TIME OF RECURSION
50 YEARS

1	Arroyo. Santa Rita

TRIANGULAR HYDROGRAM

NAME	BASIN04	CODE:

CARACTERISTIC ELEMENTS

A (km2):	3,07	AH (m) :	35,00
L (km) :	1,75	I (%) :	2,00

CALCULATED ELEMENTS

tc (hs) :	0,90	tb (hs) :	1,67
tp (hs) :	0,63	At (hs) :	0,18
tr (hs) :	1,05	qp (m3/s) :	10,19

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
0,18	223,52	4,00	4,37	0,37	0,37
0,36	165,16	5,92	6,46	1,21	0,84
0,54	130,93	7,04	7,68	1,85	0,64
0,72	109,28	7,83	8,54	2,35	0,50
0,90	94,30	8,45	9,21	2,76	0,41
1,07	84,06	9,03	9,86	3,18	0,41
1,25	76,91	9,64	10,52	3,62	0,44
1,43	70,98	10,17	11,10	4,02	0,40
1,61	65,98	10,64	11,61	4,38	0,36

HYDROGRAM OF PROJECT

At (hs)	qi (m3/s)	EFECTIVE PRECIPITATION 0,37	0,84	0,64	0,50	0,41	0,41	0,44	0,40	0,36	Q m3/s
0,00	0,00	0,00									0,00
0,18	2,91	1,07	0,00								1,07
0,36	5,82	2,14	2,44	0,00							4,58
0,54	8,73	3,21	4,89	1,86	0,00						9,95
0,72	9,31	3,42	7,33	3,72	1,46	0,00					15,94
0,90	7,57	2,78	7,82	5,58	2,93	1,21	0,00				20,31
1,07	5,83	2,14	6,36	5,95	4,39	2,41	1,20	0,00			22,46
1,25	4,09	1,50	4,90	4,84	4,69	3,62	2,41	1,29	0,00		23,24
1,43	2,34	0,86	3,43	3,72	3,81	3,86	3,61	2,58	1,15	0,00	23,04
1,61	0,60	0,22	1,97	2,61	2,93	3,14	3,85	3,88	2,31	1,04	21,95

2 Arroyo. Piraty

TRIANGULAR HYDROGRAM

NAME	BASIN 05	CODE:	

CARACTERISTIC ELEMENTS

A (km2):	9,62	AH (m) :	35,00
L (km) :	2,50	I (%) :	1,40

CALCULATED ELEMENTS

tc (hs) :	1,56	tb (hs) :	2,92
tp (hs) :	1,09	At (hs) :	0,31
tr (hs) :	1,83	qp (m3/s) :	18,29

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
0,31	177,26	5,54	5,77	0,89	0,89
0,63	119,24	7,45	7,76	1,89	1,00
0,94	91,43	8,57	8,93	2,58	0,69
1,25	77,05	9,63	10,03	3,29	0,71
1,56	67,28	10,51	10,95	3,91	0,62
1,88	59,90	11,23	11,70	4,44	0,53
2,19	54,13	11,84	12,33	4,90	0,46
2,50	49,47	12,37	12,88	5,31	0,41
2,81	45,63	12,84	13,37	5,67	0,36

HYDROGRAM OF PROJECT

At (hs)	qi (m3/s)	EFECTIVE PRECIPITATION									Q
		0,89	1,00	0,69	0,71	0,62	0,53	0,46	0,41	0,36	m3/s
0,00	0,00	0,00									0,00
0,31	5,23	4,66	0,00								4,66
0,63	10,45	9,32	5,24	0,00							14,56
0,94	15,68	13,98	10,48	3,61	0,00						28,06
1,25	16,73	14,91	15,72	7,21	3,70	0,00					41,54
1,56	13,60	12,12	16,77	10,82	7,40	3,25	0,00				50,36
1,88	10,47	9,33	13,63	11,54	11,10	6,51	2,76	0,00			54,88
2,19	7,34	6,54	10,49	9,38	11,84	9,76	5,52	2,40	0,00		55,95
2,50	4,21	3,75	7,36	7,22	9,63	10,42	8,29	4,80	2,12	0,00	53,58
2,81	1,08	0,96	4,22	5,06	7,41	8,47	8,84	7,20	4,24	1,90	48,31

TRIANGULAR HYDROGRAM

NAME: BASIN 06

CODE:

CARACTERISTIC ELEMENTS

A (km2):	13,45	AH (m) :	30,00
L (km) :	3,40	I (%) :	0,88

CALCULATED ELEMENTS

tc (hs) :	2,21	tb (hs) :	4,13
tp (hs) :	1,55	At (hs) :	0,44
tr (hs) :	2,58	qp (m3/s) :	18,08

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
0,44	146,97	6,50	6,67	1,31	1,31
0,88	95,13	8,41	8,64	2,41	1,09
1,33	74,39	9,86	10,13	3,36	0,95
1,77	62,22	11,00	11,30	4,16	0,80
2,21	53,76	11,88	12,20	4,81	0,65
2,65	47,52	12,60	12,94	5,35	0,55
3,09	42,70	13,21	13,57	5,82	0,47
3,54	38,85	13,74	14,11	6,24	0,42
3,98	35,70	14,20	14,59	6,61	0,37

HYDROGRAM OF PROJECT

At (hs)	qi (m3/s)	EFECTIVE PRECIPITATION 1,31	1,09	0,95	0,80	0,65	0,55	0,47	0,42	0,37	Q m3/s
0,00	0,00	0,00									0,00
0,44	5,17	6,79	0,00								6,79
0,88	10,33	13,57	5,64	0,00							19,21
1,33	15,50	20,36	11,28	4,92	0,00						36,56
1,77	16,54	21,72	16,92	9,84	4,13	0,00					52,62
2,21	13,44	17,66	18,06	14,76	8,27	3,35	0,00				62,09
2,65	10,35	13,59	14,68	15,75	12,40	6,70	2,82	0,00			65,94
3,09	7,25	9,53	11,30	12,80	13,23	10,06	5,64	2,44	0,00		64,99
3,54	4,16	5,47	7,92	9,85	10,75	10,73	8,46	4,87	2,15	0,00	60,20
3,98	1,07	1,40	4,54	6,91	8,28	8,72	9,03	7,31	4,29	1,92	52,40

TRIANGULAR HYDROGRAM

NAME BASIN07 CODE:

CARACTERISTIC ELEMENTS

A (km2):	68,38	AH (m) :	20,00
L (km) :	10,00	I (%) :	0,20

CALCULATED ELEMENTS

tc (hs) :	8,09	tb (hs) :	15,12
tp (hs) :	5,66	At (hs) :	1,62
tr (hs) :	9,46	qp (m3/s) :	25,12

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
1,62	65,84	10,65	10,18	3,39	3,39
3,24	41,38	13,39	12,80	5,25	1,85
4,85	30,89	14,99	14,33	6,41	1,17
6,47	24,92	16,13	15,42	7,27	0,86
8,09	21,03	17,01	16,26	7,95	0,68
9,71	18,26	17,73	16,95	8,51	0,56
11,32	16,19	18,34	17,53	8,99	0,48
12,94	14,58	18,86	18,04	9,41	0,42
14,56	13,28	19,33	18,48	9,78	0,37

HYDROGRAM OF PROJECT

EFECTIVE PRECIPITATION

At (hs)	qi (m3/s)	3,39	1,85	1,17	0,86	0,68	0,56	0,48	0,42	0,37	Q m3/s
0,00	0,00	0,00									0,00
1,62	7,18	24,36	0,00								24,36
3,24	14,36	48,72	13,31	0,00							62,03
4,85	21,53	73,07	26,63	8,37	0,00						108,07
6,47	22,97	77,96	39,94	16,73	6,14	0,00					140,77
8,09	18,67	63,38	42,61	25,10	12,27	4,86	0,00				148,22
9,71	14,38	48,79	34,64	26,77	18,41	9,72	4,03	0,00			142,36
11,32	10,08	34,20	26,67	21,76	19,64	14,58	8,06	3,44	0,00		128,36
12,94	5,78	19,62	18,69	16,76	15,97	15,56	12,09	6,89	3,01	0,00	108,58
14,56	1,48	5,03	10,72	11,75	12,29	12,65	12,90	10,33	6,02	2,67	84,36

								5	Arroyo Pirayuby		
				TRIANGULAR HYDROGRAM							
NAME		BASIN 15							CODE:		
				CARACTERISTIC ELEMENTS							
A (km2):		39,10				AH (m) :		64,00			
L (km) :		7,65				I (%) :		0,84			
				CALCULATED ELEMENTS							
tc (hs) :		3,66				tb (hs) :		6,84			
tp (hs) :		2,56				At (hs) :		0,73			
tr (hs) :		4,28				qp (m3/s) :		31,77			
EFECTIVE PRECIPITATION					CN:	70			TR:	50	
At (hs)		i (mm/h)		p (cm)		p' (cm)		Pe (cm)		A Pe (cm)	
	0,00		0,00		0,00		0,00		0,00		0,00
	0,73		107,82		7,89		7,73		1,88		1,88
	1,46		70,08		10,25		10,05		3,31		1,43
	2,19		54,02		11,85		11,62		4,39		1,08
	2,93		44,40		12,99		12,74		5,20		0,81
	3,66		37,93		13,87		13,60		5,85		0,65
	4,39		33,25		14,59		14,31		6,39		0,54
	5,12		29,69		15,20		14,91		6,86		0,47
	5,85		26,88		15,73		15,42		7,27		0,41
	6,58		24,60		16,19		15,88		7,64		0,37
				HYDROGRAM OF PROJECT							
				EFECTIVE PRECIPITATION							
At	qi										
(hs)	(m3/s)										Q
		1,88	1,43	1,08	0,81	0,65	0,54	0,47	0,41	0,37	m3/s
0,00	0,00	0,00									0,00
0,73	9,08	17,04	0,00								17,04
1,46	18,15	34,09	12,97	0,00							47,06
2,19	27,23	51,13	25,94	9,83	0,00						86,89
2,93	29,05	54,55	38,90	19,65	7,37	0,00					120,47
3,66	23,62	44,34	41,50	29,48	14,73	5,90	0,00				135,96
4,39	18,18	34,14	33,74	31,45	22,10	11,80	4,93	0,00			138,16
5,12	12,75	23,93	25,97	25,57	23,57	17,71	9,86	4,24	0,00		130,85
5,85	7,31	13,73	18,21	19,68	19,16	18,89	14,79	8,48	3,72	0,00	116,66
6,58	1,88	3,52	10,44	13,80	14,75	15,36	15,78	12,71	7,44	3,31	97,12

				TRIANGULAR HYDROGRAM							
NAME		BASIN 108							CODE:		
				CARACTERISTIC ELEMENTS							
A (km2):		9,54				AH (m) :		50,00			
L (km) :		4,50				I (%) :		1,11			
				CALCULATED ELEMENTS							
tc (hs) :		1,92				tb (hs) :		3,59			
tp (hs) :		1,35				At (hs) :		0,38			
tr (hs) :		2,25				qp (m3/s) :		14,74			
EFECTIVE PRECIPITATION					CN:	70			TR:	50	
At (hs)		i (mm/h)		p (cm)		p' (cm)		Pe (cm)		A Pe (cm)	
	0,00		0,00		0,00		0,00		0,00		0,00
	0,38		158,93		6,11		6,37		1,17		1,17
	0,77		104,34		8,03		8,36		2,24		1,08
	1,15		80,73		9,32		9,70		3,08		0,84
	1,54		67,94		10,45		10,89		3,87		0,80
	1,92		58,93		11,33		11,81		4,52		0,65
	2,31		52,23		12,05		12,56		5,07		0,55
	2,69		47,03		12,66		13,19		5,54		0,47
	3,08		42,87		13,19		13,74		5,96		0,42
	3,46		39,45		13,65		14,23		6,33		0,37
				HYDROGRAM OF PROJECT							
				EFECTIVE PRECIPITATION							
At (hs)	qi (m3/s)										Q
		1,17	1,08	0,84	0,80	0,65	0,55	0,47	0,42	0,37	m3/s
0,00	0,00	0,00									0,00
0,38	4,21	4,91	0,00								4,91
0,77	8,42	9,81	4,53	0,00							14,34
1,15	12,64	14,72	9,06	3,52	0,00						27,31
1,54	13,48	15,71	13,59	7,05	3,35	0,00					39,69
1,92	10,96	12,77	14,50	10,57	6,70	2,73	0,00				47,26
2,31	8,44	9,83	11,78	11,28	10,05	5,46	2,30	0,00			50,70
2,69	5,91	6,89	9,07	9,17	10,72	8,18	4,60	1,99	0,00		50,63
3,08	3,39	3,95	6,36	7,06	8,71	8,73	6,91	3,98	1,76	0,00	47,46
3,46	0,87	1,01	3,65	4,95	6,71	7,10	7,37	5,98	3,51	1,57	41,84

TRIANGULAR HYDROGRAM

NAME: BASIN 09 CODE:

CARACTERISTIC ELEMENTS

A (km2):	12,98	AH (m) :	30,00
L (km) :	5,00	I (%) :	0,60

CALCULATED ELEMENTS

tc (hs) :	2,76	tb (hs) :	5,15
tp (hs) :	1,93	At (hs) :	0,55
tr (hs) :	3,22	qp (m3/s) :	13,99

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
0,55	128,92	7,11	7,31	1,64	1,64
1,10	82,86	9,14	9,40	2,88	1,23
1,65	64,93	10,74	11,04	3,98	1,10
2,20	53,85	11,87	12,21	4,81	0,83
2,76	46,28	12,75	13,12	5,48	0,67
3,31	40,74	13,47	13,86	6,05	0,56
3,86	36,50	14,08	14,48	6,53	0,48
4,41	33,13	14,61	15,03	6,96	0,43
4,96	30,39	15,08	15,51	7,34	0,38

HYDROGRAM OF PROJECT

At (hs)	qi (m3/s)	EFECTIVE PRECIPITATION									Q
		1,64	1,23	1,10	0,83	0,67	0,56	0,48	0,43	0,38	m3/s
0,00	0,00	0,00									0,00
0,55	4,00	6,57	0,00								6,57
1,10	8,00	13,15	4,93	0,00							18,08
1,65	11,99	19,72	9,87	4,40	0,00						33,99
2,20	12,80	21,04	14,80	8,81	3,33	0,00					47,98
2,76	10,40	17,10	15,79	13,21	6,67	2,68	0,00				55,45
3,31	8,01	13,16	12,84	14,09	10,00	5,37	2,25	0,00			57,71
3,86	5,61	9,23	9,88	11,46	10,67	8,05	4,50	1,94	0,00		55,72
4,41	3,22	5,29	6,93	8,82	8,67	8,59	6,75	3,87	1,70	0,00	50,63
4,96	0,83	1,36	3,97	6,18	6,68	6,98	7,20	5,81	3,40	1,52	43,10

TRIANGULAR HYDROGRAM

NAME: BASIN 10 | CODE:

CARACTERISTIC ELEMENTS

A (km2):	20,13	AH (m) :	10,00
L (km) :	5,10	I (%) :	0,20

CALCULATED ELEMENTS

tc (hs) :	4,94	tb (hs) :	9,23
tp (hs) :	3,46	At (hs) :	0,99
tr (hs) :	5,77	qp (m3/s) :	12,12

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
0,99	88,26	8,72	8,80	2,50	2,50
1,97	57,92	11,44	11,55	4,33	1,83
2,96	44,02	13,04	13,16	5,52	1,18
3,95	35,89	14,18	14,31	6,39	0,88
4,94	30,50	15,06	15,20	7,09	0,70
5,92	26,63	15,78	15,93	7,67	0,58
6,91	23,71	16,39	16,54	8,17	0,50
7,90	21,41	16,91	17,07	8,61	0,44
8,89	19,56	17,38	17,54	8,99	0,39

HYDROGRAM OF PROJECT

EFECTIVE PRECIPITATION

At (hs)	qi (m3/s)	2,50	1,83	1,18	0,88	0,70	0,58	0,50	0,44	0,39	Q m3/s
0,00	0,00	0,00									0,00
0,99	3,46	8,67	0,00								8,67
1,97	6,92	17,33	6,33	0,00							23,67
2,96	10,38	26,00	12,67	4,10	0,00						42,76
3,95	11,08	27,73	19,00	8,20	3,04	0,00					57,97
4,94	9,01	22,55	20,27	12,30	6,07	2,42	0,00				63,61
5,92	6,93	17,36	16,48	13,12	9,11	4,83	2,01	0,00			62,91
6,91	4,86	12,17	12,69	10,66	9,72	7,25	4,02	1,72	0,00		58,23
7,90	2,79	6,98	8,89	8,21	7,90	7,73	6,03	3,44	1,51	0,00	50,70
8,89	0,72	1,79	5,10	5,76	6,08	6,29	6,43	5,17	3,01	1,34	40,97

TRIANGULAR HYDROGRAM

NAME: BASIN 14 — CODE:

CARACTERISTIC ELEMENTS

A (km2):	3800,00	AH (m):	150,00
L (km):	100,00	I (%):	0,15

CALCULATED ELEMENTS

tc (hs):	48,00	tb (hs):	89,72
tp (hs):	33,60	At (hs):	9,60
tr (hs):	56,12	qp (m3/s):	235,22

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
9,60	18,42	17,68	13,83	6,02	6,02
19,20	10,64	20,42	15,97	7,71	1,68
28,80	7,65	22,02	17,22	8,73	1,02
38,40	6,03	23,16	18,11	9,46	0,74
48,00	5,01	24,04	18,80	10,04	0,58
57,61	4,30	24,76	19,36	10,52	0,48
67,21	3,78	25,37	19,84	10,92	0,41
76,81	3,37	25,90	20,25	11,28	0,35
86,41	3,05	26,36	20,61	11,59	0,31

HYDROGRAM OF PROJECT

At (hs)	qi (m3/s)	EFECTIVE PRECIPITATION 6,02	1,68	1,02	0,74	0,58	0,48	0,41	0,35	0,31	Q m3/s
0,00	0,00	0,00									0,00
9,60	67,20	404,68	0,00								404,68
19,20	134,41	809,36	113,20	0,00							922,56
28,80	201,61	1214,04	226,40	68,56	0,00						1509,00
38,40	215,10	1295,22	339,60	137,13	49,53	0,00					1821,47
48,00	174,85	1052,89	362,30	205,69	99,06	38,87	0,00				1758,82
57,61	134,61	810,57	294,52	219,44	148,59	77,74	32,03	0,00			1582,90
67,21	94,37	568,25	226,74	178,39	158,52	116,61	64,06	27,26	0,00		1339,83
76,81	54,13	325,92	158,95	137,33	128,87	124,41	96,09	54,52	23,74	0,00	1049,84
86,41	13,88	83,60	91,17	96,28	99,21	101,13	102,52	81,78	47,48	21,03	724,20

								10	Arroyo. Jhy		
				TRIANGULAR HYDROGRAM							
NAME		BASIN 01							CODE:		
				CARACTERISTIC ELEMENTS							
A (km2):		23,38				AH (m) :		25,00			
L (km) :		6,60				I (%) :		0,38			
				CALCULATED ELEMENTS							
tc (hs) :		4,18				tb (hs) :		7,81			
tp (hs) :		2,92				At (hs) :		0,84			
tr (hs) :		4,88				qp (m3/s) :		16,63			
EFECTIVE PRECIPITATION					CN:	70			TR:	50	
At (hs)		i (mm/h)		p (cm)		p' (cm)		Pe (cm)		A Pe (cm)	
	0,00		0,00		0,00		0,00		0,00		0,00
	0,84		98,78		8,25		8,28		2,19		2,19
	1,67		64,49		10,78		10,81		3,82		1,63
	2,51		49,38		12,38		12,42		4,96		1,14
	3,34		40,44		13,52		13,56		5,82		0,85
	4,18		34,46		14,40		14,44		6,50		0,68
	5,01		30,15		15,12		15,16		7,06		0,57
	5,85		26,89		15,73		15,77		7,55		0,49
	6,69		24,31		16,25		16,30		7,98		0,43
	7,52		22,23		16,72		16,77		8,36		0,38
				HYDROGRAM OF PROJECT							
				EFECTIVE PRECIPITATION							
At (hs)	qi (m3/s)										Q
		2,19	1,63	1,14	0,85	0,68	0,57	0,49	0,43	0,38	m3/s
0,00	0,00	0,00									0,00
0,84	4,75	10,41	0,00								10,41
1,67	9,50	20,82	7,73	0,00							28,55
2,51	14,25	31,23	15,46	5,44	0,00						52,13
3,34	15,21	33,32	23,19	10,88	4,05	0,00					71,43
4,18	12,36	27,09	24,74	16,31	8,10	3,23	0,00				79,47
5,01	9,52	20,85	20,11	17,40	12,15	6,47	2,70	0,00			79,68
5,85	6,67	14,62	15,48	14,15	12,96	9,70	5,39	2,31	0,00		74,61
6,69	3,83	8,38	10,85	10,89	10,54	10,35	8,09	4,63	2,03	0,00	65,76
7,52	0,98	2,15	6,22	7,64	8,11	8,41	8,63	6,94	4,05	1,80	53,96

TRIANGULAR HYDROGRAM

NAME: BASIN 03 — CODE:

CARACTERISTIC ELEMENTS

A (km2):	17,60	AH (m) :	65,00
L (km) :	4,70	I (%) :	1,38

CALCULATED ELEMENTS

tc (hs) :	2,14	tb (hs) :	3,99
tp (hs) :	1,49	At (hs) :	0,43
tr (hs) :	2,50	qp (m3/s) :	24,49

EFECTIVE PRECIPITATION

CN: 70 — TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
0,43	149,89	6,40	6,50	1,23	1,23
0,85	97,34	8,32	8,44	2,29	1,06
1,28	75,93	9,73	9,88	3,19	0,90
1,71	63,60	10,87	11,03	3,97	0,78
2,14	55,01	11,75	11,93	4,61	0,63
2,56	48,65	12,47	12,66	5,14	0,53
2,99	43,73	13,08	13,28	5,60	0,46
3,42	39,81	13,60	13,81	6,01	0,41
3,84	36,60	14,07	14,28	6,37	0,36

HYDROGRAM OF PROJECT

EFECTIVE PRECIPITATION

At (hs)	qi (m3/s)	1,23	1,06	0,90	0,78	0,63	0,53	0,46	0,41	0,36	Q m3/s
0,00	0,00	0,00									0,00
0,43	7,00	8,60	0,00								8,60
0,85	13,99	17,19	7,42	0,00							24,61
1,28	20,99	25,79	14,83	6,31	0,00						46,93
1,71	22,39	27,51	22,25	12,62	5,46	0,00					67,84
2,14	18,20	22,36	23,73	18,93	10,93	4,44	0,00				80,40
2,56	14,01	17,22	19,29	20,20	16,39	8,88	3,74	0,00			85,72
2,99	9,82	12,07	14,85	16,42	17,49	13,32	7,48	3,23	0,00		84,87
3,42	5,63	6,92	10,41	12,64	14,22	14,21	11,22	6,47	2,85	0,00	78,94
3,84	1,45	1,78	5,97	8,86	10,95	11,55	11,97	9,70	5,70	2,55	69,03

TRIANGULAR HYDROGRAM

NAME: BASIN 02 CODE:

CARACTERISTIC ELEMENTS

A (km2):	9,22	AH (m) :	60,00
L (km) :	2,80	I (%) :	2,14

CALCULATED ELEMENTS

tc (hs) :	1,33	tb (hs) :	2,49
tp (hs) :	0,93	At (hs) :	0,27
tr (hs) :	1,56	qp (m3/s) :	20,58

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
0,27	191,47	5,10	5,32	0,70	0,70
0,53	131,66	7,01	7,31	1,65	0,94
0,80	101,79	8,13	8,48	2,31	0,67
1,06	84,50	9,00	9,39	2,87	0,56
1,33	74,22	9,88	10,31	3,48	0,60
1,60	66,36	10,60	11,06	3,99	0,51
1,86	60,15	11,21	11,69	4,44	0,45
2,13	55,10	11,74	12,24	4,84	0,40
2,40	50,92	12,20	12,73	5,19	0,36

HYDROGRAM OF PROJECT

EFECTIVE PRECIPITATION

At (hs)	qi (m3/s)	0,70	0,94	0,67	0,56	0,60	0,51	0,45	0,40	0,36	Q m3/s
0,00	0,00	0,00									0,00
0,27	5,88	4,14	0,00								4,14
0,53	11,76	8,27	5,55	0,00							13,82
0,80	17,64	12,41	11,10	3,91	0,00						27,42
1,06	18,82	13,24	16,65	7,82	3,30	0,00					41,01
1,33	15,30	10,76	17,76	11,74	6,60	3,55	0,00				50,40
1,60	11,78	8,29	14,44	12,52	9,90	7,09	3,03	0,00			55,26
1,86	8,26	5,81	11,11	10,18	10,56	10,64	6,05	2,64	0,00		56,99
2,13	4,74	3,33	7,79	7,84	8,59	11,35	9,08	5,28	2,34	0,00	55,58
2,40	1,21	0,85	4,47	5,49	6,61	9,22	9,68	7,91	4,68	2,10	51,03

TRIANGULAR HYDROGRAM

NAME: BASIN 11 — CODE:

CARACTERISTIC ELEMENTS

A (km2):	231,77	AH (m) :	40,00
L (km) :	17,00	I (%) :	0,24

CALCULATED ELEMENTS

tc (hs) :	12,15	tb (hs) :	22,72
tp (hs) :	8,51	At (hs) :	2,43
tr (hs) :	14,21	qp (m3/s) :	56,66

EFECTIVE PRECIPITATION

CN: 70 — TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
2,43	50,43	12,26	11,07	4,00	4,00
4,86	30,85	15,00	13,55	5,81	1,81
7,29	22,76	16,60	14,99	6,93	1,12
9,72	18,24	17,73	16,02	7,75	0,82
12,15	15,32	18,62	16,82	8,40	0,65
14,59	13,26	19,34	17,47	8,93	0,54
17,02	11,72	19,95	18,02	9,39	0,46
19,45	10,53	20,47	18,49	9,79	0,40
21,88	9,57	20,94	18,91	10,14	0,35

