6.2 Project Cost and Maintenance Cost

6.2.1 Summary of Project Cost

Based on the quantity of input by work and its unit cost described in the latter part of this Section, the project cost was estimated by construction section as shown in Section 5.1.1 and then summed up to the total cost. The total project cost is shown in Table 6.2-1 and the construction cost of each section is shown in Tables 6.2-2(1) to 6.2-2(6). In addition, the project cost was estimated for the asphalt surface roads and the gravel surface road. The direct construction cost of bridges is shown in Table 6.2-3(1) and Table 6.2-3(2).

Table 6.2-1 Total Project Cost
(L=108.63km)

Items		Cost	Unit	Quantity	Unit Cost (US$) L.C Duties	Unit Cost (US$) L.C Others	Unit Cost (US$) F.C	Cost (1000US$) L.C Duties	Cost (1000US$) L.C Others	Cost (1000US$) L.C SubTotal	Cost (1000US$) F.C	Cost (1000US$) Total	Ratio
Earth Work	Clearing and Grubbing		ha	182.49	2789	2599	9460	509	474	983	1726	2709	
	Excavation A		m³	1596994	1.4	1.03	2.67	2236	1645	3881	4264	8145	
	Excavation B		m³	8684325	1.42	1.38	4.72	12332	11984	24316	40990	65306	
	Finished Rolling of Subgrade		m²	1085401	0.01	0.02	0.04	11	22	33	43	76	
	Slope	Seed Spraying	m²	233246	0.13	1.13		30	264	294	0	294	
		Concrete Spraying	m²	95455	3.29	11.97	7.59	314	1143	1457	725	2182	
		Cribworks	m²	11544	6.95	24.58	15.71	80	284	364	181	545	
		Concrete Pitching	m²	2210	5.15	13.68	13.12	11	30	41	29	70	
	Retaining Wall	Gravity(4m)	m	50	35.21	224.54	50.02	2	11	13	3	16	
		Stone Masonry	m²	24754	4.12	27.66	4.69	102	685	787	116	903	
		Grid Type	m²	45260	17.07	67.07	30.87	773	3036	3809	1397	5206	
	Culvert	Box 3.0×3.0	m	375	202	488	523	76	183	259	196	455	
		Box 4.0×4.0	m	45	282	696	730	13	31	44	33	77	
		Pipe φ1.0	m	8560	17.58	131.21	12.43	150	1123	1273	106	1379	
	Disaster	Catch Netting	m²	3840	2	1.59	5.95	8	6	14	23	37	
		Gabion	m	144	11.56	25.22	29.94	2	4	6	4	10	
		Catch Fence	m	147	20.48	39.02	53.3	3	6	9	8	17	
		Gabion Dam	m³	11154	12.78	28.54	35.45	143	318	461	395	856	
		Shed	m	62	1565	2904	4445	97	180	277	276	553	
		French Drain	m	1010	3.54	7.63	10.44	4	8	12	11	23	
	Drainage		km	107.1	4530	29637	5826	485	3174	3659	624	4283	
Pavement	Subbase Course		m²	1065264	0.36	0.3	1.28	383	320	703	1364	2067	
	Base Course		m²	1025095	0.74	1.17	2.4	759	1199	1958	2460	4418	
	Binder Course		m²	996281	1.08	0.93	3.67	1076	927	2003	3656	5659	
	Surface Course		m²	979571	1.28	0.88	4.04	1254	862	2116	3957	6073	
Bridge	L≧50m		Set					387	602	989	1124	2113	
	L<50m		Set					254	474	728	741	1469	
Tunnel	Lining		m	120	1022	3180	2713	123	382	505	326	831	
	Unsupported		m	625	751	2076	2038	469	1298	1767	1274	3041	
	Portal		Pcs	4	2827	9317	7176	11	37	48	29	77	
Others	Gard Rail		km	107.1	5917	1762	14069	634	189	823	1507	2330	
	Marking & Traffic Sign		km	107.1	47.5	427.5		5	46	51	0	51	
Direct Construction Cost				(D)				22736	30947	53683	67588	121271	
General Expenses				(G=Dx25%)				5684	7737	13421	16897	30318	
Total				(C=D+G)				28420	38684	67104	84485	151589	1395/Km
Engineering Cost				(E=Cx6.5%) L.C=40%, F.C=60%				394	3547	3941	5912	9853	
Administration Cost				(A=C.TOTALx1.5%, D=Ax0.1, O=Ax0.9)				227	2047	2274	0	2274	
Land Acquisition & Compensation Cost				(I)				0	146	146	0	146	
Contingencies				(F=(C+E+A)x15%)				4356	6642	10998	13560	24558	
Project Costs	within Duties			(C+E+A+I+F)				33397	51066	84463	103957	188420	1735/Km
	without Duties								51066	51066	103957	155023	1427/Km

Table 6.2-2(1) Project Cost for Each Sub-Section
(Sub-Section 1, No. 0+00 - No. 25+300 L=25.30km)

Items			Unit	Quantity	Unit Cost (US$) L.C Duties	Unit Cost (US$) L.C Others	Unit Cost (US$) F.C	Cost (1000US$) L.C Duties	Cost (1000US$) L.C Others	Cost (1000US$) L.C SubTotal	Cost (1000US$) F.C	Cost (1000US$) Total	Ratio
Earth Work	Clearing and Grubbing		ha	48.13	2789	2599	9460	134	125	259	455	714	
	Excavation A		m³	120489	1.4	1.03	2.67	169	124	293	322	615	
	Excavation B		m³	2745026	1.42	1.38	4.72	3898	3788	7686	12957	20643	
	Finished Rolling of Subgrade		m²	253756	0.01	0.02	0.04	3	5	8	10	18	
	Slope	Seed Spraying	m²	20527	0.13	1.13		3	23	26	0	26	
		Concrete Spraying	m²	18184	3.29	11.97	7.59	60	218	278	138	416	
		Cribworks	m²	2627	6.95	24.58	15.71	18	65	83	41	124	
		Concrete Pitching	m²		5.15	13.68	13.12	0	0	0	0	0	
	Retaining Wall	Gravity(4m)	m	50	35.21	224.54	50.02	2	11	13	3	16	
		Stone Masonry	m²	2947	4.12	27.66	4.69	12	82	94	14	108	
		Grid Type	m²	6206	17.07	67.07	30.87	106	416	522	192	714	
	Culvert	Box 3.0×3.0	m	50	202	488	523	10	24	34	26	60	
		Box 4.0×4.0	m	35	282	696	730	10	24	34	26	60	
		Pipe φ1.0	m	1997	17.58	131.21	12.43	35	262	297	25	322	
	Disaster	Catch Netting	m²		2	1.59	5.95	0	0	0	0	0	
		Gabion	m		11.56	25.22	29.94	0	0	0	0	0	
		Catch Fence	m	51	20.48	39.02	53.3	1	2	3	3	6	
		Gabion Dam	m³		12.78	28.54	35.45	0	0	0	0	0	
		Shed	m		1565	2904	4445	0	0	0	0	0	
		French Drain	m		3.54	7.63	10.44	0	0	0	0	0	
	Drainage		km	25	4530	29637	5826	113	741	854	146	1000	
Pavement	Subbase Course		m²	249048	0.36	0.3	1.28	90	75	165	319	484	
	Base Course		m²	239657	0.74	1.17	2.4	177	280	457	575	1032	
	Binder Course		m²	232917	1.08	0.93	3.67	252	217	469	855	1324	
	Surface Course		m²	229010	1.28	0.88	4.04	293	202	495	925	1420	
Bridge	L≧50m		Set					215	297	512	625	1137	
	L<50m		Set					108	203	311	316	627	
Tunnel	Lining		m		1022	3180	2713	0	0	0	0	0	
	Unsupported		m		751	2076	2038	0	0	0	0	0	
	Portal		Pcs		2827	9317	7176	0	0	0	0	0	
Others	Gard Rail		km	25	5917	1762	14069	148	44	192	352	544	
	Marking & Traffic Sign		km	25	47.5	427.5		1	11	12	0	12	
Direct Construction Cost				(D)				5858	7239	13097	18325	31422	
General Expenses				(G=Dx25%)				1465	1810	3275	4581	7856	
Total				(C=D+G)				7323	9049	16372	22906	39278	1553/Km
Engineering Cost				(E=Cx6.5%) L.C=40%, F.C=60%				102	919	1021	1532	2553	
Administration Cost				(A=C.TOTALx1.5%, D=Ax0.1, O=Ax0.9)				59	530	589	0	589	
Land Acquisition & Compensation Cost				(I)				0	55	55	0	55	
Contingencies				(F=(C+E+A)x15%)				1123	1575	2698	3666	6364	
Project Costs	within Duties			(C+E+A+I+F)				8607	12128	20735	28104	48839	1930/Km
	without Duties								12128	12128	28104	40232	1590/Km

Table 6.2-2(2) Project Cost for Each Sub-Section
(Sub-Section 2, No. 25+300 - No. 46+760 L=21.46km)

Items	Cost		Unit	Quantity	Unit Cost (US$) L.C Duties	Unit Cost (US$) L.C Others	Unit Cost (US$) F.C	Cost (1000US$) L.C Duties	Cost (1000US$) L.C Others	Cost (1000US$) L.C SubTotal	Cost (1000US$) F.C	Cost (1000US$) Total	Ratio
Earth Work	Clearing and Grubbing		ha	38.38	2789	2599	9460	107	100	207	363	570	
	Excavation A		m³	143289	1.4	1.03	2.67	201	148	349	383	732	
	Excavation B		m³	2483795	1.42	1.38	4.72	3527	3428	6955	11724	18679	
	Finished Rolling of Subgrade		m²	208162	0.01	0.02	0.04	2	4	6	8	14	
	Slope	Seed Spraying	m²	15104	0.13	1.13		2	17	19	0	19	
		Concrete Spraying	m²	37113	3.29	11.97	7.59	122	444	566	282	848	
		Cribworks	m²	3737	6.95	24.58	15.71	26	92	118	59	177	
		Concrete Pitching	m²		5.15	13.68	13.12	0	0	0	0	0	
	Retaining Wall	Gravity(4m)	m		35.21	224.54	50.02	0	0	0	0	0	
		Stone Masonry	m²	1230	4.12	27.66	4.69	5	34	39	6	45	
		Grid Type	m²	5222	17.07	67.07	30.87	89	350	439	161	600	
	Culvert	Box 3.0×3.0	m	50	202	488	523	10	24	34	26	60	
		Box 4.0×4.0	m	10	282	696	730	3	7	10	7	17	
		Pipe φ1.0	m	1643	17.58	131.21	12.43	29	216	245	20	265	
	Disaster	Catch Netting	m²	800	2	1.59	5.95	2	1	3	5	8	
		Gabion	m	42	11.56	25.22	29.94	0	1	1	1	2	
		Catch Fence	m	42	20.48	39.02	53.3	1	2	3	2	5	
		Gabion Dam	m³		12.78	28.54	35.45	0	0	0	0	0	
		Shed	m	62	1565	2904	4445	97	180	277	276	553	
		French Drain	m		3.54	7.63	10.44	0	0	0	0	0	
	Drainage		km	20.5	4530	29637	5826	93	608	701	119	820	
Pavement	Subbase Course		m²	204300	0.36	0.3	1.28	74	61	135	262	397	
	Base Course		m²	196596	0.74	1.17	2.4	145	230	375	472	847	
	Binder Course		m²	191071	1.08	0.93	3.67	206	178	384	701	1085	
	Surface Course		m²	187867	1.28	0.88	4.04	240	165	405	759	1164	
Bridge	L≧50m		Set					55	107	162	153	315	
	L<50m		Set					87	158	245	255	500	
Tunnel	Lining		m	120	1022	3180	2713	123	382	505	326	831	
	Unsupported		m	625	751	2076	2038	469	1298	1767	1274	3041	
	Portal		Pcs	4	2827	9317	7176	11	37	48	29	77	
Others	Card Rail		km	20.5	5917	1762	14069	121	36	157	288	445	
	Marking & Traffic Sign		km		47.5	427.5		0	0	0	0	0	
Direct Construction Cost				(D)				5847	8308	14155	17961	32116	
General Expenses				(G=Dx25%)				1462	2077	3539	4490	8029	
Total				(C=D+G)				7309	10385	17694	22451	40145	1871/Km
Engineering Cost				(E=Cx6.5%) L.C=40%, F.C=60%				104	940	1044	1565	2609	
Administration Cost				(A=C.TOTALx1.5%, D=Ax0.1, O=Ax0.9)				60	542	602	0	602	
Land Acquisition & Compensation Cost				(I)				0	36	36	0	36	
Contingencies				(F=(C+E+A)x15%)				1121	1780	2901	3602	6503	
Project Costs	within Duties			(C+E+A+I+F)				8594	13683	22277	27618	49895	2325/Km
	without Duties								13683	13683	27618	41301	1925/Km

Table 6.2-2(3) Project Cost for Each Sub-Section
(Sub-Section 3, No. 46+760 - No. 60+000 L=20.24km)

Items		Cost	Unit	Quantity	Unit Cost (US$) L.C Duties	Unit Cost (US$) L.C Others	Unit Cost (US$) F.C	Cost (1000US$) L.C Duties	Cost (1000US$) L.C Others	Cost (1000US$) L.C SubTotal	Cost (1000US$) F.C	Cost (1000US$) Total	Ratio
Earth Work	Clearing and Grubbing		ha	20.85	2789	2599	9460	58	54	112	197	309	
	Excavation A		m^3	319514	1.4	1.03	2.67	447	329	776	853	1629	
	Excavation B		m^3	514153	1.42	1.38	4.72	730	710	1440	2427	3867	
	Finished Rolling of Subgrade		m^2	132327	0.01	0.02	0.04	1	3	4	5	9	
	Slope	Seed Spraying	m^2	41430	0.13	1.13		5	47	52	0	52	
		Concrete Spraying	m^2	6660	3.29	11.97	7.59	22	80	102	51	153	
		Cribworks	m^2	890	6.95	24.58	15.71	6	22	28	14	42	
		Concrete Pitching	m^2	400	5.15	13.68	13.12	2	5	7	5	12	
	Retaining Wall	Gravity(4m)	m		35.21	224.54	50.02	0	0	0	0	0	
		Stone Masonry	m^2	14373	4.12	27.66	4.69	59	398	457	67	524	
		Grid Type	m^2	2343	17.07	67.07	30.87	40	157	197	72	269	
	Culvert	Box 3.0×3.0	m	75	202	488	523	15	37	52	39	91	
		Box 4.0×4.0	m		282	696	730	0	0	0	0	0	
		Pipe φ1.0	m	1045	17.58	131.21	12.43	18	137	155	13	168	
	Disaster	Catch Netting	m^2		2	1.59	5.95	0	0	0	0	0	
		Gabion	m		11.56	25.22	29.94	0	0	0	0	0	
		Catch Fence	m		20.48	39.02	53.3	0	0	0	0	0	
		Gabion Dam	m^3	3764	12.78	28.54	35.45	48	107	155	133	288	
		Shed	m		1565	2904	4445	0	0	0	0	0	
		French Drain	m		3.54	7.63	10.44	0	0	0	0	0	
	Drainage		km	13.1	4530	29637	5826	59	388	447	76	523	
Pavement	Subbase Course		m^2	129872	0.36	0.3	1.28	47	39	86	166	252	
	Base Course		m^2	124975	0.74	1.17	2.4	92	146	238	300	538	
	Binder Course		m^2	121463	1.08	0.93	3.67	131	113	244	446	690	
	Surface Course		m^2	119426	1.28	0.88	4.04	153	105	258	482	740	
Bridge	L≧50m		Scl					0	0	0	0	0	
	L<50m		Scl					0	0	0	0	0	
Tunnel	Lining		m		1022	3180	2713	0	0	0	0	0	
	Unsupported		m		751	2076	2038	0	0	0	0	0	
	Portal		Pcs		2827	9317	7176	0	0	0	0	0	
Others	Gard Rail		km	13.1	5917	1762	14069	78	23	101	184	285	
	Marking & Traffic Sign		km	13.1	47.5	427.5		1	6	7	0	7	
Direct Construction Cost				(D)				2012	2906	4918	5530	10448	
General Expenses				(G=Dx25%)				503	727	1230	1383	2613	
Total				(C=D+G)				2515	3633	6148	6913	13061	986/Km
Engineering Cost				(E=Cx6.5%) L.C=40%, F.C=60%				34	306	340	509	849	
Administration Cost				(A=C.TOTALx1.5%, D=Ax0.1, O=Ax0.9)				20	176	196	0	196	
Land Acquisition & Compensation Cost				(I)				0	22	22	0	22	
Contingencies				(F=(C+E+A)x15%)				385	617	1002	1113	2115	
Project Costs		within Duties		(C+E+A+I+F)				2954	4754	7708	8535	16243	1227/Km
		without Duties							4754	4754	8535	13289	1004/Km

Table 6.2-2(4) Project Cost for Each Sub-Section
(Sub-Section 4, No. 60+000 - No. 79+550 L=19.55km)

Items		Cost	Unit	Quantity	Unit Cost (US$) L.C Duties	Unit Cost (US$) L.C Others	Unit Cost (US$) F.C	Cost (1000US$) L.C Duties	Cost (1000US$) L.C Others	Cost (1000US$) L.C SubTotal	Cost (1000US$) F.C	Cost (1000US$) Total	Ratio
Earth Work	Clearing and Grubbing		ha	30.3	2789	2599	9460	85	79	164	287	451	
	Excavation A		m³	204155	1.4	1.03	2.67	286	210	496	545	1041	
	Excavation B		m³	1078869	1.42	1.38	4.72	1532	1489	3021	5092	8113	
	Finished Rolling of Subgrade		m²	196742	0.01	0.02	0.04	2	4	6	8	14	
	Slope	Seed Spraying	m²	55703	0.13	1.13		7	63	70	0	70	
		Concrete Spraying	m²	24475	3.29	11.97	7.59	81	293	374	186	560	
		Cribworks	m²	2500	6.95	24.58	15.71	17	61	78	39	117	
		Concrete Pitching	m²	1810	5.15	13.68	13.12	9	25	34	24	58	
	Retaining Wall	Gravity(4m)	m		35.21	224.54	50.02	0	0	0	0	0	
		Stone Masonry	m²	2623	4.12	27.66	4.69	11	73	84	12	96	
		Grid Type	m²	3573	17.07	67.07	30.87	61	240	301	110	411	
	Culvert	Box 3.0×3.0	m	40	202	488	523	8	20	28	21	49	
		Box 4.0×4.0	m		282	696	730	0	0	0	0	0	
		Pipe φ1.0	m	1553	17.58	131.21	12.43	27	204	231	19	250	
	Disaster	Catch Netting	m²	2000	2	1.59	5.95	4	3	7	12	19	
		Gabion	m	102	11.56	25.22	29.94	1	3	4	3	7	
		Catch Fence	m		20.48	39.02	53.3	0	0	0	0	0	
		Gabion Dam	m³	5211	12.78	28.54	35.45	67	149	216	185	401	
		Shed	m		1565	2904	4445	0	0	0	0	0	
		French Drain	m		3.54	7.63	10.44	0	0	0	0	0	
	Drainage		km	19.4	4530	29637	5826	88	575	663	113	776	
Pavement	Subbase Course		m²	193092	0.36	0.3	1.28	70	58	128	247	375	
	Base Course		m²	185811	0.74	1.17	2.4	138	217	355	446	801	
	Binder Course		m²	180589	1.08	0.93	3.67	195	168	363	663	1026	
	Surface Course		m²	177550	1.28	0.88	4.04	227	156	383	717	1100	
Bridge	L≧50m		Set					117	198	315	346	661	
	L<50m		Set					36	78	114	99	213	
Tunnel	Lining		m		1022	3180	2713	0	0	0	0	0	
	Unsupported		m		751	2076	2038	0	0	0	0	0	
	Portal		Pcs		2827	9317	7176	0	0	0	0	0	
Others	Gard Rail		km	19.4	5917	1762	14069	115	34	149	273	422	
	Marking & Traffic Sign		km	19.4	47.5	427.5		1	8	9	0	9	
Direct Construction Cost				(D)				3185	4408	7593	9447	17040	
General Expenses				(G=Dx25%)				796	1102	1898	2362	4260	
Total				(C=D+G)				3981	5510	9491	11809	21300	1090/Km
Engineering Cost				(E=Cx6.5%) L.C=40%, F.C=60%				55	499	554	831	1385	
Administration Cost				(A=C.TOTALx1.5%, D=Ax0.1, O=Ax0.9)				32	288	320	0	320	
Land Acquisition & Compensation Cost				(I)				0	26	26	0	26	
Contingencies				(F=(C+E+A)x15%)				610	945	1555	1896	3451	
Project Costs		within Duties		(C+E+A+I+F)				4678	7268	11946	14536	26482	1355/Km
		without Duties							7268	7268	14536	21804	1115/Km

Table 6.2-2(5) Project Cost for Each Sub-Section
(Sub-Section 5, No.79+550 - No.101+300 L=21.75km)

