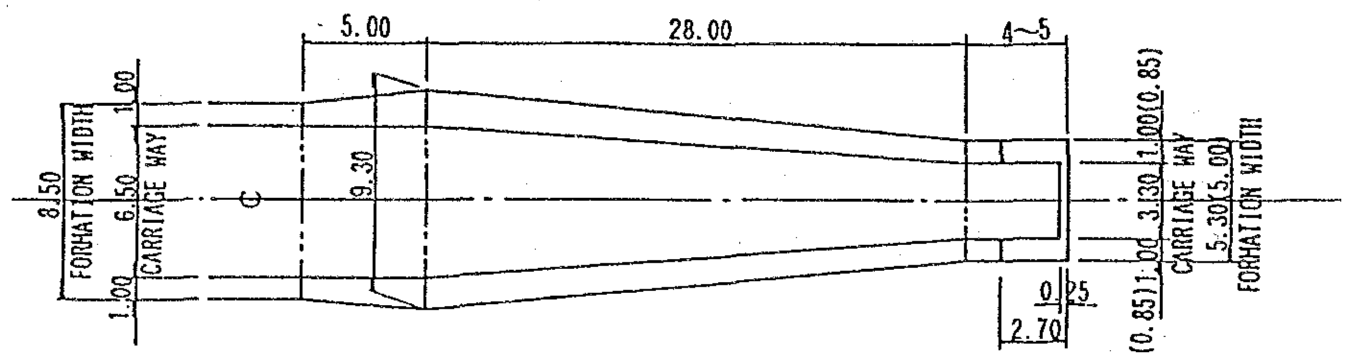


Fig Development of Superelevation in the case of a 200 m radius curve

(2) APPROACH SECTION OF SINGLE LANE BRIDGE

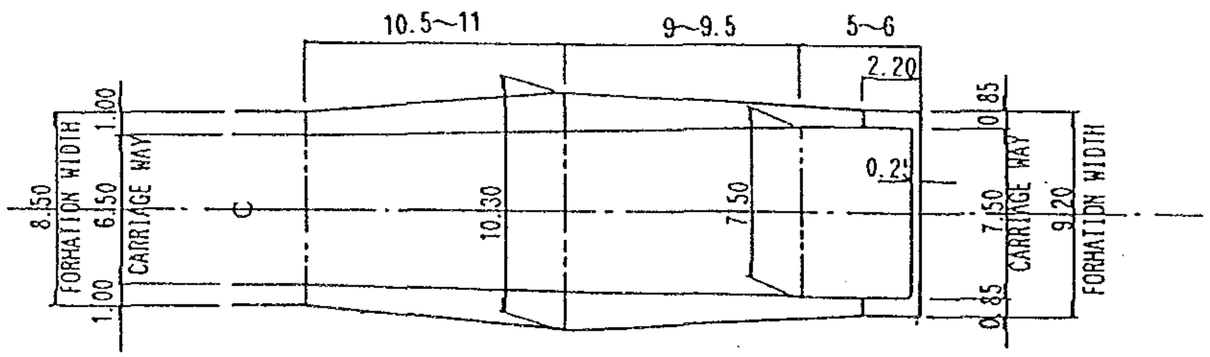
At the approach to single lane bridges, formation width is reduced as below.



Note: Figures in ( ) are for KAPURI BRIDGE.

Single lane bridges where this is to be applied are Miaru, Kapuri, Lakekamu, Tauri, Makara, Sapaharo Bridges.