HYDROGRAM OF PROJECT

EFECTIVE PRECIPITATION

At (hs)	qi (m3/s)	4,00	1,81	1,12	0,82	0,65	0,54	0,46	0,40	0,35	Q m3/s
0,00	0,00	0,00									0,00
2,43	16,19	64,76	0,00								64,76
4,86	32,38	129,53	29,26	0,00							158,79
7,29	48,57	194,29	58,52	18,16	0,00						270,97
9,72	51,81	207,28	87,78	36,32	13,26	0,00					344,64
12,15	42,12	168,50	93,65	54,48	26,51	10,47	0,00				353,61
14,59	32,43	129,72	76,13	58,12	39,77	20,94	8,66	0,00			333,34
17,02	22,73	90,94	58,61	47,25	42,43	31,41	17,33	7,40	0,00		295,35
19,45	13,04	52,16	41,09	36,37	34,49	33,51	25,99	14,79	6,46	0,00	244,86
21,88	3,34	13,38	23,57	25,50	26,55	27,24	27,73	22,19	12,91	5,73	184,79

TRIANGULAR HYDROGRAM

NAME: BASIN 12

CODE:

CARACTERISTIC ELEMENTS

A (km2):	300,00	AH (m) :	45,00
L (km) :	26,80	I (%) :	0,17

CALCULATED ELEMENTS

tc (hs) :	16,46	tb (hs) :	30,77
tp (hs) :	11,52	At (hs) :	3,29
tr (hs) :	19,25	qp (m3/s) :	54,15

EFECTIVE PRECIPITATION

CN: 70 TR: 50

At (hs)	i (mm/h)	p (cm)	p' (cm)	Pe (cm)	A Pe (cm)
0,00	0,00	0,00	0,00	0,00	0,00
3,29	40,87	13,46	12,00	4,66	4,66
6,59	24,59	16,20	14,45	6,50	1,84
9,88	18,02	17,80	15,88	7,63	1,13
13,17	14,38	18,93	16,89	8,46	0,82
16,46	12,04	19,81	17,68	9,10	0,65
19,76	10,39	20,53	18,32	9,64	0,54
23,05	9,17	21,14	18,86	10,10	0,46
26,34	8,23	21,67	19,33	10,50	0,40
29,63	7,47	22,14	19,75	10,85	0,35

HYDROGRAM OF PROJECT

At (hs)	qi (m3/s)	EFECTIVE PRECIPITATION									Q
		4,66	1,84	1,13	0,82	0,65	0,54	0,46	0,40	0,35	m3/s
0,00	0,00	0,00									0,00
3,29	15,47	72,14	0,00								72,14
6,59	30,94	144,27	28,45	0,00							172,73
9,88	46,41	216,41	56,90	17,50	0,00						290,82
13,17	49,52	230,88	85,35	35,01	12,73	0,00					363,97
16,46	40,25	187,69	91,06	52,51	25,46	10,03	0,00				366,74
19,76	30,99	144,49	74,02	56,02	38,19	20,06	8,29	0,00			341,07
23,05	21,72	101,29	56,99	45,54	40,74	30,09	16,57	7,07	0,00		298,29
26,34	12,46	58,10	39,95	35,06	33,12	32,10	24,86	14,13	6,16	0,00	243,49
29,63	3,20	14,90	22,91	24,58	25,50	26,10	26,52	21,20	12,33	5,47	179,51

Dimension of the Watershed for Discharge Calculation

Basin	River Name	Area	Length	H2	H1	Slope	K	TC	Rainfall Intensity (mm/min)			C	Peak Discharge (m3/s)		
No.		(ha)	(m)	(el.m)	(el.m)	(%)		(min)	10 anos	25 anos	50 anos		10 anos	25 anos	50 anos
1	Arroyo. Santa Rita	307	1,750	160	125	2	3.5	54	1.18	1.34	1.46	0.3	18	21	22
2	Arroyo. Piraty	962	2,500	150	115	1.4	3.5	94	0.81	0.93	1.01	0.3	39	45	49
3	Arroyo. Tulio	1345	3,400	150	120	0.882	3.5	133	0.63	0.72	0.79	0.3	43	49	53
4	Arroyo. Tororo	6838	10,000	160	140	0.200	3.5	485	0.25	0.28	0.31	0.3	85	97	106
5	Arroyo Pirayuby	3910	7,650	200	136	0.837	3.5	219	0.44	0.5	0.55	0.3	86	99	108
6	Arroyo. Pachongo	954	4,500	190	140	1.111	3.5	115	0.7	0.8	0.87	0.3	33	38	42
7	Arroyo. Tacuaremboy	1298	5,000	160	130	0.600	3.5	165	0.54	0.62	0.67	0.3	35	40	44
8	Arroyo. Caundy	2013	5,100	120	110	0.196	3.5	296	0.35	0.41	0.44	0.3	36	41	45
9	Rio Tebicuary Mi	380000	100,000	250	100	0.150	3.5	2880	0.07	0.08	0.09	0.3	1296	1500	1649
10	Arroyo. Jhy	2338	6,600	130	105	0.379	3.5	251	0.4	0.46	0.5	0.3	47	54	58
11	Arroyo. Rory	1760	4,700	200	135	1.383	3.5	128	0.65	0.74	0.81	0.3	57	65	71
12	Arroyo. Rory-mi	922	2,800	200	140	2.143	3.5	80	0.91	1.04	1.13	0.3	42	48	52
13	Arroyo. Tebicuary- mi	23177	17,000	150	110	0.235	3.5	729	0.18	0.21	0.23	0.3	214	246	269
14	Arroyo. Tebicuary- mi	30000	26,800	150	105	0.168	3.5	988	0.15	0.17	0.19	0.3	222	256	280

Note :

Area: Catchment Area

Length: River Length

H2,H1 : Highest ,Lowest Elevation in the Length

TC: Concentration Time

C: Runoff Coefficient (0.3 , assumed)

Ao Tullo (Bri. site=1) H.W.L= 121.5

B.L= 119

Channel Width= 6.8 Slope= 0.006 n= 0.03

Water Depth	Water Area(m2)	S	Hydraulic Radius	r**0.667	Velocity (m/s)	Discharge (m3/s)
1.0	6.80	8.80	0.773	0.842	2.17	14.8
1.2	8.16	9.20	0.887	0.923	2.38	19.4
1.4	9.52	9.60	0.992	0.994	2.57	24.4
1.6	10.88	10.00	1.088	1.058	2.73	29.7
1.8	12.24	10.40	1.177	1.115	2.88	35.2
2.0	13.60	10.80	1.259	1.166	3.01	41.0
2.2	14.96	11.20	1.336	1.213	3.13	46.9
2.4	16.32	11.60	1.407	1.256	3.24	52.9
2.6	17.68	12.00	1.473	1.295	3.34	59.1
2.8	19.04	12.40	1.535	1.331	3.44	65.4
3.0	20.40	12.80	1.594	1.365	3.52	71.9
3.2	21.76	13.20	1.648	1.396	3.60	78.4
3.4	23.12	13.60	1.700	1.425	3.68	85.0
3.6	24.48	14.00	1.749	1.452	3.75	91.8
3.8	25.84	14.40	1.794	1.477	3.81	98.5
4.0	27.20	14.80	1.838	1.501	3.87	105.4
4.2	28.56	15.20	1.879	1.523	3.93	112.3
4.4	29.92	15.60	1.918	1.544	3.99	119.3

Ao Tororo (Bri.Site=2) H.W.L= 138.2

B.L= 135

Channel Width= 20 Slope= 0.0015 n= 0.03

Water Depth	Water Area(m2)	S	Hydraulic Radius	r**0.667	Velocity (m/s)	Discharge (m3/s)
1.0	20	22.0	0.909	0.938	1.21	24.2
1.2	24	22.4	1.071	1.047	1.35	32.4
1.4	28	22.8	1.228	1.147	1.48	41.5
1.6	32	23.2	1.379	1.239	1.60	51.2
1.8	36	23.6	1.525	1.325	1.71	61.6
2.0	40	24.0	1.667	1.406	1.82	72.6
2.2	44	24.4	1.803	1.482	1.91	84.2
2.4	48	24.8	1.935	1.553	2.01	96.3
2.6	52	25.2	2.063	1.621	2.09	108.8
2.8	56	25.6	2.188	1.686	2.18	121.9
3.0	60	26.0	2.308	1.747	2.26	135.3
3.2	64	26.4	2.424	1.805	2.33	149.1

Ao Pirayuvy (Bri. site=3) H.W.L= 138.5

B.L= 136.5

Channel Width= 20 Slope= 0.004 n= 0.025

Water Depth	Water Area(m2)	S	Hydraulic Radius	r**0.667	Velocity (m/s)	Discharge (m3/s)
1.0	20.00	22.00	0.909	0.938	2.37	47.5
1.2	24.00	22.40	1.071	1.047	2.65	63.6
1.4	28.00	22.80	1.228	1.147	2.90	81.2
1.6	32.00	23.20	1.379	1.239	3.14	100.3
1.8	36.00	23.60	1.525	1.325	3.35	120.7
2.0	40.00	24.00	1.667	1.406	3.56	142.3
2.2	44.00	24.40	1.803	1.482	3.75	164.9
2.4	48.00	24.80	1.935	1.553	3.93	188.6
2.6	52.00	25.20	2.063	1.621	4.10	213.3
2.8	56.00	25.60	2.188	1.686	4.26	238.8
3.0	60.00	26.00	2.308	1.747	4.42	265.1
3.2	64.00	26.40	2.424	1.805	4.57	292.3
3.4	68.00	26.80	2.537	1.861	4.71	320.1
3.6	72.00	27.20	2.647	1.914	4.84	348.7
3.8	76.00	27.60	2.754	1.965	4.97	377.9
4.0	80.00	28.00	2.857	2.014	5.10	407.6
4.2	84.00	28.40	2.958	2.061	5.21	438.0
4.4	88.00	28.80	3.056	2.106	5.33	469.0

Ao Pachongo (Bri. site=4) H.W.L= 141.9

B.L= 137.7

Channel Width= 4 Slope= 0.004 n= 0.025

Water Depth	Water Area(m2)	S	Hydraulic Radius	r**0.667	Velocity (m/s)	Discharge (m3/s)
1.0	4.0	6.0	0.667	0.763	1.93	7.72
1.2	4.8	6.4	0.750	0.825	2.09	10.02
1.4	5.6	6.8	0.824	0.879	2.22	12.45
1.6	6.4	7.2	0.889	0.924	2.34	14.97
1.8	7.2	7.6	0.947	0.965	2.44	17.57
2.0	8.0	8.0	1.000	1.000	2.53	20.24
2.2	8.8	8.4	1.048	1.032	2.61	22.96
2.4	9.6	8.8	1.091	1.060	2.68	25.74
2.6	10.4	9.2	1.130	1.085	2.75	28.55
2.8	11.2	9.6	1.167	1.108	2.80	31.40
3.0	12.0	10.0	1.200	1.129	2.86	34.28
3.2	12.8	10.4	1.231	1.149	2.91	37.19
3.4	13.6	10.8	1.259	1.166	2.95	40.12
3.6	14.4	11.2	1.286	1.182	2.99	43.08
3.8	15.2	11.6	1.310	1.198	3.03	46.05
4.0	16.0	12.0	1.333	1.212	3.06	49.04
4.2	16.8	12.4	1.355	1.225	3.10	52.04
4.4	17.6	12.8	1.375	1.237	3.13	55.06

Arroyo Caundy (Bri. Site=5) H.W.L= 118.5

B.L= 116.9

Channel Width= 12 Slope= 0.005 n= 0.025

Water Depth	Water Area(m2)	S	Hydraulic Radius	r**0.667	Velocity (m/s)	Discharge (m3/s)
1.0	12.00	14.00	0.857	0.902	2.55	30.6
1.2	14.40	14.40	1.000	1.000	2.83	40.7
1.4	16.80	14.80	1.135	1.088	3.08	51.7
1.6	19.20	15.20	1.263	1.169	3.31	63.5
1.8	21.60	15.60	1.385	1.242	3.51	75.9
2.0	24.00	16.00	1.500	1.311	3.71	89.0
2.2	26.40	16.40	1.610	1.374	3.89	102.6
2.4	28.80	16.80	1.714	1.433	4.05	116.7
2.6	31.20	17.20	1.814	1.488	4.21	131.3
2.8	33.60	17.60	1.909	1.539	4.35	146.3
3.0	36.00	18.00	2.000	1.588	4.49	161.7
3.2	38.40	18.40	2.087	1.633	4.62	177.4
3.4	40.80	18.80	2.170	1.677	4.74	193.5
3.6	43.20	19.20	2.250	1.718	4.86	209.9
3.8	45.60	19.60	2.327	1.756	4.97	226.5
4.0	48.00	20.00	2.400	1.793	5.07	243.4
4.2	50.40	20.40	2.471	1.828	5.17	260.6
4.4	52.80	20.80	2.538	1.861	5.26	278.0

Ao Tebicuary Mi (Bri.Site=7) H.W.L= 119.3

B.L= 116.3

Channel Width= 12 Slope= 0.002 n= 0.025

Water Depth	Water Area(m2)	S	Radius	r**0.667	Velocity (m/s)	Discharge (m3/s)
1.0	12.0	14.0	0.857	0.902	1.614	19.4
1.2	14.4	14.4	1.000	1.000	1.789	25.8
1.4	16.8	14.8	1.135	1.088	1.947	32.7
1.6	19.2	15.2	1.263	1.169	2.090	40.1
1.8	21.6	15.6	1.385	1.242	2.222	48.0
2.0	24.0	16.0	1.500	1.311	2.344	56.3
2.2	26.4	16.4	1.610	1.374	2.457	64.9
2.4	28.8	16.8	1.714	1.433	2.563	73.8
2.6	31.2	17.2	1.814	1.488	2.661	83.0
2.8	33.6	17.6	1.909	1.539	2.754	92.5
3.0	36.0	18.0	2.000	1.588	2.840	102.3
3.2	38.4	18.4	2.087	1.633	2.922	112.2
3.4	40.8	18.8	2.170	1.677	2.999	122.4
3.6	43.2	19.2	2.250	1.718	3.072	132.7
3.8	45.6	19.6	2.327	1.756	3.142	143.3
4.0	48.0	20.0	2.400	1.793	3.208	154.0
4.2	50.4	20.4	2.471	1.828	3.270	164.8
4.4	52.8	20.8	2.538	1.861	3.330	175.8

Ao Tebicuary Mi (Bailey Bridge) H.W.L = 107.2

2.1875 B.L= 102

Channel Width= 7.5 Slope= 0.001 n= 0.03

Water Depth	Water Area(m2)	S	Hydraulic Radius	r**0.667	Velocity (m/s)	Discharge (m3/s)
1.0	17.19	19.81	0.868	0.910	0.96	16.48
1.2	21.15	20.77	1.018	1.012	1.07	22.56
1.4	25.29	21.73	1.163	1.106	1.17	29.49
1.6	29.60	22.70	1.304	1.194	1.26	37.25
1.8	34.09	23.66	1.441	1.276	1.34	45.84
2.0	38.75	24.62	1.574	1.353	1.43	55.27
2.2	43.59	25.58	1.704	1.427	1.50	65.55
2.4	48.60	26.55	1.831	1.497	1.58	76.68
2.6	53.79	27.51	1.955	1.564	1.65	88.68
2.8	59.15	28.47	2.078	1.629	1.72	101.54
3.0	64.69	29.43	2.198	1.691	1.78	115.30
3.2	70.40	30.39	2.316	1.751	1.85	129.95
3.4	76.29	31.36	2.433	1.809	1.91	145.51
3.6	82.35	32.32	2.548	1.866	1.97	161.99
3.8	88.59	33.28	2.662	1.921	2.03	179.41
4.0	95.00	34.24	2.774	1.975	2.08	197.79
4.2	101.59	35.20	2.886	2.028	2.14	217.12
4.4	108.35	36.17	2.996	2.079	2.19	237.44
4.6	115.29	37.13	3.105	2.129	2.24	258.75
4.8	122.40	38.09	3.213	2.178	2.30	281.07
5.0	129.69	39.05	3.321	2.227	2.35	304.40
5.2	137.15	40.01	3.428	2.274	2.40	328.78
5.4	144.79	40.98	3.533	2.321	2.45	354.21
5.6	152.60	41.94	3.639	2.367	2.49	380.70
5.8	160.59	42.90	3.743	2.412	2.54	408.27
6.0	168.75	43.86	3.847	2.456	2.59	436.93
6.2	177.09	44.82	3.951	2.500	2.64	466.71
6.4	185.60	45.79	4.054	2.543	2.68	497.60
6.6	194.29	46.75	4.156	2.586	2.73	529.64
6.8	203.15	47.71	4.258	2.628	2.77	562.82
7.0	212.19	48.67	4.359	2.670	2.81	597.17
7.2	221.40	49.64	4.461	2.711	2.86	632.70
7.4	230.79	50.60	4.561	2.752	2.90	669.42
7.6	240.35	51.56	4.662	2.792	2.94	707.35
7.8	250.09	52.52	4.762	2.832	2.98	746.50
8.0	260.00	53.48	4.861	2.871	3.03	786.89
8.2	270.09	54.45	4.961	2.910	3.07	828.53
8.4	280.35	55.41	5.060	2.949	3.11	871.43
8.6	290.79	56.37	5.159	2.987	3.15	915.61
8.8	301.40	57.33	5.257	3.025	3.19	961.08
9.0	312.19	58.29	5.355	3.063	3.23	1007.85
9.2	323.15	59.26	5.453	3.100	3.27	1055.95
9.4	334.29	60.22	5.551	3.137	3.31	1105.37
9.6	345.60	61.18	5.649	3.174	3.35	1156.14

ANNEX C

PAVEMENT DESIGN

ANNEX C PAVEMENT DESIGN

(1) Design of Pavement Structure (initial)

Pavement structure was designed according to the "AASHTO - Guide for the Design of a Pavement Structure (1986)". The design method stipulated in it is schematically shown in Figure A.C.1.

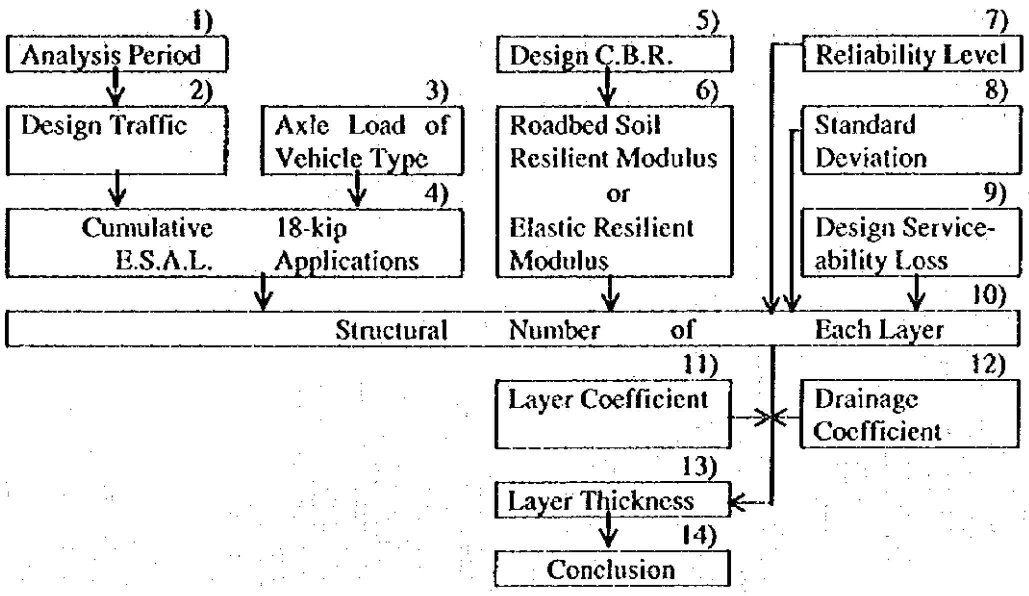


Figure A.C.1 Pavement Design Step (AASHTO)

1) Analysis Period

The analysis period in the design of pavement structure was considered to be ten (10) years from the commencement of use of the developed roads.

2) Design Traffic

The design traffic is the cumulative traffic volume during the analysis period. It is expressed by type of vehicle. In this case, the design traffic was calculated for the period from 2005 to 2015, although the completion of development of the study roads was estimated to be in 2002, as described later. This modification came from the target year of the future traffic demand estimation described in Chapter 5, and therefore, its influence on the results of pavement design is somewhat on the safe side.

The calculated design traffic, based on the estimated traffic volume for the years 2005 and 2015 summarized in Table 5.5.1, is shown in Table A.C.1.

Table A.C.1 Design Traffic

(unit: vehicles)

Road Section	Passenger Cars	Buses	Trucks
Paraguarí - Río Tebicuary-mí	5,288,850	1,153,400	4,387,300
Río Tebicuary-mí - Villarrica	3,878,125	1,084,050	3,221,125
La Colmena - Tebicuary	1,036,600	740,950	417,925

Note: 1) Division of the road section coincides with that of the CBR value of sub-grade described later.
2) Design traffic for each road section has been calculated for the road segment where the estimated traffic volume is greatest.

3) Axle Load of Each Vehicle Type

According to this design method, it is necessary to know the axle load of each type of vehicle first, then to convert it to an 18-kip equivalent single axle load (E.S.A.L.). However, there is no reliable data on the axle load of actual traffic in Paraguay. Therefore, data obtained from traffic on the principal roads in Japan, shown in Table A.C.2, was applied to this case.

Table A.C.2 Axle Load Distribution by Type of Vehicle

(unit:tons)

Vehicle Type	Total Weight	Ratio of Axle Load		Load Distribution	
		Front wheel	Rear wheel	Front wheel	Rear wheel
Passenger Car	1.30	0.501W+0.03	0.498W-0.03	(S) 0.6813	(S) 0.6174
Bus	13.80	0.376W-0.464	0.624W+0.464	(S) 4.7248	(S) 9.0752
Truck	17.00	0.109W+3.22	0.891W-3.22	(S) 5.073	(T) 11.927

Note: 1) P. car means Passenger car.
2) W = Total weight, (S) = Single axle, (T) = Tandem axle

4) Cumulative 18-kip Equivalent Single Axle Load (E.S.A.L.)

First, applying the values in Table A.C.2, the ESAL Factor for each type of vehicle was calculated as shown in Table A.C.3.

Table A.C.3 Calculation of Total ESAL Factor

Vehicle Type	Axle	Axle Load		ESAL Factor	
		tons	kips	Axle	Total
Passenger Car	Front (S)	0.6813	1.5	0.0002	0.0004
	Rear (S)	0.6174	1.4	0.0002	
Bus	Front (S)	4.7248	10.4	0.0880	1.5980
	Rear (S)	9.0752	20.0	1.5100	
Truck	Front (S)	5.073	11.2	0.1890	0.9170
	Rear (T)	11.927	26.3	0.3640×2	

Note: 1) kips = kilo-pounds
2) ESAL Factors of axle in the fifth column come from the Tables D.4 and D.5 in the "AASHTO Guide for Design of Pavement Structure (1986)", assuming that the serviceability and structural numbers are 2.5 and 5.0, respectively. The Guide said " In most cases, such an assumption provides information sufficiently accurate for design purposes."

Using the Total ESAL Factor calculated above, the Design ESAL and Cumulative 18-kip ESAL for each road section were obtained as follows.

Table A.C.4 Design ESAL and Cumulative 18-kip ESAL by Road Section

Road Section	Vehicle Type	Design Traffic (A)	ESAL Factor (B)	Design ESAL (A×B)	Cumulative 18-kip ESAL
Paraguarí - Río Tebicuary-mí	Passenger Car	5,288,850	0.0004	2,116	
	Bus	1,153,400	1.5980	1,843,133	
	Truck	4,387,300	0.9170	4,023,154	
	Total			5,868,403	2,934,202
Río Tebicuary-mí - Villarrica	Passenger Car	3,878,125	0.0004	1,551	
	Bus	1,084,050	1.5980	1,732,312	
	Truck	3,221,125	0.9170	2,953,772	
	Total			4,687,635	2,343,818
La Colmena - Tebicuary	Passenger Car	1,036,600	0.0004	415	
	Bus	740,950	1.5980	1,184,038	
	Truck	417,925	0.9170	383,237	
	Total			1,567,690	783,845

Note: (Cumulative 18-kip ESAL) = (Design ESAL) × D_D × D_L

where, D_D = Directional Distribution Factor = 0.5, D_L = Lane Distribution Factor = 1.0

5) CBR of Sub-grade

As for the construction method for earthworks, a sub-grade layer between 50 and 100 cm thick was considered to be possible to construct using soil from some borrow pits.

Referring to the study results on the candidate borrow areas along the study road described in the section, 6-4-3 (1), the values of sub-grade CBR were predicted. That is, soil classified as A-1, A3, and A-2-4, in other words, soil indicated with the symbol "S" in Figure 6.4.8, was predicted to have a CBR value of 6, while the other type of soil from the borrow pits was considered to have only a CBR value of 4. Examining, by segments road, the balance of required volume of sub-grade that could be obtained from borrow pits in the vicinity, and the type of material of sub-grade was forecast, and its CBR value was determined for each segment as below:

Table A.C.5 CBR of Sub-grade

Road Segment	CBR
Paraguarí - Río Tebicuary-mí	6
Río Tebicuary-mí - Villarrica	4
La Colmena - Tebicuary	4

Note: For the alternative routes, the conditions above are considered to be the same.

6) Elastic Resilient Modulus (M_i)

The AASHTO's Guide recommends calculating the Elastic Resilient Modulus of the roadbed (M_R), of the base course (M_B) and of the sub-base course (M_S) according to the following formula and tables:

a) Roadbed M_R

$M_R = 1{,}500 \times CBR$ (psi)

where CBR = CBR value of roadbed soil (%)

b) Base and Sub-base, M_B and M_S

$M_i = K_1 \times \Theta_i^{K_2}$

where Θ_i = stress state (refer to Table A.C.6),

K_1, K_2 = regression constants related to material type (refer to Table A.C.7)

Table A.C.6 Recommended Stress State Θ_i

(unit : psi)

Asphalt Concrete Thickness(inches)	Θ_B for Base			Θ_S for Sub-base
	M_R = 3,000	M_R = 7,500	M_R = 15,000	
Less than 2	20	25	30	10
2 - 4	10	15	20	7.5
4 - 6	5	10	15	5
More than 6	5	5	5	5

Table A.C.7 Regression Constants K_1, K_2

Moisture Conditions	for Base		for Sub-base	
	K_1	K_2	K_1	K_2
Dry	6,000 - 10,000	0.5 - 0.7	6,000 - 8,000	0.4 - 0.6
Damp	4,000 - 6,000		4,000 - 6,000	
Wet	2,000 - 4,000		1,500 - 4,000	

According to this recommendation, the Elastic Resilient Modulus of each layer was calculated. The results are summarized in Table A.C.8.