Items			Unit	Quantity	Unit Cost (US$) L.C Duties	Unit Cost (US$) L.C Others	Unit Cost (US$) F.C	Cost (1000US$) L.C Duties	Cost (1000US$) L.C Others	Cost (1000US$) L.C SubTotal	Cost (1000US$) F.C	Cost (1000US$) Total	Ratio
Earth Work	Clearing and Grubbing		ha	36.85	2789	2599	9460	103	96	199	349	548	
	Excavation A		m³	642126	1.4	1.03	2.67	899	661	1560	1714	3274	
	Excavation B		m³	1662497	1.42	1.38	4.72	2361	2294	4655	7847	12502	
	Finished Rolling of Subgrade		m²	220139	0.01	0.02	0.04	2	4	6	9	15	
	Slope	Seed Spraying	m²	75375	0.13	1.13		10	85	95	0	95	
		Concrete Spraying	m²	8229	3.29	11.97	7.59	27	99	126	62	188	
		Cribworks	m²	1790	6.95	24.58	15.71	12	44	56	28	84	
		Concrete Pitching	m²		5.15	13.68	13.12	0	0	0	0	0	
	Retaining Wall	Gravity(4m)	m		35.21	224.54	50.02	0	0	0	0	0	
		Stone Masonry	m²	2869	4.12	27.66	4.69	12	79	91	13	104	
		Grid Type	m²	26304	17.07	67.07	30.87	449	1764	2213	812	3025	
	Culvert	Box 3.0×3.0	m	160	202	488	523	32	78	110	84	194	
		Box 4.0×4.0	m		282	696	730	0	0	0	0	0	
		Pipe φ1.0	m	1738	17.58	131.21	12.43	31	228	259	22	281	
	Disaster	Catch Netting	m²	1040	2	1.59	5.95	2	2	4	6	10	
		Gabion	m		11.56	25.22	29.94	0	0	0	0	0	
		Catch Fence	m	54	20.48	39.02	53.3	1	2	3	3	6	
		Gabion Dam	m³		12.78	28.54	35.45	0	0	0	0	0	
		Shed	m		1565	2904	4445	0	0	0	0	0	
		French Drain	m		3.54	7.63	10.44	0	0	0	0	0	
	Drainage		km	21.7	4530	29637	5826	98	643	741	126	867	
Pavement	Subbase Course		m²	216055	0.36	0.3	1.28	78	65	143	277	420	
	Base Course		m²	207908	0.74	1.17	2.4	154	243	397	499	896	
	Binder Course		m²	202065	1.08	0.93	3.67	218	188	406	742	1148	
	Surface Course		m²	198675	1.28	0.88	4.04	254	175	429	803	1232	
Bridge	L≧50m		Set					0	0	0	0	0	
	L<50m		Set					23	35	58	71	129	
Tunnel	Lining		m		1022	3180	2713	0	0	0	0	0	
	Unsupported		m		751	2076	2038	0	0	0	0	0	
	Portal		Pcs		2827	9317	7176	0	0	0	0	0	
Others	Gard Rail		km	21.7	5917	1762	14069	128	38	166	305	471	
	Marking & Traffic Sign		km	21.7	47.5	427.5		1	9	10	0	10	
Direct Construction Cost				(D)				4895	6832	11727	13772	25499	
General Expenses				(G=Dx25%)				1224	1708	2932	3443	6375	
Total				(C=D+G)				6119	8540	14659	17215	31874	1465/Km
Engineering Cost				(E=Cx6.5%) L.C=40%, F.C=60%				83	746	829	1243	2072	
Administration Cost				(A=C.TOTALx1.5%, D=Ax0.1, O=Ax0.9)				48	430	478	0	478	
Land Acquisition & Compensation Cost				(I)				0	2	2	0	2	
Contingencies				(F=(C+E+A)x15%)				938	1457	2395	2769	5164	
Project Costs		within Duties		(C+E+A+I+F)				7188	11175	18363	21227	39590	1820/Km
		without Duties							11175	11175	21227	32402	1490/Km

Table 6.2-2(6) Project Cost for Each Sub-Section
(Sub-Section 6, No. 101+300 - No. 108+630 L=7.33km)

Items		Cost	Unit	Quantity	Unit Cost (US$)			Cost (1000US$)					Ratio
					L.C		F.C	L.C			F.C	Total	
					Duties	Others		Duties	Others	SubTotal			
Earth Work	Clearing and Grubbing		ha	7.98	2789	2599	9460	22	21	43	75	118	
	Excavation A		m³	167421	1.4	1.03	2.67	234	172	406	447	853	
	Excavation B		m³	199985	1.42	1.38	4.72	284	276	560	944	1504	
	Finished Rolling of Subgrade		m²	74275	0.01	0.02	0.04	1	1	2	3	5	
	Slope	Seed Spraying	m²	25107	0.13	1.13		3	28	31	0	31	
		Concrete Spraying	m²	794	3.29	11.97	7.59	3	10	13	6	19	
		Cribworks	m²		6.95	24.58	15.71	0	0	0	0	0	
		Concrete Pitching	m²		5.15	13.68	13.12	0	0	0	0	0	
	Retaining Wall	Gravity(4m)	m		35.21	224.54	50.02	0	0	0	0	0	
		Stone Masonry	m²	712	4.12	27.66	4.69	3	20	23	3	26	
		Grid Type	m²	1612	17.07	67.07	30.87	28	108	136	50	186	
	Culvert	Box 3.0×3.0	m		202	488	523	0	0	0	0	0	
		Box 4.0×4.0	m		282	696	730	0	0	0	0	0	
		Pipe φ1.0	m	584	17.58	131.21	12.43	10	77	87	7	94	
	Disaster	Catch Netting	m²		2	1.59	5.95	0	0	0	0	0	
		Gabion	m		11.56	25.22	29.94	0	0	0	0	0	
		Catch Fence	m		20.48	39.02	53.3	0	0	0	0	0	
		Gabion Dam	m³	2179	12.78	28.54	35.45	28	62	90	77	167	
		Shed	m		1565	2904	4445	0	0	0	0	0	
		French Drain	m	1010	3.54	7.63	10.44	4	8	12	11	23	
	Drainage		km	7.4	4530	29637	5826	34	219	253	43	296	
Pavement	Subbase Course		m²	72897	0.36	0.3	1.28	26	22	48	93	141	
	Base Course		m²	70148	0.74	1.17	2.4	52	82	134	168	302	
	Binder Course		m²	68176	1.08	0.93	3.67	74	63	137	250	387	
	Surface Course		m²	67033	1.28	0.88	4.04	86	59	145	271	416	
Bridge	L≧50m		Sct					0	0	0	0	0	
	L<50m		Sct					0	0	0	0	0	
Tunnel	Lining		m		1022	3180	2713	0	0	0	0	0	
	Unsupported		m		751	2076	2038	0	0	0	0	0	
	Portal		Pcs		2827	9317	7176	0	0	0	0	0	
Others	Gard Rail		km	7.4	5917	1762	14069	44	13	57	104	161	
	Marking & Traffic Sign		km		47.5	427.5		0	0	0	0	0	
Direct Construction Cost				(D)				936	1241	2177	2552	4729	
General Expenses				(G=Dx25%)				234	310	544	638	1182	
Total				(C=D+G)				1170	1551	2721	3190	5911	806/Km
Engineering Cost				(E=Cx6.5%) L.C=40%, F.C=60%				15	139	154	230	384	
Administration Cost				(A=C.TOTALx1.5%, D=Ax0.1, O=Ax0.9)				9	80	89	0	89	
Land Acquisition & Compensation Cost				(I)				0	5	5	0	5	
Contingencies				(F=(C+E+A)x15%)				179	266	445	513	958	
Project Costs	within Duties			(C+E+A+I+F)				1373	2041	3414	3933	7347	1002/Km
	without Duties								2041	2041	3933	5974	815/Km

Table 6.2-3(1) Direct Construction Cost of Bridges

Unit : $

Name of Bridges		L. C.		F. C.	Total
		Duties	Others		
Point A Br.	ℓ = 132.5m	215313	296855	624590	1136758
Putini Br.	ℓ = 40.0m	29482	62576	84723	176781
Challa Br.	ℓ = 20.0m	16126	32476	45374	93976
Cascada Br.	ℓ = 18.0m	12850	27484	35272	75606
Alto Choro Br.	ℓ = 50.0m	50155	79609	151110	280874
Pto Leon Br.	ℓ = 75.0m	54932	107137	152700	314769
Cajones Br.	ℓ = 25.0m	18337	36256	52061	106654
Chojna Br.	ℓ = 22.0m	14020	27763	39109	80892
San Silverio Br.	ℓ = 50.0m	55234	93914	163853	313001
San Lorenzo Br.	ℓ = 52.0m	58618	98708	173469	330795
Espiritu Br.	ℓ = 52.0m	58231	98680	172688	329599
Carrasco Br.	ℓ = 30.0m	36275	78285	98843	213403
Avaroa Br.	ℓ = 25.0m	23232	34578	71059	128869
Total		642805	1074321	1864851	3581977

note
Spr.S : Superstructure
Sub.S : Substructure
I : PCI-compsite Girder
B : Box Girder
A : Abutment
P : Pier

Table 6.2-3 (2) Direct Construction Cost of Bridges

1. Unit : $

Name of Bridges		L. C. Duties	L. C. Others	F. C.	Total
Point A Br.	Spr.S (B)	174074	195257	516789	886120
	Sub.S (A)	4125	12273	10146	26544
(ℓ=132.5m)	(P)	37114	89325	97655	224094
	Subtotal	215313	296855	624590	1136758
Putini Br.	Spr.S (B)	21502	34974	62124	118600
	Sub.S (A)	4612	18446	14121	37179
(ℓ= 40.0m)	(P)	3368	9156	8478	21002
	Subtotal	29482	62576	84723	176781
Challa Br.	Spr.S (I)	10839	17006	31660	59505
	Sub.S (A)	5287	15470	13714	34471
(ℓ= 20.0m)	Subtotal	16126	32476	45374	93976
Cascada Br.	Spr.S (I)	8877	14953	25813	49643
	Sub.S (A)	3973	12531	9459	25963
(ℓ= 18.0m)	Subtotal	12850	27484	35272	75606
Alto Choro	Spr.S (B)	41236	53891	128976	224103
Br.	Sub.S (A)	5930	17769	14547	38246
(ℓ= 50.0m)	(P)	2989	7949	7587	18525
	Subtotal	50155	79609	151110	280874
Pto Leon Br.	Spr.S (B)	40733	65842	117659	224234
	Sub.S (A)	8169	24891	19871	52931
(ℓ= 75.0m)	(P)	6030	16404	15170	37604
	Subtotal	54932	107137	152700	314769
Cajones Br.	Spr.S (I)	13612	21701	39678	74991
	Sub.S (A)	4725	14555	12383	31663
(ℓ= 25.0m)	Subtotal	18337	36256	52061	106654
Chojna Br.	Spr.S (I)	9528	15165	27768	52461
	Sub.S (A)	4492	12598	11341	28431
(ℓ= 22.0m)	Subtotal	14020	27763	39109	80892
San Silverio	Spr.S (B)	41236	53891	128976	224103
Br.	Sub.S (A)	9740	28516	24135	62391
(ℓ= 50.0m)	(P)	4258	11507	10742	26507
	Subtotal	55234	93914	163853	313001
San Lorenzo	Spr.S (B)	43347	56709	135550	235606
Br.	Sub.S (A)	7669	23526	18614	49809
(ℓ= 52.0m)	(P)	7602	18473	19305	45380
	Subtotal	58618	98708	173469	330795

2. Unit : $

Name of Bridges		L. C.		F. C.	Total
		Duties	Others		
Espiritu Br.	Spr.S (B)	43347	56709	135550	235606
	Sub.S (A)	6245	19416	15069	40730
(ℓ = 52.0m)	(P)	8639	22555	22069	53263
	Subtotal	58231	98680	172688	329599
Carrasco Br.	Spr.S (I)	21917	34423	64125	120465
	Sub.S (A)	14358	43862	34718	92938
(ℓ = 30.0m)	Subtotal	36275	78285	98843	213403
Avaroa Br.	Spr.S (I)	20878	27006	65476	113360
	Sub.S (A)	2354	7572	5583	15509
(ℓ = 25.0m)	Subtotal	23232	34578	71059	128869

note Spr.S : Superstructure
Sub.S : Substructure
I : PCI-compsite Girder
B : Box Girder
A : Abutment
P : Pier

6.2.2 Maintenance Cost

The maintenance cost required after the completion of the project was estimated on the basis of works mentioned in Section 5.5. Table 6.2-4 summarized this maintenance cost. The detailed cost estimation process is shown in Appendix-6-4.

Table 6.2-4 Maintenance Cost
(Thousand Dollars in 1990 Price)

(Unit:1000US$)

	Gravel Road Maintenance				Asphalt Road Maintenance				Macadam Road Maintenance			
Year	L.C		F.C	Total	L.C		F.C	Total	L.C		F.C	Total
	C.D	Other			C.D	Other			C.D	Other		
1st Year	63	124	191	378	26	84	63	173	53	84	140	320
				(315)				(147)				(267)
2nd Year	63	124	191	378	26	84	63	173	53	127	140	320
				(315)				(147)				(267)
3rd Year	63	124	191	378	26	84	63	173	53	127	140	320
				(315)				(147)				(267)
4th Year	127	247	381	755	26	84	63	173	106	254	280	640
				(628)				(147)				(534)
5th Year	127	247	381	755	26	84	63	173	106	254	280	640
				(628)				(147)				(534)
6th Year	127	247	381	755	53	168	126	347	106	254	280	640
				(628)				(294)				(534)
7th Year	127	247	381	755	53	168	126	347	106	254	280	640
				(628)				(294)				(534)
:	:	:	:	:	:	:	:	:	:	:	:	:

Note: ( ): without duties

6.2.3 Quantities

Based on the preliminary design, the construction quantities are estimated as shown in Tables 6.2-1 and 6.2-2. The detailed estimation is shown in Appendix 6-1.

6.2.4 Unit Cost

Through the discussion with SNC, the unit cost was determined to be represented in terms of 1990 price.

The unit cost was divided into three categories, that is, local currencies, foreign currencies and tax. The local currencies consist of the following items:

a) Construction materials produced in Bolivia such as cement, concrete block, oil, paints and wooden materials.
b) Personal expenses of local persons.
c) Land acquisition cost and compensation.
d) Taxies.

The remained part of the cost is foreign currencies.

The following tax ratio was applied for excluding tax from the project cost.

a) Imported construction equipments ; 26.3%
b) Imported construction materials ; 33.3%
c) Local construction materials ; 10.0%

The unit cost by working item is shown in Table 6.2-1. Materials and works involved in working item is shown in Table 6.2-4.

Table 6.2-5 Main Materials and Works Included in Unit Cost

Work Items		Unit	Material and Works
Clearing & Gruffing		ha	Cleaning and gruffing (t=30cm) Waste soil transport (L=2.0km)
Excavation A		m^3	Excavation, transportation(distance=2km), spreading and compaction for embankment. Unit price is the weighted average by expected excavation volume of common soil, soft rock and hard rock.
Excavation B		m^3	Excavation, transportation (distance=1km) to spoilbank and disposing. Unit price is the weighted average by expected excavation volume of soil, soft rock and hard rock.
Finished Rolling of Subgrade		m^3	Compacted by motor grader (3 times) and Rubber tired roller (3 times)
Slop	Seed Spraying	m^2	Speed spraying by manpower
	Concrete Spraying	m^2	Concrete t=15cm, wire netting, Anchor (L=40cm, 0.5m^2 per unit)
Retaining wall	Gravity	m	4.0 m hight
	Stone Masonry	m^2	Counterfort width B=35cm, Backfilling with concrete t=15cm, Backfilling with cobblestone t=20cm
	Grid type	m^2	Counterfort width B=1.0m
Cul-vert	Box	m	Concrete 2.0 x 2.0
	Pipe	m	Concrete pipe(600) with in-let & out-let
Pave-ment	Subbase Course	m^2	Crushed stone (t=150cm) including compaction
	Base Course	m^2	Mechanical stabilization (t=15cm) including compaction
	Binder Course	m^2	Hot-mixed asphalt t=7cm
	Surface Course	m^2	Hot-mixed asphalt t=5cm
Tunnel	Lining	m	Excavation of hard rock, concrete lining, much transport, pavement
	Unsup-ported	m	Excavation of hard rock, shotcrete, much transport, pavement
	Portal	pcs.	Potal concrete

7. OVERALL EVALUATION OF THE PROJECT

7. OVERALL EVALUATION AND IMPLEMENTATION PROGRAM

7.1 Overall Evaluation of the Project

From the wide range of engineering and economic studies, undertaken by the Study Team for the Improvement Project of the 115.5 km Road from Santa Bårbara to Bella Vista, the Project was evaluated as follows:

(1) National Road No. 3 (including the section covered by the Project) is not only a trunk road of the national road network but is also an important part of the infra-structure necessary for penetrating and making good use of the northern flat lands.

The need for developing these northern area is one of the foremost national policies, and viewed from this perspective, the entire region (excluding this Project section) has been improved or is being improved to a level such that the road has two lanes and a good geometric alignment. This guarantees overtaking of vehicles at all times along the road, increasing efficiency and safety.

Therefore, the Project section should only be a traffic bottleneck after improvement work for the other sections has been completed in the near future.

From this, it has been confirmed that the improvement of the Project section is essential.

(2) After performing several comparative studies, it has been concluded that the Project (i.e., the content and method of the improvement work) should be as described in the next section, "7.2 Project Description".

The total Project and the construction cost in this case have been estimated to be US$ 188 Million and US$ 152 Million, respectively.

Attention should be paid to the following points in the Project :

1) The extent of improvement (i.e. widening of the existing road and detour construction) is as follows;

Total length : 108.63 km (existing road: 115.5 km)
by widening : 92.29 km (85 %)
by constructing: 16.34 km (15 %)

2) The earthwork volume will be considerably large and the cost will account for more than 60 % of the total. Above all, 8.7 Million cubic meters of soil, which is equivalent to 85 % of the total volume cut, must be disposed of.

   It was confirmed in the Study that it would be possible to locate sufficient spoilbanks for the disposing of the soil as described above. These would be in the vicinity of the road and would minimize any environmental disturbance through careful planning and skillful utilization.

(3) As an implementation program of the Project, there is an idea that the Project road is constructed up to the gravel base course firstly, and then the asphalt concrete surface layer of the pavement is laid a few years after the completion of the first construction work.

The reason why this idea comes across is as follows:

1) Since this Project includes large volumes of soil excavation, it is considered that unavoidable disasters such as slope failure will often happen after the completion of earthwork operations. A period of a few years is required until the improved road can be considered stabilized in this sense.

   As disasters repair work is likely to damage the pavement surface, an idea will come out to leave the road having a gravel surface for a few years after completion of the earthworks, when disasters are most probable.

2) Assuming that the improvement would be completed in the year 2000 (as described later), it has been confirmed by referring the AASHTO Pavement Design Manual, that a gravel road without any asphalt layer would cope with the expected traffic load for a total of three years from 2000 to 2003.

3) Other sections of National Road No. 3 adjacent to the Project section will be improved using an asphalt Macadam layer or gravel surface. Considering the continuity and consistency with those sections, it would not be satisfactory for only the Project section to have an asphalt concrete pavement.

On the contrary, the idea to construct the surface layer separately from the first stage of the improvement work, has a disadvantage that the financial arrangement for the Project would be required twice for the first stage and the second stage work individually.

As SNC has evaluated the disadvantage to be very serious, this idea of the stagewise construction has not been adopted finally in the Study, in spite of its merits described above being fairly meaningful from the engineering viewpoint.

Incidentally, the adoption of the asphalt Macadam surface layer has not been accepted in the Study for the following reasons:

a) Referring to common pavement design manuals such as AASHTO, it is apparent that pavement with an asphalt Macadam surface only, cannot support the expected traffic load satisfactorily.

b) Furthermore, durability of an asphalt Macadam layer is low. In the case of the Project section, which is subject to a lot of rain (the estimated annual rainfall is between 1,800 and 2,500 mm), an asphalt Macadam layer with a thickness of 3 - 3.5 cm would be destroyed within 5 - 7 years of construction, and it would be necessary to overlay another layer of asphalt concrete at that time.

c) By comparing two cases; 1) constructing an asphalt Macadam surface (3-3.5 cm thick) in the beginning and then overlaying an asphalt concrete layer (10 cm thick) five years later, and 2) constructing an asphalt concrete surface (10 cm thick) in the beginning; it has been confirmed in the economic study that the former case would not necessarily be more advantageous even from a socio-economic viewpoint. Furthermore although the amount of initial investment would be 7.1 % less than that for the latter case, an accumulated amount of investment up until the construction of the overlay would be 4.2 % more. This also indicates that the former case would not always be more beneficial than the latter.

(4) In the case that whole construction work including surface layer of the pavement would be done together, the socio-economic effect has been estimated as follows;

- IRR (Internal Rate of Return) = 19.7 %
- NPV (Net Present Value -1990) = US$ 97,625,000

It can be considered that these values indicate that the Project is feasible for this country.