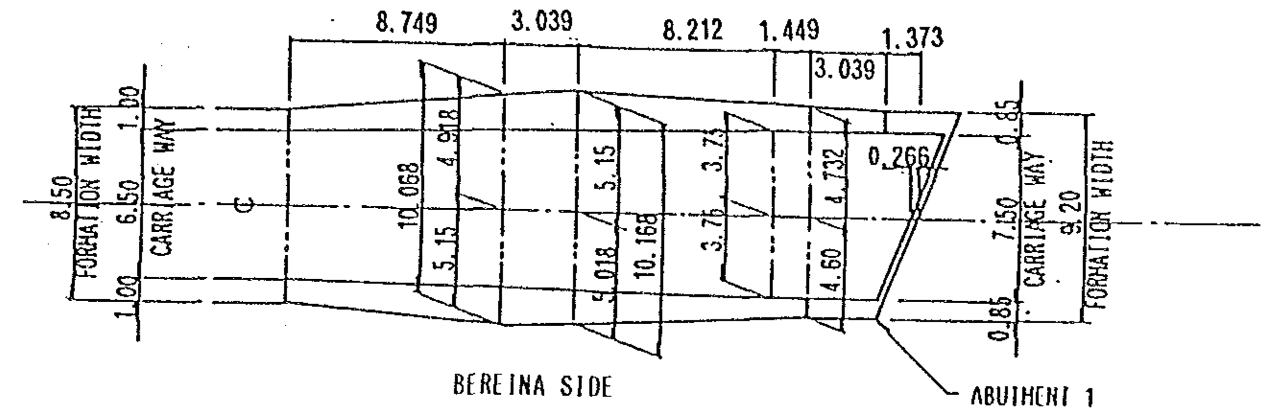
(3) APPROACH SECTION OF TWO WAY BRIDGE

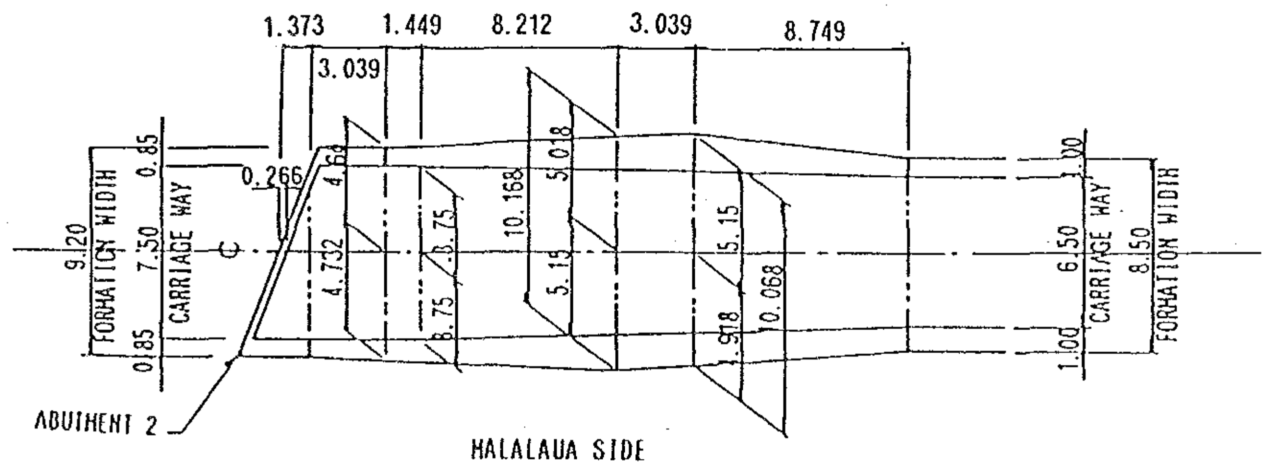


Two Way Bridges where this is to be applied are Taiena, Agobino, Ungongo Bridges.

(4) APPROACH SECTION OF TWO WAY SKEWED BRIDGE

UNGONGO BRIDGE





2-5 GRADIENT

General Maximum ----------- 6 %
Absolute Maximum ---------- 8 % L < 700 m

2-6 VERTICAL CURVES

① Minimum Radius of Crest Curve --- 1755 m

Length of crest curve

$$L = \frac{D^2 \times A}{200(\sqrt{h1} + \sqrt{h2})^2} = \frac{90^2 \times A}{200(\sqrt{1.15} + \sqrt{0.2})^2} = 17.55 \times A$$