Table A.C.8 Elastic Resilient Modulus Mf

(Unit : psi)

Road Section	Road Bed		Sub-base				Base			
	CBR	M_R	Θ_S	K_1	K_2	M_S	Θ_B	K_1	K_2	M_B
Paraguarí - Río Tebicuary-mí	6	9,000	5.0	7,000	0.5	15,650	11.0	8,000	0.6	33,720
Río Tebicuary-mí - Villarrica	4	6,000					8.3			28,480
La Colmena - Tebicuary	4	6,000					8.3			28,480

7) Reliability (R)

The AASHTO Guide recommends that the value of Reliability for a principal arterial road in a rural area such as the study road should be from 75% to 95%. In this case, a value of 85% was applied.

8) Standard Deviation (So)

In flexible pavement design, the standard deviation can be considered to be 0.45.

9) Design Serviceability Loss (△PSI)

Design Serviceability Loss can be obtained from the following formula:

△PSI = Po - Pt

where Po = Initial Serviceability (AASHTO Guide recommends 4.2 for a flexible pavement.)

Pt = Terminal Serviceability (AASHTO Guide recommends 2.5 for a principal arterial road.)

So, △PSI = 4.2 - 2.5 = 1.7

10) Structural Number (SNi)

Based on the values of Cumulative 18-kip ESAL, Elastic Resilient Modulus, Reliability, Standard Deviation, and Design Serviceability Loss, the Structural Number can be obtained using a nomogram prepared in the Guide. The obtained Structural Numbers by road section and by layer are summarized in Table A.C.9, and the used nomograms are shown in Figures A.C.2 - A.C.10.

Table A.C.9 Structural Number (SNi)

Layer	Paraguarí - Río Tebicuary-mí	Río Tebicuary-mí - Villarrica	La Colmena - Tebicuary
Roadbed soil	3.7	4.2	3.5
Sub-base	3.0	2.8	2.5
Base	2.3	2.4	2.0

11) Layer Coefficient (a_i)

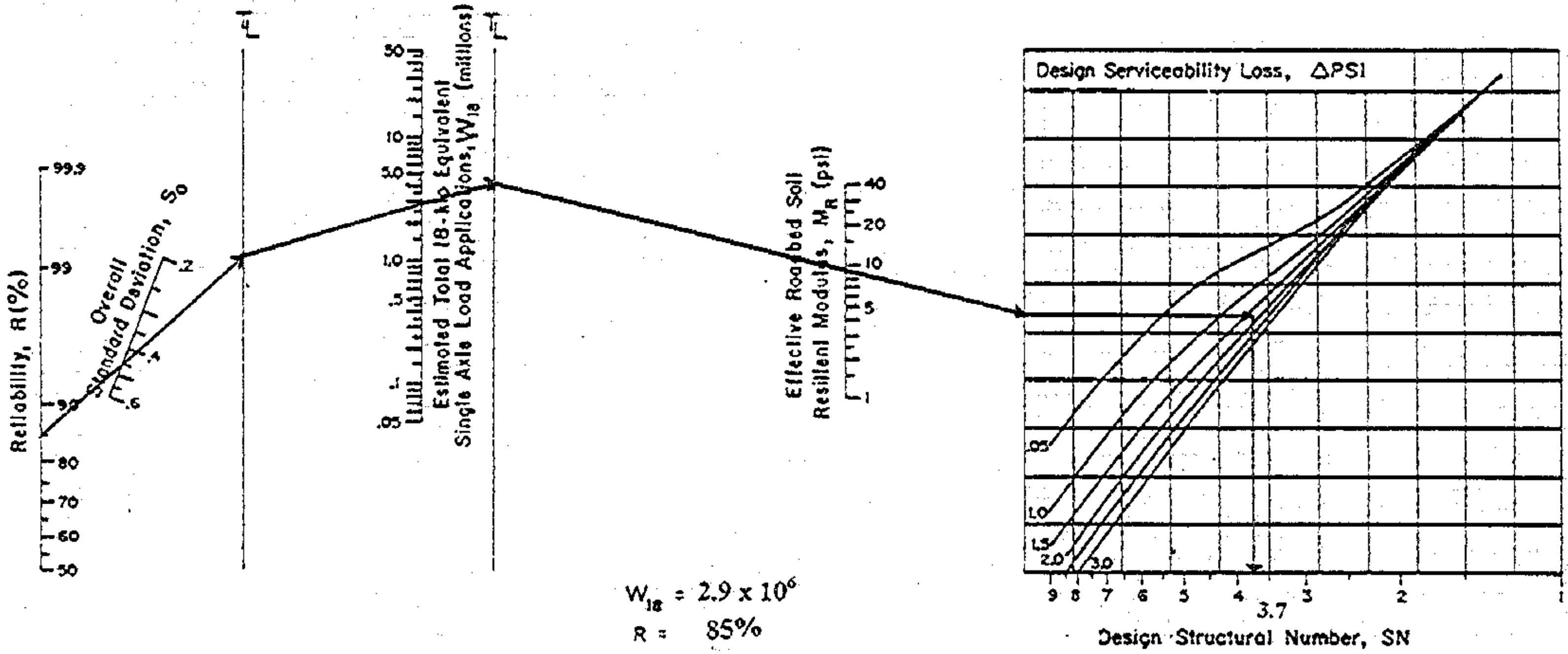
The Layer Coefficient of a layer is determined by the characteristics of the layer material. According to the description of the Guide, the following values have been assumed for this case:

- for an asphalt concrete surface layer : $a_1 = 0.44$
- for a base course of mechanically stabilized crushed stone : $a_2 = 0.14$
- for a sub-base course of crushed stone (crusher-run) : $a_3 = 0.11$

12) Drainage Coefficient (m_i)

Referring to the recommendation in the Guide, 1.0 was adopted as the value of the Drainage Coefficient of the base course (m_2) and the sub-base course (m_3) in this case.

Paraguary - Rio Tebicuary-mi : Road bedsoil



W_{18} = 2.9×10^6

R = 85%

S_o = 0.45

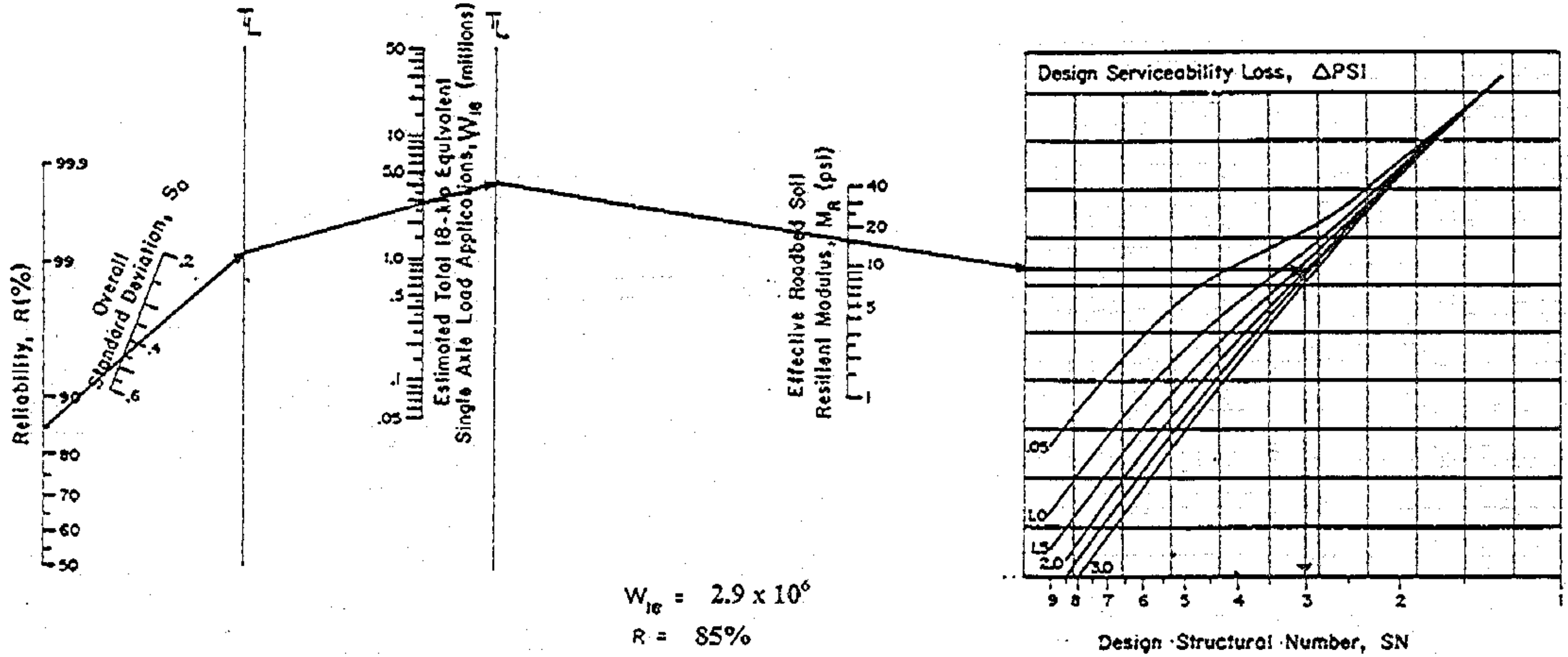
M_R = 9×10^3

ΔPSI = 1.7

Solution: SN = 3.7

Figure A.C. 2 Design chart for flexible pavements based on using mean values for each input

Paraguary - Rio Tebicuary-mi : Sub-base



W_{18} = 2.9 x 10^6

R = 85%

S_o = 0.45

M_R = 15,650 psi

ΔPSI = 1.7

Solution: SN = 3.0

Figure A.C. 3 Design chart for flexible pavements based on using mean values for each input

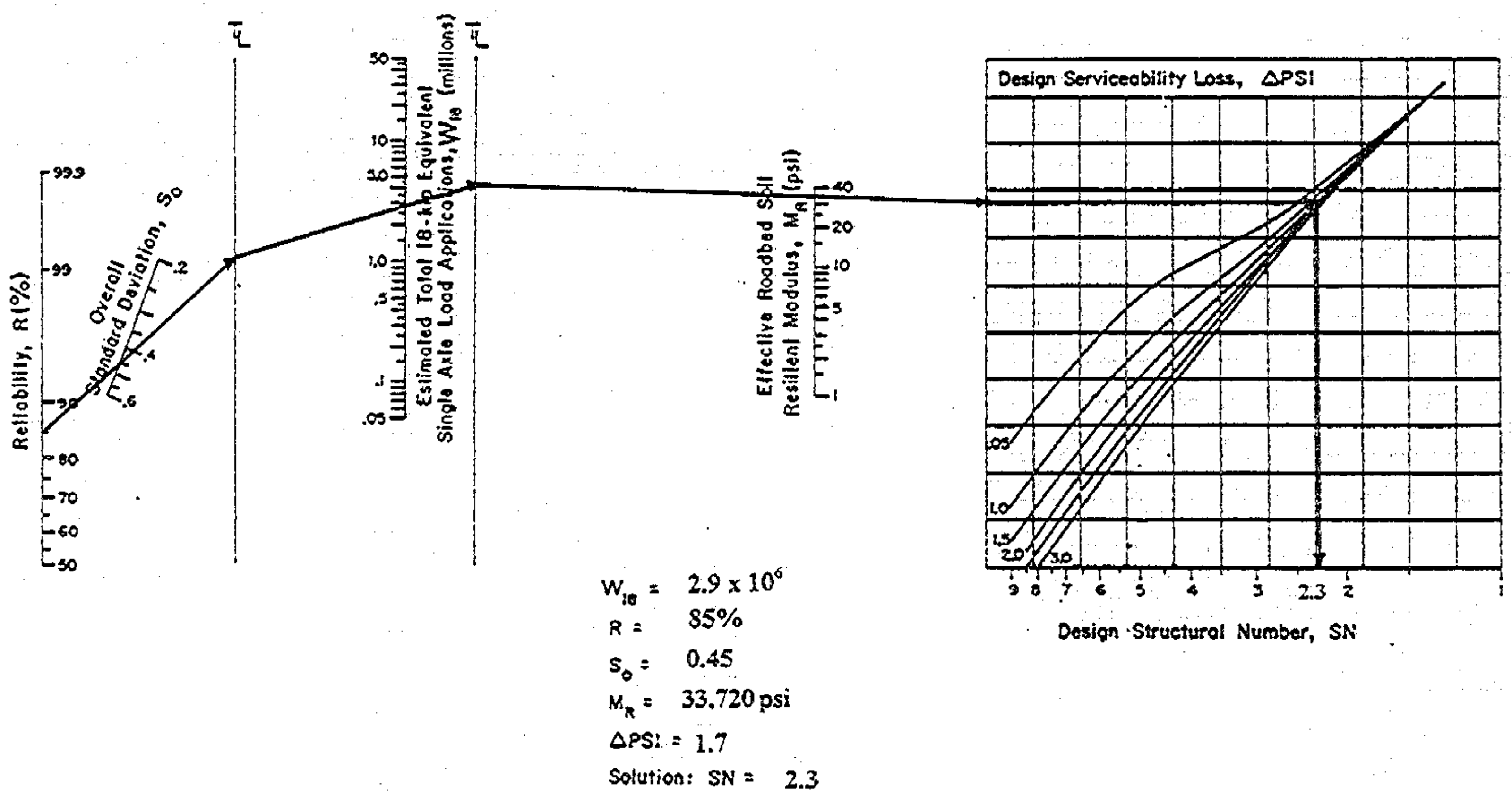
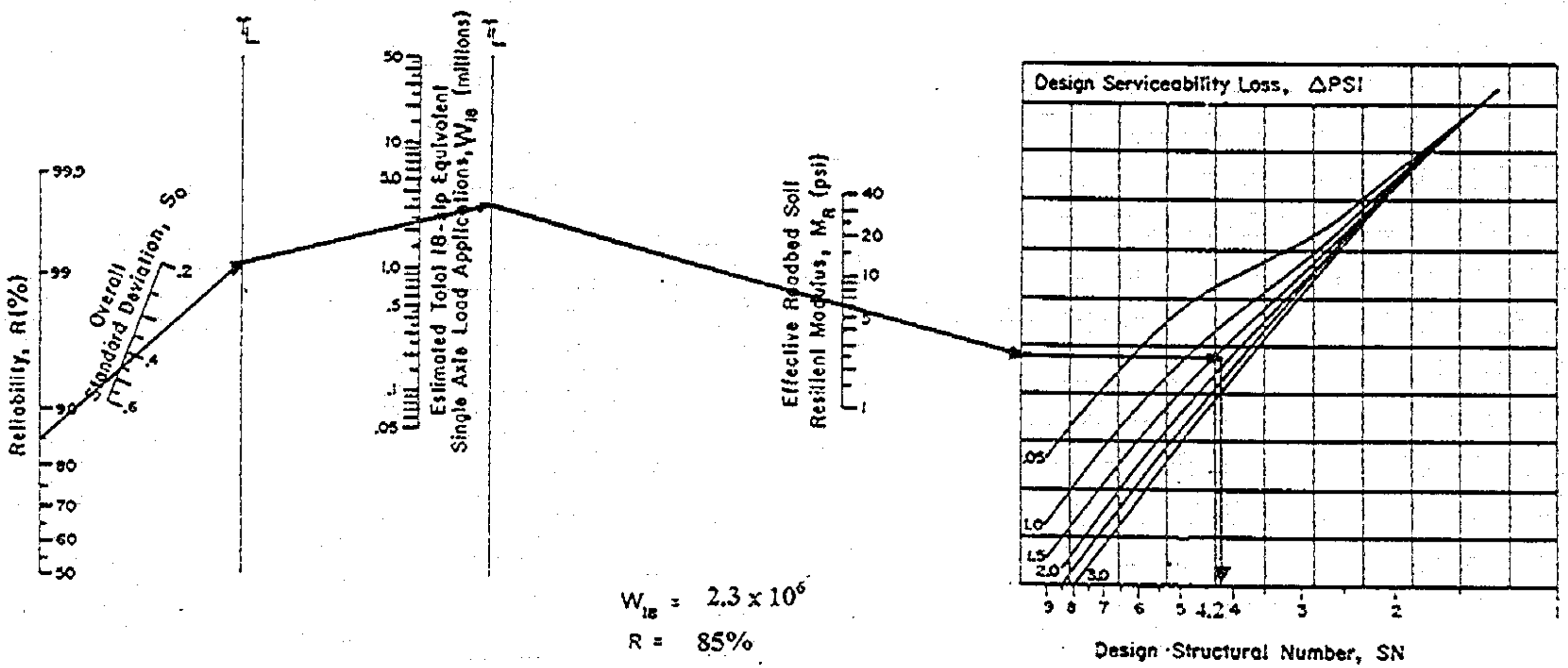


Figure A.C. 4 Design chart for flexibie pavements based on using mean values for each input

Rio Tebicuary-mi - Villarrica : Road bedsoil



W_{18} = 2.3 x 10^6
R = 85%
S_o = 0.45
M_R = 6,000 psi
ΔPSI = 1.7
Solution: SN = 4.2

Figure A.C. 5 Design chart for flexible pavements based on using mean values for each input

Rio Tebicuary-mi - Villarrica : Sub-base

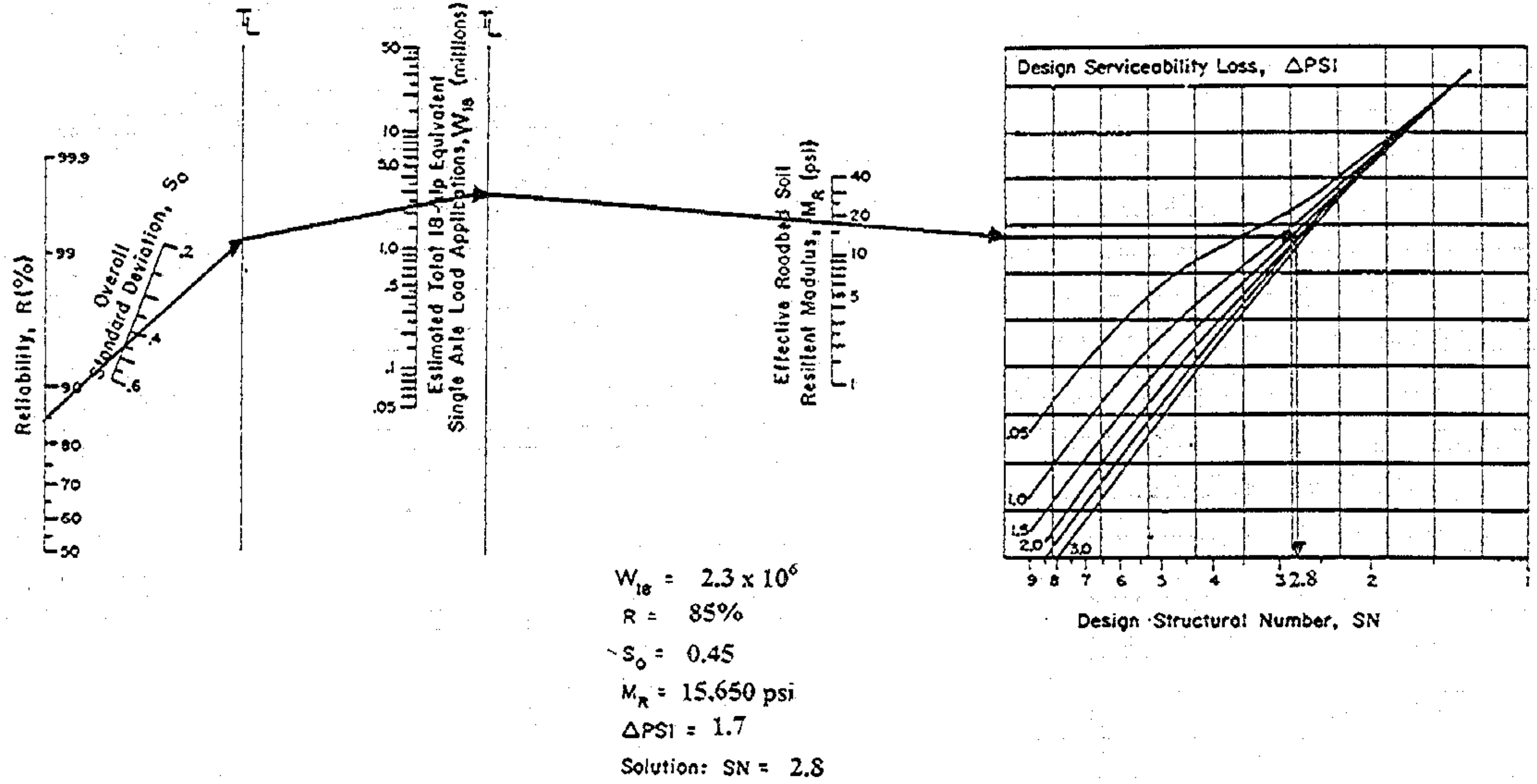


Figure A.C. 6 Design chart for flexible pavements based on using mean values for each input

Rio Tebicuary-mi - Villarrica : Base

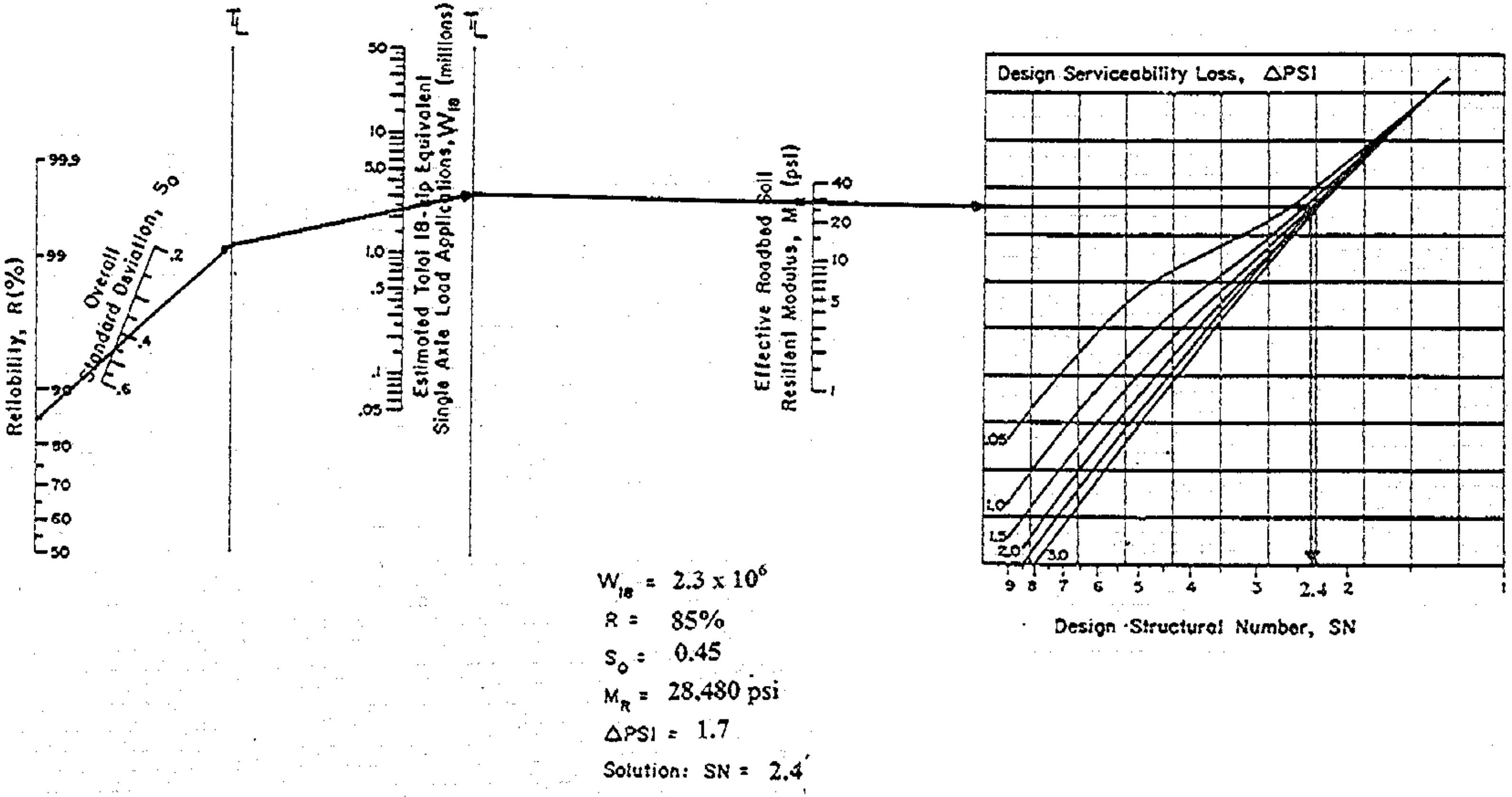
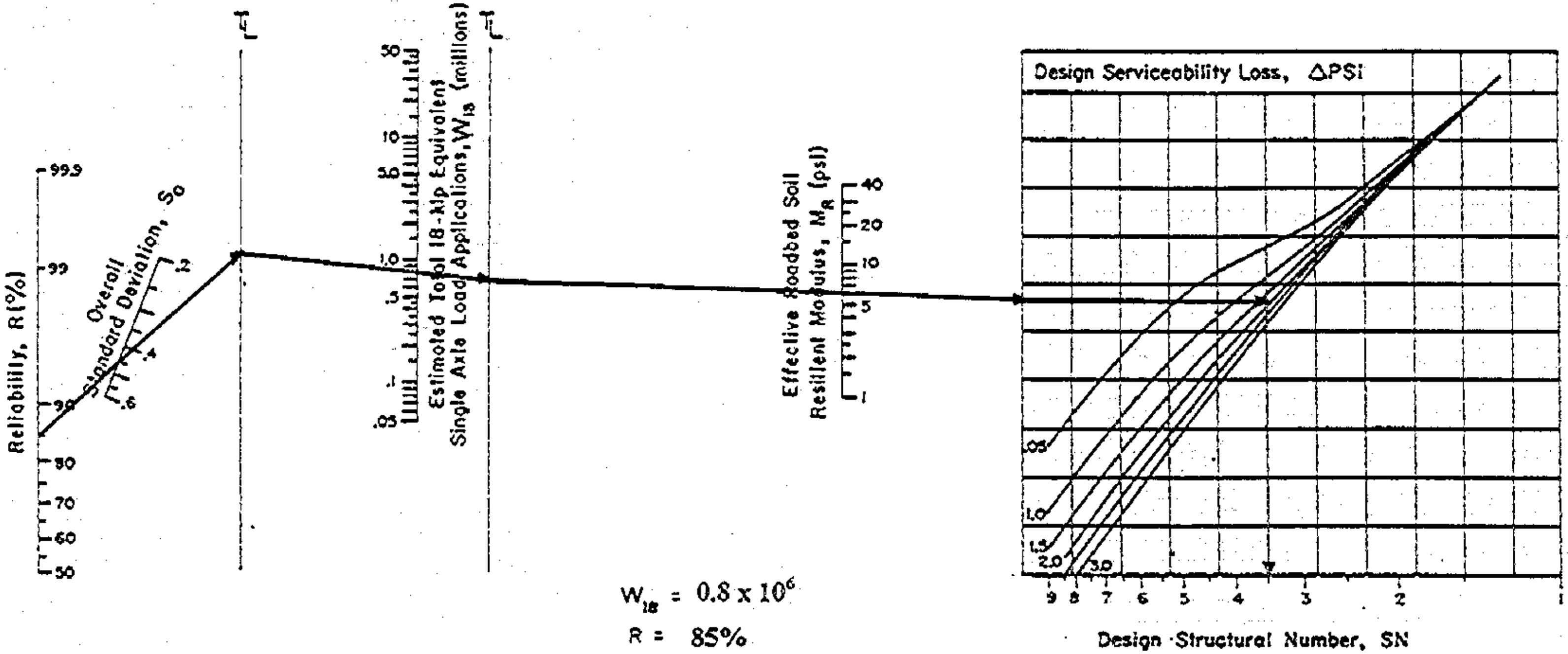