7.2 Project Description

The outline of the recommended Project, derived as a result of the Study, is as follows:

(1) General

* Origin Point for the Project : Santa Bårbara
  End Point : Bella Vista
  (Nor Yungas, Dpto. La Paz)

* Length of the Project Road

Open road	:	107.11 km
Bridge	:	0.77 km (14 bridges)
Tunnel	:	0.75 km (2 tunnels)
Total	:	108.63 km

* Characteristics of the Road

Category	:	Class I. B
Design Speed	:	40 km/h
Road Width	:	9.0 - 10.4 m (variable)
Number and		

width of lanes : 2 lanes x 3.5 m = 7.0 m
Pavement : with asphalt concrete surface layer

(2) Principal work items

* Earthwork
  - cut volume : 10,196,000 m^3 (C)
  - embankment volume : 1,512,000 m^3 (E)
  - spoil volume : 8,684,000 m^3 (S=C-E)

* Bridges : 13 bridges

* Tunnels : 2 tunnels

* Pavement
  - subbase : t= 15 cm, v= 159,800 m^3
  - base : t= 15 cm, v= 153,800 m^3
  - surface : t= 10 cm, v= 98,800 m^3

* Drainage
  - box culvert : 11 locations
  - pipe culvert : 428 locations (x 20^m = 8560^m)

* Retaining walls and other structures

(3) Estimated cost

Table 7.2-1 Summary of Estimated Cost (unit: US$ 1,000)

	Foreign Currency	Local Currency	Total	RATE
Construction Cost	84,485	67,104	151,589	80 %
Others	19,472	17,364	36,831	20 %
Project Cost	103,957	84,468	188,420	100 %
RATE	55 %	45 %	100 %	

Breakdown of the Project Costs for each sub-section is shown below:

Table 7.2-2 Estimated Cost by Sub-section

	distance	Project Cost		
Sub-section	(km)	(US$1000)	(%)	(1000$/km)
Santa Barbara				
- Point F	25.30	48,839	25.9	1,930
- Point K	21.46	49,895	26.5	2,325
- Caranavi	13.24	16,243	8.6	1,227
- Point Q	19.55	26,482	14.1	1,355
- Point V	21.75	39,590	21.0	1,820
- Bella Vista	7.33	7,347	3.9	1,002
Total	108.63	188,420	100.0	1,735

7.3 Implementation Program

(1) Commencement of construction

The commencement of construction work for the Project has been assumed to be in 1996, based on the following schedule.

- 1991 - 1993 : 2.5 years
  for Final Design, and
  Environmental Impact Study.
- 1994 - 1995 : 2 years
  for Financial Arrangements, and
  Tendering for Construction.
- 1996 : Commencement of Construction.

(2) Construction Period

As described previously, the Project includes a large amount of earthwork operations. Therefore, it is considered that the required time to complete the construction work for the Project would be five years.
Assuming that the efficiency of construction in the initial and final year would be half of that in other years, the average productivity per month should be as follows to ensure completion within five years:

* length of completed road : 2.25 km/month
* earthwork : 212,000 m^3/month
  (approx. 10,000 m^3/day)
* Production (const.cost) : 3,925,000 US$/month

If the construction was to be executed by dividing the Project road into several sub-sections for several contractors, the above figures could be said to be possible though not necessarily easy to achieve.

(3) Implementation schedule

From the considerations given and the assumptions made up to this point, the chart below has been derived as an implementation schedule.

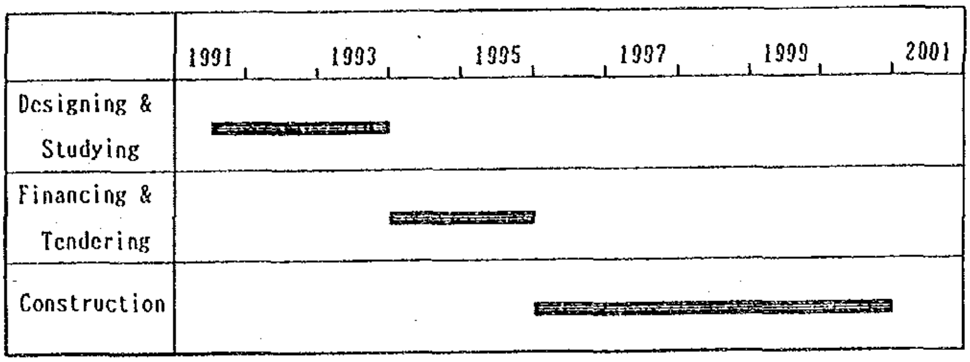


Fig. 7.3-1 Implementation Schedule

(4) Required annual funds

Based on the implementation schedule shown on the previous clause, the required annual funds for construction have been estimated as follows;

- 1996	20.934	Million US$
- 1997	41.872	Million US$
- 1998	41.872	Million US$
- 1999	41.872	Million US$
- 2000	41.872	Million US$
Total	188.420	Million US$

7.4 Recommended Further Studies

The Final Design of the Project to be carried out following this Study must include the following studies.

(1) Topographic survey

Since the Project site has a steep and complicated topography, an accurate topographical map must be prepared prior to the Final Design. At minimum, a map with a scale of 1 to 1,000 in general, and of 1 to 500 for some specific places, would be required.
For this purpose, detailed and sufficient ground surveying is necessary in order to supplement and verify the map made by aerophotography.

(2) Sounding of subsoil conditions

For the accurate estimation of earthwork costs, obtaining available data for the design of the sub-structure at bridge sites, and obtaining fundamental data to determine design and construction methods at tunnel sites, more detailed investigations for sub-soil condition should be performed in the course of the Final Design.
A boring survey at each bridge site and seismic geographical exploration at tunnel sites are essential.

(3) Material survey

It is considered for this Study that gravel and sand from the Alto Beni and Suwapi Rivers, and from the Coroico and Yara Rivers can be utilized as concrete aggregates and as subbase and base course material, respectively. A quantity of the rock obtained during earthworks will also be available for use as subbase and base course.
It is necessary to verify if this idea would be suitable from the viewpoint of both quantity and quality by carrying out more detailed investigations and tests.

(4) Dividing the Project into sub-sections

As described previously, one of the distinctive features of this Project is the huge amount of earthworks required. It may be advantageous in order to complete the job in a

shorter period to divide it into a limited number of sub-sections and to execute it using several groups of contractors.
When an outline of the content of Final Design would be available, division into sub-sections should be studied and examined closely.

(5) Determination of spoilbank areas

Eight million cubic meters of spoil soil has been estimated for the Project. From the viewpoint of preservation of the environment, this spoil soil should be disposed of in the pre-specified areas. For such a purpose, a sufficient number of candidate areas for spoilbank construction must be found and studied in the course of the design.

APPENDIX

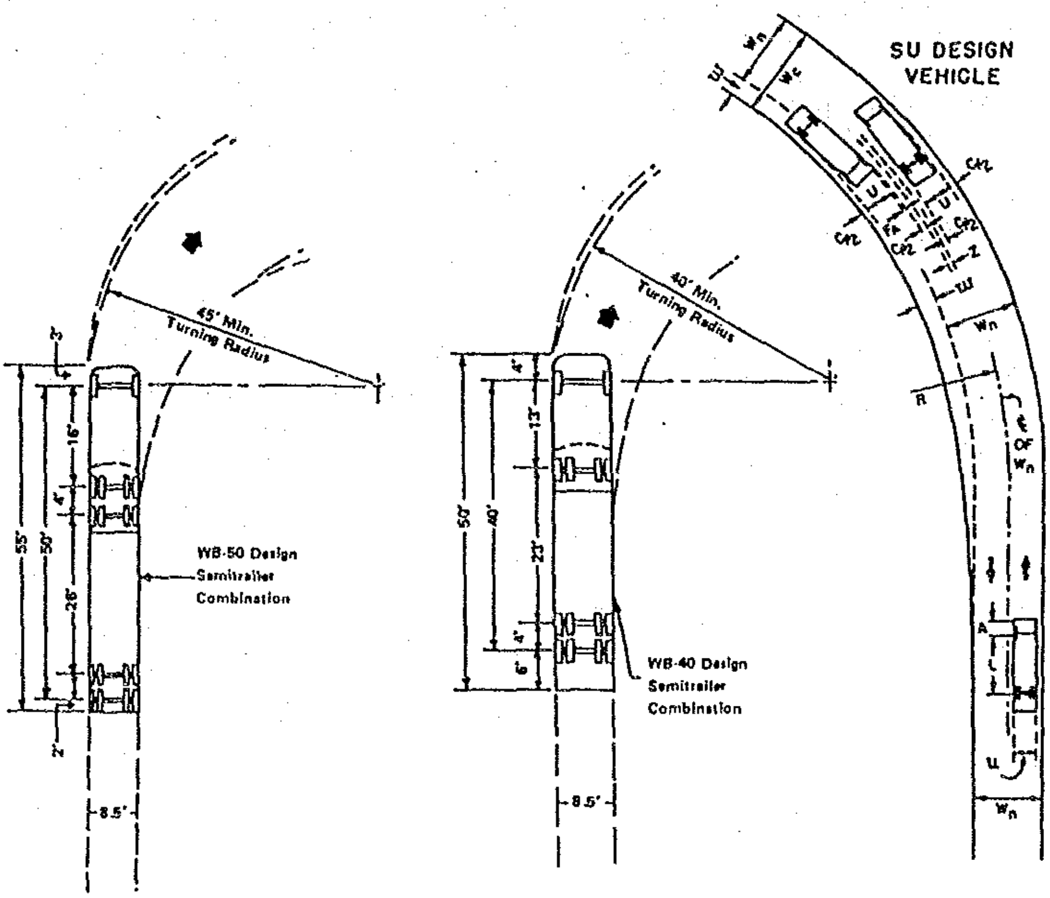
Appendix 1-1 List of the Road Projects in Execution (1984 - 1991)

No.	Name of Project	Location or Road No.	Length (km)	Type of Project	Cost (1000US$)	Foreign Finance	Compl. Year	Remarks
1	Approach of Chimore-Yapacani	No. 7	261	Maintenance	129100	IDB-CAF	1990	just started
* 2	Bella Vista-Quiquibey	No. 3	141	Construction	26400	Brazil	1988	finished
3	Secondary Road Phase I	LPB,Chuq.,S/Cru	1200	Const.,Improve.	17283	USAID	1991	
4	ditto Phase II	Cochabamba	260	ditto	13031	USAID	1989	
5	ditto Santa Cruz	Santa Cruz	500	ditto	24543	IDB-CAF	1990	
6	ditto Yungas	La Paz	250	ditto	5122	UN	1990	
* 7	Cotapata-Santa Barbara	No. 3	38	Final Design	7120	IDB	1989	
8	Challapata-Tarapaya	No. 1	184	ditto	800	FONPLATA	1989	
9	Chimore-Yapacani	No. 7	151	Construction	139556	IDB-CAF	1988	
10	Agricultural Area,North Chuqui	Chuquisaca	72	Const.,Improve.	1087	FIDA	1988	
*11	Guayarameria-Santa Rosa	No. 8	410	Maintenance	2500	JICA		starting
12	Padcaya-Bermejo	No. 1	160	Final design	596	FONPLATA	1988	
*13	Pave.,La Paz-Cotapata	No. 3	10	Construction	1661		1989	
*14	Porvenir-Chive	No. 2	180	ditto	5010		1989	
15	Maintenance, South Region		3250	Maintenance	36539	CAF	1990	
16	Puerto Rico-Nueva Ethea	Pando, Beni	81	Construction	648		1989	
17	Cotagaita-San Juan del Oro	Potosi	90	Const.,Improve.	2058	FIDA	1991	
18	Parmar Grande-Yacuiba	No. 9	60	Construction	22540	FONPLATA	1990	
*19	Yucumo-Rurrenabaque	No. 2	102	ditto	25300	OECF	1988	
20	Confital-Caihuasi	No. 4	50	ditto	55350	IDB	1992	tendering now
21	Samaipata-Taruma	Santa Cruz	70	Maintenance	7882	IDB	1991	
*22	San Borja-Trinidad	No. 3	228	Feasib. Study	2924	JICA	1988	
23	San Julian	Santa Cruz	250	Maintenance	3869	Germany	1991	
24	Santa Cruz-Trinidad	No. 9	544	Construction	47815	FONPLATA	1993	
*25	San Buenaventura-Cobija	No. 2	540	Feasib. Study	1177	CAF	1990	
*26	Santa Ana-Santa Rosa	Beni	150	Final design	600		1989	
*27	Santa Rosa-Riberalta	No. 8	410	Construction	4100		1989	
*28	San Buenaventura-Ixiamas	No. 2	110	Improvement	4853		1993	
29	Sucre-Ipati	No. 6	440	Final Design	1500	IDB	1990	
*30	Quiquibey-Yucumo	No. 3	41	Const.,Improve.	46757	IDB	1992	
31	Totacoa-Puente Mendez	Chuquisaca	30	Construction	12975	FONPLATA	1991	tendering now
*32	Cobija-Conquista	Pando	225	Maintenance	2500	JICA		

Note : 1) The Projects marked with an asterisk are considered to be related with this Study.
2) Bridge construction projects are not included in this table.

Appendix 4-1 Calculation of Widening on Curves

AASHTO's Formula (WB 50/40)



(1) $w = W_c - W_n$

(2) $W_c = N(U+C) + (N-1)F_A + Z$

N = Number of lanes
w = widening for pavement on curve, ft.
W_c = width of pavement on curve, ft.

(3) $U = u + R - \sqrt{R^2 - L^2}$

(4) $F_A = \sqrt{R^2 + A(2L + A)} - R$

(5) $Z = V/\sqrt{R}$

W_n = width of pavement on tangent, ft.
U = track width of vehicle (out-to-out tires), ft.
C = lateral clearance per vehicle; assumed 2,2.5 & 3 ft for W_n of 20, 22 & 24 ft, respectively.
F_A = width of front overhang, ft.
Z = extra width allowance for difficulty of driving on curves, ft.

u = track width on tangent (out-to-out) 8.5 ft
R = radius on centerline of 2-lane pavement, ft
L = wheelbase
A = front overhang
V = design speed of highway, mph

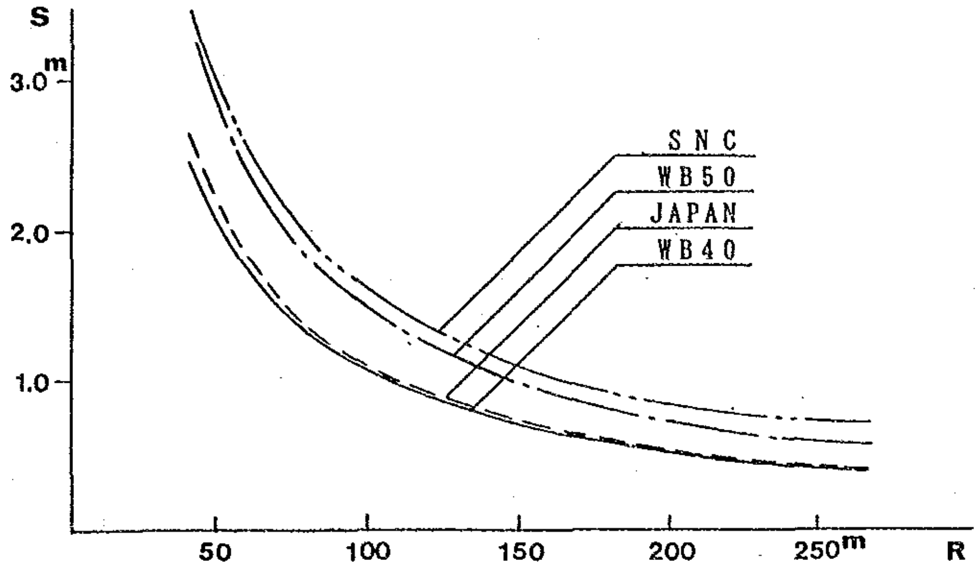
SNC's Formula (SR=WB50)

$$S = 2\left(R - \sqrt{R^2 - (L_1^2 + L_2^2)}\right) + \left(\sqrt{R^2 + A(2L_1 + A)} - R\right) + \frac{V}{10\sqrt{R}}$$

$$= 2(U - u) + F_A + Z \qquad = W + (W_n - 2(u + C))$$

↓ ↓ ↓

R=45 → 2.56 + 0.12 + 0.62 = 3.26
(WB50)



Pavement Widening on Curves (See Table 6.1-5)

Appendix 4-2

Cost Estimates of Alternatives (Gometrical Alignment)

Comparison of Cost Estimation of Construction for Road Improvement

Item			Unit	Unit Cost	Improvement of Existing Road		New Alignment		Dual Carriage Way Road	
					Volume	Cost	Volume	Cost	Volume	Cost
Clearing and Grubbing			m^2	3.94	27,500	108,350	33,000	130,020	38,000	149,720
Excavation of Road	Soil		m^3	3.04	29,525	89,756	57,750	175,560	35,475	107,844
	Soft Rock		m^3	12.13	17,715	214,883	35,650	420,304	21,285	258,187
	Hard Rock		m^3	15.03	11,810	177,504	23,100	347,193	14,190	213,276
Embankment			m^3	5.03	0	0	0	0	0	0
Pavement			m^2	16.68	9,000	150,120	9,000	150,120	11,000	183,480
Slope	Cut	Soil	m^2	1.31	11,500	15,065	14,000	18,340	15,825	20,731
		Rock	m^2	21.10	11,500	242,650	14,000	295,400	15,825	333,907
	Embankment		m^2	1.31	0	0	0	0	0	0
Drainage			Km	23,266	1.0	23,266	1.0	23,266	2.0	40,942
Direct Cost						1,021,594		1,560,203		1,308,087
Indirect Cost(25%)						255,399		390,051		327,022
Construction Cost						1,276,993		1,950,254		1,635,109

Cost Estimation around Point (L) (Santa Ana)

Item			Unit	Unit Cost	Improvement of Existing Road		New Alignment	
					Volume	Cost	Volume	Cost
Clearing and Grubbing			m^2	3.94	70,770	278,834	67,600	266,344
Excavation of Road	Soil		m^3	3.04	152,285	462,946	122,378	372,029
	Soft Rock		m^3	12.13	65,265	791,664	52,447	636,182
	Hard Rock		m^3	15.03	—	—	—	—
Embankment			m^3	5.03	31,500	158,445	44,625	224,464
Pavement			m^2	16.68	27,000	450,360	21,600	360,288
Slope	Cut	Soil	m^2	1.31	31,563	41,348	26,460	34,663
		Rock	m^2	21.10	13,527	285,420	11,340	239,274
	Embankment		m^2	1.31	5,700	7,467	9,180	12,026
Drainage			Km	23,266	3.0	69,798	2.4	55,838
Direct Cost						2,546,282		2,221,108
Indirect Cost(25%)						636,571		555,727
Construction Cost						3,182,853		2,776,385

Cost Estimation from Point (H)+2.5Km to (I)+0.35Km

Item			Unit	Unit Cost	Improvement of Existing Road (Earth-Work)		New Alignment (Tunnel)		Improvement of Existing Road (Semi-Tunnel)		Dual Carriage Way Road (One-lane Tunnel+Steg)	
					Volume	Cost	Volume	Cost	Volume	Cost	Volume	Cost
Clearing and Grubbing			m^2	3.94	—	—	—	—	—	—	—	—
Excavation of Road	Soil		m^3	3.04	—	—	—	—	—	—	—	—
	Soft Rock		m^3	12.13	—	—	—	—	—	—	—	—
	Hard Rock		m^3	15.03	587,195	8,825,541	13,394	201,312	84,450	1,269,284	13.069	196,427
Embankment			m^3	5.03	—	—	475	2,389	—	—	475	2,389
Pavement			m^2	16.68	8,235	137,360	1,710	28,523	7,105	118,511	2,708	45,169
Slope	Cut	Soil	m^2	1.31	—	—	—	—	—	—	—	—
		Rock	m^2	21.10	—	—	—	—	—	—	—	—
	Embankment		m^2	1.31	—	—	—	—	—	—	—	—
Drainage			Km	23,266	0.915	21,288	0.19	4,421	0.25	5,817	0.19	4,421
Bridge	50m <	Superstructure	m^2	1,730	620.5	850,085	—	—	620.5	850,085	446.25	604,513
		Substructure	m^3	278	627.8	174,528	—	—	627.8	174,528	508.5	141,363
	50m >	Superstruture	m^2	584	—	—	225.0	131,400	—	—	131.25	76,650
		Substruture	m^3	278	—	—	179.5	49,901	—	—	127.5	35,445
Tunnel	Lining		m	5,833	—	—	120	705,960	—	—	—	—
	Excavation without Timbering		m	4,547	—	—	615	2,796,405	—	—	—	—
One-lane Tunnel	Lining		m	4,309	—	—	—	—	—	—	120	517,080
	Excavation without Timbering		m	3,331	—	—	—	—	—	—	615	2,048,565
Semi-Tunnel			m	6,846	—	—	—	—	665	2,215,115	—	—
Steg			m	890	—	—	—	—	—	—	765	680,850
Retaining wall (H=6.8m)			m	670	—	—	95	63,650	—	—	95	63,650
Direct Cost						10,008,802		3,983,961		4,633,342		4,416,522
Indirect Cost(25%)						2,502,201		995,990		1,158,336		1,104,131
Construction Cost						12,511,003		4,979,951		5,791,678		5,520,653