Where: L = length of vertical curve (metres)
D = sight distance (metres)
A = algebraic difference in grades (%)
h_1 = height of eye above road (metres) = 1.15 metres
h_2 = height of object above road (metres)
= 1.15 if another vehicle
= 0.2 metres if an object on the ground

$$\text{Therefore } R = \frac{100 \times L}{A} = \frac{100 \times 17.55 \times A}{A} = 100 \times 17.55 = 1755 \text{ m}$$

② Minimum Radius of Sag Curve --- 1740 m

Length of sag curve

$$L = \frac{D^2 \times A}{150 + 3.5 \times D} = \frac{90^2 \times A}{150 + 3.5 \times 90} = 17.40 \times A$$

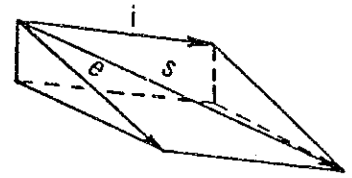
$$\text{Therefore } R = \frac{100 \times L}{A} = \frac{100 \times 17.40 \times A}{A} = 100 \times 17.40 = 1740 \text{ m}$$

2-7 MAXIMUM COMBINED GRADIENT

Smax ----- 10.5 %

To avoid the combination of steep gradient and steep superelevation, maximum combined gradient is adopted refering to ROAD STRUCTURE ORDINANCE OF JAPAN.

$$S = \sqrt{e^2 + i^2}$$



Where:
S = Combined Gradient
e = Superelevation
i = Gradient

Relations between Superelevation and Gradient at Mazimum Combined Gradient are shown below.

e %	S %	i %
10	10.5	3.2
9	10.5	5.4
8	10.5	6.8
7	10.5	7.8
6	10.5	8.6

2-8 TAKING OFFSET DISTANCE AT CUTTING SECTION

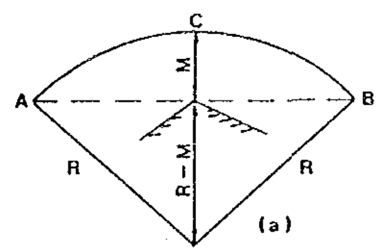
Minimum offset distance should be provided to obtain the stopping sight distance.

Therefor, the minimum offset distance is compared with the width carriageway and lateral clearance at the smallest horizontal curve in the cutting section.

Minimum offset distance (R = 200 m)

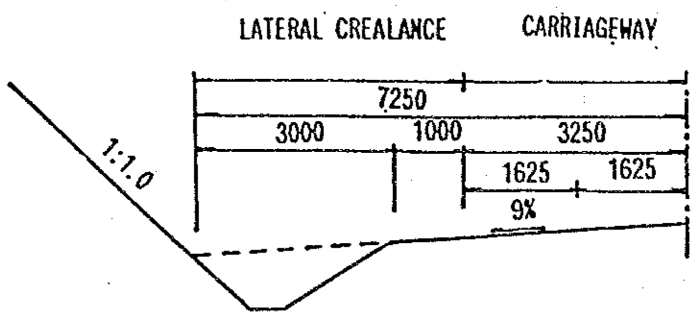
$$M = \frac{D^2}{8(R-1.625)} + 1.625 = \frac{90^2}{8(200-1.625)} + 1.625$$

$$= 5.1 + 1.625 = 6.725 \text{ m} < 7.250 \text{ m}$$ 1)



Where D = stopping sight distance ---- 90 m
R = horizontal curve radius ---- 200 m

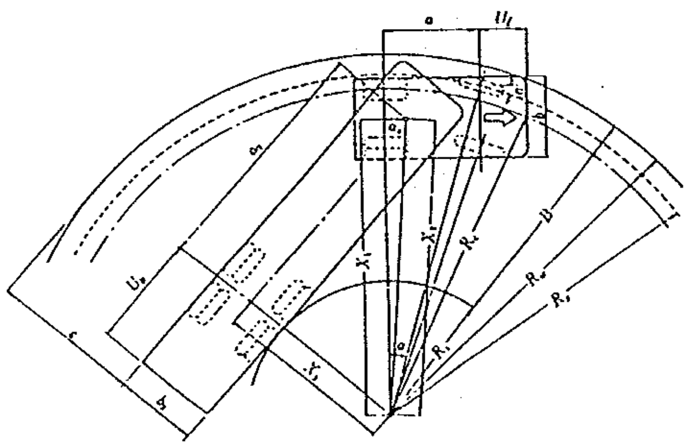
Note 1) As shown below, the width carriageway and lateral clearance is greater than the minimum off set distance.