Figure A.C. 7 Design chart for flexible pavements based on using mean values for each input

La Colmena - Tebicuary : Road bedsoil



W_{18} = 0.8 x 10^6

R = 85%

S_o = 0.45

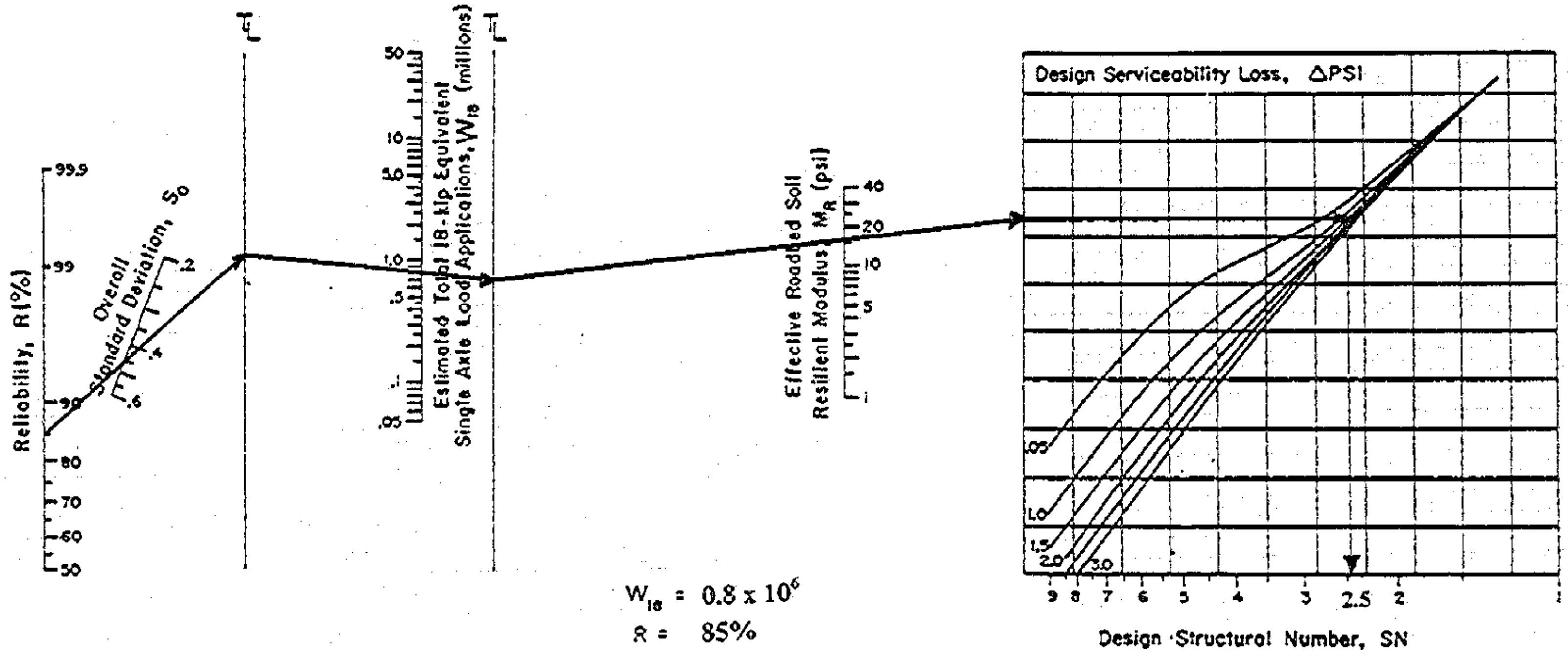
M_R = 6,000 psi

ΔPSI = 1.7

Solution: SN = 3.5

Figure A.C. 8 Design chart for flexible pavements based on using mean values for each input

La Colmena - Tebicuary : Sub-base



W_{18} = 0.8×10^6

R = 85%

S_o = 0.45

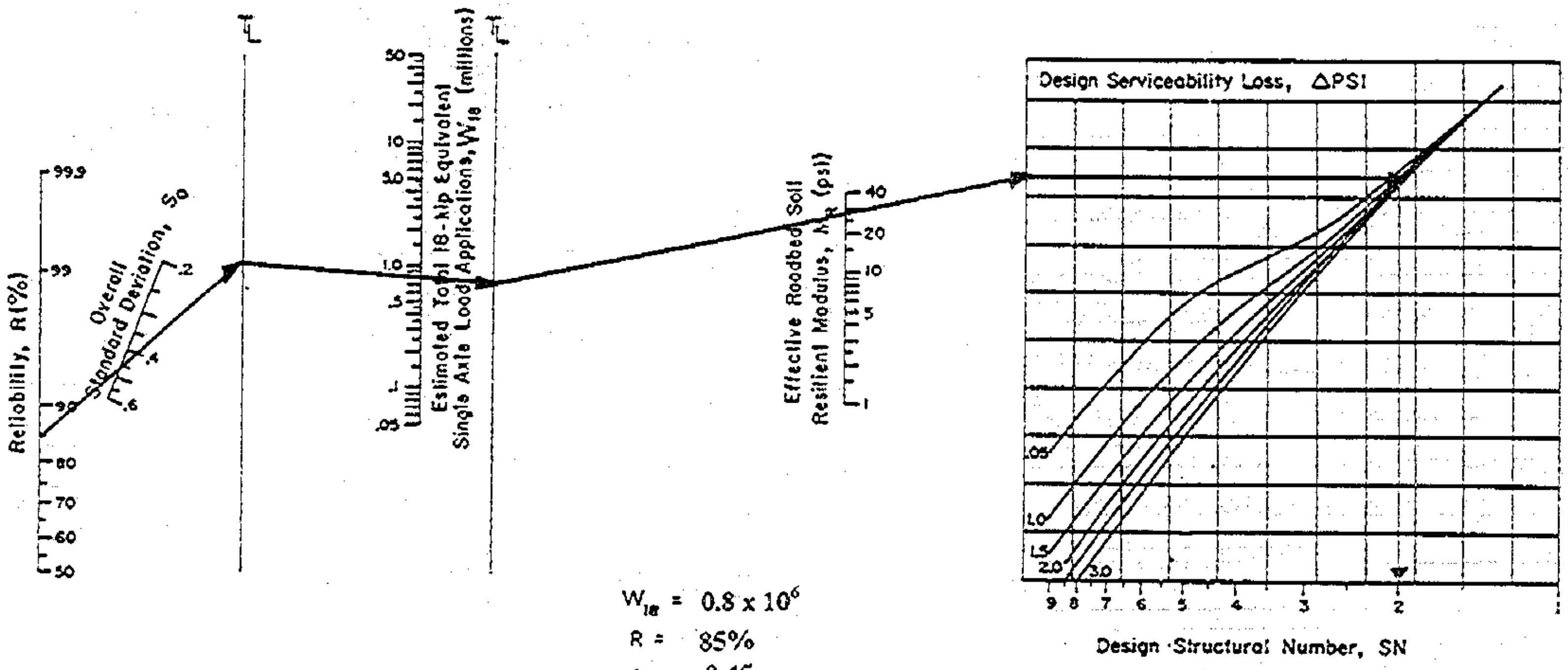
M_R = 15,650 psi

ΔPSI = 1.7

Solution: SN = 2.5

Figure A.C. 9 Design chart for flexible pavements based on using mean values for each input

La Colmena - Tebicuary : Base



W_{18} = 0.8 x 10^6

R = 85%

S_o = 0.45

M_R = 28,480 psi

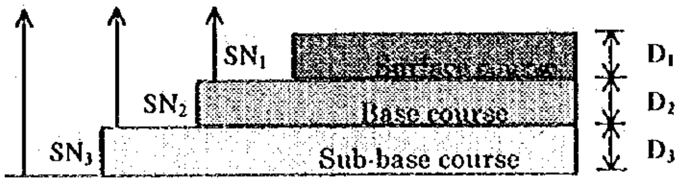
ΔPSI = 1.7

Solution: SN = 2.0

Figure A.C. 10 Design chart for flexible pavements based on using mean values for each input

13) Thickness of each layer

Based on the values of the Structural Number (SNi) and Layer Coefficient (a_i) obtained up to this point, the thickness of each layer can be calculated according to the formulas shown in Figure A.C.11.



$D^*_1 \geqq SN_1 / a_1$

$SN^*_1 = a_1 \times D^*_1 \geqq SN_1$

$D^*_2 \geqq (SN_2 - SN^*_1) / (a_2 \times m_2)$

$SN^*_1 + SN^*_2 \geqq SN_2$

$D^*_3 \geqq (SN_3 - SN^*_1 - SN^*_2) / (a_3 \times m_3)$

Note : An asterisk with D or SN indicates that it represents the value actually used, which must be equal to or greater than the required value.

Figure A.C.11 Calculation Method of Layer Thickness

Since the Guide specifies the minimum thickness of the surface layer and base course as shown in Table A.C.10, the calculated results must also comply with this.

Table A.C.10 Minimum Thickness

(Unit : inches)

Traffic, ESAL	Asphalt Concrete	Granular Base
Less than 50,000	1.0	4
50,000 - 150,000	2.0	4
150,001 - 500,000	2.5	4
500,001 - 2,000,000	3.0	6
2,000,001 - 7,000,000	3.5	6
Greater than 7,000,000	4.0	6

Each layer thickness is calculated as follows:

a) Paraguarí - Río Tebicuary-mí

$SN_1 / a_1 = 2.3 / 0.44 = 5.2 < \underline{D^*_1 = 5.5}$

$SN^*_1 = a_1 \times D^*_1 = 0.44 \times 5.5 = 2.4 > SN_1 = 2.3$

$(SN_2 - SN^*_1) / (a_2 \times m_2) = (3.0 - 2.4) / (0.14 \times 1.0) = 4.3 < \underline{D^*_2 = 6.0}$ ---min. thickness

$SN^*_2 = a_2 \times m_2 \times D^*_2 = 0.14 \times 1.0 \times 6.0 = 0.84$

$SN^*_1 + SN^*_2 = 2.4 + 0.84 = 3.24 > SN_2 = 3.0$

$(SN_3 - SN^*_1 - SN^*_2)/(a_3 \times m_3) = (3.7 - 2.4 - 0.84)/(0.11 \times 1.0) = 4.2 < \underline{D^*_3 = 6.0}$

b) Río Tebicuary-mí - Villarrica

$SN_1/a_1 = 2.4/0.44 = 5.5 \leqq \underline{D^*_1 = 5.5}$

$SN^*_1 = a_1 \times D^*_1 = 0.44 \times 5.5 = 2.4 \geqq SN_1 = 2.4$

$(SN_2 - SN^*_1)/(a_2 \times m_2) = (2.8 - 2.4)/(0.14 \times 1.0) = 2.9 < \underline{D^*_2 = 6.0}$ ---min. thickness

$SN^*_2 = a_2 \times m_2 \times D^*_2 = 0.14 \times 1.0 \times 6.0 = 0.84$

$SN^*_1 + SN^*_2 = 2.4 + 0.84 = 3.24 > SN_2 = 2.8$

$(SN_3 - SN^*_1 - SN^*_2)/(a_3 \times m_3) = (4.2 - 2.4 - 0.84)/(0.11 \times 1.0) = 8.7 < \underline{D^*_3 = 9.0}$

c) La Colmena - Tebicuary

$SN_1/a_1 = 2.0/0.44 = 4.5 \leqq \underline{D^*_1 = 4.5}$

$SN^*_1 = a_1 \times D^*_1 = 0.44 \times 4.5 = 2.0 \geqq SN_1 = 2.0$

$(SN_2 - SN^*_1)/(a_2 \times m_2) = (2.5 - 2.0)/(0.14 \times 1.0) = 3.6 < \underline{D^*_2 = 6.0}$ ---min. thickness

$SN^*_2 = a_2 \times m_2 \times D^*_2 = 0.14 \times 1.0 \times 6.0 = 0.84$

$SN^*_1 + SN^*_2 = 2.0 + 0.84 = 2.84 > SN_2 = 2.3$

$(SN_3 - SN^*_1 - SN^*_2)/(a_3 \times m_3) = (3.5 - 2.0 - 0.84)/(0.11 \times 1.0) = 6.0 \leqq \underline{D^*_3 = 6.0}$

14) Determination of layer thickness

Calculation results are schematically shown in Figure A.C.12.

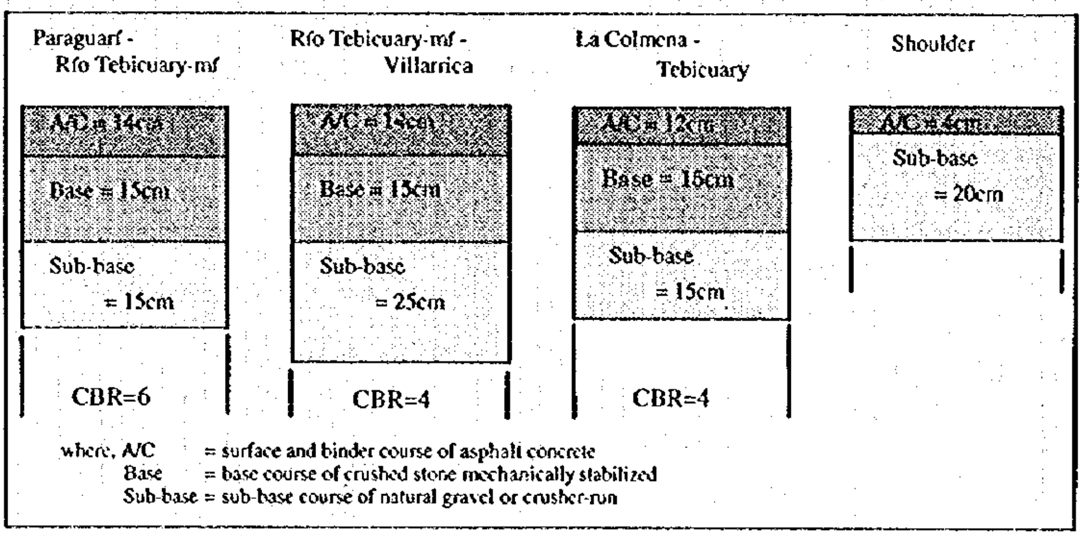


Figure A.C.12 Flexible Pavement Design Results

(2) Design of Overlay Pavement

1) Analysis Period

The analysis period for the design of the overlay pavement was considered to be fifteen (15) years from 2015.

2) Design Traffic

In this case, the design traffic was calculated for the period from 2015 to 2030, based on the assumption that the traffic increase rate in the period would be the same as that between 2005 and 2015.

Table A.C.11 Design Traffic

(unit: vehicles)

Road Section	Passenger Cars	Buses	Trucks
Paraguarí - Río Tebicuary-mí	11,259,338	3,098,850	10,030,200
Río Tebicuary-mí - Villarrica	8,781,900	3,720,263	7,207,838
La Colmena - Tebicuary	3,265,838	2,753,925	1,921,725

3) Cumulative 18-kip Equivalent Single Axle Load (E.S.A.L.)

The calculation method is the same as that in Annex C (1).

Table A.C.12 Design ESAL and Cumulative 18-kip ESAL by Road Section

Road Section	Vehicle Type	Design Traffic (A)	ESAL Factor (B)	Design ESAL (A×B)	Cumulative 18-kip ESAL
Paraguarí - Río Tebicuary-mí	Passenger Car	11,259,338	0.0004	4,504	
	Bus	3,098,850	1.5980	4,951,962	
	Truck	10,030,200	0.9170	9,197,693	
	Total			14,154,159	7,077,080
Río Tebicuary-mí - Villarrica	Passenger Car	8,781,900	0.0004	3,513	
	Bus	3,720,263	1.5980	5,944,980	
	Truck	7,207,838	0.9170	6,609,587	
	Total			12,558,080	6,279,040
La Colmena - Tebicuary	Passenger Car	3,265,838	0.0004	1,306	
	Bus	2,753,925	1.5980	4,400,772	
	Truck	1,821,725	0.9170	1,762,222	
	Total			6,164,300	3,082,150

Note: (Cumulative 18-kip ESAL) = (Design ESAL) × D_D × D_L

where; D_D = Directional Distribution Factor = 0.5, D_L = Lane Distribution Factor = 1.0

4) Reliability(R), Standard Deviation (So) and Effective Resilient Modulus (M)

For the above factors the same values as those used for the calculation of the initial pavement are applied.

Table A.C.13 Applied Values of R, So and M

Road Section	(R)	(So)	(M)
Paraguarí - Río Tebicuary-mí	85%	0.45	9,000 psi
Río Tebicuary-mí - Villarrica	85%	0.45	6,000 psi
La Colmena - Tebicuary	85%	0.45	6,000 psi

5) Design Serviceablity loss ($\triangle PSI_{TR}$)

$\triangle PSI_{TR}$ = $\triangle PSI$ - $\triangle PSIsw$

where $\triangle PSI$ = Po - Pt = 4.2 - 2.5 = 1.7

The value of $\triangle PSIsw$ is expressed as the difference of the values of $\triangle PSI$ for 25 years and 10 years, which can be obtained from the Figure 11.2 in the AASHTO Guide.

$\triangle PSIsw$ = 0.28 - 0.18 = 0.1

$\triangle PSI_{TR}$ = 1.7 - 0.1 = 1.60

6) Structural Number of a New Pavement (SNy)

The values of SNy for each road section are obtained in Figures A.C.13, 14 and 15.

SNy = 4.4 (for the section between Paraguarí and Río Tebicuary-mí)

SNy = 4.8 (for the section between Río Tebicuary-mí and Villarrica)

SNy = 4.4 (for the section between La Colmena and Tebicuary)

7) Remaining Life Factor (F_{RL})

The Remaining Life Factor (F_{RL}) is established based on the estimated remaining life (R_{LX}) of the original pavement at the time of the overlay and the estimated remaining life (R_{LY}) of the overlay when it reaches its design terminal serviceability of 2.5.

- R_{LX} = 43 %,

This was obtained from the Figure 5.15 in the AASHTO Guide, assuming that Serviceability at the time of overlay Pt_1 is 2.5.

- R_{LY} = (Nfy - Y)/Nfy

where

Nfy : the estimated future 18-kips ESAL traffic when the serviceability drops to 2.0.

Y : the estimated future 18-kips ESAL traffic when terminal serviceabilty is 2.5; therefore, the value of Y can be obtained from the values in Table A.C.12.

The $\triangle PSI_{TR}$ corresponding to the case of (the serviceability = 2.0) is 2.10 based on the following formula:

$\triangle PSI_{TR}$ = (4.2 - 2.0) - 0.10 = 2.10

Using this value on Figures A.C.16, 17 and 18, the Nfy value can be obtained. Calculation results are shown in Table A.C.15.

Table A.C.15 Calculation of R_{LY}

Road Section	(Nfy)	(Y)	(R_{LY})
Paraguarí - Río Tebicuary-mí	12.0×10^6	7.1×10^6	0.408
Río Tebicuary-mí - Villarrica	10.0×10^6	6.3×10^6	0.370
La Colmena - Tebicuary	5.0×10^6	3.1×10^6	0.380

From the values of R_{LX} and R_{LY} above, F_{RL} is obtained from Figure 5.17 in the AASHTO Guide, and the results are summarized below:

- Paraguarí - Río Tebicuary-mí : $F_{RL} = 0.71$
- Río Tebicuary-mí - Villarrica : $F_{RL} = 0.69$
- La Colmena - Tebicuary : $F_{RL} = 0.70$

8) Effective Structural Number (SNxeff)

SNxeff = Cx×Sno

where Cx : pavement condition factor : = 0.86 (obtained from Figure 5.18 in the Guide)

SNo: SN of original pavement : = 5.0

Therefore, SNxeff = 0.86×5.0 = 4.30

9) Structural Number of the Required Asphalt Concrete Overlay (SN_{OL})

SN_{OL} = SNy - (F_{RL}×SNxeff)

10) Thickness of Asphalt Concrete Overlay (D_{OL})

$D_{OL} = SN_{OL} / a_1$

where $a_1 = 0.44$

Table A.C.16 Required Thickness of Overlay Pavement

Road Section	(SNy)	(F_{RL})	(SNxeff)	(SN_{OL})	(D_{OL})	
					inches	cm
Paraguarí - Río Tebicuary-mí	4.4	0.71	4.3	1.35	3.1	8.0
Río Tebicuary-mí - Villarrica	4.8	0.69	4.3	1.83	4.2	11.0
La Colmena - Tebicuary	4.4	0.70	4.3	1.39	3.2	8.0

(3) Design of Rigid Pavement

1) Analysis Period

The analysis period in the design of rigid pavement structure was considered in this case to be 25 years from the commencement of use of the developed roads.

2) Design Traffic

The design traffic is the cumulative traffic volume during the analysis period. It is expressed by type of vehicle, exactly the same as in the case of flexible pavement in Annex C (1).

The calculated design traffic, based on the estimated traffic volume for the years 2005 and 2015 summarized in Table 5.5.1, is shown in Table A.C.17.

Table A.C.17 Design Traffic for 25 Years

(unit: vehicles)

Road Section	Passenger Cars	Buses	Trucks
Paraguarí - Río Tebicuary-mí	16,548,188	4,252,250	14,417,500
Río Tebicuary-mí - Villarrica	12,660,938	4,804,0313	10,429,875
La Colmena - Tebicuary	4,302,438	3,494,875	2,340,563

3) Cumulative 18-kips Equivalent Single Axle Load (ESAL)

The calculation method to obtain the Design ESAL and Cumulative 18-kip ESAL for each road section is exactly the same as in the case of flexible pavement. (see, Annex C (1))

Table A.C.18 Design ESAL and Cumuiative 18-kip ESAL by Road Section

Road Section	Vehicle Type	Design Traffic (A)	ESAL Factor (B)	Design ESAL (A×B)	Cumulative 18-kip ESAL
Paraguarí - Río Tebicuary-mí	Passenger Car	16,548,188	0.0004	6,619	
	Bus	4,252,250	1.5980	6,795,096	
	Truck	14,417,500	0.9170	13,226,848	
	Total			20,022,563	10,011,282
Río Tebicuary-mí - Villarrica	Passenger Car	12,660,938	0.0004	5,064	
	Bus	4,804,313	1.5980	7,677,292	
	Truck	10,429,875	0.9170	9,564,195	
	Total			17,246,551	8,623,276
La Colmena - Tebicuary	Passenger Car	4,302,438	0.0004	1,721	
	Bus	3,494,875	1.5980	5,584,810	
	Truck	2,340,563	0.9170	2,146,296	
	Total			7,732,827	3,866,414

Note: (Cumulative 18 kip ESAL) = (Design ESAL) × D_D × D_L

where D_D = Directional Distribution Factor = 0.5, D_L = Lane Distribution Factor = 1.0

4) Effective Modulus of Subgrade Reaction (k psi)

In the course of flexible pavement design described Annex C (1), Roadbed Modulus

(M_R) and Subbase Modulus (M_B =E_{SB}) where calculated as shown in Table A.C.19. Applying those values to the Figure 3.3, Figure 3.6 and Table 2.7 in the Guide, the Effective Modulus of Subgrade Reaction (k value) can be obtained.

Table A.C.19 Corrected Effective Modulus of Subgrade Reaction (k)

Road Section	(M_R)	(E_{SB})	Composite k value (Figure 3.3)	Corrected k value (Fig.3.6, Tab. 2.7)
Paraguarí - Río Tebicuary-mí	9,000	33,700	550 psi	49 psi
Río Tebicuary-mí - Villarrica	6,000	28,500	380	36
La Colmena - Tebicuary	6,000	28,500	380	36

Note: Thickness of subbase and LS are assumed to be 6 inches and 2.0, respectively.

5) Reliability (R), Standard Deviation (So), Design Serviceability Loss (△PSI), and Load Transfer Coeffcient (J)

According to the suggestion in the AASHTO Guide, these values were determined as shown below:

R = 85 %

So = 0.35

△PSI = 4.5 - 2.5 = 2.0

J = 3.1 (see, Table 2.6 in the Guide)

6) Characteristics of Cement Concrete for Pavement

As representative values of normal concrete for pavement, the following were determined.