Cost Estimation around Point (O) +1. 8Km

Item			Unit	Unit Cost	Imprevement of Existing Road		New Alignment	
					Volume	Cost	Volume	Cost
Clearing and Grubbing			m²	3.94	17,370	68,438	13,335	52,540
Excavation of Road	Soil		m³	3.04	65,363	195,664	21,000	63,840
	Soft Rock		m³	12.13	28,012	339,786	9,000	109,170
	Hard Rock		m³	15.03	—	—	—	—
Embankment			m³	5.03	—	—	6,188	31,126
Pavement			m²	16.68	5,400	90,072	4,860	81,065
Slope	Cut	Soil	m²	1.31	10,962	14,360	4,069	5,330
		Rock	m²	21.10	4,698	99,128	1,744	36,798
	Embankment		m²	1.31	—	—	2,475	3,242
Drainage			Km	23,266	0.60	13,956	0.54	12,560
Direct Cost						821,404		395,671
Indirect Cost (25%)						205,351		98,918
Construction Cost						1,026,755		494,589

Cost Estimation Around Point (Q) +5Km

Item			Unit	Unit Cost	Imprevement of Existing Road		New Alignment	
					Volume	Cost	Volume	Cost
Clearing and Grubbing			m²	3.94	22,360	88,098	21,300	83,922
Excavation of Road	Soil		m³	3.04	33,677	102,378	17,750	53,960
	Soft Rock		m³	12.13	33,677	408,502	17,750	215,308
	Hard Rock		m³	15.03	-	-	-	-
Embankment			m³	5.03	9,675	48,965	22,137	111,349
Pavement			m²	16.68	10,800	180,144	10,800	180,144
Slope	Cut	Soil	m²	1.31	10,815	14,168	4,200	5,502
		Rock	m²	21.10	10,815	228,197	4,200	88,620
	Embankment		m²	1.31	1,100	1,441	6,050	7,926
Drainage			Km	23,266	1.2	27,919	1.2	27,919
Direct Cost						1,099,512		774,650
Indirect Cost (25%)						274,878		193,663
Construction Cost						1,374,390		968,313

Cost Estimation from Point ② to ④

Item	Unit	Unit Cost	Earthwork		Tunnel	
			Volume	Cost	Volume	Cost
Length of Earthwork	m	1,675	4,600	7,705,000	3,640	6,097,000
Tunnel	m	7,354	-	-	500	3,677,000
Total			7,705,000		9,774,000	

Cost Estimation from Point ⑤ to ⑦

Item			Unit	Unit Cost	New Alignment (Earth-Work)		New Alignment (Tunnel)	
					Volume	Cost	Volume	Cost
Clearing and Grubbing			m^2	3.94	33,047	130,205	21,311	83,965
Excavation of Road	Soil		m^3	3.04	36,070	109,653	23,994	72,942
	Soft Rock		m^3	12.13	72,141	875,070	47,987	582,082
	Hard Rock		m^3	15.03	72,141	1,084,279	47,987	721,245
Embankment			m^3	5.03	33,616	169,088	47,952	241,199
Pavement			m^2	16.68	12,105	201,911	6,075	101,331
Slope	Cut	Soil	m^2	1.31	3,756	4,920	1,636	2,143
		Rock	m^2	21.10	33,808	713,349	14,724	310,676
	Embankment		m^2	1.31	2,271	2,975	4,108	5,381
Drainage			Km	23,266	1.3	30,246	1.1	25,593
Tunnel	Lining		m	5,833	-	-	60	705,960
	Excavation without Timbering		m	4,547	-	-	390	2,796,405
Retaining wall (H=7.0m)			m	670	35	-	-	-
Direct Cost						3,345,146		4,272,867
Indirect Cost(25%)						836,287		1,068,217
Construction Cost						4,181,433		5,341,084

Cost Estimation from Point ⑥ to ⑧

Item	Unit	Unit Cost	Earthwork		Long-span Bridge	
			Volume	Cost	Volume	Cost
Length of Earthwork	m	1,675	1,800	3,015,000	710	1,189,250
Long-span Bridge	m^2	5,400	-	-	1,825	9,855,000
Total			3,015,000		11,044,250	

Cost Estimation from Point (S) to (V)

Item			Unit	Unit Cost	Improvement of Existing Road		New Alignment	
					Volume	Cost	Volume	Cost
Clearing and Grubbing			m^2	3.94	307,180	1,210,289	293,650	1,156,981
Excavation of Road	Soil		m^3	3.04	468,600	1,424,544	329,840	1,002,714
	Soft Rock		m^3	12.13	351,450	4,263,089	247,380	3,000,719
	Hard Rock		m^3	15.03	351,450	5,282,294	247,380	3,718,121
Embankment			m^3	5.03	377,100	1,896,813	259,875	1,307,171
Pavement			m^2	16.68	123,930	2,067,152	116,550	1,944,054
Slope	Cut	Soil	m^2	1.31	105,874	138,695	59,584	78,055
		Rock	m^2	21.10	158,811	3,350,912	89,376	1,885,833
	Embankment		m^2	1.31	31,500	41,265	50,820	66,574
Drainage			Km	23,266	13.77	320,373	12.95	301,295
Direct Cost						19,995,426		14,461,517
Indirect Cost (25%)						4,998,857		3,615,379
Construction Cost						24,994,283		18,076,896

Appendix 4-3
Cost Estimates of Alternatives (Bridges)

B- 1

Point A (Poute ①) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	5,095	8.48	43,206	
(Soft Rock)		m^3	20,379	12.13	247,197	ΣV=25,474m^2
(Hard Rock)		m^3		-	-	
Pavement (Carriage Way)		m^2	1,555	16.68	25,937	
Sub-Total					316,340	
Bridge (Superstructure)		m^2	1,235	1,370	1,691,950	ℓ=130m
(Abutment)		m^3	130.2	278.4	36,248	
(Pier)		m^3	738.8	251.5	185,808	
Sub-Total					1,914,006	
Total					2,230,346	

B- 2

Point A (Poute ②) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	591	8.48	5,012	
(Soft Rock)		m^3	2,366	12.13	28,700	ΣV=2,957m^2
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	808	16.68	13,477	
Sub-Total					47,189	
Bridge (Superstructure)		m^2	1,283	1,370	1,751,710	ℓ=135m
(Abutment)		m^3	130.2	278.4	36,248	
(Pier)		m^3	996.0	251.5	250,494	
Sub-Total					2,044,452	
Total					2,091,641	

B- 3

Patuni	(Poute ①)					Unit : US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	17,220	8.48	146,026	
(Soft Rock)		m^3	43,050	12.13	522,197	ΣV=86,100m^3
(Hard Rock)		m^3	25,870	15.03	388,826	
Pavement (Carriage Way)		m^2	7,015	16.68	117,010	
Sub-Total					1,174,059	
Bridge (Superstructure)		m^2	312	830	258,960	ℓ=30m
(Abutment)		m^3	215.6	278.4	60,023	
(Pier)		m^3	-	-	-	
Sub-Total					318,983	
Total					1,493,042	

B- 4

Patuni	(Poute ②)					Unit : US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	7,820	8.48	66,314	
(Soft Rock)		m^3	19,550	12.13	237,142	
(Hard Rock)		m^3	11,730	15.03	176,302	ΣV=39,100m^3
Pavement (Carriage Way)		m^2	6,325	16.68	105,501	
Sub-Total					585,259	
Bridge (Superstructure)		m^2	468	830	398,440	ℓ=45m
(Abutment)		m^3	215.6	278.4	60,023	
(Pier)		m^3	221.5	251.5	55,707	
Sub-Total					514,170	
Total					1,099,429	

B- 5

Patuni (Poute ③) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	3,449	8.48	29,248	
(Soft Rock)		m^3	8,623	12.13	104,597	$\Sigma V=17,246m^3$
(Hard Rock)		m^3	5,174	15.03	77,765	
Pavement (Carriage Way)		m^2	3,335	16.68	55,628	
Sub-Total					267,238	
Bridge (Superstructure)		m^2	797	1,370	1,091,890	$\ell=90m$
(Abutment)		m^3	118.8	2778.4	33,074	
(Pier)		m^3	1,045.0	251.5	262,818	
Sub-Total					1,387,782	
Total					1,655,020	

B- 6

Challa (Poute ①) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	23,740	8.48	201,315	
(Soft Rock)		m^3	12,002	12.13	145,584	$\Sigma V=35,742m^3$
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	6,785	16.68	113,174	
Sub-Total					460,073	
Bridge (Superstructure)		m^2	312	830.0	258,960	$\ell=30m$
(Abutment)		m^3	118.8	278.4	33,074	
(Pier)		m^3	-	-	-	
Sub-Total					292,034	
Total					752,107	

B- 7

Challa (Poute ②)						Unit :US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	12,220	8.48	103,626	
(Soft Rock)		m^3	10,137	12.13	122,962	ΣV=22,357m^3
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	5,980	16.68	99,746	
Sub-Total					326,334	
Bridge (Superstructure)		m^2	570	830	473,100	ℓ=60m
(Abutment)		m^3	143.4	278.4	39,922	
(Pier)		m^3	150.9	251.5	37,951	
Sub-Total					550,973	
Total					877,307	

B- 8

Challa (Poute ③)						Unit :US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	15,480	8.48	131.270	
(Soft Rock)		m^3	5,834	12.13	70.766	ΣV=21,314m^3
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	3,196	16.68	53,209	
Sub-Total					255,245	
Bridge (Superstructure)		m^2	946	1,370.0	1,296,020	ℓ=110m
(Abutment)		m^3	115.4	278.4	32,127	
(Pier)		m^3	351.2	251.5	88,327	
Sub-Total					1,416,474	
Total					1,671,719	

B- 9

San Silverio (Poute ①) Unit :US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	1,030	8.48	8,734	
(Soft Rock)		m^3	8,950	12.13	108,563	ΣV=9,980m^3
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	2,280	16.68	38,030	
Sub-Total					155,327	
Bridge (Superstructure)		m^2	380	830	315,400	ℓ=60m
(Abutment)		m^3	118.8	278.4	33,074	
(Pier)		m^3	150.9	251.5	37,951	
Sub-Total					386,425	
Total					541,752	

B- 10

San Silverio (Poute ②) Unit :US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	680	8.48	5,766	
(Soft Rock)		m^3	3,584	12.13	43,474	ΣV=4,264m^3
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	1,805	16.68	30,107	
Sub-Total					79,347	
Bridge (Superstructure)		m^2	760	830.0	361,000	ℓ=50m
(Abutment)		m^3	143.4	278.4	39,923	
(Pier)		m^3	150.9	251.5	37,951	
Sub-Total					438,874	
Total					518,221	

B- 11

San Lorenzo (Poute ①)						Unit : US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m³	87,300	8.48	740,304	
(Soft Rock)		m³	52,380	12.13	635,369	
(Hard Rock)		m³	34,920	15.03	524,848	ΣV=174,600m³
Pavement (Carriage Way)		m²	7,125	12.90	91,913	
Sub-Total					1,992,434	
Bridge (Superstructure)		m²	475	830	394,250	ℓ=50m
(Abutment)		m³	129.0	278.4	35,914	
(Pier)		m³	183.8	251.5	46,226	
Sub-Total					476,390	
Total					2,468,824	

B- 12

Sqan Lorengo (Poute ②)						Unit : US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m³	56,330	8.48	477,678	
(Soft Rock)		m³	33,798	12.13	409,970	
(Hard Rock)		m³	22,532	15.03	338,656	ΣV=112,660m³
Pavement (Carriage Way)		m²	6,650	12.90	85,785	
Sub-Total					1,312,089	
Bridge (Superstructure)		m²	570	830	473,100	ℓ=60m
(Abutment)		m³	167.3	278.4	46,576	
(Pier)		m³	183.8	251.5	42,226	
Sub-Total					565,902	
Total					1,877,991	

B－ 13

San Lorenzo (Poute ③) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	33,669	8.48	285,513	
(Soft Rock)		m^3	20,201	12.13	245,038	
(Hard Rock)		m^3	13,467	15.03	202,409	$\Sigma V=67,337m^3$
Pavement (Carriage Way)		m^2	2,850	12.90	36,765	
Sub-Total					769,725	
Bridge (Superstructure)		m^2	1,118	1,370	1,531,660	$\ell=130m$
(Abutment)		m^3	167.3	278.4	46,576	
(Pier)		m^3	630.3	251.5	158,520	
Sub-Total					1,736,756	
Total					2,506,481	

B－ 14

Espiritú (Poute ①) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	15,500	8.48	131,440	
(Soft Rock)		m^3	15,792	12.13	191,552	$\Sigma V=31,292m^3$
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	2,871	12.90	37,035	
Sub-Total					360,027	
Bridge (Superstructure)		m^2	364.0	830.0	302,120	$\ell=35m$
(Abutment)		m^3	105.8	278.4	29,455	
(Pier)		m^3	164.0	251.5	41,246	
Sub-Total					372,821	
Total					732,848	

B- 15

Espiritú (Poute ②) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	5,248	8.48	44,503	
(Soft Rock)		m^3	5,100	12.13	61,863	ΣV=10,348m^3
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	2,876.6	12.90	37,109	
Sub-Total					143,475	
Bridge (Superstructure)		m^2	475	830	394,250	ℓ=50m
(Abutment)		m^3	123.0	278.4	34,243	
(Pier)		m^3	286.5	251.5	72,055	
Sub-Total					500,548	
Total					643,220	

B- 16

Espiritú (Poute ③) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	1,300	8.48	11,024	
(Soft Rock)		m^3	1,100	12.13	13,343	ΣV=2,400m^3
(Hard Rock)		m^3	-	-	-	
Pavement (Carriage Way)		m^2	1,490	12.90	19,217	
Sub-Total					43,584	
Bridge (Superstructure)		m^2	920	1,370	1,260,400	ℓ=100m
(Abutment)		m^3	123.0	278.4	34,243	
(Pier)		m^3	351.2	251.5	88,327	
Sub-Total					1,382,970	
Total					1,426,554	

B- 17

Pto Leon (Poute ①) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m³	-	-	-	
(Soft Rock)		m³	8,647	12.13	104,888	
(Hard Rock)		m³	-	-	-	
Stone Masonry		m²	532	28.56	15,208	
Pavement (Carriage Way)		m²	1,155	16.68	19,265	
Sub-Total					139,361	
Bridge (Superstructure)		m²	523	730	381,790	I -Section ℓ=55m
(Abutment)		m³	118.8	278.4	33,073	
(Pier)		m³	-		414,863	
Sub-Total					554,224	
Total						

B- 18

Pto Leon (Poute ②) Unit : US$

Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m³	-	-	-	
(Soft Rock)		m³	23,060	12.13	279,718	
(Hard Rock)		m³	-	-	-	
Pavement (Carriage Way)		m²	1,710	16.18	28,523	
Sub-Total					308,241	
Bridge (Superstructure)		m²	312.0	830.0	258,960	ℓ=30m
(Abutment)		m³	135.8	278.4	37,806	
(Pier)		m³	-	-	-	
Sub-Total					296,766	
Total					605,007	

B- 19

Carrasco (Poute ①)						Unit : US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	41,123	8.48	348,723	
(Soft Rock)		m^3	-	12.13	-	
(Hard Rock)		m^3	-	15.03	-	
Seed Spraying		m^2	6,388	1.31	8,368	
Pavement (Carriage Way)		m^2	2,647	12.90	34,151	
Sub-Total					391,242	
Bridge (Superstructure)		m^2	126.5	584.0	73,876	ℓ=65m
(Abutment)		m^3	281.4	278.4	78,342	
(Pier)		m^3	-	-	-	
Sub-Total					152,218	
					543,460	

B- 20

Carrasco (Poute ②)						Unit : US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	5,473	8.48	46,411	
(Soft Rock)		m^3	-	12.13	-	
(Hard Rock)		m^3	-	15.03	-	
Seed Spraying		m^2	1,254	1.31	1,643	
Pavement (Carriage Way)		m^2	1,980	12.90	25,543	
Sub-Total					73,597	
Bridge (Superstructure)		m^2	354.0	584.0	206,736	ℓ=30m
(Abutment)		m^3	316.2	278.4	88,030	
(Pier)		m^3	-	251.5	-	
Sub-Total					294,766	
					368,363	

B− 21

Carrasco (Poute ③)						Unit : US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3	4,289	8.48	36,371	
(Soft Rock)		m^3	-	12.13	-	
(Hard Rock)		m^3	-	15.03	-	
Seed Spraying		m^2	1,026	1.31	1,344	
Pavement (Carriage Way)		m^2	1,547	12.90	19,959	
Sub-Total					57,674	
Bridge (Superstructure)		m^2	585.0	584.0	341,640	ℓ=23m
(Abutment)		m^3	281.4	278.4	78,342	
(Pier)		m^3	39.3	251.5	9,884	
Sub-Total					429,866	
Total					487,540	

B−

(Poute)						Unit : US$
Name of Work	Type	Unit	Volume	Unit Cost	Cost	Remarks
Excavation (Soil)		m^3				
(Soft Rock)		m^3				
(Hard Rock)		m^3				
Pavement (Carriage Way)		m^2				
Sub-Total						
Bridge (Superstructure)		m^2				
(Abutment)		m^3				
(Pier)		m^3				
Sub-Total						
Total						

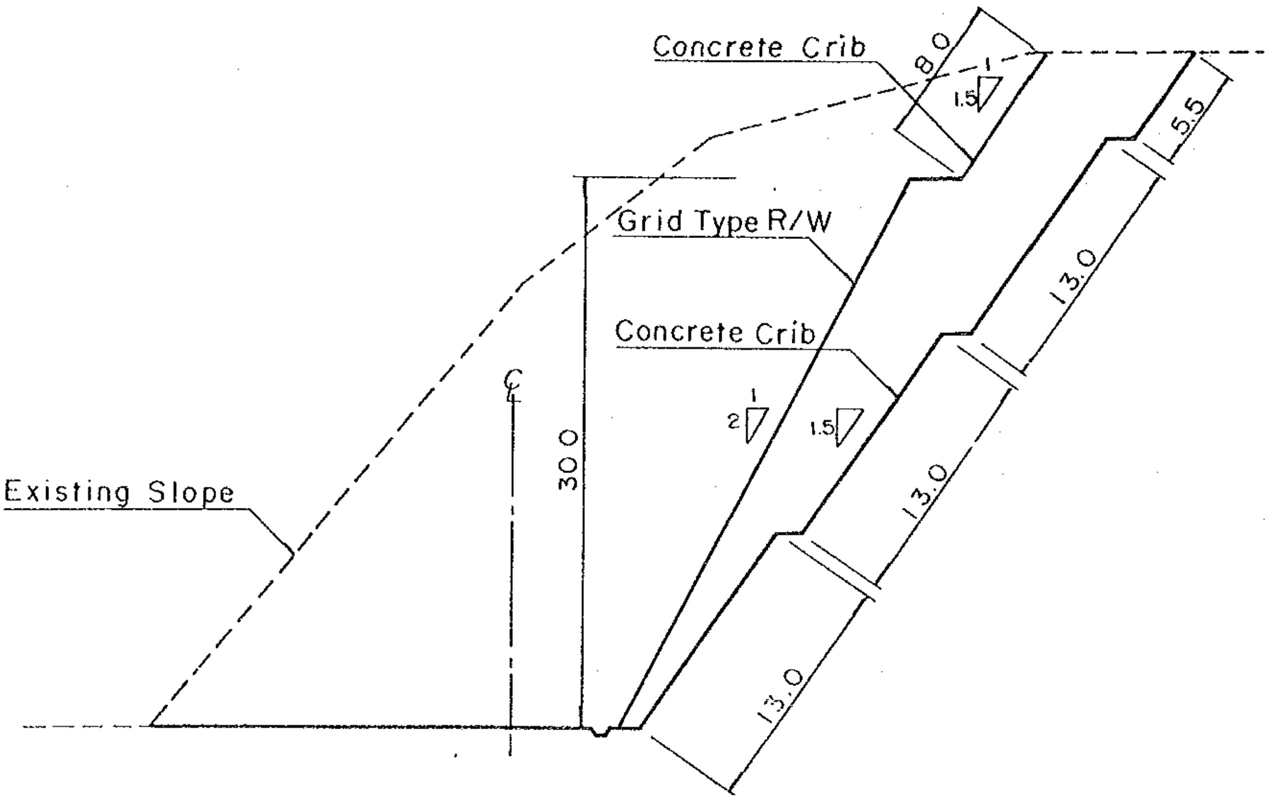
Appendix 4 - 4 Optimum Countermeasure(s)

(1) Selection for S.B. + 0.8 / No.0 + 700

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring 1)
- Grid Type Concrete Retaining Wall + Concrete Crib 2)

Optimum Countermeasure:
As described below, <u>Grid Type Concrete Retaining Wall (+) Concrete Crib is advantageous</u> to the location in economical view point.