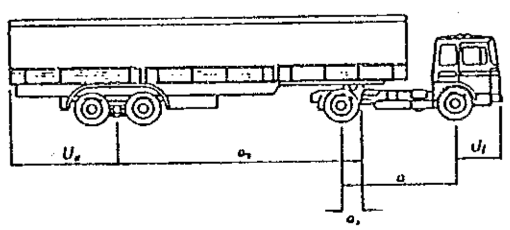


2-9 WIDENING OF CARRIAGEWAY AT SMALL HORIZONTAL CURVE

The carriageway widthis compared with the necessary width for the semi-Trailer at the smallest horizontal curve.

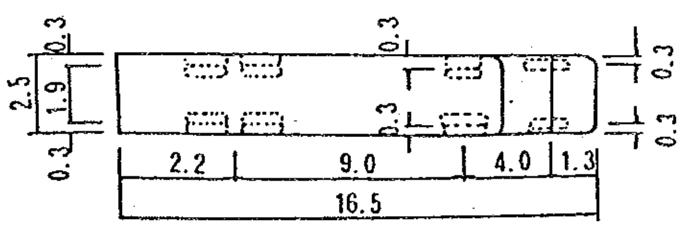
SEMI TRAILER





B = Necessary Width
Rc = Radius of Center line
Rw = Radius of Outer line
Rs = Radius of Front Wheel

$a = 4.0$ m	$b = b_2 = 2.5$ m
$b = b_2 = 2.5$ m	$a_2 = 9.0$ m
$a_2 = 9.0$ m	$a_o = 0$ m
$Uf = 1.3$ m	$U_B = 2.2$ m



Derivation of Formula of Necessary Width on Curve

The following equations are found from the figure:

$$B = R_w - R_1 \quad \cdots\cdots \quad (1)$$

$$(X_1 + b/2)^2 = R_w^2 - (a + U_f)^2$$

$$X_2^2 = a_o^2 + X_1^2$$

$$X_3^2 = X_2^2 - a_2^2 = X_1^2 + a_o^2 - a_2^2$$

$$B = R_w - X_3 + b_2/2 = R_w + b_2/2 - \sqrt{\{\sqrt{R_w^2 - (a+U_f)^2} - b/2\}^2 - a_2^2 + a_o^2} \quad \cdots \quad (2)$$

$$X_1^2 + (a + U_f)^2 = R_c^2 \quad \cdots\cdots \quad (3)$$

From equations (1) and (3),the following equation is derived:

$$R_w = \sqrt{\{\sqrt{R_c^2 - (a+U_f)^2} + b/2\}^2 + (a+U_f)^2}$$

Combining equation (2) and adove,the following eqution in derived:

$$B = \sqrt{\{\sqrt{R_c^2 - (a+U_f)^2} + b/2\} + (a+U_f)^2} + b_2/2 - \sqrt{R_c^2 - (a+U_f)^2 - a_2^2 + a_o^2}$$

The dimensions of the semi trailer are:

$a=4.0,\ b=b_2=2.5,\ U_f=1.3,\ a_2=9.0,\ a_o=0$

Substituting the dimensions of the semi trailer into the equation the following formula is obtained:

$$B = R_w + 1.25 - \sqrt{R_c^2 - 109.09}$$

Where,

$$R_w = \sqrt{(\sqrt{R_c^2 - 28.09} + 1.25)^2 + 28.09}$$

The necessary width calculated by the above formula is smaller than the carriageway width.

Therefore widening is not necessary.

In the case of R=200

R_w = 200 m

$$B = R_w + 1.25 - \sqrt{R_c^2 - 109.09}$$

$$= 200 + 1.25 - \sqrt{198.375^2 - 109.09}$$

$$= 3.15 < 3.25 \text{ m}$$