- Elastic Modulus $E_C = 3.1 \times 10^6$ psi
- Flexural Strength $S'_C = 640$ psi

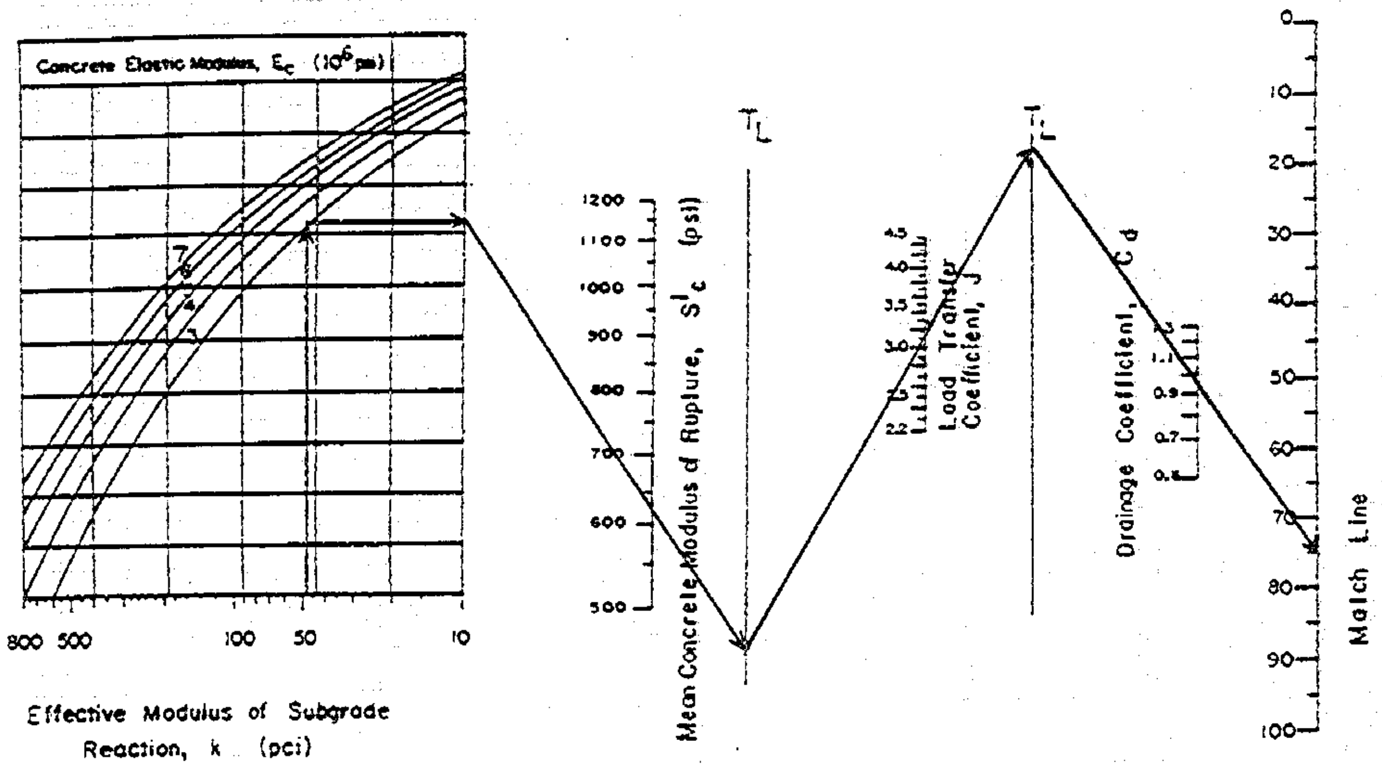
7) Determination of Required Slab Thickness

From the values obtained up to this point, the required slab thickness for each road section is determined using the chart in the AASHTO Guide. Applied charts are shown as Figures A.C.19 - A.C.23. The results are summarized below:

Table A.C.20 Required Thickness of Layers of Rigid Pavement

Road Section	Thickness of Subbase (inches) cm	Thickness of Concrete Slab (inches) cm
Paraguarí - Río Tebicuary-mí	(6.0) 16	(11.0) 28
Río Tebicuary-mí - Villarrica	(6.0) 16	(11.0) 28
La Colmena - Tebicuary	(6.0) 16	(9.0) 23

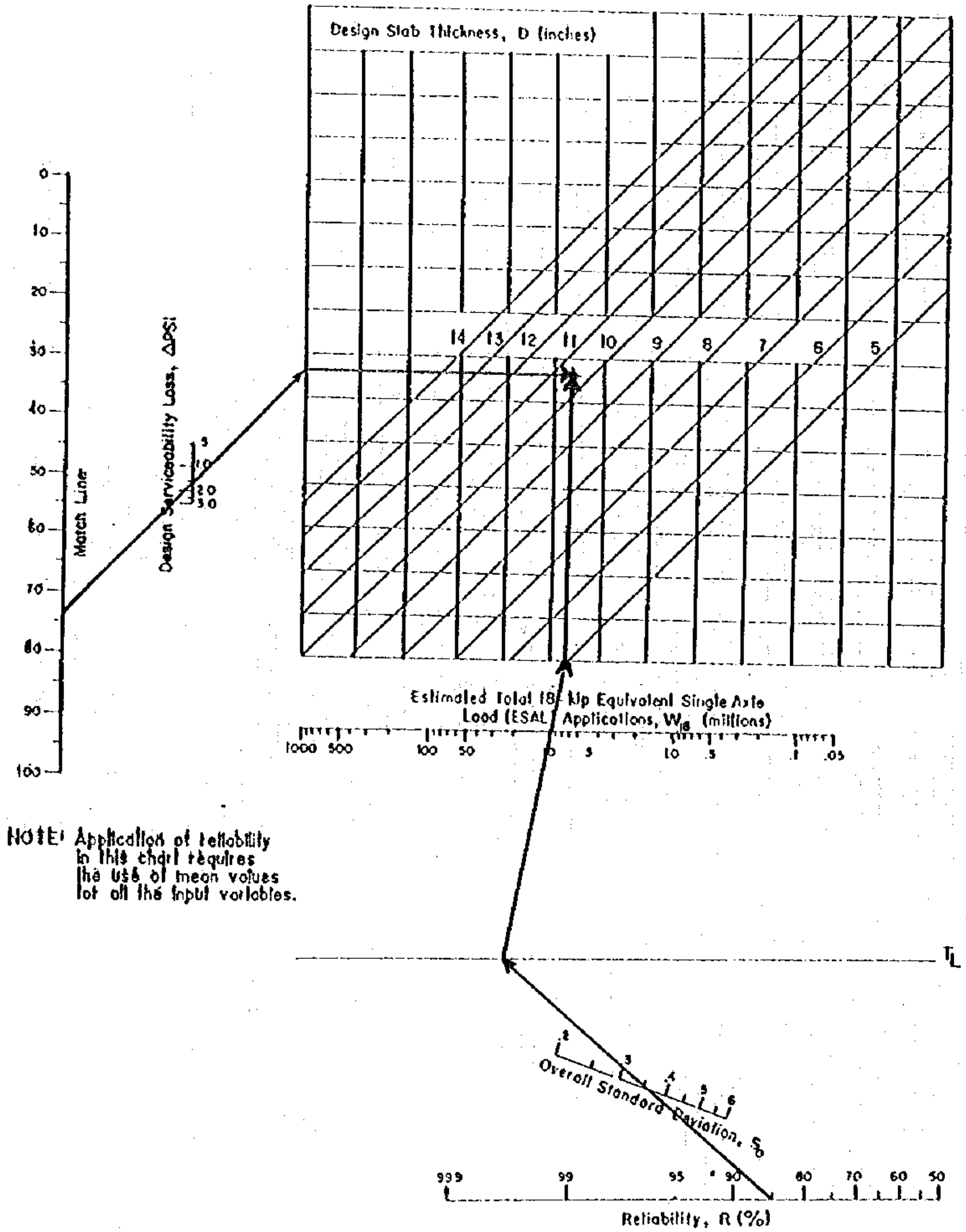
Paraguari - Rio Tebicuary mi



$k = 49$ psi
$E_c = 3.1 \times 10^6$
$S'_c = 640$ psi
$J = 3.1$
$C_d = 1.0$

$S_o = 0.35$
$R = 85\%$
Δ PSI $= 4.5 - 2.5 = 2.0$
$W_{18} = 10 \times 10^6$
Solution : $D = 11.0$

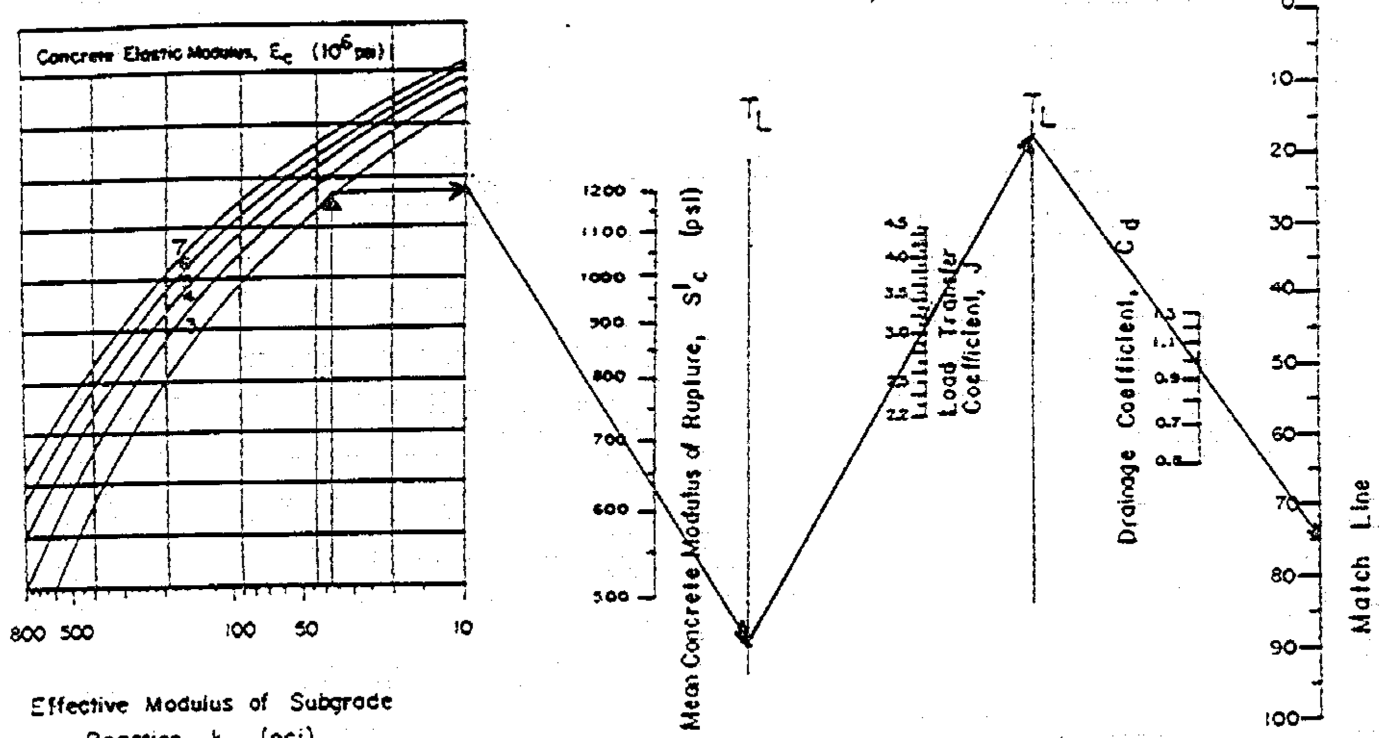
Figures A.C.13 Design chart for rigid pavement based on using mean values for each input variable (Segment 1).



Figures A.C.14 **Design chart for rigid pavements based on using mean values for each input variable (Segment 2).**

1) Rio Tebicuary - Villarrica

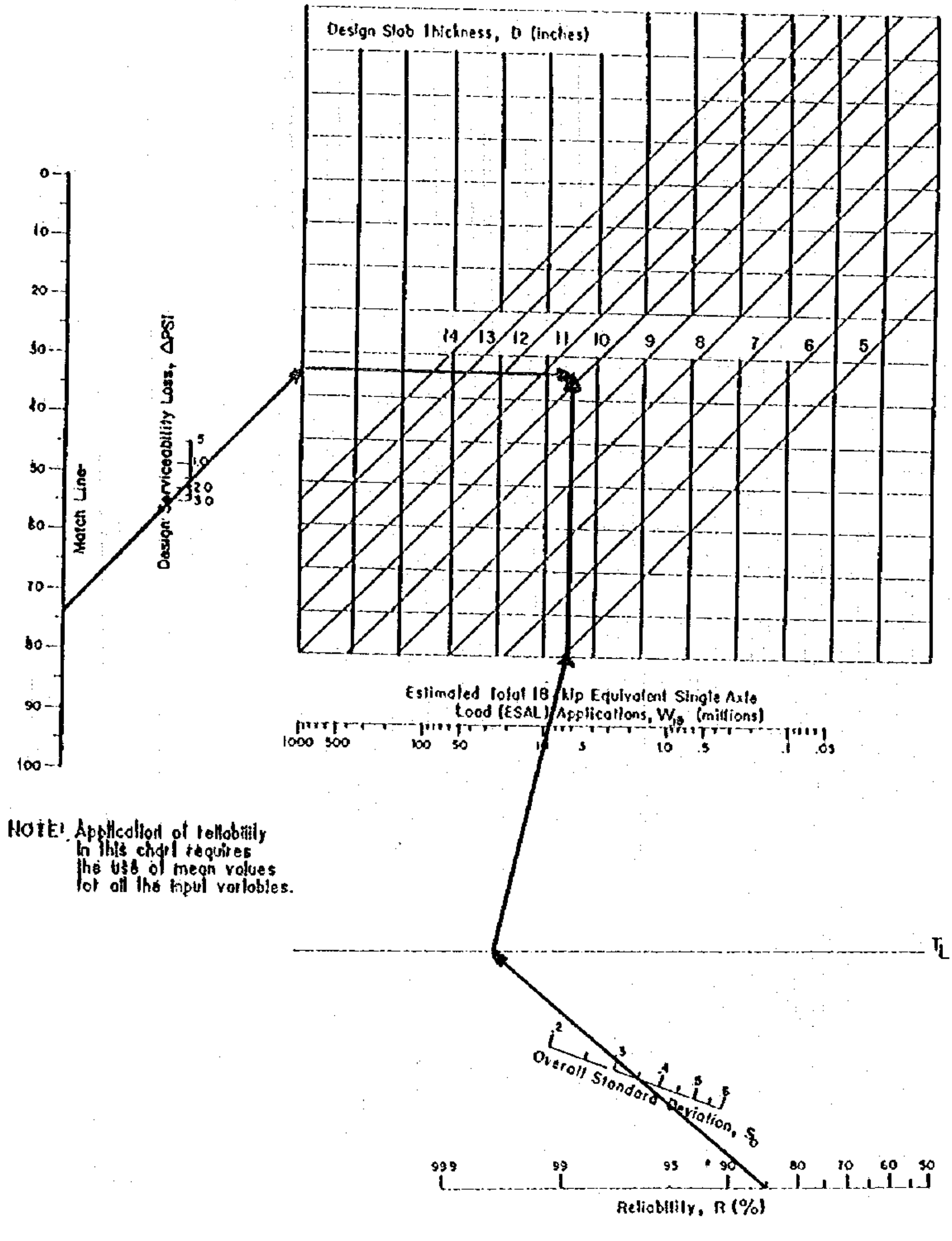
2) La Colmena - Tebicuary



$k = 36$ psi
$E_c = 3.1 \times 10^6$
$S'_c = 640$ psi
$J = 3.1$
$C_d = 1.0$

$S_o = 0.35$
$R = 85\%$
$\Delta PSI = 4.5 - 2.5 = 2.0$
$W_{18} =$ 1) 8.6×10^6
2) 3.9×10^6
Solution : 1) $D = 11.0$
2) $D = 9.0$

Figures A.C.15 Design chart for rigid pavement based on using mean values for each input variable (Segment 1).



Figures A.C.16 Design chart for rigid pavements based on using mean values for each input variable (Segment 2).

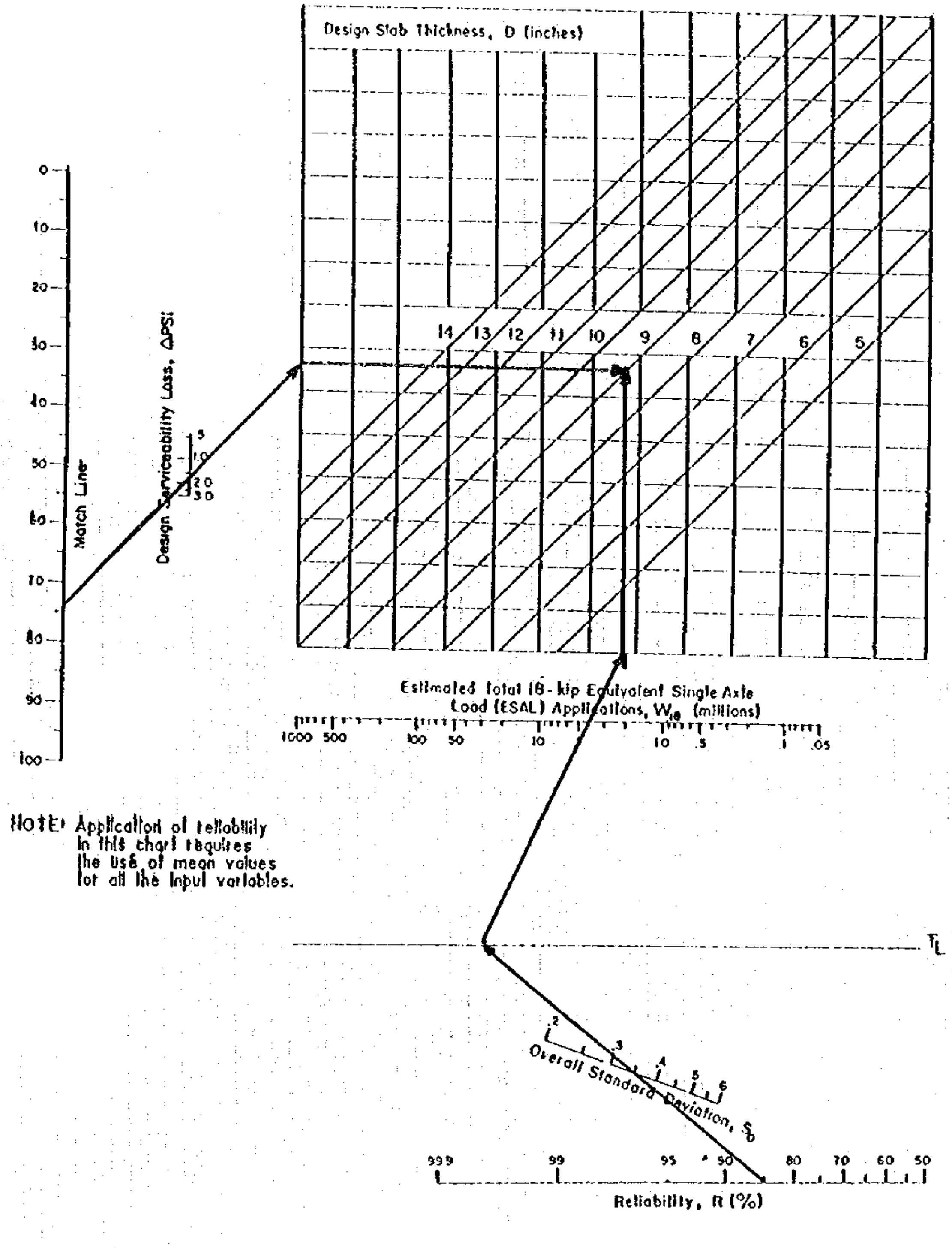


Figure A.C.17 Design chart for rigid pavements based on using mean values for each input variable (Segment 2).

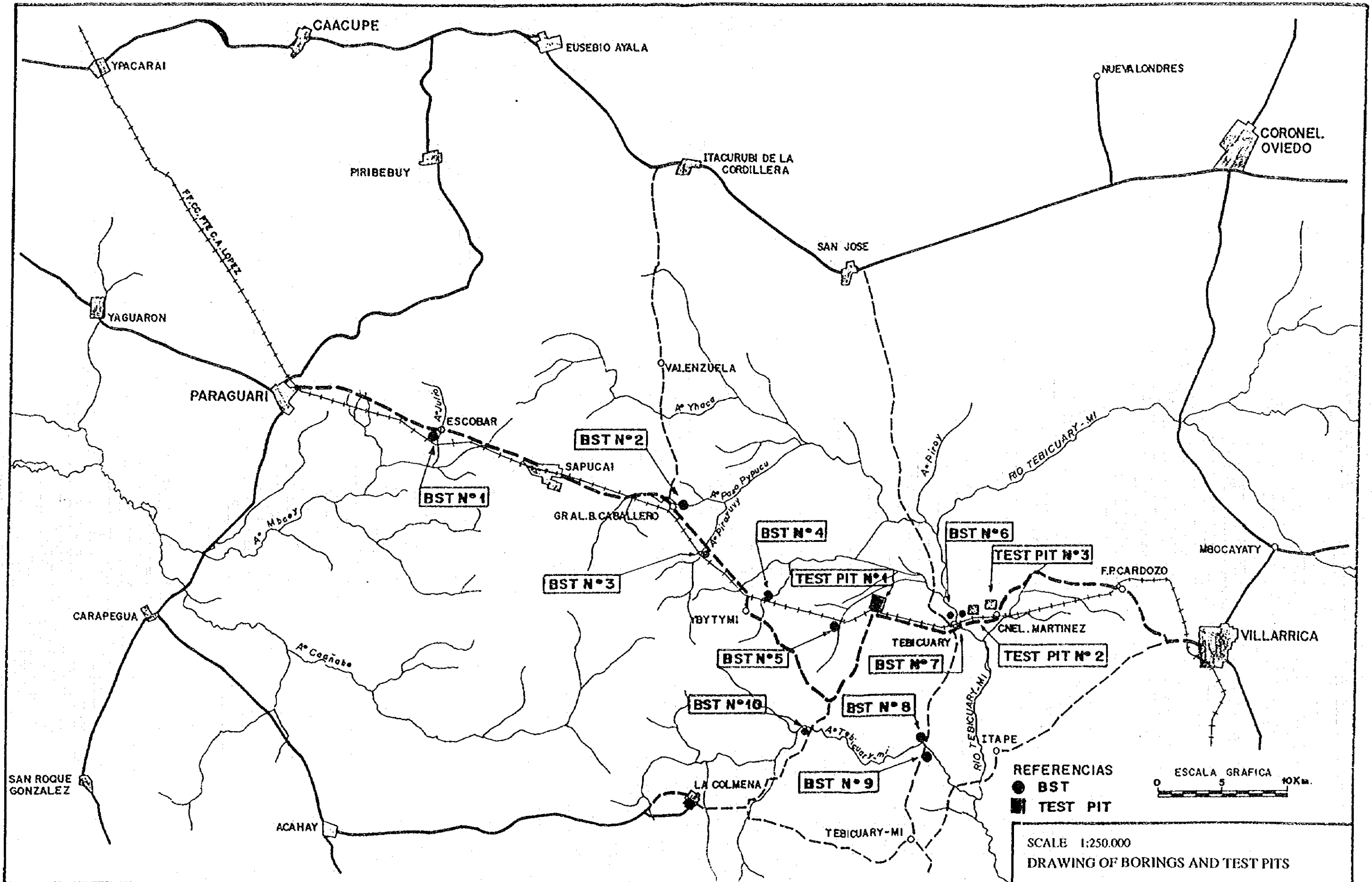
ANNEX D

RESULT OF BORING SURVEY,

TESTS OF MATERIAL FROM TEST PITS

AND STONE OF QUARRY AT PARAGUARI (C1)

Results of Boring Survey
and
Laboratory Tests



SCALE 1:250.000

DRAWING OF BORINGS AND TEST PITS

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		REFERENCES
SOUNDING N° BST 1	WORK JICA	CLAY
DIAMETER OF BORING 3"	LOCATION ESCOBAR..	SILT
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SAND
PERFORMED BY E. MARTINEZ	VERTICAL SCALE 1:100	GRAVEL
INSPECTED BY	PREPARED BY C. LOPEZ..	ROCK

Elevation	Depth	Water Level	Lithological Profile	N° of Sample / Classific	Description	Penetration Test (S.P.T.) N° of Strokes (Index N°)	Date of Laboratory Test: Natural Moisture Δ, Liquid Limit o, Plastic Limit •, Passing Sieve 200 (%) □
120,10	0,00						
	1,00			1 / SC	clayey sand, yellowish brown and gray	(6)	
	2,00			2 / SC	clayey sand, gray with small gravel..	(11)	
	3,00				Same as above.	(25)	
T.R.	4,00			4 / SC	clayey sand, reddish brown and gray with small gravel.	(>50)	
	5,00				Same as above with alternation of sandstone	(>50)	
	6,00				Same as above	(>50)	
	7,00			7 / SC	Same as above.	(>50)	
					FINAL SOUNDING.		

T.R. = Roof of stone.-

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		REFERENCES
SOUNDING N° BST2	WORK DICA	CLAY
DIAMETER OF BORING 3"	LOCATION CABALLERO	SILT
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SAND
PERFORMED BY E. MARTINEZ	VERTICAL SCALE 1:100	GRAVEL
INSPECTED BY	PREPARED BY C. LOPEZ.	ROCK

Elevation	Depth	Water Level	Lithological Profile	N° of Sample / Classific	Description	Penetration Test (S.P.T.) N° of Strokes (Index N°)	Data of Laboratory Test (Natural Moisture A; Liquid Limit o; Plastic Limit •; Passing Sieve 200 (%) □)
168,265	0,00						
	1,00		Clay	1 / CL	Clay of low compressibility, yellowish gray.-	(2)	
	2,00		Clay		Same as above.-	(7)	
	3,00		Sand	3 / SH	Muddy sand gray.-	(9)	(NP)
	4,00		Sand		Same as above.-	(10)	
	5,00		Clay	5 / CL	Clay of low compressibility yellowish gray	(10)	
	6,00		Clay		Same as above	(13)	
	7,00		Clay		Same as above.	(>50)	
T.R.	8,00		Sand	8 / SH	Muddy sand, gray.	(>50)	(NP)
	9,00		Rock		Same as above, with alteration of sands, stone.-	(>50)	
	10,00		Rock		Same as above.	(>50)	
					FINAL SOUNDING.		