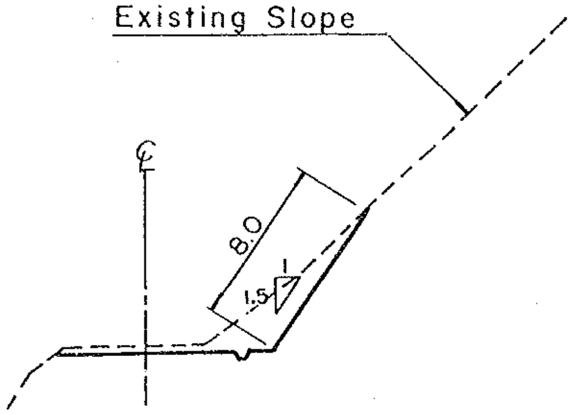
		Unit	Quantity	Unit Cost	Cost	Remarks
1)	Concrete Crib	m^2	2,225	51.08 US	113,653 US	
	Excavation	m^3	46,362	12.13	562,371	
	Total				676,024	
2)	Retaining Wall	m^2	1,677	124.95	209,541	
	Concrete Crib	m^2	400	51.08	20,432	
	Excavation	m^3	36,150	12.13	438,499	
	Total				668,472	



(2) Selection for S.B. + 2.3 / No.2 + 200

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

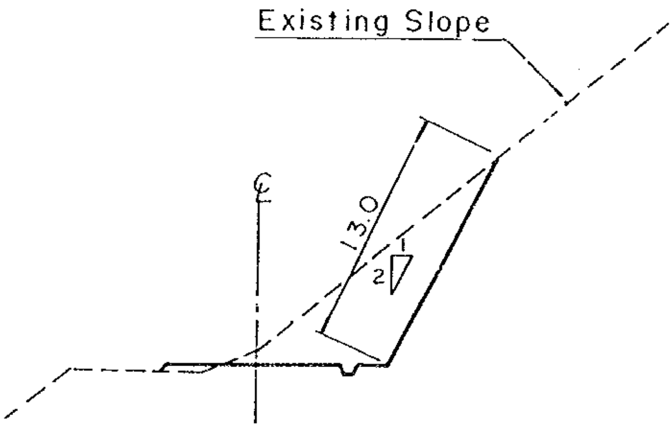
Optimum Countermeasure:
As illustrated below, <u>Concrete Crib is adaptable</u> to the location in topographical view point.



(3) Selection for B + 1.9 / No.8 + 100

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

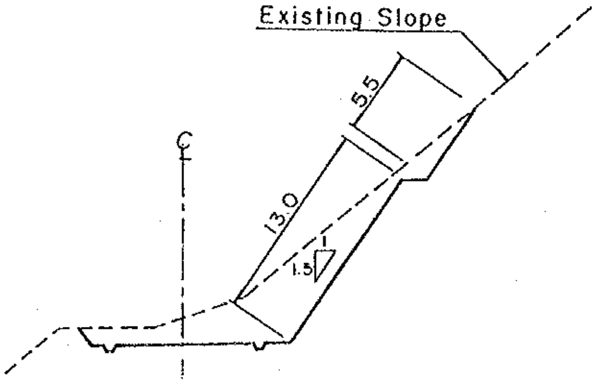
Optimum Countermeasure:
As illustrated below, <u>Concrete Crib is adaptable</u> to the location in topographical view point.



(4) Selection for C + 0.4 / No.10 + 900

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

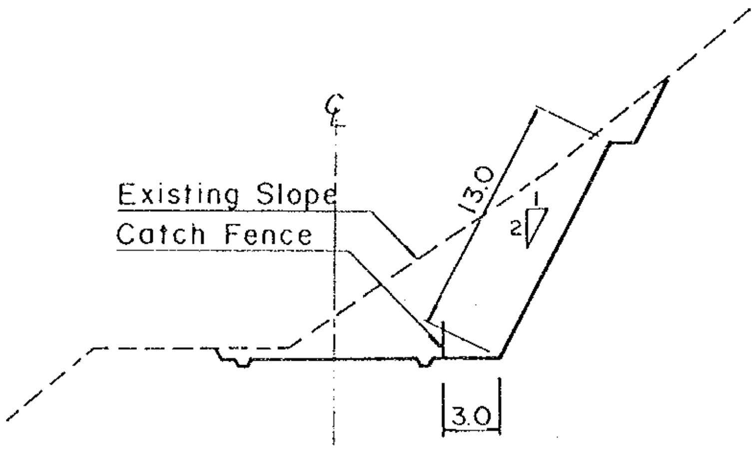
Optimum Countermeasures:
As illustrated below, Concrete Crib is adaptable to the location in topographical view point.



(5) Selection for C + 2.6 / No.12 + 780

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring + Catch Fence installed at road side
- Grid Type Concrete Retaining Wall + Catch Fence installed at road side

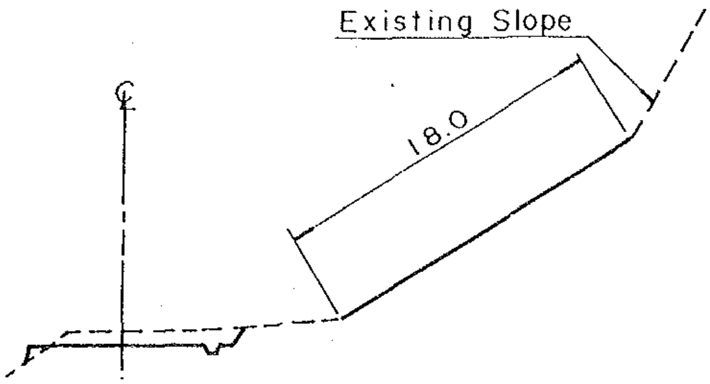
Optimum Countermeasures:
As illustrated below, Concrete Crib + Catch Fence is adaptable to the location in topographical view point.



(6) Selection for F + 4.2 / No.29 + 500

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

Optimum Countermeasure:
As illustrated below, Concrete Crib is adaptable to the location in topographical view point.

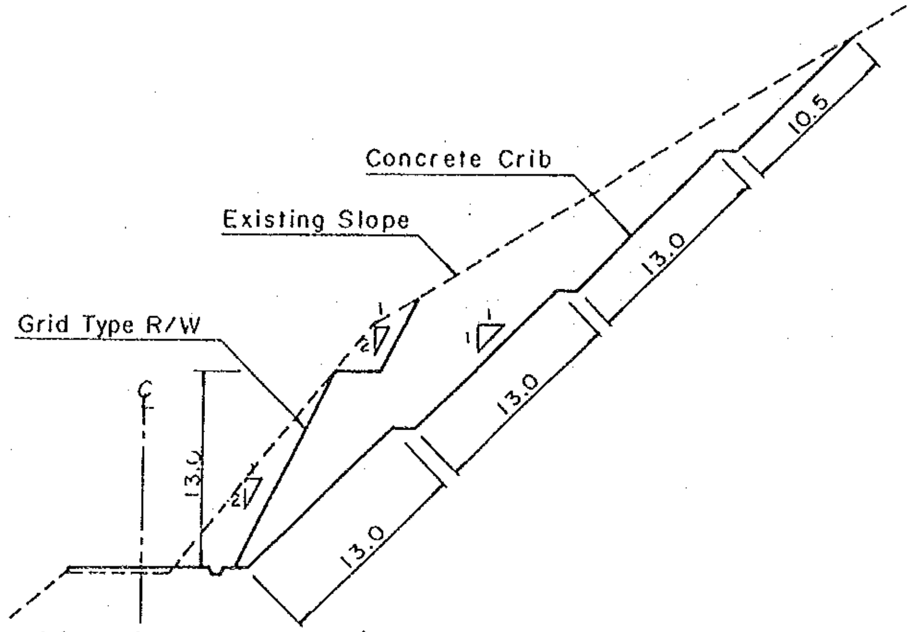


(7) Selection for H + 1.0 / No.33 + 700

Applicable Countermeasures:
- Concrete Crib with stone pitching and Anchoring + Gabion Catch Wall
- Grid Type Concrete Retaining Wall + Gabion Catch Wall

Optimum Countermeasure:
As described below, Grid Type Concrete Retaining Wall + Gabion Catch Wall is advantageous to the location in economical and topographical view points.

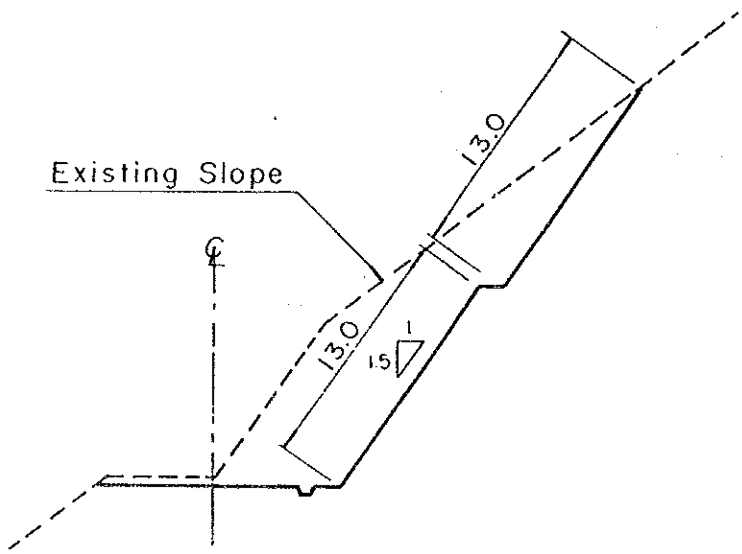
	Unit	Quantity	Unit Cost	Cost	Remarks
Concrete Crib	m^2	1,980	52.40 US	103,752 US	
Excavation	m^3	7,340	12.13	89,034	
Total				192,786	
Retaining Wall	m^2	581	124.95	72,595	
Excavation	m^3	1,539	12.13	18,668	
Total				91,263	



(8) Selection for I + 3.0 / No.38 + 740

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

Optimum Countermeasure:
As illustrated below, Concrete Crib is adaptable to the location in topographical view point.

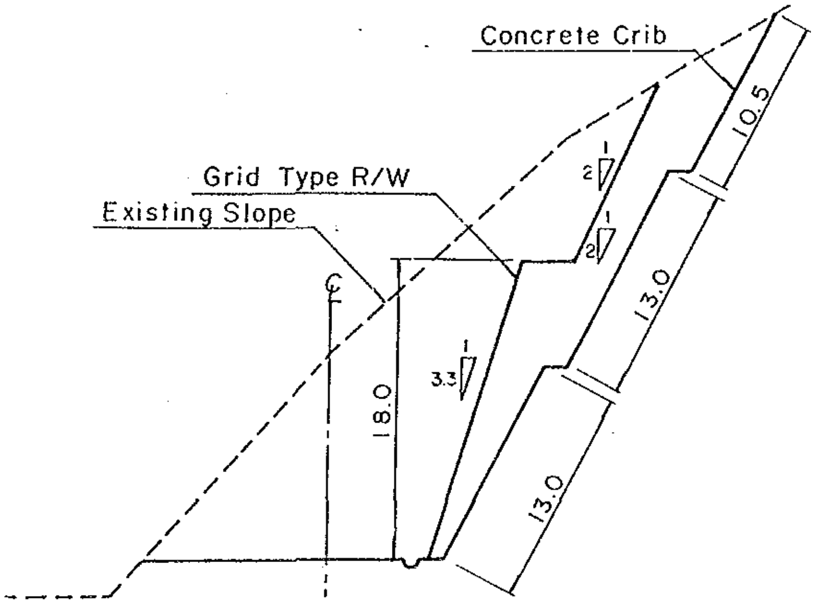


(9) Selection for I + 3.3 / No.39 + 30

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

Optimum Countermeasure:
As described below, Grid Type Concrete Retaining Wall is advantageous to the location in economical view point.

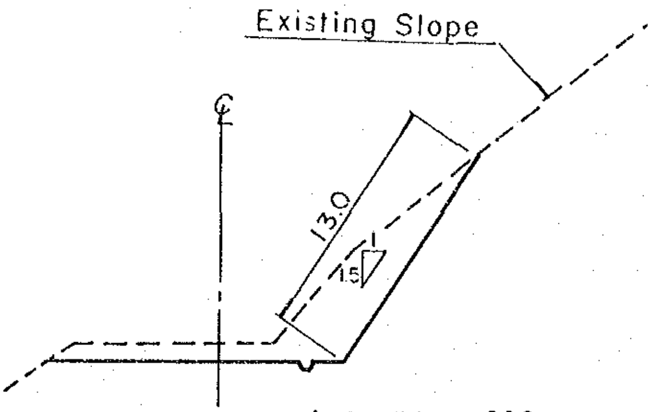
	Unit	Quantity	Unit Cost	Cost	Remarks
Concrete Crib	m^2	2,555	51.08 US	130,509 US	
Excavation	m^3	25,182	12.13	305,457	
Total				435,966	
Grid Type R/W	m^2	1,408	124.95	175,929	
Excavation	m^3	17,290	12.13	209,727	
Total				385,656	



(10) Selection for J + 4.9 / No.44 + 400

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

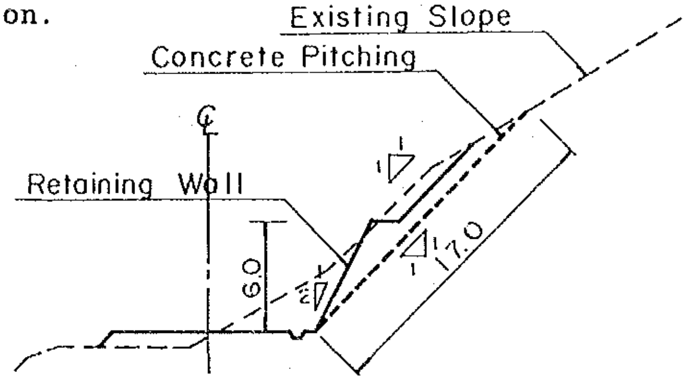
Optimum Countermeasure:
As illustrated below, Concrete Crib is adaptable to the location in topographical view point.



(11) Selection for L + 3.0 / No.52 + 200

Applicable Countermeasures:
- Stone Masonry Retaining Wall
- Concrete Pitching and Anchoring
- Grid Type Concrete Retaining Wall

Optimum Countermeasure:
As illustrated below, since Concrete Pitching is not adaptable to the location in topographical view point, Stone Masonry Retaining Wall or Grid Type Concrete Retaining Wall should be applied. Comparing those retaining walls with the cost, <u>Stone Masonry Retaining Wall is advantageous</u> to the location.

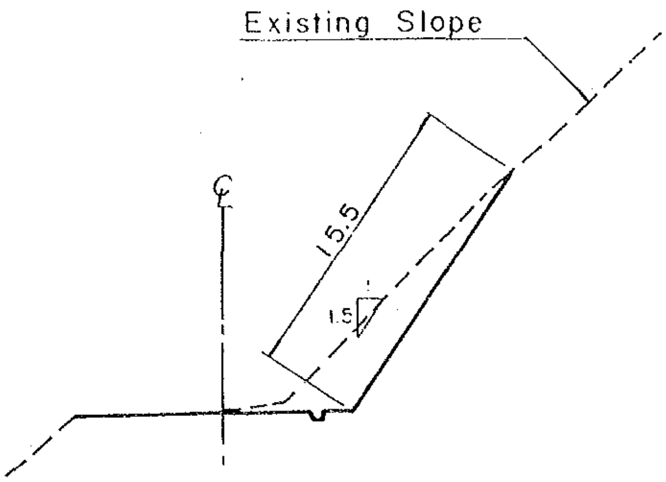


	Unit	Quantity	Unit Cost	Cost
Stone Masonry R/W	m^2	313	54.38 US	17,020 US
Grid Type R/W	m^2	268	124.95	33,486

(12) Selection for L + 6.1 / No.55 + 500

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

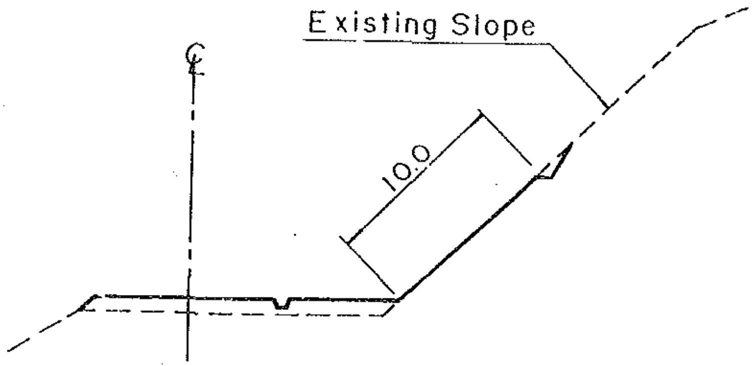
Optimum Countermeasure:
As illustrated below, <u>Concrete Crib is adaptable</u> to the location in topographical view point.



(13) Selection for M + 1.6 / No.58 + 200

Applicable Countermeasures:
- Concrete Pitching and Anchoring
- Grid Type Concrete Retaining Wall
- Supported Type Concrete Retaining Wall

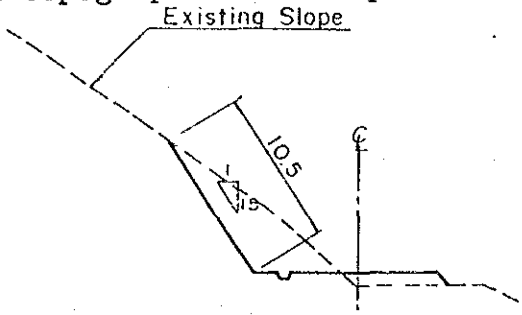
Optimum Countermeasure:
As illustrated below, Concrete Pitching and Anchoring is adaptable to the location in topographical view point.



(14) Selection for N + 2.0 / No.66 + 500

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

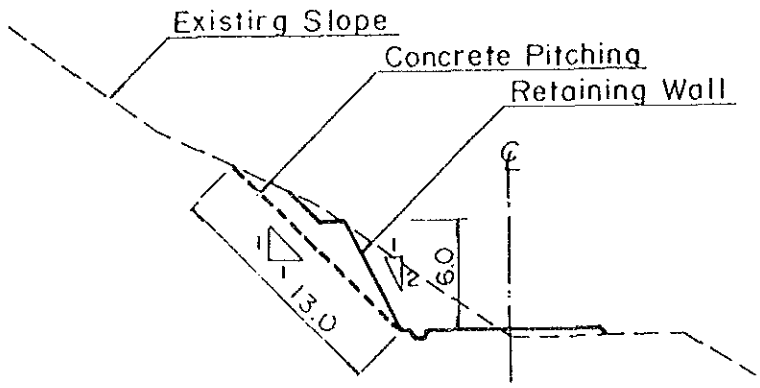
Optimum Countermeasure:
As illustrated below, Concrete Crib is adaptable to the location in topographical view point.



(15) Selection for N + 3.0 / No.68 + 440

Applicable Countermeasures:
- Concrete Pitching and Anchoring
- Grid Type Concrete Retaining Wall
- Supported Type Concrete Retaining Wall

Optimum Countermeasure:
As illustrated below, since Concrete Pitching is not adaptable to the location in topographical view point, Grid Type Concrete Retaining Wall or Supported Type Concrete Retaining Wall should be applied. Comparing those retaining walls with the cost, Grid Type Concrete Retaining Wall is advantageous to the location.

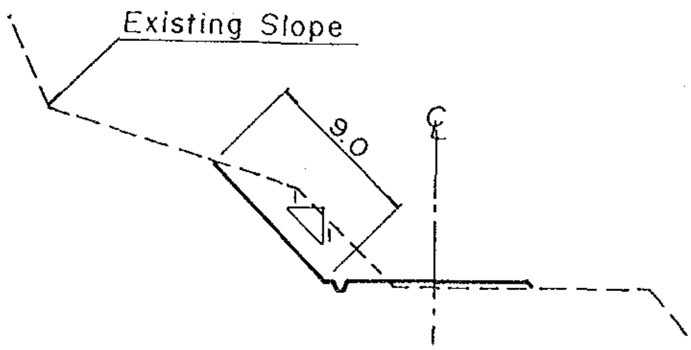


	Unit	Quantity	Unit Cost	Cost	Remarks
Grid Type R/W	m^2	1,006	124.95 US	125,699 US	
Supported Type R/W	m^2	1,173	216.42	253,860	

(16) Selection for N + 4.7 / No.70 + 100

Applicable Countermeasures:
- Stone Masonry Retaining Wall
- Concrete Pitching and Anchoring
- Grid Type Concrete Retaining Wall

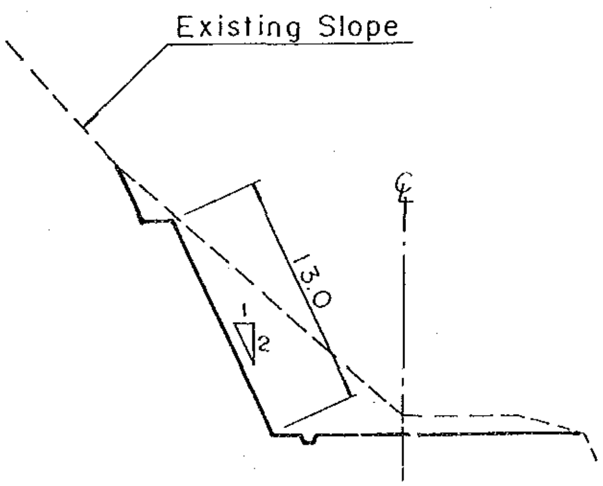
Optimum Countermeasure:
As illustrated below, Concrete Pitching is adaptable to the location in topographical view point.