T.R. = Roof of stone.-

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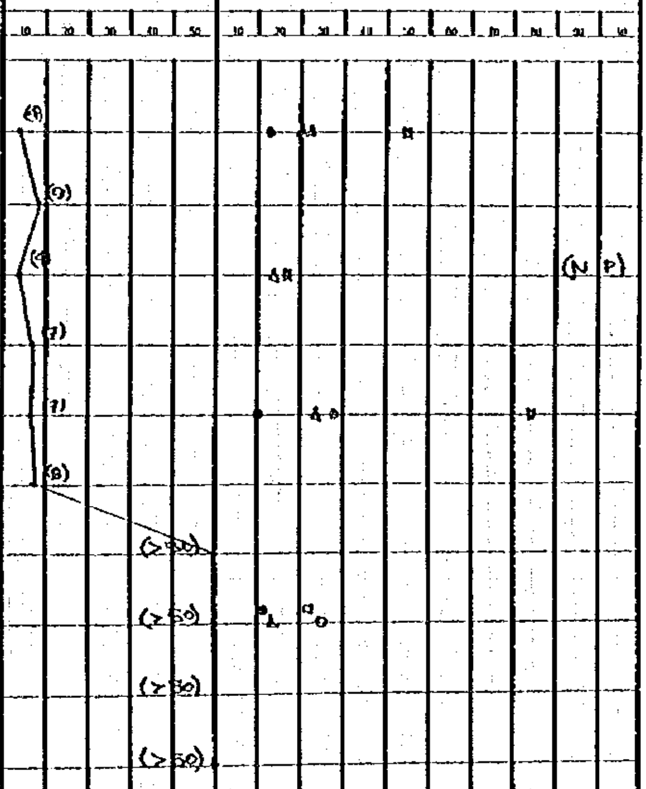
SOUNDING N° BST 3	WORK JICA.	REFERENCES
DIAMETER OF BORING 3"	LOCATION CABALLERO	CLAY
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SILT
PERFORMED BY E. MARTINEZ.	VERTICAL SCALE 1: 100	SAND
INSPECTED BY	PREPARED BY C. LOPEZ.	GRAVEL
		ROCK

Elevation	Dept	Water Level	Lithological Profile	N° of Sample / Clasific	Description	Penetration Test (S.P.T) N° of Strokes (Index N°)
110,05	0,00					
	1,00			1 / CL	Clay low compressibility, gray.-	(8)
	2,00				Same as above.-	(9)
	3,00			3 / SM	Muddy sand, gray	(9)
	4,00				Same as above.-	(7)
	5,00			5 / CL	clay of low compresibility, yellowish gray.-	(7)
	6,00				Same as above.-	(8)
	7,00				Same as above.-	(>50)
T.R.	8,00			8 / GC	Gravel of a muddy matrix, with small gravel yellowish gray	(>50)
	9,00				Same as above.-	(>50)
	10,00				Same as above.- FINAL SOUNDING.	(>50)

T.R.= Roof of stone.-

Date of Laboratory Test
Natural Moisture ...... A
Liquid Limit ...... o
Plastic Limit c
Passing Sieve 200 (%) ...... □



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SOUNDING N°	BST4	WORK	DICA.	REFERENCES	
DIAMETER OF BORING	3"	LOCATION	YBYTYMI.	CLAY	//////
METHOD OF BORING	ROTARY DRILL	DATE OF ENDING		SILT	≡≡≡
PERFORMED BY	E. MARTINEZ.	VERTICAL SCALE	1: 100	SAND	∴∴∴
INSPECTED BY		PREPARED BY	C. LOPEZ.-	GRAVEL	∘∘∘
				ROCK	^^^

Elevation	Depth	Water Level	Lithological Profile	N° of Sample / Classific	Description	Penetration Test (S.P.T.) N° of Strokes (Index N°)	Data of Laboratory Test: Natural Moisture ... Δ; Liquid Limit ... ◦; Plastic Limit ... •; Passing Sieve 200 (%) ... □
113,69	0,00						
	1,00		Clay	1 / CL	Clay of low compressibility, gray.-	(15)	
	2,00		Clay		Same as above.-	(45)	
	3,00		Sand	3 / SM	Muddy sand, light brown.-	(>50)	(N.P)
	4,00		Sand		Same as above.-	(>50)	
	5,00		Clay	5 / CL	Clay of low compressibility, dark gray	(>50)	
	6,00		Clay		Same as above.-	(>50)	
	7,00		Clay		Same as above.-	(>50)	
					FINAL SOUNDING.		

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SOUNDING Nº BST6		WORK DICA..		REFERENCES	
DIAMETER OF BORING 3"		LOCATION YBYTYMI.		CLAY	
METHOD OF BORING ROTARY DRILL		DATE OF ENDING		SILT	
PERFORMED BY E. MARTINEZ		VERTICAL SCALE 1:100		SAND	
INSPECTED BY		PREPARED BY C. LOPEZ.		GRAVEL	
				ROCK	

Elevation	Dept	Water Level	Lithological Profile	Nº of Sample / Classific.	Description	Penetration Test (S.P.T.) Nº of Strokes (Index N°)	Data of Laboratory Test: Natural Moisture Δ, Liquid Limit o, Plastic Limit •, Passing Sieve 200 (%) □
118,05	0,00						
	1,00			1 / CL	clay of low compressibility, dark gray	(16)	
	2,00			2 / SH	Muddy sand, brown	(9)	(N.P)
	3,00				Same as above..	(4)	
	4,00				Same as above.-	(<1)	
	5,00			5 / SH	Same as above..	(10)	(N.P)
	6,00				Same as above..	(19)	
	7,00				Same as above..	(34?)	
	8,00			8 / SH	Muddy sand, gray..	(24)	(N.P)
	9,00				Same as above.-	(26)	
	10,00			10 / CL	clay of low compressibility, dark gray	(28)	
	11,00				Same as above.-	(24?)	
	12,00			12 / SC	clayey sand, reddish brown	(24?)	
	13,00				Same as above..	(24?)	
	14,00				Same as above.-	(28)	
	15,00			15 / SC	Same as above.-	(>50)	
	16,00				Same as above..	(>50)	

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SOUNDING Nº BSTS (CONT.)	WORK JICA.-	REFERENCES
DIAMETER OF BORING 3"	LOCATION YBYTYMI	CLAY
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SILT
PERFORMED BY E. MARTINEZ.	VERTICAL SCALE 1:100	SAND
INSPECTED BY	PREPARED BY C. LOPEZ.	GRAVEL
		ROCK

Elevation	Depth	Water Level	Lithological Profile	Nº of Sample / Clasific	Description	Penetration Test (S.P.T.) Nº of Strokes (Index N°) 10 20 30 40 50	Data of Laboratory Test: Natural Moisture ▲, Liquid Limit ○, Plastic Limit ●, Passing Sieve 200 (%) ☐ — 10 20 30 40 50 60 70 80 90 100
	16,00						
	17,00				Clayey sand, reddish brown.-	(>50)	
	18,00			18 / SC	Same as above.-	(>50)	
					FINAL SOUNDING.		

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		REFERENCES
SOUNDING N° BST6	WORK JICA	CLAY
DIAMETER OF BORING 3"	LOCATION TEBICUARY.	SILT
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SAND
PERFORMED BY E. MARTINEZ.	VERTICAL SCALE 1:100	GRAVEL
INSPECTED BY	PREPARED BY C. LOPEZ..	ROCK

Data of Laboratory Test: Natural Moisture Δ; Liquid Limit ○; Plastic Limit ●; Passing Sieve 200 (%) ( )

Elevation	Dept	Water Level	Lithological Profile	N° of Sample (Identific)	Description	Penetration Test (SPT) N° of Strokes (Index N°)	Data of Laboratory Test
101,043	0,00						
	1,00			1 SH	Muddy sand, gray	(<1)	(NP)
	2,00				Same as above..	(1)	
	3,00				Same as above..	(2)	
	4,00			4 SH	Same as above.-	(4)	(NP)
	5,00				Same as above.-	(6)	
	6,00				Same as above.-	([illegible])	
	7,00			7 SP	Poorly graduated sand, gray.-	(14)	(NP)
	8,00				Same as above.-	(15)	
	9,00				Same as above.-	(16)	
	10,10			10 SP	Same as above.-	(15)	(NP)
	11,00				Same as above.-	([illegible])	
	12,00				Same as above.	([illegible])	
	13,00				Same as above.	([illegible])	
	14,00			14 SP-SM	Poorly graduated and muddy sand, gray.-	(19)	(NP)
	15,00				Same as above.	(>50)	
	16,00				Same as above.	(>50)	

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		REFERENCES
SOUNDING N° BST6 (CONT.)	WORK JICA.	CLAY
DIAMETER OF BORING 3"	LOCATION TEBICUARY	SILT
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SAND
PERFORMED BY B. MARTINEZ.	VERTICAL SCALE 1: 100	GRAVEL
INSPECTED BY	PREPARED BY C. LOPEZ.	ROCK

Elevation	Depth	Water Level	Lithological Profile	N° of Sample Classific	Description	Penetration Test (S.P.T.) N° of Strokes (Index N°)	Data of Laboratory Test: Natural Moisture ... A; Liquid Limit ... o; Plastic Limit ... •; Passing Sieve 200 (%) ... □
	16,00						
				17 SM.	Muddy sand, gray		
	17,00					(>50)	A □ (NP)
					Same as above.		
	18,00					(>50)	
					FINAL SOUNDING.		

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				REFERENCES	
SOUNDING N°	BST 7	WORK	JICA	CLAY	
DIAMETER OF BORING	3"	LOCATION	TEBICUARY	SILT	
METHOD OF BORING	ROTARY DRILL	DATE OF ENDING		SAND	
PERFORMED BY	E. MARTINEZ.	VERTICAL SCALE	1:100	GRAVEL	
INSPECTED BY		PREPARED BY	C. LOPEZ.	ROCK	

Elevation	Dept	Water Level	Lithological Profile	N° of Sample / Classific	Description	Penetration Test (S.P.T.) N° of Strokes (Index N°)	Data of Laboratory Test: Natural Moisture Δ, Liquid Limit ○, Plastic Limit ●, Passing Sieve 200 (%) □
105,05	0,00						
	1,00			1 / SH	Muddy sand, gray	(1)	(N P)
	2,00				Same as above.-	(1)	
	3,00				Same as above.-	(1)	
	4,00			4 / SH	Same as above.	(6)	(N P)
	5,00				Same as above	(4)	
	6,00				Same as above.-	(7)	
	7,00				Same as above.	(20)	
	8,00			8 / SP-SH	Poorly graduated and muddy sand, gray.-	(17)	(N P)
	9,00				Same as above.-	(15)	
	10,00				Same as above.-	(17)	
	11,00			11 / SP-SH	Same as above.-	(17)	(N P)
	12,00				Same as above.-	(15)	
	13,00				Same as above.-	(17)	
	14,00				Same as above	(19)	
	15,00			15 / SP-SH	Same as above.-	(28)	(N P)
	16,00			16 / CL	Clay of low compressibility, yellowish gray.-	(>50)	

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SOUNDING N° BST7 (CONT.)	WORK SICA	REFERENCES	
DIAMETER OF BORING 3"	LOCATION TEBICUARY.	CLAY	
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SILT	
PERFORMED BY E. MARTINEZ	VERTICAL SCALE 1:100	SAND	
INSPECTED BY	PREPARED BY C. LOPEZ.	GRAVEL	
		ROCK	

Elevation	Dept	Water Level	Lithological Profile	N° of Sample / Classific	Description	Penetration Test (SPT) N° of Strokes (Index N°) 10 20 30 40 50	Data of Laboratory Test: Natural Moisture ▲, Liquid Limit ○, Plastic Limit ●, Passing Sieve 200 (%) □ — 10 20 30 40 50 60 70 80 90 100
	16,00						
	17,00		Clay		Clay of low compressibility, yellowish gray.-	(>50)	
	18,00		Clay		Same as above.	(>50)	
	19,00		Clay		Same as above.-	(>50)	
					FINAL SOUNDING.		

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		REFERENCES	
SOUNDING N° BST8	WORK DICA.	CLAY	
DIAMETER OF BORING 3"	LOCATION TEBICUARYMI	SILT	
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SAND	
PERFORMED BY E. MARTINEZ.	VERTICAL SCALE 1:100	GRAVEL	
INSPECTED BY	PREPARED BY C. LOPEZ.	ROCK	

Elevation	Dept	Water Level	Lithological Profile	N° of Sample / Classific	Description	Penetration Test (S P T) N° of Strokes (Index N°)	Data of Laboratory Test: Natural Moisture A; Liquid Limit ◦; Plastic Limit ▪; Passing Sieve 200 (%) □
101,91	0,00						
	1,00			1 / SM	Muddy sand, gray.	(7)	A (N P)
	2,00				Same as above.-	(8)	
	3,00				Same as above..	(15)	
	4,00			4 / SP-SM	Poorly graduated and muddy sand, gray.-	(34)	B A (N P)
	5,00			5 / SC	Clayey sand, gray	(15)	A ◦ D
	6,00			6 / SP	Poorly graduated sand, gray.-	(15)	B A (N P)
	7,00				Same as above.-	(15)	
	8,00				Same as above.-	(16)	
	9,00			9 / SP	Same as above.	(17)	B A (N P)
	10,00				Same as above.	(19)	
	11,00				Same as above.-	(17)	
	12,00			12 / SP	Same as above.	(18)	B A (N P)
	13,00				Same as above.	(17)	
	14,00				Same as above..	(19)	
	15,00			15 / SP.	Same as above.-	(31)	B A (N P)
	16,00				Same as above	(35)	

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SOUNDING N° BST8 (CONT.)	WORK JICA	REFERENCES
DIAMETER OF BORING 3"	LOCATION TEBICUARY MI.	CLAY
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SILT
PERFORMED BY E. MARTINEZ.	VERTICAL SCALE 1:100	SAND
INSPECTED BY	PREPARED BY C. LOPEZ.	GRAVEL
		ROCK

Elevation	Dept	Water Level	Lithological Profile	N° of Sample / Classific	Description	Penetration Test (SPT) N° of Strokes (Index N°) 10 20 30 40 50	Data of Laboratory Test: Natural Moisture A, Liquid Limit o, Plastic Limit •, Passing Sieve 200 (%) □ — 10 20 30 40 50 60 70 80 90 100
	16,00						
	17,00				Poorly graduated sand, gray.-	(36) (>50)	
	18,00			18 SP-SH	Poorly graduated and muddy sand gray.-	(>50)	8 A (NP)
	19,00				Same as above.-	(>50)	
	20,00				Same as above.-	(>50)	
					FINAL SOUNDING.		

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		REFERENCES	
SOUNDING N° BST9	WORK SICA.	CLAY	
DIAMETER OF BORING 3"	LOCATION TEBICUARYMI.	SILT	
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SAND	
PERFORMED BY E. MARTINEZ.	VERTICAL SCALE 1:100	GRAVEL	
INSPECTED BY	PREPARED BY C. LOPEZ.	ROCK	

Data of Laboratory Test: Natural Moisture ... A; Liquid Limit ... o; Plastic Limit ... •; Passing Sieve 200 (%) ... □

Elevation	Depth	Water Level	Lithological Profile	N° of Sample / Classific.	Description	Penetration Test (S.P.T.) N° of Strokes (Index N°)	Data of Laboratory Test
104,246	0,00						
	1,00		Clay	1 / CL	Clay of low compressibility, gray.-	(6)	
	2,00		Clay		Same as above	(7)	
	3,00		Sand	3 / SP-SH	Poorly graduated and muddy sand, gray.-	(11)	(N.P)
	4,00		Sand		Same as above.-	(13)	
	5,00		Sand		Same as above.-	(14)	
	6,00		Sand	6 / SP-SH	Same as above.	(14)	(N.P)
	7,00		Sand		Same as above.	(15)	
	8,00		Sand		Same as above	(15)	
	9,00		Sand	9 / SP-SH	Same as above	(15)	(N.P)
	10,00		Sand		Same as above.	(17)	
	11,00		Sand		Same as above.	(17)	
	12,00		Sand	12 / SP-SH	Same as above.-	(17)	(N.P)
	13,00		Sand		Same as above.-	(18)	
	14,00		Sand		Same as above	(27)	
	15,00		Sand	15 / SP-SH	Same as above	37	(N.P)
	16,00		Sand		Same as above	(50)	

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		REFERENCES
SOUNDING Nº BST 9 (CONT.)	WORK JICA	CLAY
DIAMETER OF BORING 3"	LOCATION TEBICUARY MI.	SILT
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SAND
PERFORMED BY E. MARTINEZ.	VERTICAL SCALE 1:100. -	GRAVEL
INSPECTED BY ———	PREPARED BY C. LOPEZ..	ROCK

Data of Laboratory Test: Natural Moisture A; Liquid Limit o; Plastic Limit •; Passing Sieve 200 (%) O

Elevation	Depth	Water Level	Lithological Profile	Nº of Sample Classific	Description	Penetration Test (S.P.T.) Nº of Strokes (Index Nº)	Data of Laboratory Test
	16,00				Poorly graduated and muddy sand, gray.-	(50)	
	17,00					(> 50)	
	18,00			18 SP-SM	Same as above..	(> 50)	NP (N.P.)
	19,00				Same as above	(> 50)	
	20,00				Same as above.-	(> 50)	
					FINAL SOUNDING.		

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SOUNDING Nº BST 10	WORK JICA.	REFERENCES	
DIAMETER OF BORING 3"	LOCATION HECTOR L. VEGA	CLAY	▨
METHOD OF BORING ROTARY DRILL	DATE OF ENDING	SILT	
PERFORMED BY E. MARTINEZ.	VERTICAL SCALE 1:100.	SAND	
INSPECTED BY ------	PREPARED BY C. LOPEZ.	GRAVEL	
		ROCK	

Elevation	Dept	Water Level	Lithological Profile	Nº of Sample Classific	Description	Penetration Test (S.P.T.) Nº of Strokes (Index Nº) 10 20 30 40 50	Data of Laboratory Test: Natural Moisture ▲, Liquid Limit ○, Plastic Limit ●, Passing Sieve 200 (%) □ — 10 20 30 40 50 60 70 80 90 100
119,59	0,00						
	1,00			1 CL	Clay of low compresibility, dark gray	(12)	
	2,00				Same as above.	(10)	
	3,00			3 SC	Clayey sand, gray	(15)	
	4,00				Same as above.-	(20)	
T.R. ↓	5,00			5 SM	Gravel of a muddy matrix, brown..	(>50)	48 (N P)
	6,00			6 SP-SM	Gravel of a muddy matrix, yellowish brown.-	(>50)	(N P)
	7,00				Same as above.-	(>50)	
	8,00				Same as above.	(>50)	
					FINAL SOUNDING.		

T.R.: Roof of stone..

SEKTECI S.R.L. Servicios Técnicos de Ingeniería S.R.L. Telefax: 491-801	SUMMARY LIST OF LABORATORY TEST RESULTS	OBRA: JICA FECHA: UBICACION: SOLICITADO POR:

POZO Nº	MUESTRA Nº	PROFUNDIDAD De	PROFUNDIDAD A	W (%)	LL (%)	LP (%)	IP (%)	PASANTE TAMIZ #10	PASANTE TAMIZ #40	PASANTE TAMIZ #100	PASANTE TAMIZ #200	CUS	Specific gravity Tn/m3	DESCRIPCION
BST 1	1	0.55	1.00	15.6	24.8	10.4	14.4	100.0	82.3	79.0	29.4	SC	2.65	Arena arcillosa, marron amarillento y gris
	2	1.55	2.00	16.4	23.7	12.5	11.1	92.2	55.3	24.2	18.2	SC	2.60	Arena arcillosa, gris, con gravillas
	4	3.55	4.00	15.2	32.2	16.2	16.0	91.3	60.5	33.0	25.8	SC	2.53	Arena arcillosa, marron rojizo y gris, con gravillas
	7	6.55	7.00	12.5	31.5	14.6	16.9	93.8	69.0	45.0	38.0	SC	2.60	Idem.
BST 2	1	0.55	1.00	13.9	21.5	12.3	9.2	100.0	93.0	66.4	53.4	CL	2.65	Arcilla arenosa, de baja plasticidad, gris
	3	2.55	3.00	21.0	-	-	NP	100.0	92.4	25.0	16.8	SM	2.61	Arena limosa, gris
	5	4.55	5.00	19.4	27.5	11.0	16.5	100.0	98.6	89.5	73.8	CL	2.67	Arcilla limo arenosa, de media plast. gris amarillento
	8	7.55	8.00	18.1	-	-	NP	100.0	33.0	25.4	18.2	SM	2.62	Arena limosa, gris
BST 3	1	0.55	1.00	20.1	22.2	12.2	10.0	100.0	94.6	58.3	55.2	CL	2.64	Arcilla arenosa, de baja plasticidad, gris
	3	2.55	3.00	13.4	-	-	NP	95.5	49.2	24.0	17.3	SM	2.62	Arena limosa, gris
	5	4.55	5.00	22.7	33.0	10.5	17.5	100.0	100.0	90.4	75.0	CL	2.63	Arcilla limo arenosa, de mediana plast., gris amarillento
	8	7.55	8.00	12.3	24.1	11.2	12.9	95.9	72.5	31.3	22.0	SC	2.51	Arena arcillosa, gris amarillento con gravillas
BST 4	1	0.55	1.00	20.4	30.3	14.2	15.6	100.0	97.3	81.5	71.2	CL	2.61	Arcilla limo arenosa, de mediana plast., gris oscuro
	3	2.55	3.00	20.0	-	-	NP	100.0	94.2	35.4	19.0	SM	2.62	Arena limosa, marron claro
	5	4.55	5.00	20.0	39.5	14.0	25.5	100.0	94.4	59.0	50.0	CL	2.65	Arcilla arenosa, de mediana plasticidad, gris oscuro
BST 5	1	0.55	1.00	20.3	31.5	14.8	16.8	97.5	95.3	83.3	83.0	CL	2.68	Arcilla limo arenosa, de mediana plast., gris oscuro
	2	1.55	2.00	17.7	-	-	NP	100.0	100.0	55.0	25.2	SM	2.62	Arena limosa, marron
	5	4.55	5.00	19.0	-	-	NP	100.0	93.0	15.4	12.4	SM	2.59	Idem
	8	7.55	8.00	12.9	-	-33.0	NP	97.2	94.7	32.0	27.5	SM	2.62	Arena limosa, gris
	10	9.55	10.00	10.3	40.3	15.3	24.5	100.0	98.5	71.0	51.0	CL	2.66	Arcilla arenosa, de mediana plasticidad, gris oscuro
	12	11.55	12.00	12.9	38.2	14.9	23.3	100.0	97.3	70.4	49.1	SC	2.67	Arena arcillosa, marron rojizo
	15	14.55	15.00	3.5	39.3	16.0	23.3	100.0	100.0	59.0	45.8	SC	2.55	Idem
	18	17.55	18.00	12.3	38.7	14.7	24.0	100.0	98.3	70.3	48.5	SC	2.57	Idem.