(17) Selection for P + 0.9 / No.75 + 570

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

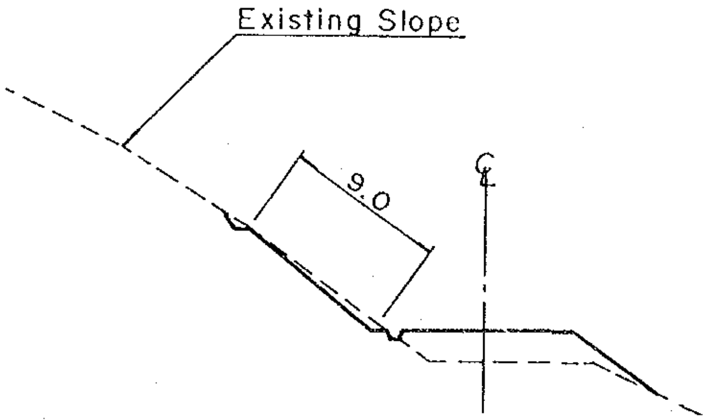
Optimum Countermeasure:
As illustrated below, Concrete Crib is adaptable to the location in topographical view point.



(18) Selection for P + 3.6 / No.77 + 800

Applicable Countermeasures:
- Concrete Pitching and Anchoring
- Grid Type Concrete Retaining Wall
- Supported Type Concrete Retaining Wall

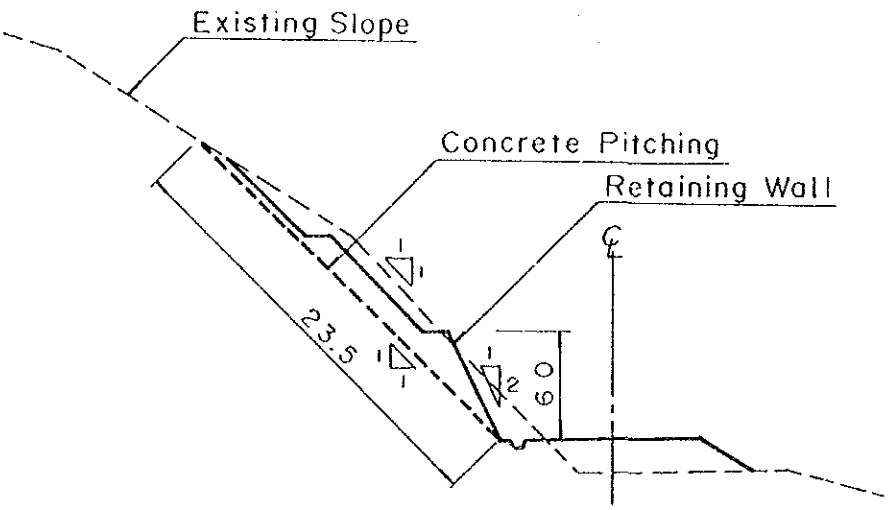
Optimum Countermeasure:
As illustrated below, Concrete Pitching is adaptable to the location in topographical view point.



(19) Selection for P + 3.7 / No.78 + 100

Applicable Countermeasures:
- Stone Masonry Retaining Wall
- Concrete Pitching and Anchoring
- Grid Type Concrete Retaining Wall

Optimum Countermeasure:
As illustrated below, since Concrete Pitching is not adaptable to the location in topographical view point, Stone Masonry Retaining Wall or Grid Type Retaining Wall should be applied. Comparing those retaining walls with the cost, Stone Masonry Retaining Wall is advantageous to the location.

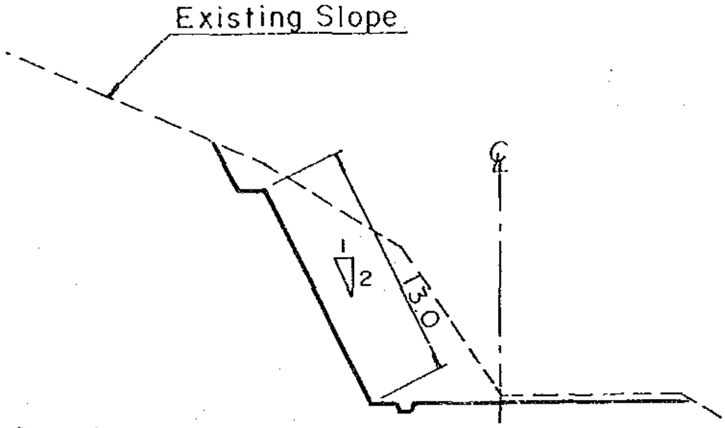


	Unit	Quantity	Unit Cost	Cost	Remarks
Stone Masonry R/W	m^2	626	54.38 US	34,041 US	
Grid Type R/W	m^2	536	124.95	66,973	

(20) Selection for P + 4.0 / No.78 + 600

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

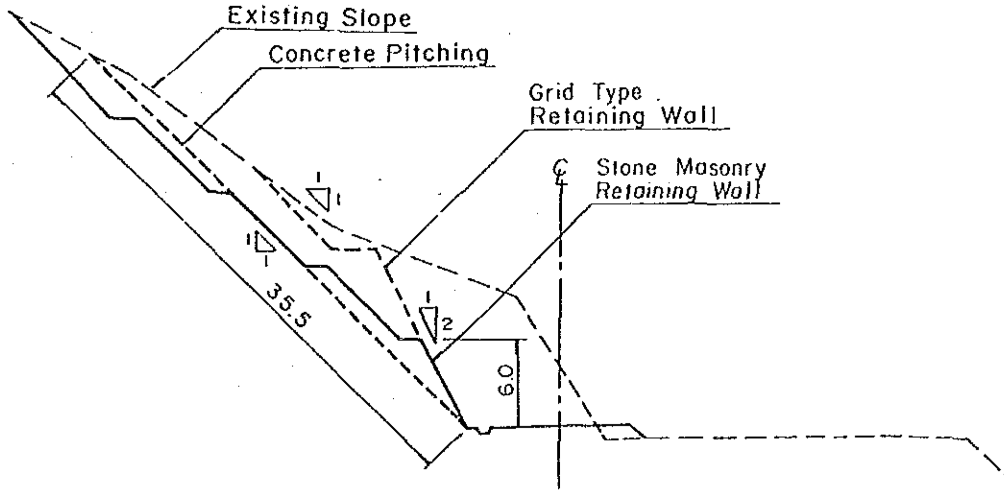
Optimum Countermeasure:
As illustrated below, Concrete Crib is adaptable to the location in topographical view point.



(21) Selection for P + 4.9 / No.79 + 500

Applicable Countermeasures:
- Stone Masonry Retaining Wall
- Concrete Pitching and Anchoring
- Grid Type Concrete Retaining Wall

Optimum Countermeasure:
As illustrated below, since Concrete Pitching is not adaptable to the location in topographical view point. Stone Masonry Retaining Wall or Grid Type Retaining Wall should be applied. Comparing those retaining walls with the cost, Stone Masonry Retaining Wall is Advantageous to the location.

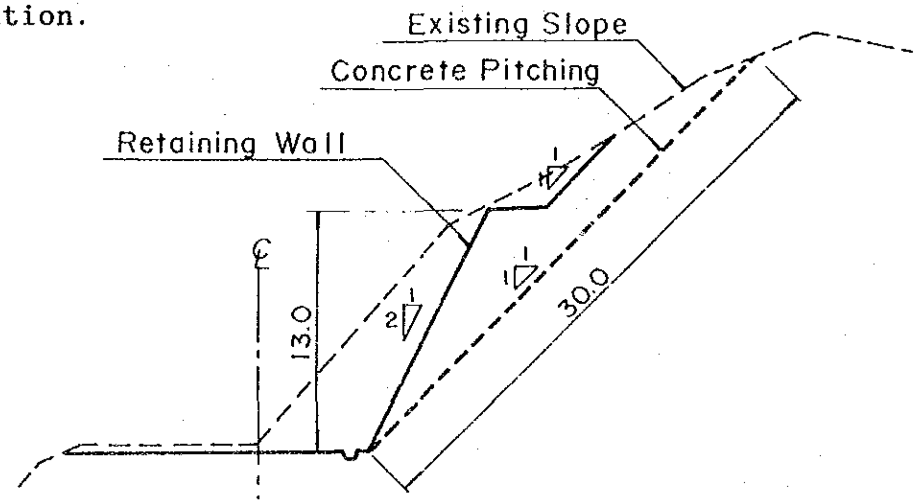


	Unit	Quantity	Unit Cost	Cost	Remark
Stone Masonry R/W	m2	355	54.38us	18.217us	
Excavation	m3	8,137	3.04	24.736	
Total				42.953	
Grid Type R/W	m2	670	124.95us	83.716	
Excavation	m3	4,447	3.04	13.518	
Total				97.234	

(22) Selection for Q + 0.6 / No.80 + 350

Applicable Countermeasures:
- Concrete Pitching and Anchoring
- Grid Type Concrete Retaining Wall
- Supported Type Concrete Retaining Wall

Optimum Countermeasure:
As illustrated below, since Concrete Pitching is not adaptable to the location in topographical view point, Grid Type Retaining Wall or Supported Type Retaining Wall should be applied. Comparing those retaining walls with the cost, Grid Type Concrete Retaining Wall is advantageous to the location.



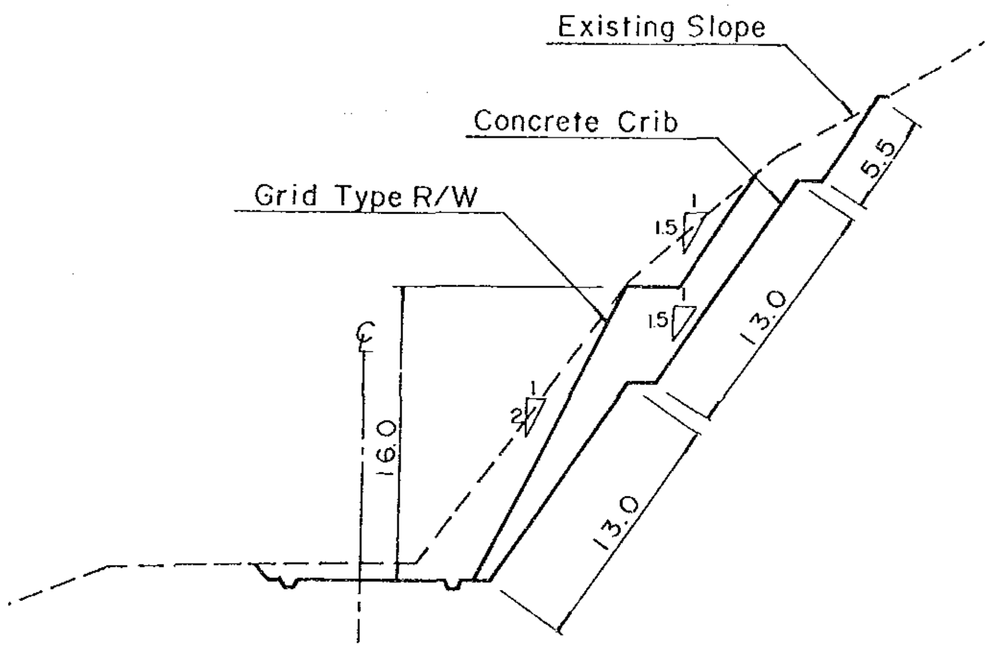
	Unit	Quantity	Unit Cost	Cost
Grid Type R/W	m^2	2,180	124.95 US	272,391 US
Supported Type R/W	m^2	2,515	216.42	544,296

(23) Selection for R + 0.3 / No.82 + 400

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

Optimum Countermeasure:
As described below, Grid Type Concrete Retaining Wall is advantageous to the location in economical view point.

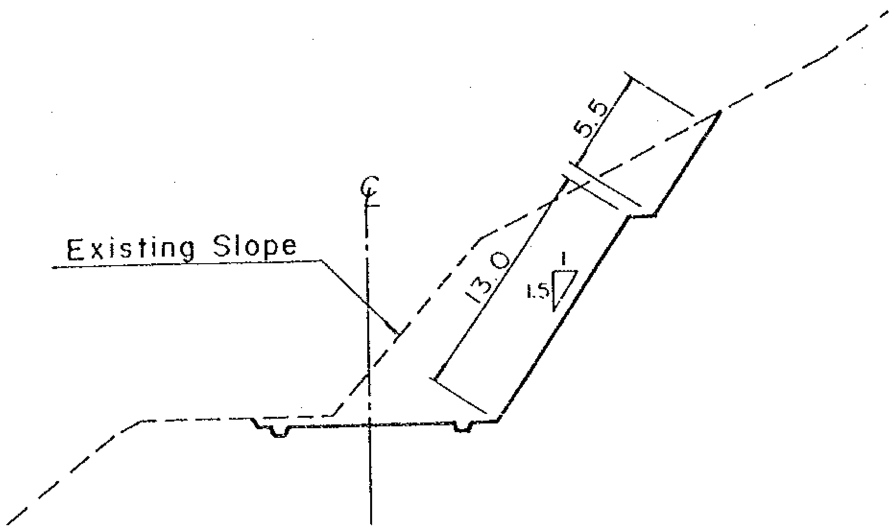
	Unit	Quantity	Unit Cost	Cost	Remarks
Concrete Crib	m^2	1,260	51.08 US	64,360 US	
Excavation	m^3	4,620	12.13	56,040	
Total				120,400	
Grid Type R/W	m^2	715	124.95	89,339	
Excavation	m^3	1,910	12.13	23,168	
Total				112,507	



(24) Selection for R + 1.8 / No.84 + 350

Applicable Countermeasures:
- Concrete Crib with concrete spraying and Anchoring
- Grid Type Concrete Retaining Wall

Optimum Countermeasure:
As illustrated below, <u>Concrete Crib is adaptable</u> to the location in topographical view point.



Appendices 5-1 Pavement Design

Appendix 5-1 (1) Derivation of ESAL Factor

ESAL Factors were based on an assumed terminal serviceability of 2.5 and structural number (SN) of 5.0. In most cases, such an assumption provides information sufficiently accurate for design purposes.

Vehicle Type		Axle Load Distribution (front/rear)		ESAL Factor	
		(tons)	(Kips)	(front/rear)	(Total)
Passenger Car	S	0.6813	1.5	0.0002	0.0004
	S	0.6174	1.4	0.0002	
Bus	S	4.7248	10.4	0.088	1.598
	S	9.0752	20.0	1.51	
Light Truck	S	1.5916	3.5	0.002	0.004
	S	2.0084	4.4	0.002	
Medium Truck	S	2.5084	5.5	0.010	0.044
	S	3.6916	8.1	0.034	
Heavy Truck	S	5.073	11.2	0.189	0.553
	T	11.927	26.3	0.364	

Note : S = Single Axle, T = Tandem Axle

Table Axle load equivalency factors for flexible pavements, tandem axles and p_t of 2.5.

Axle Load (kips)	Pavement Structural Number (SN)					
	1	2	3	4	5	6
2	.0001	.0001	.0001	.0000	.0000	.0000
4	.0005	.0005	.0004	.0003	.0003	.0002
6	.002	.002	.002	.001	.001	.001
8	.004	.006	.005	.004	.003	.003
10	.008	.013	.011	.009	.007	.006
12	.015	.024	.023	.018	.014	.013
14	.026	.041	.042	.033	.027	.024
16	.044	.065	.070	.057	.047	.043
18	.070	.097	.109	.092	.077	.070
20	.107	.141	.162	.141	.121	.110
22	.160	.198	.229	.207	.180	.166
24	.231	.273	.315	.292	.260	.242
26	.327	.370	.420	.401	.364	.342
28	.451	.493	.548	.534	.495	.470
30	.611	.648	.703	.695	.658	.633
32	.813	.843	.889	.887	.857	.834
34	1.06	1.08	1.11	1.11	1.09	1.08
36	1.38	1.38	1.38	1.38	1.38	1.38
38	1.75	1.73	1.69	1.68	1.70	1.73
40	2.21	2.16	2.06	2.03	2.08	2.14
42	2.76	2.67	2.49	2.43	2.51	2.61
44	3.41	3.27	2.99	2.88	3.00	3.16
46	4.18	3.98	3.58	3.40	3.55	3.79
48	5.08	4.80	4.25	3.98	4.17	4.49
50	6.12	5.76	5.03	4.64	4.86	5.28
52	7.33	6.87	5.93	5.38	5.63	6.17
54	8.72	8.14	6.95	6.22	6.47	7.15
56	10.3	9.6	8.1	7.2	7.4	8.2
58	12.1	11.3	9.4	8.2	8.4	9.4
60	14.2	13.1	10.9	9.4	9.6	10.7
62	16.5	15.3	12.6	10.7	10.8	12.1
64	19.1	17.6	14.5	12.2	12.2	13.7
66	22.1	20.3	16.6	13.8	13.7	15.4
68	25.3	23.3	18.9	15.6	15.4	17.2
70	29.0	26.6	21.5	17.6	17.2	19.2
72	33.0	30.3	24.4	19.8	19.2	21.3
74	37.5	34.4	27.6	22.2	21.3	23.6
76	42.5	38.9	31.1	24.8	23.7	26.1
78	48.0	43.9	35.0	27.8	26.2	28.8
80	54.0	49.4	39.2	30.9	29.0	31.7
82	60.6	55.4	43.9	34.4	32.0	34.8
84	67.8	61.9	49.0	38.2	35.3	38.1
86	75.7	69.1	54.5	42.3	38.8	41.7
88	84.3	76.9	60.6	46.8	42.6	45.6
90	93.7	85.4	67.1	51.7	46.8	49.7

Table Axle load equivalency factors for flexible pavements, single axles and p_t 2.5.

Axle Load (kips)	Pavement Structural Number (SN)					
	1	2	3	4	5	6
2	.0004	.0004	.0003	.0002	.0002	.0002
4	.003	.004	.004	.003	.002	.002
6	.011	.017	.017	.013	.010	.009
8	.032	.047	.051	.041	.034	.031
10	.078	.102	.118	.102	.088	.080
12	.168	.198	.229	.213	.189	.176
14	.328	.358	.399	.388	.360	.342
16	.591	.613	.646	.645	.623	.606
18	1.00	1.00	1.00	1.00	1.00	1.00
20	1.61	1.57	1.49	1.47	1.51	1.55
22	2.48	2.38	2.17	2.09	2.18	2.30
24	3.69	3.49	3.09	2.89	3.03	3.27
26	5.33	4.99	4.31	3.91	4.09	4.48
28	7.49	6.98	5.90	5.21	5.39	5.98
30	10.3	9.5	7.9	6.8	7.0	7.8
32	13.9	12.8	10.5	8.8	8.9	10.0
34	18.4	16.9	13.7	11.3	11.2	12.5
36	24.0	22.0	17.7	14.4	13.9	15.5
38	30.9	28.3	22.6	18.1	17.2	19.0
40	39.3	35.9	28.5	22.5	21.1	23.0
42	49.3	45.0	35.6	27.8	25.6	27.7
44	61.3	55.9	44.0	34.0	31.0	33.1
46	75.5	68.8	54.0	41.4	37.2	39.3
48	92.2	83.9	65.7	50.1	44.5	46.5
50	112.	102.	79.	60.	53.	55.

Appendix 5-1 (2) Estimation of design Structural Numbers

The estimations of this design method used the recommend nomogram are presented by each layer on page AP-38 to AP-44.
On the other hand, a method of "AASHTO Interim Guide for Design of Pavement Structures 1972" is that the value is estimated by assuming the CBR value as presented on page AP-45 to AP-46. The results of this estimations are summarized below:

Section	No.0(Santa Barbara) -No.48	No.48 -No.60(Caranavi)	No.60(Caranavi) -End Point(Bella Vista)
Design CBR of Roadbed Soil	10.0	7.0	7.0
Roadbed	2.5 (2.9)	3.0 (3.0)	2.7 (2.7)
Sub-base Course	2.3 (2.3)		2.0 (2.0)
Base Course	1.7 (1.7)		1.5 (1.5)

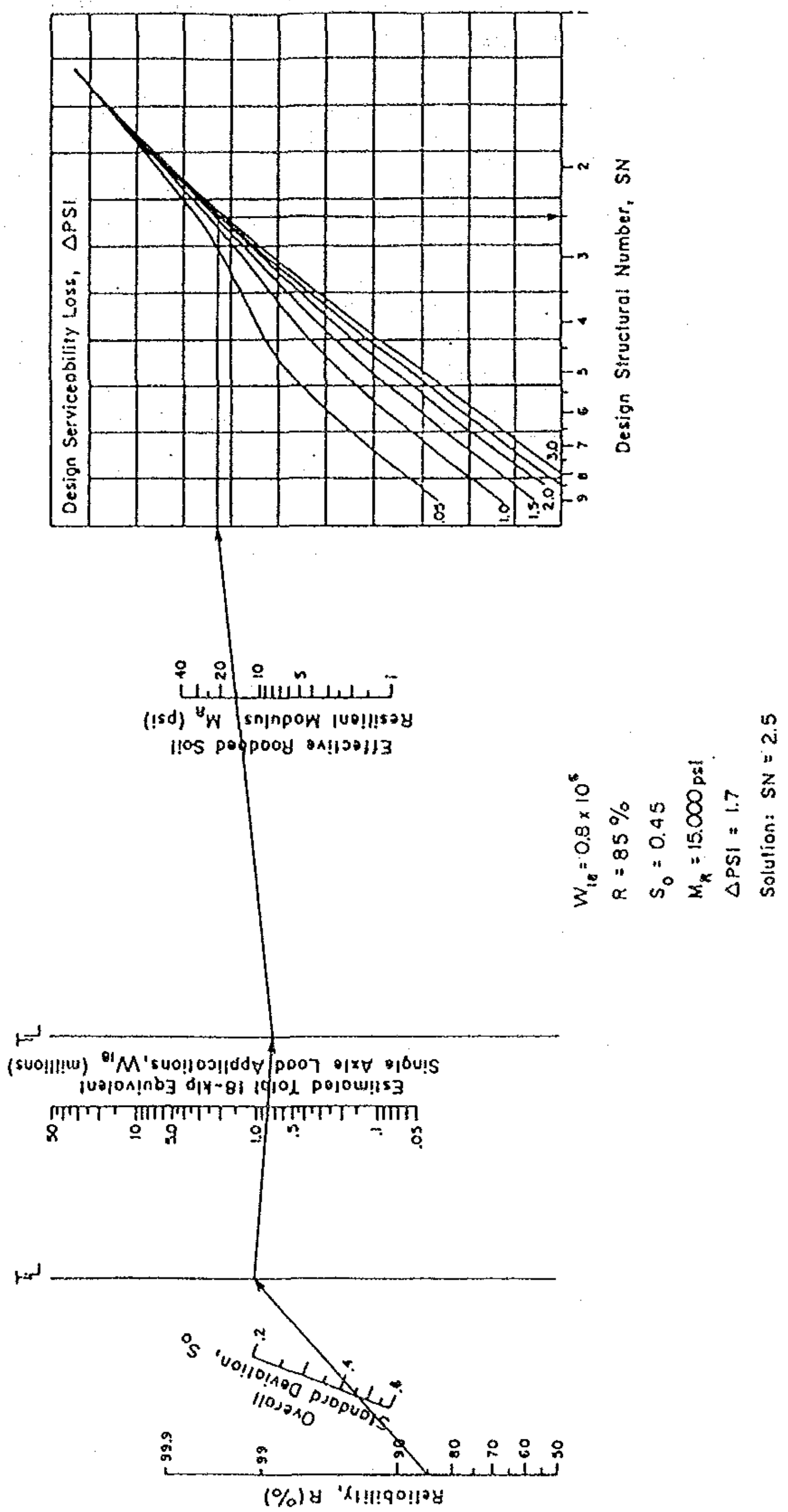
Note: Parenthesized figures indicate the values estimated by AASHTO Interim Guide Method. Underlined figures indicate the adopted values.

Reference: The adopted value (2.9) of roadbed in the section between No.0 (Santa Barbara) and No.48 corresponds to the elastic resilient modulus of 12,000psi.(AP-47)

I. Estimations by This Vesign Method

SN for Roadbed

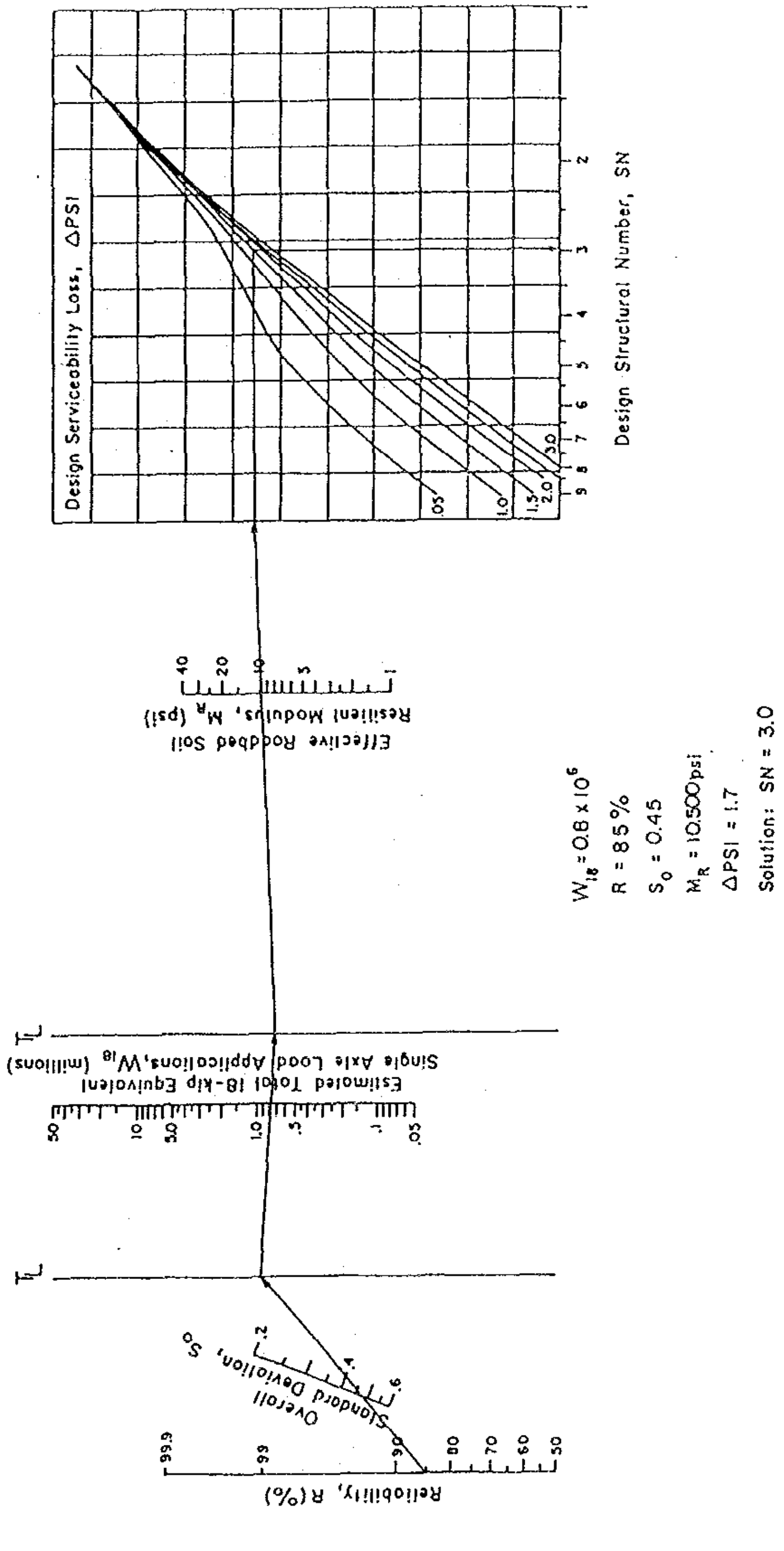
Highway Pavement Structural Design No. 0 (Sta. Barbara) - No. 48



SN for Roadbed

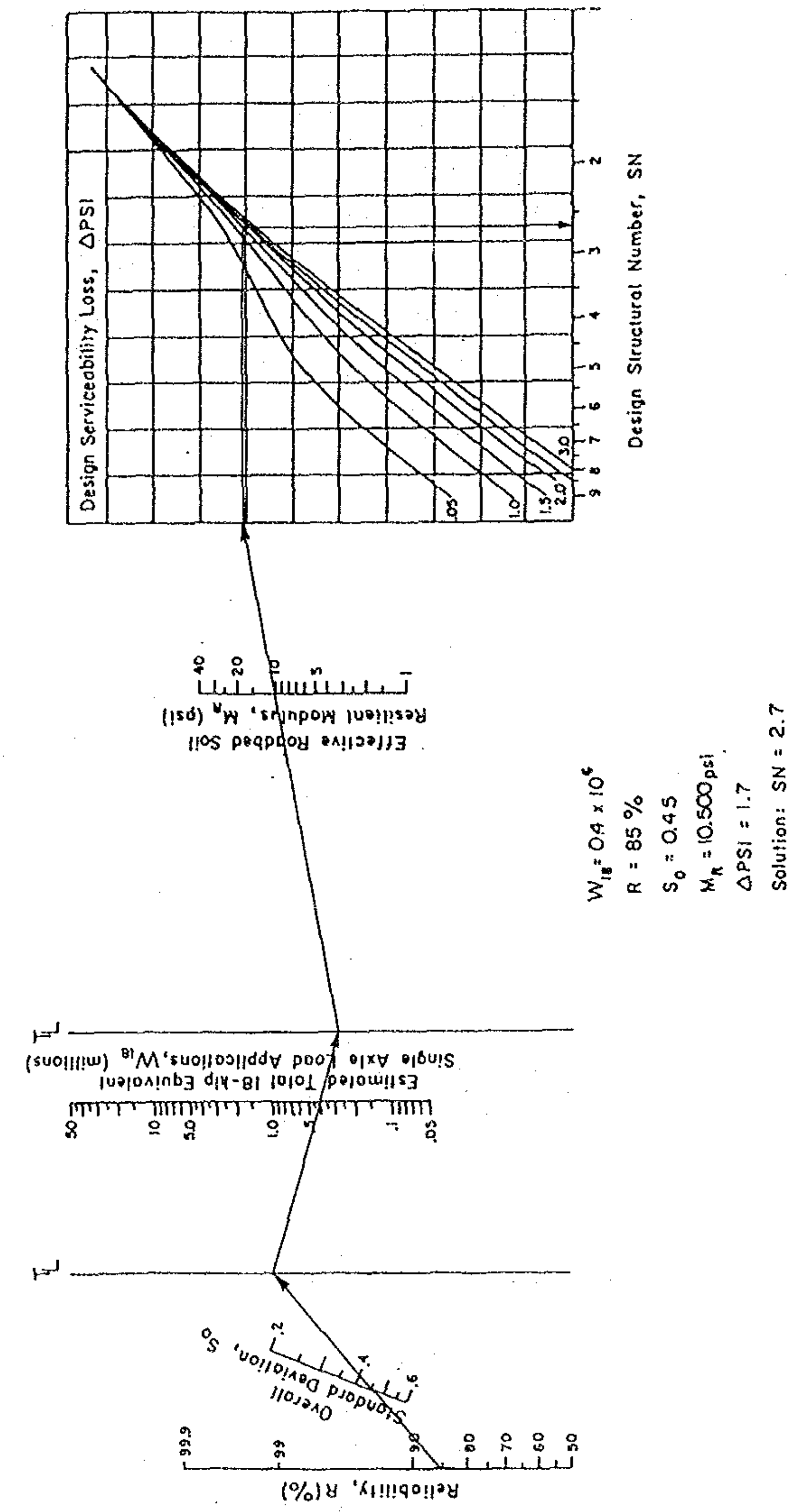
Highway Pavement Structural Design

No. 48 – No. 60 (Caranavi)



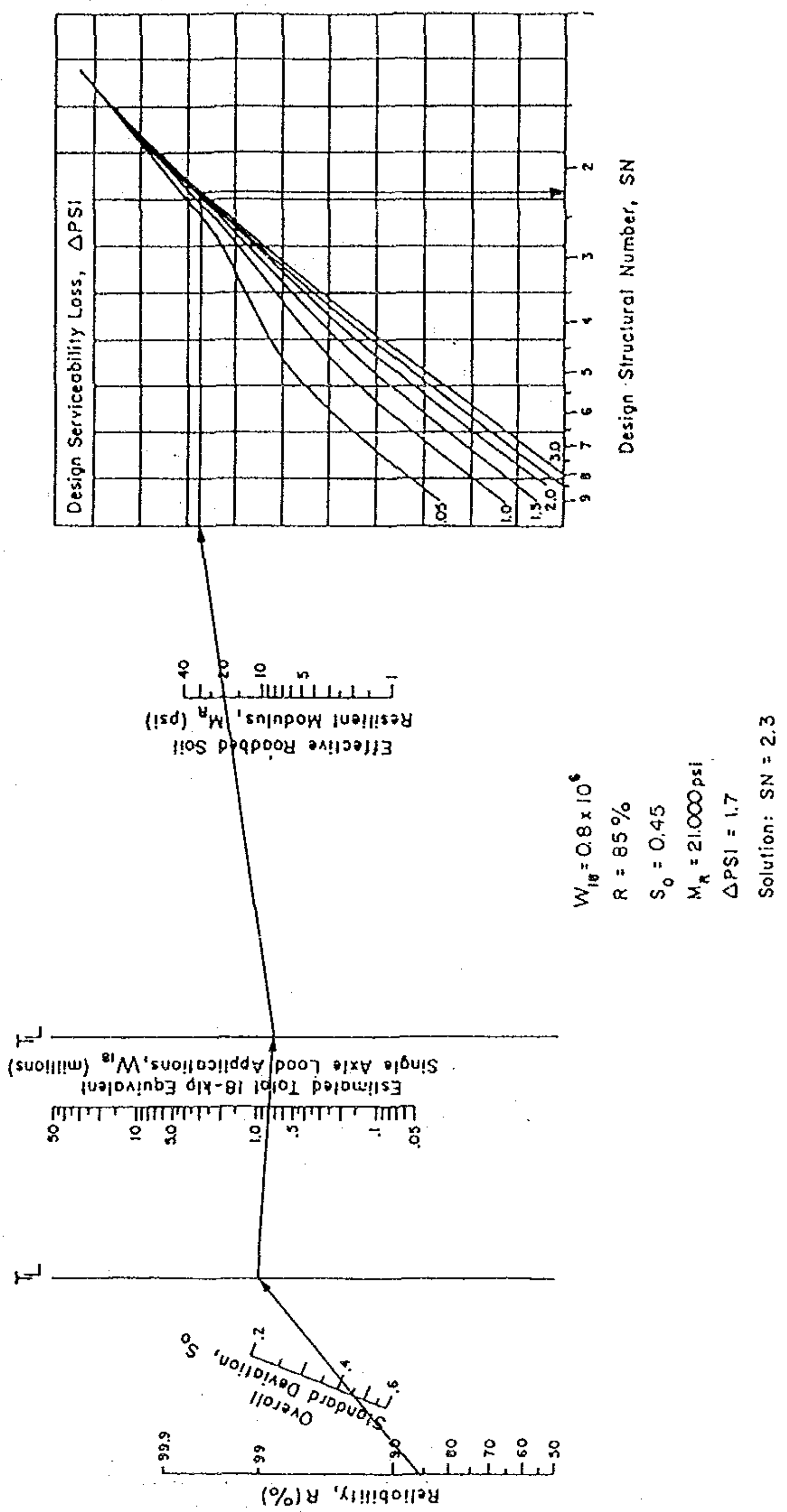
SN for Roadbed

No.60 (Caranavi) - End Point (Bella Vista)



SN for Subbase Course

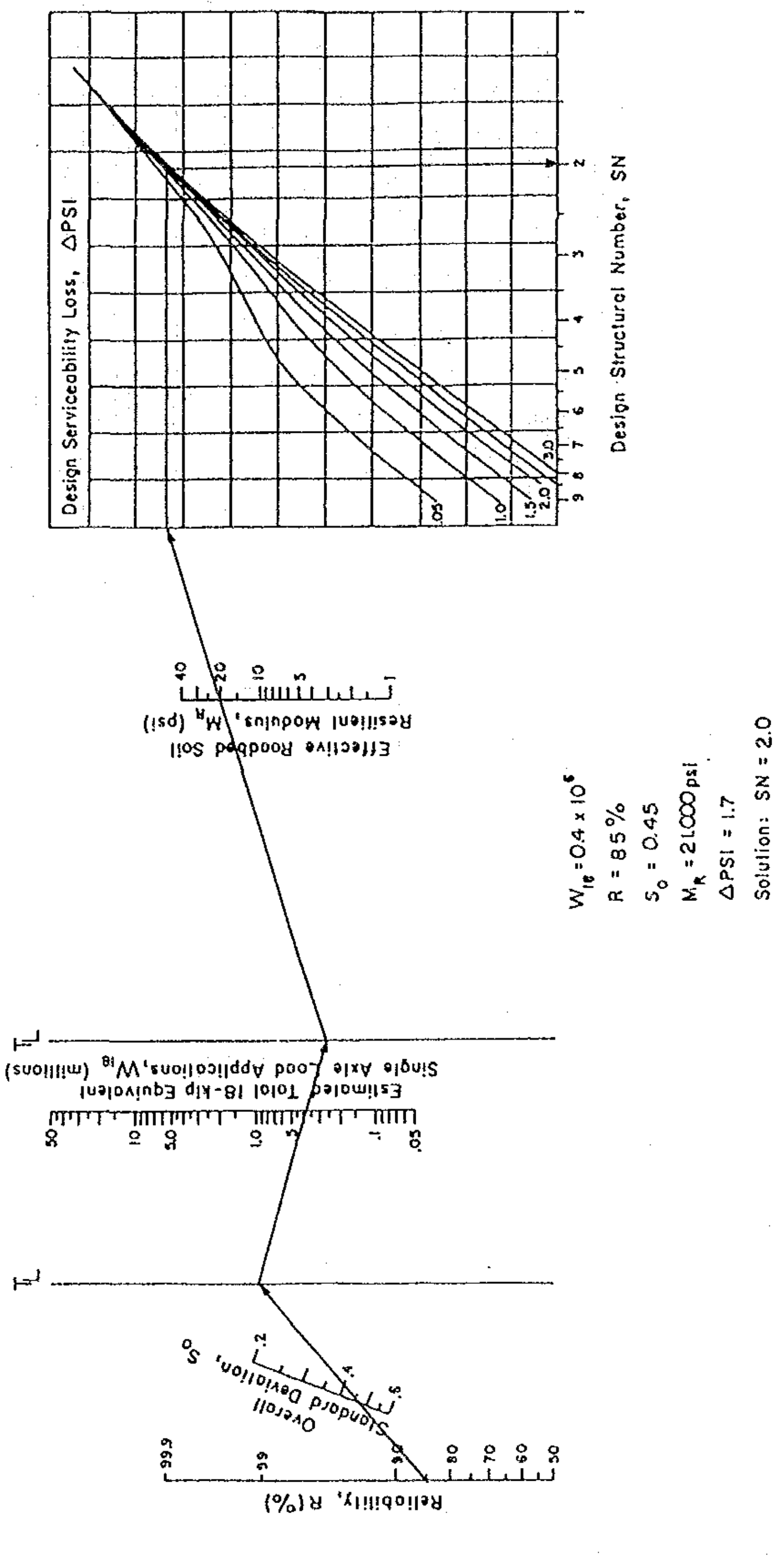
No. 0 (Sta. Barbara) - No. 60 (Caranavi)