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SUMMARY LIST OF LABORATORY TEST RESULTS

OBRA: FECHA:
UBICACION:
SOLICITADO POR:

POZO Nº	MUESTRA Nº	PROFUNDIDAD De	PROFUNDIDAD A:	W %	LL %	LP %	IPI %	PASANTE TAMIZ #10	PASANTE TAMIZ #40	PASANTE TAMIZ #100	PASANTE TAMIZ #200	CUS	Specific gravity Tn/m3.	DESCRIPCION
BST 6	1	0.55	1.00	18.5			NP	100.0	100.0	33.0	13.6	SM	2.62	Arena limosa. cns
	4	3.55	4.00	14.3			NP	100.0	85.6	33.4	13.4	SM	2.63	Idem.
	7	6.55	7.00	15.5			NP	100.0	80.0	10.0	2.0	SP	2.60	Arena fina a media. cns
	10	9.55	10.00	17.9			NP	100.0	76.4	12.1	3.0	SP	2.60	Idem.
	14	14.00	14.45	14.4			NP	100.0	78.6	15.4	8.4	SP-SM	2.62	Arena algo limosa. cns
	17	17.00	17.45	17.7			NP	91.7	76.0	24.3	20.0	SM	2.63	Arena limosa. cns
BST 7	1	0.55	1.00	13.9	-	-	NP	100.0	100.0	53.4	15.2	SM	2.62	Arena limosa. cns
	4	3.55	4.00	21.0	-	-	NP	100.0	100.0	55.0	16.6	SM	2.62	Idem
	8	7.55	8.00	19.4	-	-	NP	100.0	89.0	9.5	5.3	SP-SM	2.59	Arena algo limosa. cns
	11	10.55	11.00	18.1	-	-	NP	100.0	90.0	10.4	6.2	SP-SM	2.61	Idem.
	15	14.55	15.00	20.0	-	-	NP	100.0	88.4	9.7	6.1	SP-SM	2.60	Idem
	16	15.55	15.00	25.1	33.6	16.4	17.2	100.0	100.0	94.0	87.8	CL	2.67	Arcilla limo arenosa. de mediana plast.. cns amarillento
BST 8	1	0.55	1.00	17.4	-	-	NP	97.5	73.3	27.5	19.6	SM	2.63	Arena limosa. cns
	4	3.55	4.00	20.2	-	-	NP	100.0	95.5	22.2	5.9	SP-SM	2.60	Arena algo limosa. cns
	5	4.55	5.00	15.2	28.0	10.9	17.1	100.0	100.0	48.0	38.0	SC	2.65	Arena arcillosa. cns
	6	5.55	6.00	20.4	-	-	NP	100.0	55.3	7.4	3.2	SP	2.61	Arena fina a media. cns
	9	8.55	9.00	18.2	-	-	NP	100.0	100.0	35.5	3.0	SP	2.60	Idem.
	12	11.55	12.00	17.5	-	-	NP	100.0	93.0	17.0	2.0	SP	2.61	Idem.
	15	14.55	15.00	17.3	-	-	NP	100.0	100.0	35.5	3.0	SP	2.60	Idem.
	18	17.55	18.00	17.8	-	-	NP	90.7	43.1	12.5	8.4	SP-SM	2.63	Arena algo limosa. cns

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POZO Nº	MUESTRA Nº	PROFUNDIDAD De	PROFUNDIDAD A:	W (%)	LL (%)	LP (%)	IP (%)	PASANTE TAMIZ #10	#40	#100	#200	CUS	Specific gravity Tn/m3.	DESCRIPCION
BST 9	1	0.55	1.00	17.1	30.0	10.8	19.2	100.0	95.2	75.4	68.2	CL	2.68	Arcilla arenosa, de mediana plasticidad, gris
	3	2.55	3.00	19.1	-	-	NP	100.0	83.4	15.0	6.4	SP-SM	2.62	Arena algo limosa, gris
	6	5.55	6.00	17.3	-	-	NP	100.0	83.0	18.0	6.0	SP-SM	2.60	Idem.
	9	8.55	9.00	17.0	-	-	NP	100.0	54.5	12.2	6.0	SP-SM	2.60	Idem.
	12	11.55	12.00	16.5	-	-	NP	100.0	75.2	15.6	6.8	SP-SM	2.61	Idem.
	15	15.55	16.00	17.5	-	-	NP	97.7	58.2	14.6	5.6	SP-SM	2.62	Idem.
	18	17.55	18.00	13.7	-	-	NP	81.4	43.1	14.3	9.0	SP-SM	2.60	Idem.
BST 10	1	0.55	1.00	19.1	37.9	16.6	21.3	100.0	93.0	79.0	71.8	CL	2.64	Arcilla limo arenosa, de mediana plast., gris oscuro
	3	2.55	3.00	13.4	21.2	12.0	9.2	100.0	89.7	51.0	37.7	SC	2.63	Arena arcillosa, gris
	5	4.55	5.00	12.5	-	-	NP	100.0	89.2	17.5	16.2	SM	2.62	Arena limosa, marron
	6	5.55	6.00	17.2	-	-	NP	100.0	61.0	9.8	7.8	SP-SM	2.56	Arena algo limosa, marron amarillento

Tests Results of Material
from
Test Pits

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Servicios Técnicos de Ingeniería S.R.L.
Telefax: 491-801

SUMMARY LIST OF LABORATORY TEST RESULTS

OBRA: JICA FECHA:
UBICACION:
SOLICITADO POR:

POZO Nº	MUESTRA Nº	PROFUNDIDAD De:	PROFUNDIDAD A:	W (%)	LL (%)	LP (%)	IP (%)	PASANTE TAMIZ #10	PASANTE TAMIZ #40	PASANTE TAMIZ #100	PASANTE TAMIZ #200	CUS	Specific gravity Tn/m3	Unit weight Tn/m3	Compaction Dssmax	H op	CBR %	DESCRIPCION
TP 1	1	0.50	-	16.4	20.2	11.5	8.7	100.0	91.2	63.4	57.0	CL	2.64	1.497	2.02	9.70	16.50	Arcilla arenosa, de baja plasticidad, cns amarillento
TP 1	2	1.00	-	24.2	29.7	12.6	17.1	100.0	96.2	70.0	64.4	CL	2.66	1.500	2.01	11.50	12.50	Arcilla arenosa, de mediana plasticidad, cns amarillento
TP 2	1	0.50	-	28.1	45.5	22.1	23.4	100.0	100.0	92.0	81.4	CL	2.66	1.337	1.83	15.60	2.40	Arcilla limo arenosa, de mediana plasticidad, cns
TP 2	2	1.00	-	30.3	51.2	17.8	33.4	100.0	100.0	94.5	85.6	CH	2.70	1.422	1.82	16.20	2.10	Arcilla limo arenosa, de alta plasticidad, cns
TP 3	1	0.50	-	35.0	48.6	22.1	26.5	100.0	100.0	93.7	83.1	CL	2.67	1.225	1.69	19.70	2.90	Arcilla limo arenosa, de mediana plasticidad, cns
TP 3	2	1.00	-	37.5	56.2	23.8	32.4	100.0	100.0	96.0	89.4	CH	2.69	1.294	1.71	19.20	3.20	Arcilla limo arenosa, de alta plasticidad, cns

Laboratory Tests of Stone

from Quarry at Paraguarí (C1)

Tomas Alberto Vega
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RH : 611500 Cod.5477
Estudio de suelos
Fundaciones

ENSAYO DE PESO ESPECIFICO Y ABSORCION DE AGREGADOS GRUESOS

Obra : DICA.
Tramo y Kilómetro :
Yacimiento : CANTERA PARAGUARI.
Profundidad :
Muestra Nº : 1
Método de Ensayo : AASTHO T 85-70
Fecha del Ensayo : 25-09-96
Laboratorista : G. PAIVA.-

OPERACION	Unidad	Fórmula	Ensayo 1	Ensayo 2
Peso en el aire, de la piedra secada en la estufa...........(1)	grs.		3008	3006
Peso en el aire, de la piedra saturada y de superf. seca....(2)	grs.		3010	3008
Peso en el agua, de la piedra saturada.....................(3)	grs.		1950	1948
Volumen Aparente de la piedra...(4)	cm³	(2)-(3)	1060	1060
Peso Específico Aparente de la piedra secada en la estufa....(5)	grs/cm³	(1)/(4)	2838	2836
Peso Específico Aparente de la piedra saturada y sup. seca...(6)	grs/cm³	(2)/(4)	2840	2838
Volumen Real....................(7)	cm³	(1)-(3)	1058	1058
Peso Específico Real............(8)	grs/cm³	(1) / (1)-(3)	2843	2841
Peso del agua absorbida.........(9)	grs.	(2)-(1)	2,0	2,0
Absorción.......................(10)	%	(9)x100 / (1)	0.066	0,066

Fecha y hora del Inicio de la Absorción : 24-09-96
Fecha y hora del Término de la Absorción : 25-09-96
Promedio del Peso Especif. de la piedra secada en la estufa 2837 kgs/m³
Promedio del Peso Especif. de la piedra saturada y sup. seca 2839 Kgs/m³
Promedio del Peso Especif. Real de las particulas 2842 kgs/m³
Promedio de Absorción 0,066. %

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

Jefe del Laboratorio

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Estudio de suelos
Fundaciones

ENSAYO DE DESGASTE DE AGREGADOS POR ACCION MECANICA O ABRASION "LOS ANGELES"

Obra : DICA
Tramo y Kilómetro :
Yacimiento : CANTERA PARAGUARÍ. –
Profundidad :
Muestra Nº : 1
Especificación :
Método del Ensayo : AASHTO T96-70
Fecha del Ensayo : 25-09-96
Laboratorista : G. PAIVA . IRALA .

Tamaño del Tamiz		Peso en Gramos			
Pasando	Retenido	Graduac. A	Graduac. B	Graduac. C	Graduac. D
38.1 mm($1\frac{1}{2}$")	25.4 mm(1")	1.250±25			
25.4 mm(1")	19.0 mm(3/4")	1.250±25			
19.0 mm(3/4")	12.7 mm(1/2")	1.250±10	2.500±10		
12.7 mm(1/2")	9.5 mm(3/8")	1.250±10	2.500±10		
9.5 mm(3/8")	6.35 mm(1/4")			2.500±10	
6.35 mm(1/4")	4.75 mm(Nº 4)			2.500±10	
4.75 mm(Nº 4)	2.36 mm(Nº 8)				5.000±10
Total......................		5.000±10	5.000±10	5.000±10	5.000±10

Ensayo realizado de acuerdo a la Graduación : (B)..
Peso original de la Muestra (en gramos) = 5000
Peso del retenido en el tamiz Nº 12(en gramos) = 4057
Peso de la pérdida (en gramos) = 943

$$\text{Porcentaje de desgaste} = \frac{\text{Peso de la pérdida (gramos)}}{\text{Peso original (gramos)}} \times 100 = 18{,}86\%$$

OBSERVACIONES:

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

....
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Estudio de suelos — Fundaciones

ENSAYO DE DESGASTE DE AGREGADOS POR ACCION MECANICA O ABRASION "LOS ANGELES"

Obra : DICA
Tramo y Kilómetro :
Yacimiento : CANTERA PARAGUARI.-
Profundidad :
Muestra Nº : 2
Especificación :
Método del Ensayo : AASTHO T180-70
Fecha del Ensayo : 30-09-96
Laboratorista : G. PAIVA, - IRALA.-

Tamaño del Tamiz		Peso en Gramos			
Pesando	Retenido	Graduac.A	Graduac.B	Graduac.C	Graduac.D
38.1 mm(1½")	25.4 mm(1")	1.250±25			
25.4 mm(1")	19.0 mm(3/4")	1.250±25			
19.0 mm(3/4")	12.7 mm(1/2")	1.250±10	2.500±10		
12.7 mm(1/2")	9.5 mm(3/8")	1.250±10	2.500±10		
9.5 mm(3/8")	6.35 mm(1/4")			2.500±10	
6.35 mm(1/4")	4.75 mm(Nº 4)			2.500±10	
4.75 mm(Nº 4)	2.36 mm(Nº 8)				5.000±10
Total........................		5.000±10	5.000±10	5.000±10	5.000±10

Ensayo realizado de acuerdo a la Graduación : (A)
Peso original de la Muestra (en gramos) = 5.000.-
Peso del retenido en el tamiz Nº 12(en gramos) = 4.051.-
Peso de la pérdida (en gramos) = 949.-

$$\text{Porcentaje de desgaste} = \frac{\text{Peso de la pérdida (gramos)}}{\text{Peso original (gramos)}} \times 100 = 18{,}98$$

OBSERVACIONES:

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

Jefe del Laboratorio

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ING. CIVIL
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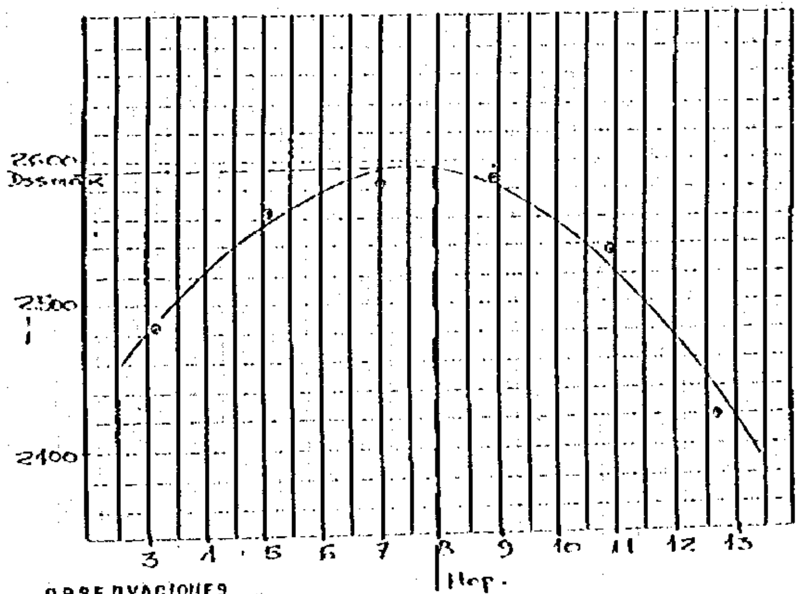
Estudio de suelos | Fundaciones

Ensayo de Compactación

MUESTRA Nº : Olca..	METODO : AASHO T-180	FECHA : 26-09-06
PROFUNDIDAD :	Nº MOLDE : 2	OPERADOR : [illegible]
UBICACION : CANTERA TARAGUARI.		VERIF. POR : A.N.

PESO MOLDE + SUELO HUMEDO	9.570	9.835	9979	10.100	10.090	9907
PESO MOLDE	4.229	4.229	4.229	4.229	4.229	4.229
PESO SUELO HUMEDO	5.341	5606	5.750	5.879	5.861	5.678
VOLUMEN MOLDE	2082	2082	2082	2082	2082	2082
DENSIDAD HUMEDA	2565	2693	2.762	2.819	2.815	2.727
Nº CAPSULA	27	3	74	29	60	100
PESO TOTAL HUMEDO	142,92	116,67	109,60	165,17	131,97	174,46
PESO TOTAL SECO	139,68	112,37	104,15	154,57	123,15	159,06
TARA CAPSULA	38,27	28,00	26,26	35,75	42,23	37,86
PESO DEL AGUA	3,24	4,30	5,45	10,60	8,82	15,4
PESO SUELO SECO	101,41	84,37	77,89	118,82	80,92	121,20
% HUMEDAD	3,2	5,1	7,0	8,9	10,9	12,7
PROMEDIO HUMEDAD	2185	2.562	2.581	2589	2538	
DENSIDAD SECA	2185	2562	2.581	2589	2538	2420



HUMEDAD HIGROSCOPICA	
Nº CAPSULA	
PESO TOTAL HUMEDO	
PESO TOTAL SECO	
TARA CAPSULA	
PESO DEL AGUA	
PESO SUELO SECO	
% HUMEDAD	

RESULTADOS	
DENSIDAD MAX. SECA	2.59
HUMEDAD OPTIMA	7,9%
DENS. DEL SUELO SECO	--
GRADO DE COMPACTACION	---

OBSERVACIONES

- La muestra utilizada cumple con la faja granulométrica de la M-10.

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

Asunción, 10 de octubre de 1996

INFORME TECNICO DE ENSAYOS

DE LABORATORIO

OBRA: JICA - RUTA: "PARAGUARI - VILLARRICA"

I) GENERALIDADES - OBJETIVOS

El trabajo tiene por objeto la verificación de la resistencia a la penetración (C.B.R.) de una mezcla para Base Estabilizada Granulometricamente que cumple con la faja de las Especificaciones correspondiente de la ruta "Limpio - Emboscada" que se adjunta y cuyos materiales fueron extraídos en las proximidades del trazado de la ruta mencionada: (PARAGUARI - VILLARRICA).

II) TRABAJOS REALIZADOS

1 - DE CAMPO:

Se procedió a la extracción de muestras para la mezcla a las que fueron denominadas: M1, M2 y M3; y cuyos lugares son los siguientes:

M1 - Cantera Paraguarí.

M2 - Arena Río Tebicuary - Localidad de Tebicuary.

M3 - Suelo seleccionado - (A2 - 4) - Próximo al sondeo BST5 (Ybytymí) DE 1,50 - 2,00 de profundidad.

2 - DE LABORATORIO

Se realizaron los siguientes ensayos:

- "Análisis granulométrico" de cada material.
- "Limites de Atterberg" del material M3.
- Proyecto de la mezcla por el método de la D.N.V. de Argentina.
- "Compactación AASHO T180" de la mezcla.
- "Análisis granulométrico" de la mezcla.
- "CBR" - Método dinámico simplificado en condición embebida y sin embeber.

III) RESULTADOS OBTENIDOS

Los resultados como se puede observar en las planillas correspondientes son satisfactorios, han superado en un 85% o más las exigencias de las especificaciones a la densidad máxima del proctor por lo que es apta para su objetivo.

ESTUDIO DE SUELOS

TOMAS ALBERTO VEGA

ING. CIVIL

TEL: 610345 R.U. : 449943

FUNDACIONES

ANALISIS GRANULOMETRICO

OBRA: Ica

MUESTRA Nº: (M1) -- Pt = 8.000 gr.							MUESTRA Nº: (M2) -- Pt = 2.000 gr.				
MUESTRA TIPO: CANTERA TARAGUARI							MUESTRA TIPO: ARENA				
TAMIZ Nº	ABERTURA en mm	PESO RETENIDO	PESO RETENIDO ACUMULADO	% RETENIDO ACUMULADO	PESO QUE PASA	% QUE PASA	PESO RETENIDO	PESO RETENIDO ACUMULADO	% RETENIDO ACUMULADO	PESO QUE PASA	% QUE PASA
2"	50.8	0,00	0,00	0,00	8000	100%					
1½"	38.1	328	328	4,1	7672	95,9					
1"	25.4	-	-	-	-	-					
3/4"	19.1	2.160	2488	31,1	5.512	68,9					
1/2"	12.7	-	-	-	-	-					
3/8"	9.52	-	-	-	-	-					
1/4"	6.35	-	-	-	-	-					
4	4.76	2000	4.488	56,1	3.512	43,9					
8	2.38	776	5.264	65,8	2.736	34,2					
10	2.00	-	-	-	-	-	0,0	0,0	0,0	2000	100,0
12	1.68	-	-	-	-	-	-	-	-	-	-
16	1.19	-	-	-	-	-	-	-	-	-	-
20	0.84	-	-	-	-	-	-	-	-	-	-
30	0.59	-	-	-	-	-	-	-	-	-	-
40	0.42	1456	6.720	84,0	1280	16,0	111,0	111,0	5,7	1889	94,3
50	0.297	-	-	-	-	-	382,0	496,0	24,8	1504	75,2
60	0.250	-	-	-	-	-	-	-	-	-	-
70	0.210	-	-	-	-	-	-	-	-	-	-
80	0.177	-	-	-	-	-	-	-	-	-	-
100	0.149	-	-	-	-	-	1002	1498	74,9	502	25,1
120	0.125	-	-	-	-	-	-	-	-	-	-
140	0.105	-	-	-	-	-	-	-	-	-	-
170	0.088	-	-	-	-	-	-	-	-	-	-
200	0.074	960	7680	96,0	320	4,0	470	1968	98,4	32	1,6
240	0.063	-	-	-	-	-	-	-	-	-	-
270	0.053	-	-	-	-	-	-	-	-	-	-
FONDO		-	-	-	-	-	-	-			
PESO TOTAL		-									

OMAR A. VEGA CENTURION
INGENIERO CIVIL

FECHA 2-10-96 OPERADOR PAIVA-IPALA VERIFICO A.V

TOMAS ALBERTO VEGA

ING. CIVIL

ESTUDIO DE SUELOS TEL: 610345 R.U. : 449943 FUNDACIONES

ANALISIS GRANULOMETRICO

OBRA: Oica

P_i = 8.000 gr

MUESTRA Nº: (M_3) - PT = 200 gr

MUESTRA Nº: Mezcla ($M_1+M_2+M_3$)

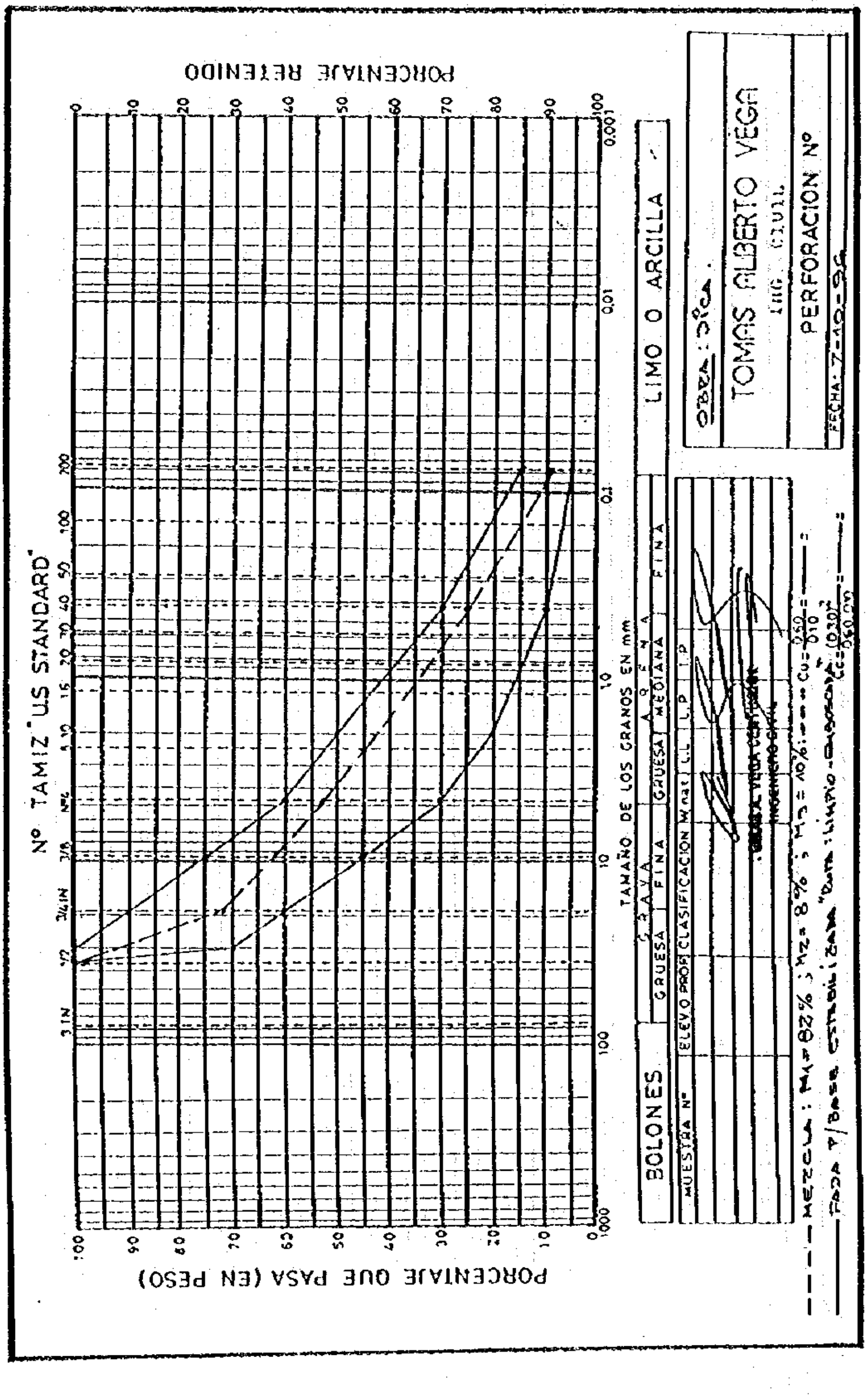
MUESTRA TIPO: Suelo seleccionado:

MUESTRA TIPO: M_1=82,0%; M_2=8%; M_3=10%

TAMIZ Nº	ABERTURA en mm	PESO RETENIDO	PESO RETENIDO ACUMULADO	% RETENIDO ACUMULADO	PESO QUE PASA	% QUE PASA	PESO RETENIDO	PESO RETENIDO ACUMULADO	% RETENIDO ACUMULADO	PESO QUE PASA	% QUE PASA
2"	50.8						-	-	-	-	
1 1/2"	38.1						120	120	1,5	7880	98,5
1"	25.4						-	-		-	
3/4"	19.1						2120	2240	28,0	5760	72,0
1/2"	12.7							-	-	-	
3/8"	9.52						-	-	-		
1/4"	6.35						-	-	-		
4	4.76						1.520	3.760	47,0	4.240	53,0
8	2.38						640	4.400	55,0	3.600	45,0
10	2.00	0,00	0,00	0,00	200,0	100,0	-	-	-	-	
12	1.68	-	-	-	-	-	-	-	-	-	-
16	1.19	-	-	-	-	-	-	-	-	-	-
20	0.84	-	-	-	-	-	-	-	-	-	-
30	0.59	-	-	-	-	-	-	-	-	-	-
40	0.42	40,2	40,2	20,1	159,8	79,9	1.560	5.960	74,5	2.040	25,5
50	0.297	-	-	-	-	-	-	-	-	-	-
60	0.250	-	-	-	-	-	-	-	-	-	-
70	0.210	-	-	-	-	-	-	-	-	-	-
80	0.177	-	-	-	-	-	-	-	-	-	-
100	0.149	-	-	-	-	-	-	-	-	-	-
120	0.125	-	-	-	-	-	-	-	-	-	-
140	0.105	-	-	-	-	-	-	-	-	-	-
170	0.088	-	-	-	-	-	-	-	-	-	-
200	0.074	103,8	144,0	72,0	56,0	28,0	1.280	7.240	90,5	760	9,5
240	0.063	-	-	-	-	-	-	-	-	-	-
270	0.053	-	-	-	-	-	-	-	-	-	-
FONDO		-					-	-	-	-	-
PESO TOTAL		-	-				-	-	-	-	-

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

FECHA 2-10-96 OPERADOR Paiva - Ibalo VERIFICO A.V.



PORCENTAJE RETENIDO
Nº TAMIZ "US STANDARD"
PORCENTAJE QUE PASA (EN PESO)
TAMAÑO DE LOS GRANOS EN mm
BOLONES
GRAVA
GRUESA
FINA
ARENA
GRUESA
MEDIANA
FINA
LIMO O ARCILLA
MUESTRA Nº
ELEVO PROF.
CLASIFICACION
W nat
LL
LP
IP
OBRA: Dica.
TOMAS ALBERTO VEGA
ING. CIVIL
PERFORACION Nº
FECHA: 7-10-96
MEZCLA: M1 = 82% ; M2 = 8% ; M3 = 10%
PASA P/BASE ESTABILIZADA

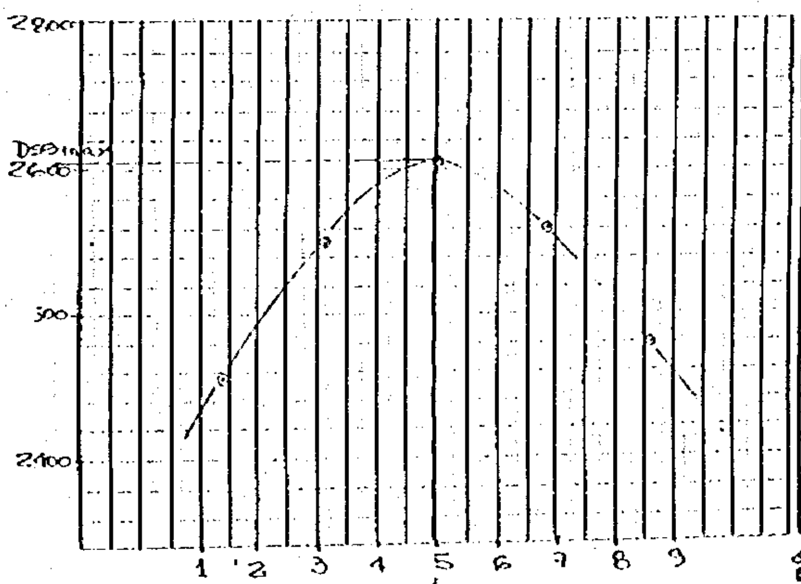
TOMAS ALBERTO VEGA
ING. CIVIL
Tel: 610315 - R.M. : 611500 COD.5177

Estudio de suelos — Fundaciones

Ensayo de Compactación

MUESTRA Nº 2 - Dica	METODO AASHO T 180	FECHA 3-10-96
PROFUNDIDAD --	Nº MOLDE Nº 55	OPERADOR: PAIVA - IBALA
UBICACION "CANTERA PARAGUARI"		VERIF. POR: A.V.