SN for Subbase Course

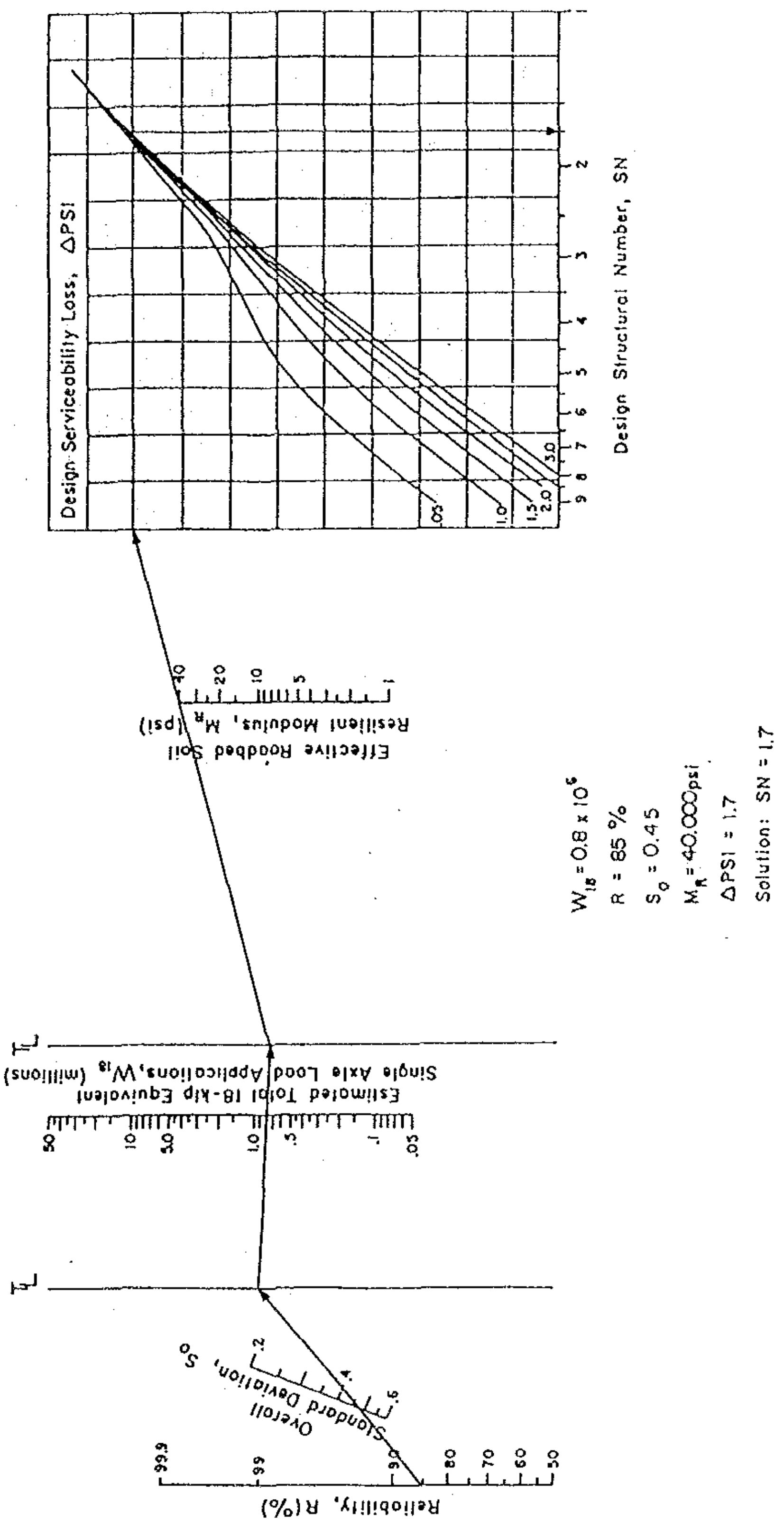
Highway Pavement Structural Design

No. 60 (Caranavi) - End Point (Bella Vista)



SN for Base Course

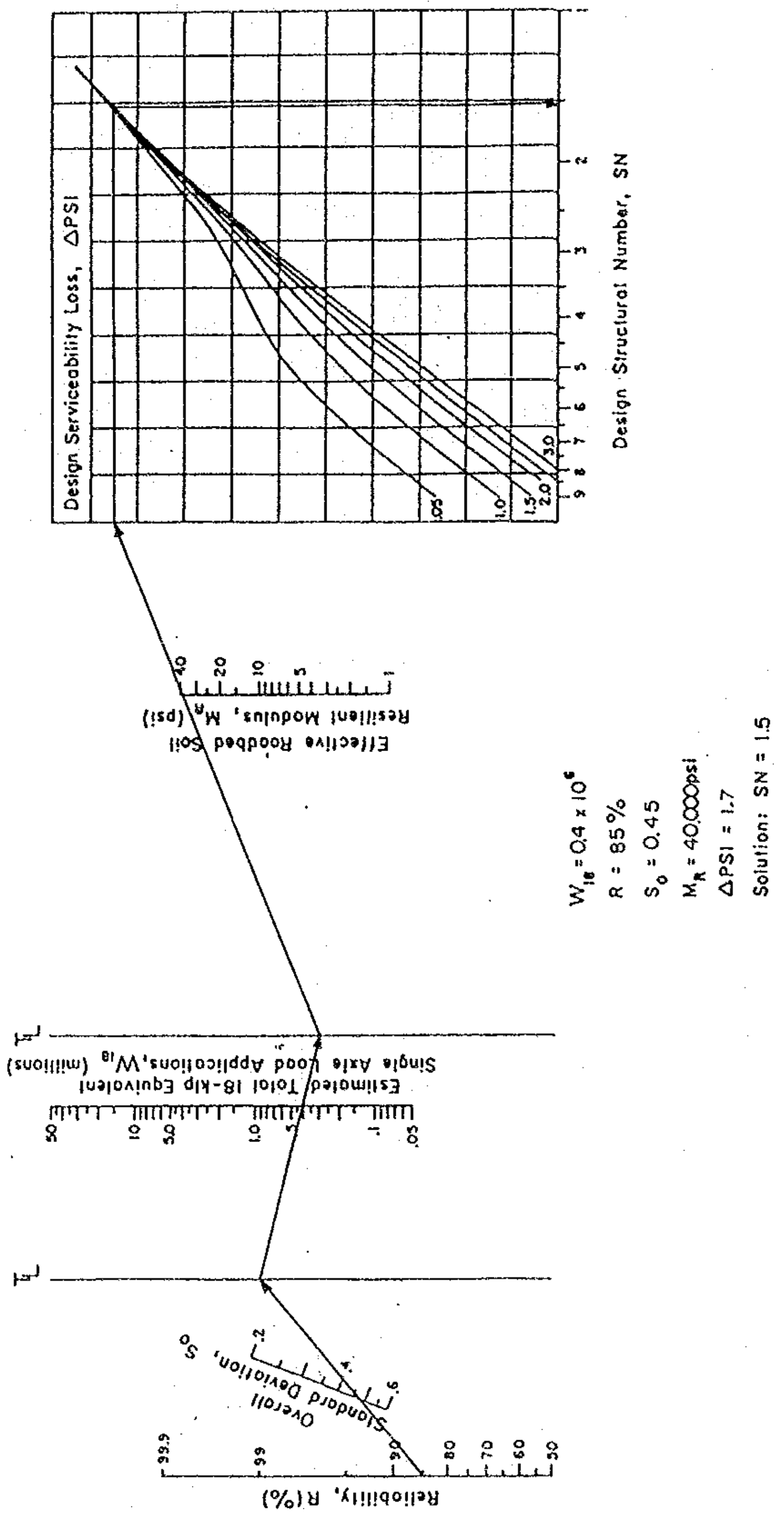
Highway Pavement Structural Design No.0 (Sta. Barbara) - No.60 (Caranavi)



SN for Base Course

Highway Pavement Structural Design

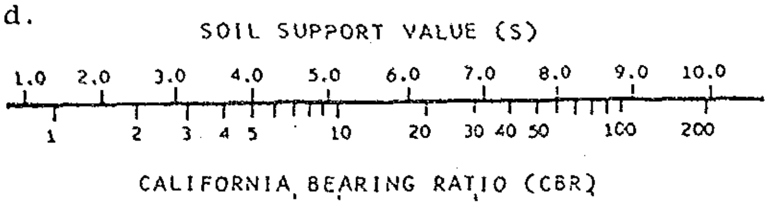
No. 60 (Caranavi) – End Point (Belle Vista)



II Estimation by AASHTO Interim Guide Method

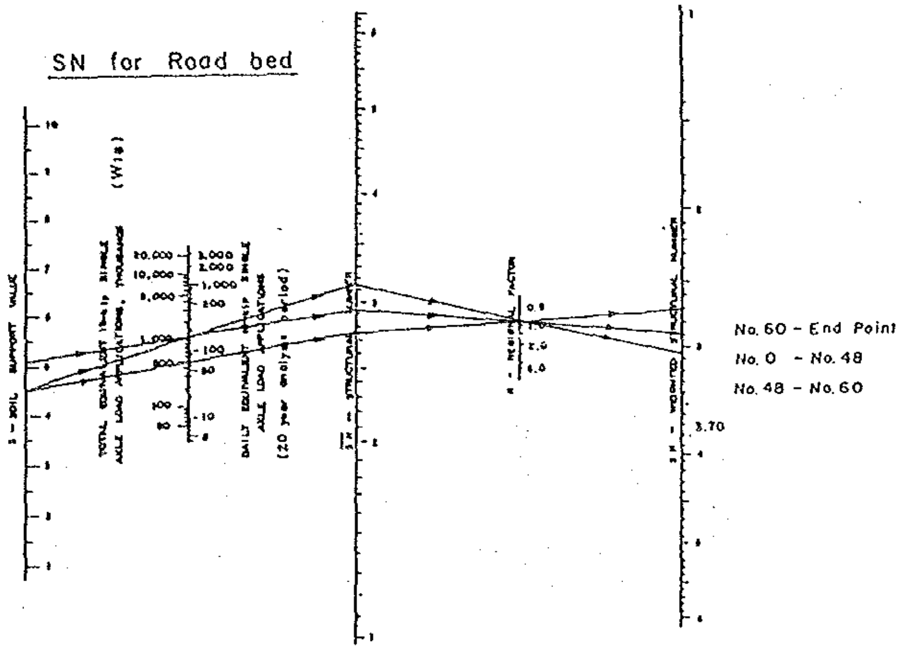
Step 1

The Soil support values for roadbed, base course and sub-base course were estimated using the following scale established.



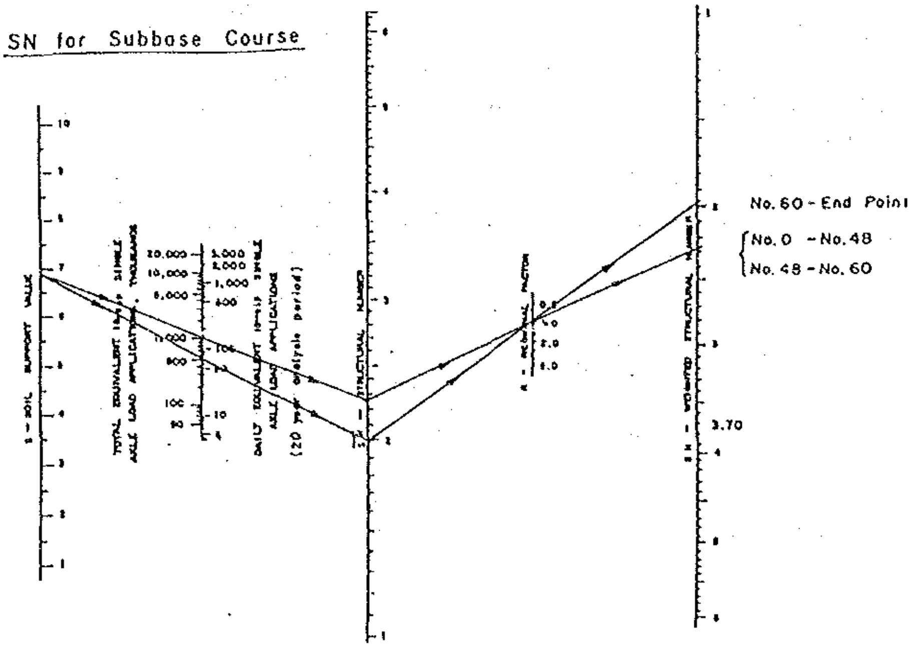
	Design CBR(%)	Soil Support Value	Remarks
Roadbed	10.0	5.1	No.0 - No.48
	7.0	4.5	No.48 - End Point
Sub-base Course	30.0	6.8	The CBR value was determined by the availability on site.
Base Course	80.0	8.5	- ditto -

Step 2



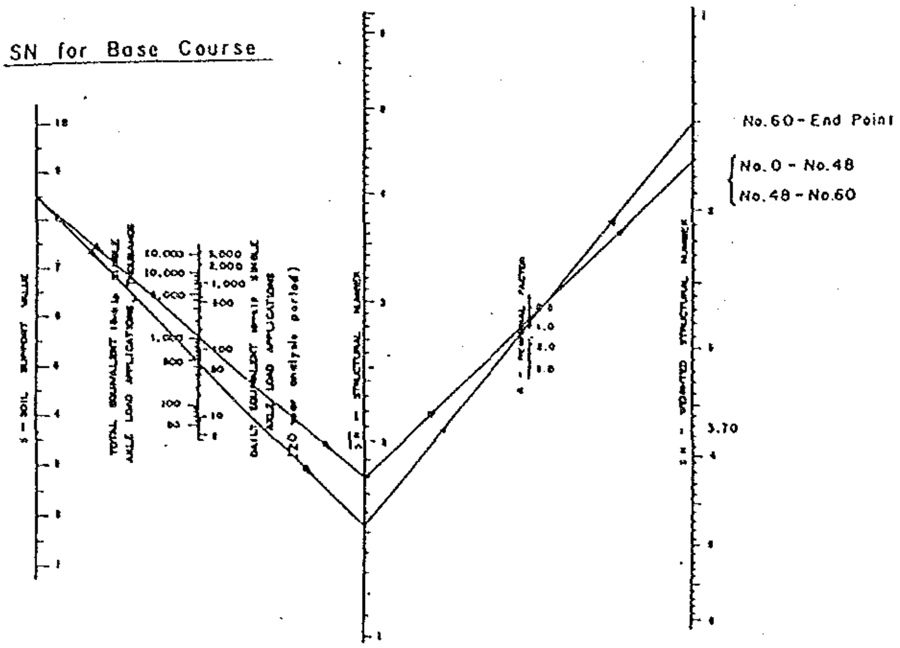
	S	W_{18}	R	SN
No. 0 - No.48	5.1	861.066	0.9	2.9
No.48 - No.60	4.5	861.066	0.9	3.0
No.60 - End Point	4.5	409.645	0.9	2.7

SN for Subbase Course

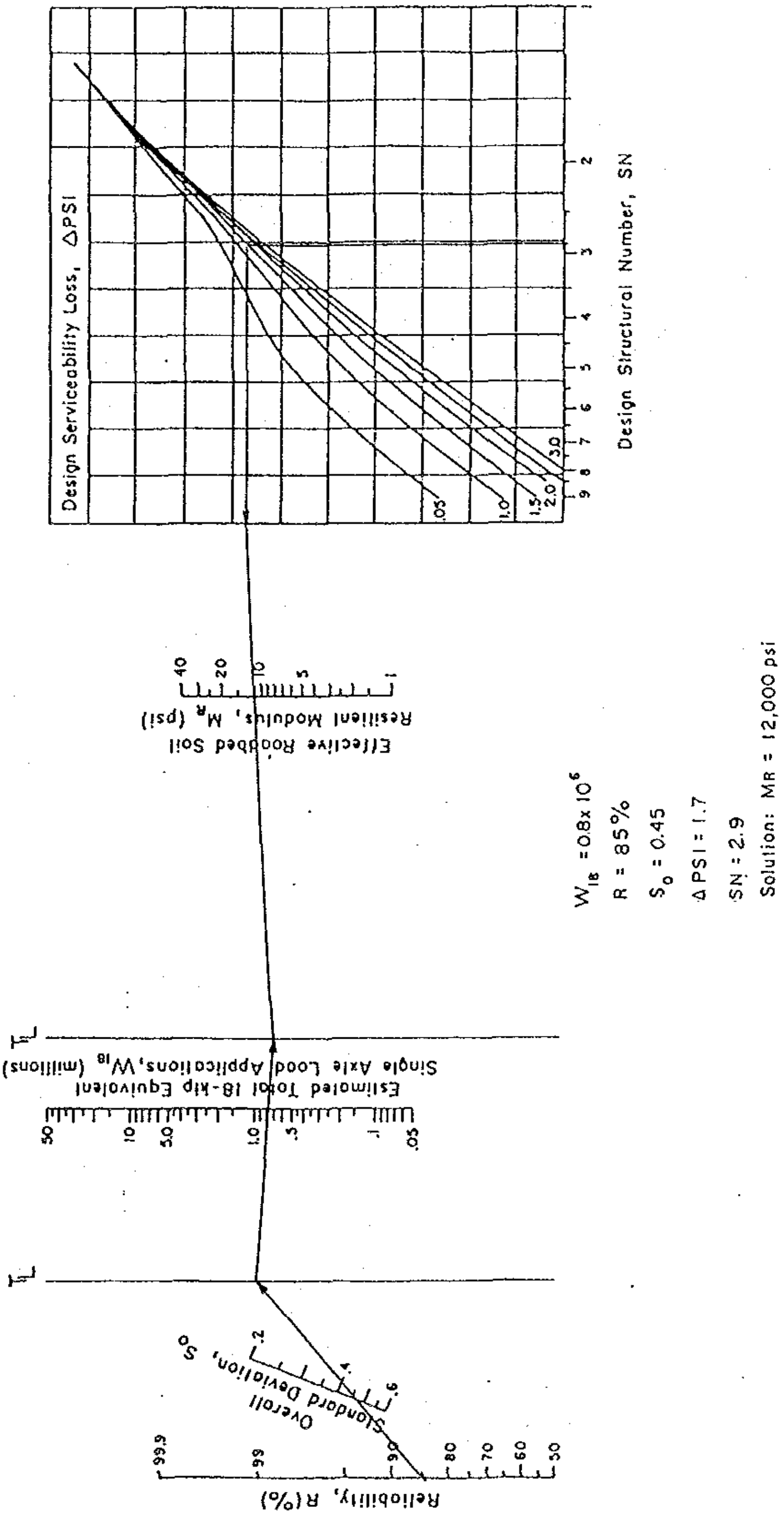


	S	W_{18}	R	SN
No. 0 - No.48	8.8	861.066	0.9	2.3
No.48 - No.60	8.8	861.066	0.9	2.3
No.60 - End Point	8.8	409.645	0.9	2.0

SN for Base Course



	S	W_{18}	R	SN
No. 0 - No.48	8.5	861.066	0.9	1.7
No.48 - No.60	8.5	861.066	0.9	1.7
No.60 End Point	8.5	409.645	0.9	1.5



Design chart for flexible pavements based on using mean values for each input.

Appendix 5-1 (3) Determination of Layer Thicknesses

No. 0 (Santa Barbara) - No.48

$SN_1 / a_1 = 1.7 / 0.44 = 3.86 < \underline{D_1^* = 4}$

$SN_1^* = a_1 D_1^* = 0.44 \times 4 = 1.76 > SN_1 = 1.7$

$(SN_2 - SN_1^*) / a_2 m_2 = (2.3 - 1.76 / 0.14 \times 1.0 = 3.86 < \underline{D_2^* = 6}$

$SN_2^* = a_2 D_2^* m_2 = 0.14 \times 6 \times 1.0 = 0.84$

$SN_1^* + SN_2^* = 1.76 + 0.84 = 2.6 > SN_2 = 2.3$

$\{SN_3 - (SN_1^* + SN_2^*)\} / a_3 m_3 = (2.9-2.6) / 0.11 \times 1.0 = 2.73 < \underline{D_3^* = 6}$

No.48 - No.60 (Caranavi)

$SN_1 / a_1 = 1.7 / 0.44 = 3.86 < \underline{D_1^* = 4}$

$SN_1^* = a_1 D_1^* = 0.44 \times 4 = 1.76 > SN_1 = 1.7$

$(SN_2 - SN_1^*)/a_2 m_2 = (2.3-1.76)/0.14 \times 1.0 = 3.86 < \underline{D_2^* = 6}$

$SN_2^* = a_2 D_2^* m_2 = 0.14 \times 6 \times 1.0 = 0.84$

$SN_1^* + SN_2^* = 1.76 + 0.84 = 2.6 > SN_2 = 2.3$

$\{SN_3 - (SN_1^* + SN_2^*)\} / a_3 m_3 = (3.0 - 2.6) / 0.11 \times 1.0 = 3.64 < \underline{D_3^* = 6}$

No.60 (Caranavi) - End Point (Bella Vista)

$SN_1 / a_1 = 1.5 / 0.44 = 3.41 < \underline{D_1^* = 4}$

$SN_1^* = a_1 D_1^* = 0.44 \times 4 = 1.76 > SN_1 = 1.5$

$(SN_2 - SN_1^*) / a_2 m_2 = (2.0 - 1.76) / 0.14 \times 1.0 = 1.71 < \underline{D_2^* = 6}$

$SN_2^* = a_2 D_2^* m_2 = 0.14 \times 6 \times 1.0 = 0.84$

$SN_1^* + SN_2^* = 1.76 + 0.84 = 2.6 > SN_2 = 2.0$

$\{SN_3 - (SN_1^* + SN_2^*)\} / a_3 m_3 = (2.7-2.6) / 0.11 \times 1.0 = 0.91 < \underline{D_3^* = 6}$

Note: In the AASHTO Guide (1986), a minimum thickness of 6 inches is recommended to aggregate base. Furthermore, a minimum thickness of base and subbase should be 2.5 to 3.0 times of maximum aggregate diameter from previous experience. Assuming that the maximum aggregate diameter is 2 inches, the minimum thicknesses should be 6 inches. As described above, all of the estimated thickness of base and subbase were less than the minimum thickness. Thus, the design layer thickness of base and subbase adopted 6 inches of minimum thickness.