PESO MOLDE + SUELO HUMEDO	9.425	9.413	9.927	9925	9.840
PESO MOLDE	4.233	4.233	4233	4.233	4.233
PESO SUELO HUMEDO	5.192	5.180	5.694	5.692	5607
VOLUMEN MOLDE	2082	2082	2.082	2082	2082
DENSIDAD HUMEDA	2494	2632	2.735	2734	2693
Nº CAPSULA	36	80	104	121	108
PESO TOTAL HUMEDO	78,30	84,39	90,89	90.06	88,51
PESO TOTAL SECO	77,46	82,31	87,39	85,42	82,86
TARA CAPSULA	17,31	17,21	17,29	17.47	17,16
PESO DEL AGUA	0,84	2,08	3,50	4,64	5,65
PESO SUELO SECO	60,15	65,10	70,10	68,75	65,70
% HUMEDAD	1,4	3,2	5,0	6,8	8,6
PROMEDIO HUMEDAD	--	--	--	--	--
DENSIDAD SECA	2459	2550	2605	2560	2480



HUMEDAD HIGROSCOPICA	
Nº CAPSULA	
PESO TOTAL HUMEDO	
PESO TOTAL SECO	
TARA CAPSULA	
PESO DEL AGUA	
PESO SUELO SECO	
% HUMEDAD	

RESULTADOS	
DENSIDAD MAX SECA	2605
HUMEDAD OPTIMA	5,0 %
DENS DEL SUELO SECO	--
GRADO DE COMPACTACION	--

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

OBSERVACIONES
- MUESTRA Nº 2:
- MEZCLA ESTABILIZADA CON : 82 % TRIT. CANTERA PARAGUARI (M1)
10 % SUELO SELECCIONADO : (M3)
8 % ARENA RIO : (M2)

Tomas Alberto Vega

Ing civil
Tel: 610345

Obra : Dica

Muestra Nº : 2 Fecha del Ensayo: 7-10-96

Camada (Ensayo Nº: 1)-S/embeber. Laboratorista : Paiva-Irala

Yacimiento: Cantera Paraguari.- Método del Ensayo: Dinamico Simplificado - 5 x 12 golpes.

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION
Nº de la cápsula	36	
Peso total húmedo	152,73	
Peso total seco	147,25	
Peso de la cápsula	37,70	
Peso del agua	5,48	
Peso del suelo seco	109,55	
% de humedad	5,0	
PROMEDIO	—	—

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION	DATOS DEL PROCTOR
Nº del cilindro	40		—
Peso total húmedo	9.630		—
Peso del cilindro	4.200		—
Peso del suelo húmedo	5.430		—
% de humedad	5,0		5,0
Peso seco calculado	5.171		—
Volumen del cilindro	2.077,[illegible]		—
Densidad Apar. Seca (T/m3)	2.489		2205

Factor de presion: f = 0,113 Kg/cm² x 0,001 mm.

Alt. de la muestra comp. 124,0 mm

PENETRACION Tiempo	Milímetro	0,001 Pulg.	LECTURA DEFLEC. 0,001mm	PRESION CALCUL. kgs/cm2	PRESION CORREG. kgs/cm2	PRESION PADRON kgs/cm2
00'30"	0,63	25	260	29,4	—	
01'00"	1,27	50	530	59,9	—	
01'30"	1,91	75	660	74,6	—	
02'00"	2,54	100	930	105,1	105,1	70.31
04'00"	5,08	200	1725	194,9	185,0	105.46
06'00"	7,62	300	2210	249,7	—	133.58
08'00"	10,16	400	2650	299,4	—	161.71
10'00"	12,70	500	—	—	—	182.80

CALCULO DEL PORCENTAJE DE CBR

A 2,5mm de penetrac.

$\frac{\text{Pres. 2,5mm}}{70,31?} \times 100 = 149,5\%$

A 5,0mm de penetrac.

$\frac{\text{Pres. 5,0mm}}{105,46?} \times 100 = 175,4\%$

CBR = 175,4 %

EXPANSION POR IMBIBICION

Día	Hora	Lectura Expansion (10⁻² mm)	Expans. (%)

OBSERVACION: Probeta moldeada con mezcla de:

M1 = 82 %
M2 = 8 %
M3 = 10 %.

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

Jefe del Laboratorio

Tomas Alberto Vega
Ing civil
Tel: 610345

Obra : DICA

Muestra Nº : 2

Fecha del Ensayo: 7-10-96

Camada(ensayo Nº : 1)-5/embeber. Laboratorista : Paiva - Irala

Yacimiento: Cantera Paraguarí

Método del Ensayo: Dinámico simplificado - 5x25 Golpes.

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION
Nº de la cápsula	27	
Peso total húmedo	197,27	
Peso total seco	189,27	
Peso de la cápsula	38,27	
Peso del agua	8,00	
Peso del suelo seco	151,00	
% de humedad	5,3	
PROMEDIO		

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION	DATOS DEL PROCTOR
Nº del cilindro	5		—
Peso total húmedo	9.825		—
Peso del cilindro	4.240		—
Peso del suelo húmedo	5.585		—
% de humedad	5.3		5.0
Peso seco calculado	5.304		—
Volumen del cilindro	2082		—
Densidad Apar. Seca (γ_a)	2548		2605

FACTOR DE PRESION: f = 0.113 Kg/cm² · 0.001 mm.

PENETRACION			LECTURA DEFLEC. 0.001mm	PRESION CALCUL. Kgs/cm²	PRESION CORREG. Kgs/cm²	PRESION PADRON Kgs/cm²
Tiempo	Milímetro	0,001 Pulg.				
00'30"	0.63	25	220	24.9		
01'00"	1.27	50	580	65.5		
01'30"	1.91	75	840	94.9		
02'00"	2.54	100	1195	135.0	127.0	70.31
04'00"	5.08	200	2030	229.4	225.0	105.45
06'00"	7.62	300	2740	309.6		133.58
08'00"	10.16	400	3180	359.3		161.71
10'00"	12.70	500	—	—		182.80

CALCULO DEL PORCENTAJE DE CBR

A 2.5mm de penetrac.

$\frac{\text{Pres. 2.5mm}}{70.31} \times 100 = 180.6\%$

A 5.0mm de penetrac.

$\frac{\text{Pres. 5.0mm}}{105.45} \times 100 = 213.3\%$

CBR = 213,3%

Alt. de la muestra comp. 124,0 mm

EXPANSION POR IMBIBICION			
Día	Hora	Lectura Extensom. (10^{-2}mm)	Expans. (%)

OBSERVACION: Probeta moldeada con mezcla de:

M_1 = 32 %
M_2 = 8 %
M_3 = 10 %

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

Jefe del Laboratorio

Tomas Alberto Vega
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Tel: 610345

Obra : Dica .

Muestra Nº : 2

Camada (Ensayo Nº : 1)-3/ensayer.

Fecha del Ensayo: 7-10-96

Laboratorista : Paiva - Irala

Yacimiento: Cantera Paraguari.

Método del Ensayo: Dinamico simplificado - 5×56 golpes.

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION
Nº de la cápsula	103	
Peso total húmedo	160.08	
Peso total seco	153.63	
Peso de la cápsula	38.51	
Peso del agua	6.45	
Peso del suelo seco	115.12	
% de humedad	5,6	
PROMEDIO	—	

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION	DATOS DEL PROCTOR
Nº del cilindro	15		-
Peso total húmedo	10.135		-
Peso del cilindro	4.548		—
Peso del suelo húmedo	5.587		—
% de humedad	5.6		5,0
Peso seco calculado	5.291		-
Volumen del cilindro	2.035		-
Densidad Apar.Seca (γ_d)	2.600		2.605

Factor de presion : $f = 0.113\ Kg/cm^2 \cdot 0.001\ mm$.

Alt. de la muestra comp. 124.0 mm

PENETRACION			LECTURA DEFLEC. 0.001mm	PRESION CALCUL. kgs/cm2	PRESION CORREG. kgs/cm2	PRESION PADRON kgs/cm2
Tiempo	Milímetro	0,001 Pulg.				
00'30"	0.63	25	354	40.0		
01'00"	1.27	50	710	80.0		
01'30"	1.91	75	980	110.7		
02'00"	2,54	100	1370	154.8	154.8	70.31
04'00"	5.08	200	2380	268.9	260.0	105.45
06'00"	7.62	300	3010	340.1		133.58
08'00"	10.16	400	3450	389,8		161.71
10'00"	12.70	500	—			182.30

CALCULO DEL PORCENTAJE DE CBR

A 2.5mm de penetrac.

$\frac{Pres.2.5mm}{70,31} \times 100 = 220,2\%$

A 5.0mm de penetrac.

$\frac{Pres.5.0mm}{105,45} \times 100 = 246,5\%$

CBR = 246,5 %

EXPANSION POR IMBIBICION			
Día	Hora	Lectura Expansom (10^{-2} mm)	Expans. (%)

OBSERVACION: Probeta moldeada con mezcla de:
$M_1 = 82\%$
$M_2 = 8\%$
$M_3 = 10\%$

TOMAS A. VEGA CENTURION
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Jefe del Laboratorio

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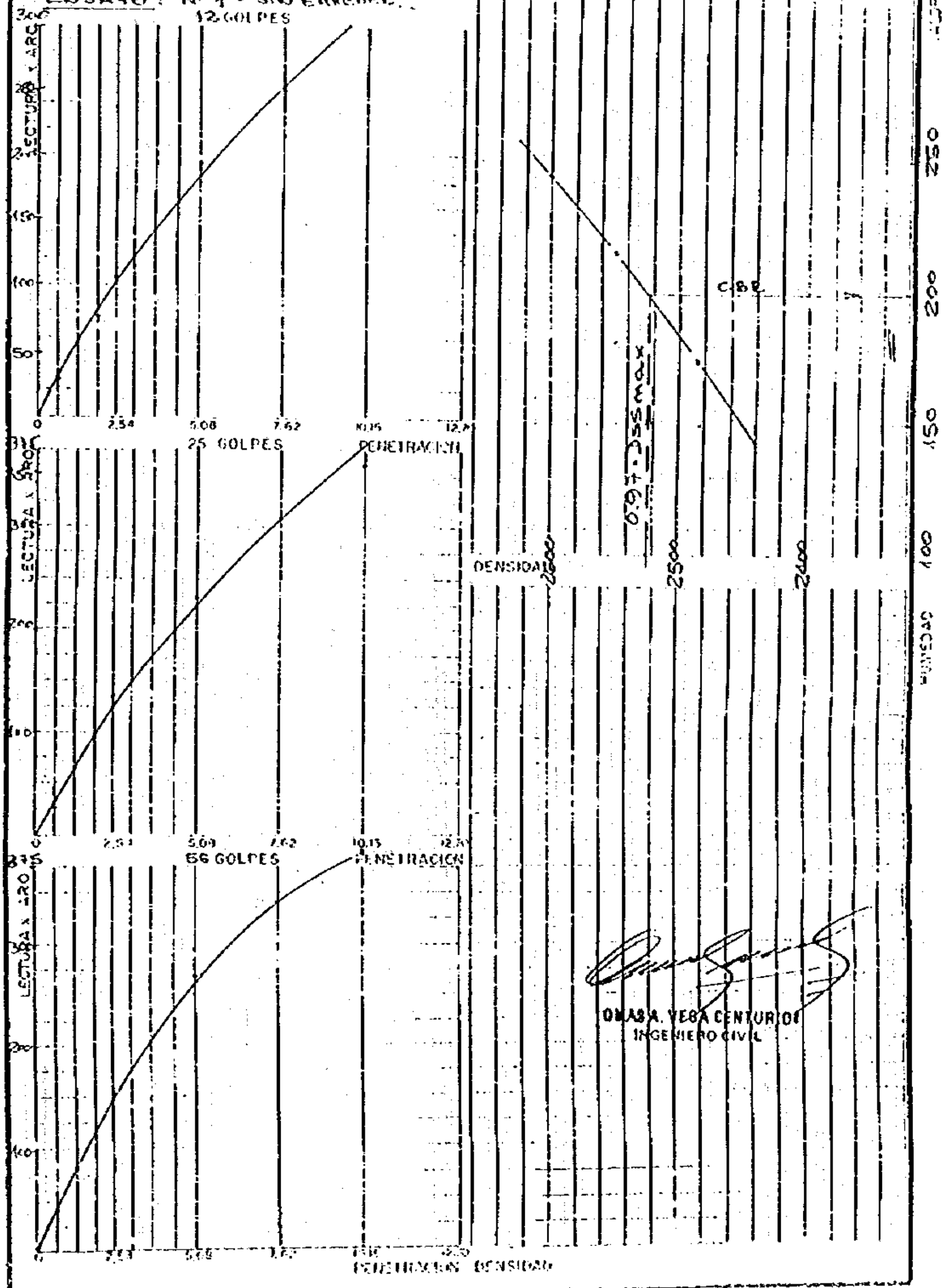
RH : 611500 Cod.5477

Estudio de suelos | Fundaciones

OBRA: SICA

ENSAYO DE VALOR
SOPORTE DINAMICO

MUESTRA: Nº 2
ENSAYO: Nº 1 - SIN EMBEBER



Tomas Alberto Vega
Ing civil
Tel: 610345

Obra : Dica

Muestra Nº : 2 — Fecha del Ensayo: 7-10-96

Camada (Ensayo Nº : 2) (embebido) — Laboratorista : Paiva - Izaca

Yacimiento: Cantera Paraguari — Método del Ensayo: Dinamico simplificado. - 5x12 Golpes

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION
Nº de la cápsula	37	38
Peso total húmedo	148,05	142,29
Peso total seco	142,54	136,66
Peso de la cápsula	36,54	37,91
Peso del agua	5,51	5,63
Peso del suelo seco	106,00	98,75
% de humedad	5,2	5,7
PROMEDIO	—	—

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION	DATOS DEL PROCTOR
Nº del cilindro	21	21	—
Peso total húmedo	9.952	9.978	—
Peso del cilindro	4.530	4.530	—
Peso del suelo húmedo	5.422	5.448	—
% de humedad	5,2	5,7	5,0
Peso seco calculado	5.154	5.154	—
Volumen del cilindro	2070	2070	—
Densidad Apar. Seca (δa)	2.490	2.490	1.605

Factor de presion: f = 0.113 Kg/cm². 0.001 mm.

PENETRACION Tiempo	Milímetro	0,001 Pulg.	LECTURA DEFLEC. 0.001mm	PRESION CALCUL. kgs/cm²	PRESION CORREG. kgs/cm²	PRESION PADRON kgs/cm²
00'30"	0.63	25	243	27,5		
01'00"	1.27	50	354	40,0		
01'30"	1.91	75	532	60,1		
02'00"	2,54	100	697	78,8	78,8	70.31
04'00"	5.08	200	1224	138,3	138.3	105.46
06'00"	7.62	300	1845	208,5		133.58
08'00"	10.16	400	2268	256,3		161.71
10'00"	12.70	500				182.80

CALCULO DEL PORCENTAJE DE CBR

A 2.5mm de penetrac.

$\frac{\text{Pres. 2.5mm}}{70,31} \times 100 = 112,1\%$

A 5.0mm de penetrac.

$\frac{\text{Pres. 5.0mm}}{105,46} \times 100 = 131,1\%$

CBR = 131,1%

Alt. de la muestra comp. 124,0 mm

EXPANSION POR IMBIBICION Día	Hora	Lectura Extensom. (10^{-2} mm)	Expans. (%)
5-10	9³⁰ hs	2,0	0,016
6-10	9,00	3,0	0,024
7-10	10,30	5,0	0,040
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—

OBSERVACION: Probeta moldeada con mezcla de:
$u_1 = 82\%$
$u_2 = 8\%$
$u_3 = 10\%$.

TOMAS A. VEGA CENTURION
INGENIERO CIVIL

Jefe del Laboratorio

Tomas Alberto Vega

Ing civil

Tel: 610345

Obra : DICA — Muestra Nº : 2 — Fecha del Ensayo: 7-10-96

Camada (ENSAYO Nº: 2) -EMBEBIDO — Laboratorista : PAIVA - IRALA

Yacimiento: CANTERA PARAGUARI — Método del Ensayo: DINAMICO SIMPLIFICADO - 5 x 25 Golpes.-

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION
Nº de la cápsula	45	46
Peso total húmedo	156,24	160,65
Peso total seco	150,02	153,91
Peso de la cápsula	39,00	39,66
Peso del agua	6,22	6,74
Peso del suelo seco	111,02	114,25
% de humedad	5,6	5,9
PROMEDIO	—	—

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION	DATOS DEL PROCTOR
Nº del cilindro	20	20	—
Peso total húmedo	9.829	9.845	—
Peso del cilindro	4.230	4.230	—
Peso del suelo húmedo	5.599	5615	—
% de humedad	5,6	5,9	5,0
Peso seco calculado	5.302	5.302	—
Volumen del cilindro	2079	2079	—
Densidad Apar.Seca(γ_a)	2550	2550	2.605

FACTOR DE PRESION: $f = 0{,}113\ Kg/cm^2 - 0{,}001\ mm$.

PENETRACION Tiempo	Milímetro	0,001 Pulg.	LECTURA DEFLEC. 0,001mm	PRESION CALCUL. kgs/cm²	PRESION CORREG. kgs/cm²	PRESION PADRON kgs/cm²
00'30"	0,63	25	186	21,0		
01'00"	1,27	50	444	50,2		
01'30"	1,91	75	664	75,0		
02'00"	2,54	100	842	95,1	95,1	70,31
04'00"	5,08	200	1614	182,4	182,4	105,45
06'00"	7,62	300	2339	264,3		133,58
08'00"	10,16	400	2835	320,4		161,71
10'00"	12,70	500	—	—	—	182,80

CALCULO DEL PORCENTAJE DE CBR

A 2,5mm de penetrac.

$\frac{Pres. 2,5mm}{70,31} x100 = 135,2\%$

A 5,0mm de penetrac.

$\frac{Pres. 5,0mm}{105,45} x100 = 173,0\%$

CBR = 173,3%

Alt. de la muestra comp. 124,0 mm

EXPANSION POR IMBIBICION Día	Hora	Lectura Extensom. (10^{-2}mm)	Expans. (%)
5-10	9,30	1,5	0,012
6-10	9,00	2,5	0,020
7-10	10,30	4,0	0,032
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—

OBSERVACION: Probeta moldeada con mezcla de:

$H_1 = 87\%$

$H_2 = 3\%$

$H_3 = 10\%$

TOMAS A. VEGA CANTURION
INGENIERO CIVIL

Jefe del Laboratorio

Tomas Alberto Vega
Ing civil
Tel: 610345

Obra : Dica.

Muestra Nº : 2 Fecha del Ensayo: 7-10-96

Camada (Ensayo Nº : 2) - Embebido. - Laboratorista : Paiva - Irala. -

Yacimiento: Cantera Paraguari. - Método del Ensayo: Dinamico simplificado - 5x56 golpes. -

	ANTES DE LA IMBIBICION		DESPUES DE LA IMBIBICION	
Nº de la cápsula	63		65	
Peso total húmedo	159,35		158,61	
Peso total seco	144,95		152,40	
Peso de la cápsula	36,90		37,45	
Peso del agua	5,4		6,21	
Peso del suelo seco	108,05		114,95	
% de humedad	5,0		5,4	
PROMEDIO	—		—	

	ANTES DE LA IMBIBICION	DESPUES DE LA IMBIBICION	DATOS DEL PROCTOR
Nº del cilindro	16	16	—
Peso total húmedo	10.107	10.128	—
Peso del cilindro	4.525	4.525	—
Peso del suelo húmedo	5.582	5.603	—
% de humedad	5,0	5.4	5%
Peso seco calculado	5316	5316	—
Volumen del cilindro	2040,5	2040.5	—
Densidad Apar. Seca (γ_a)	2.605	2.605	2.605

Factor de presion: $f = 0.113$ Kg/cm² = 0.001 mm.

Alt. de la muestra comp 124.0 mm

PENETRACION Tiempo	Milímetro	0,001 Pulg.	LECTURA DEFLEC. 0.001mm	PRESION CALCUL. kgs/cm²	PRESION CORREG. kgs/cm²	PRESION PADRON kgs/cm²
00'30"	0,63	25	35	40,0		
01'00"	1.27	50	597	67,5		
01'30"	1,91	75	819	92,5		
02'00"	2,54	100	1016	114,8	114,8	70.51
04'00"	5.08	200	1729	195,4	195,4	105.45
06'00"	7.62	300	2315	261,6		133.58
08'00"	10.16	400	2839	320,8		161.71
10'00"	12.70	500	—	—	—	182.80

CALCULO DEL PORCENTAJE DE CBR

A 2.5mm de penetrac.

$\frac{\text{Pres. 2.5mm}}{70,31} \times 100 = 163,3\%$

A 5.0mm de penetrac.

$\frac{\text{Pres. 5.0mm}}{105,45} \times 100 = 185,3\%$

CBR = 185,3 %

EXPANSION POR IMBIBICION

Día	Hora	Lectura Extensom (10^{-2}mm)	Expans. (%)
5-10	9³⁰	1.0	0,008
6-10	9⁰⁰	1,0	0,008
7-10	10,30	2,5	0,020
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—

Observación: Probeta moldeada con mezcla de:
M_1 = 82 %
M_2 = 8 %
M_3 = 10 %

TOMAS A. VEGA CENTURION
INGENIERO CIVIL
Jefe del Laboratorio

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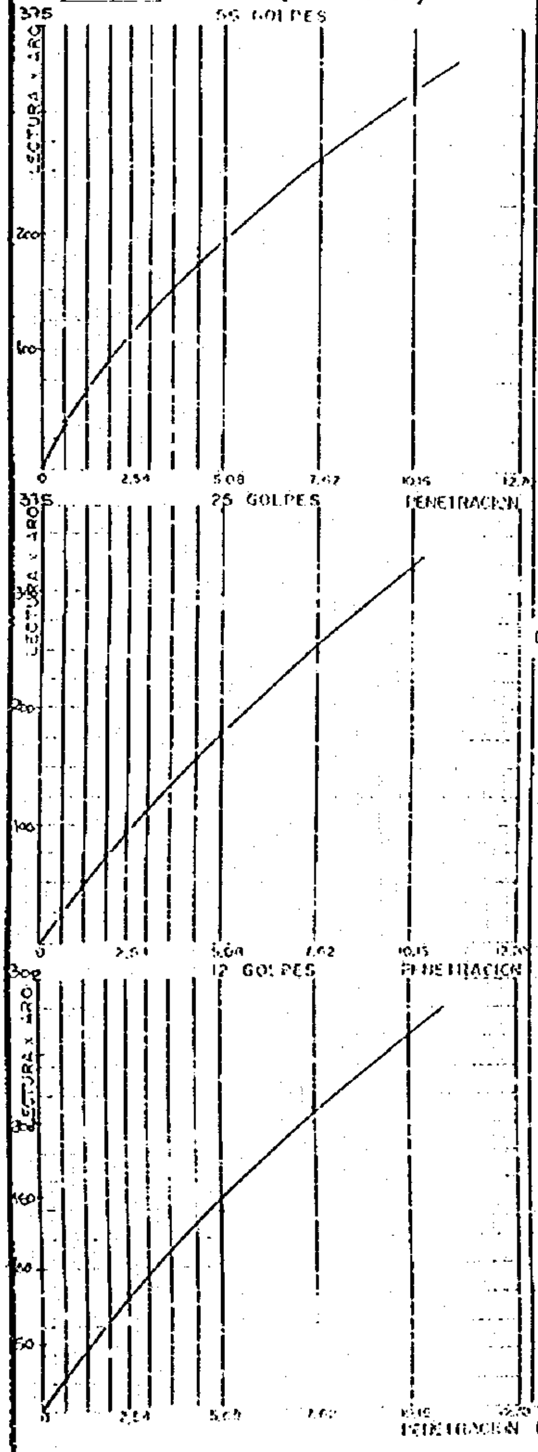
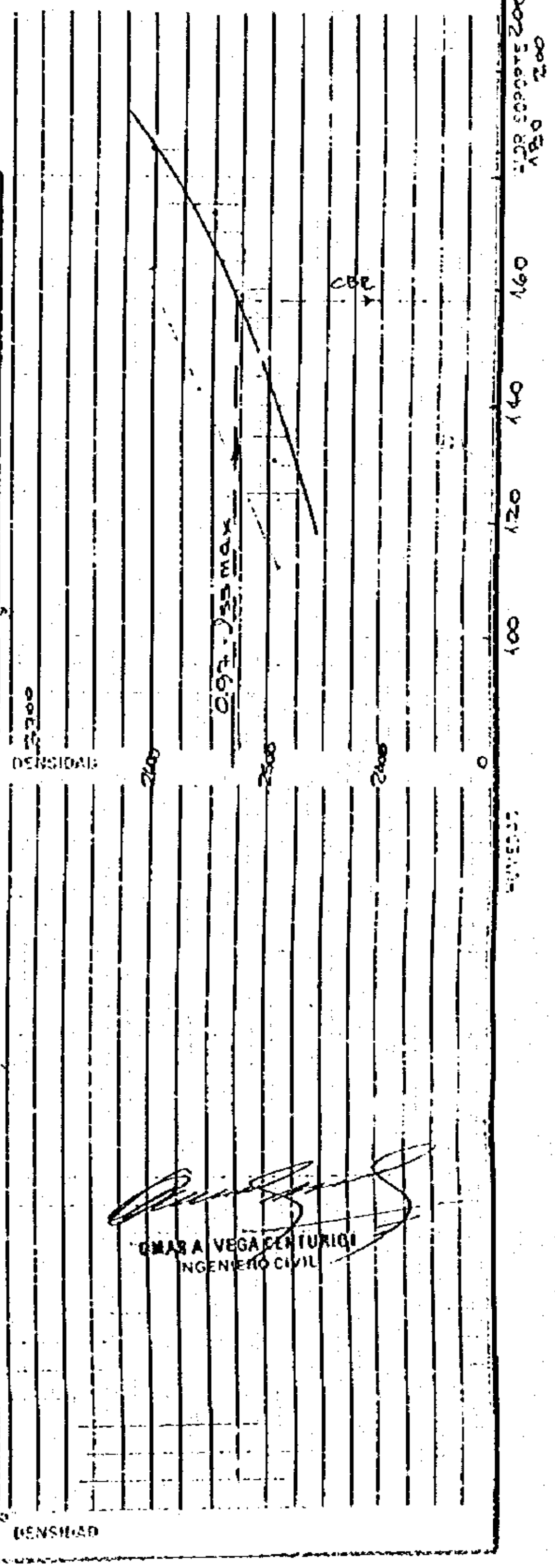
Estudio de suelos | Fundaciones

OBRA: Díca.-

ENSAYO DE VALOR SOPORTE DINAMICO

MUESTRA: Nº 2
ENSAYO: Nº 2 (embebido)





OMAR A. VEGA CENTURIÓN
INGENIERO CIVIL