

APPENDIX 24

URBAN STREET IMPROVEMENT PLAN

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Table of Contents

A24.1 Pavement Design Inputs.....	A24- 1
A24.2 Design of Pavement Structure.....	A24- 8
A24.3 Construction Cost of the Urban Streets Improvement Project	A24-12
A24.4 Economic Evaluation for Urban Streets Improvement Project	A24-26

APPENDIX 24-1 PAVEMENT DESIGN INPUTS

1. DESIGN VARIABLES

1.1 Traffic

1) Truck Load Factor

The truck load factor (average number of 18-kip equivalent single axle loads, ESAL) is estimated at 0.170, based on the analysis using the survey data in the Urban Infrastructure Rehabilitation and Management Project, as shown in Table A24.1-1.

Table A24.1-1 Truck Axle Load Distribution and Truck Load Factor

SN=3.0, Pt=2.5

Axle Load Survey Data (t) (S):Single Axle, (T):Tandem Axle	Number of 18-kip Equivalent Single Axle Loads (ESAL)			
	Total			
2.80(S) 3.00(S)	.019	.025	.044	
1.60(S) 4.70(S)	.003	.134	.137	
1.80(S) 7.80(S)	.004	.844	.848	
1.40(S) 1.50(S)	.002	.002	.003	
3.00(S) 8.75(T)	.025	.141	.166	
2.55(S) 11.25(T)	.013	.355	.368	
3.40(S) 10.20(T)	.040	.248	.288	
1.90(S) 5.00(T)	.005	.016	.021	
2.00(S) 5.00(T)	.006	.016	.022	
2.00(S) 3.10(T)	.006	.003	.009	
2.57(S) 3.50(S) 10.20(T)	.014	.044	.248	.306
1.70(S) 4.20(S) 6.10(T)	.003	.088	.036	.127
2.50(S) 5.20(S) 9.40(T)	.013	.194	.184	.391
2.20(S) 4.10(S) 8.80(T)	.008	.081	.144	.233
2.60(S) 6.40(S) 11.70(T)	.014	.410	.408	.833
2.20(S) 3.00(S) 5.70(T)	.008	.025	.028	.060
2.00(S) 3.50(S) 6.60(T)	.006	.044	.049	.099
2.25(S) 2.45(S) 4.15(T)	.009	.012	.008	.028
1.50(S) 2.30(T) 1.55(T)	.002	.001	.000	.003
3.40(S) 10.00(T) 8.80(T)	.040	.231	.144	.415
3.40(S) 7.40(T) 5.20(T)	.040	.075	.019	.134
2.00(S) 2.70(T) 2.85(T)	.006	.002	.002	.010
2.50(S) 8.20(T) 6.00(T)	.013	.111	.034	.157
2.20(S) 3.90(T) 2.30(T)	.008	.006	.001	.015
2.25(S) 5.00(S)	.009	.168		.177
1.00(S) 5.50(S)	.000	.238		.238
1.30(S) 1.20(S)	.001	.001		.002
2.50(S) 2.00(S)	.013	.006		.018
2.10(S) 4.30(S)	.007	.097		.103
2.50(S) 1.20(S)	.013	.001		.013
1.30(S) 1.50(S)	.001	.002		.003
1.50(S) 2.20(S)	.002	.008		.010
1.60(S) 2.50(S)	.003	.013		.015
1.40(S) 2.30(S)	.002	.009		.011
6.60(S) 5.20(S)	.459	.194		.653
1.40(S) 2.20(S)	.002	.008		.009
3.60(S) 9.90(T)	.049	.222		.272
1.30(S) 1.90(T)	.001	.000		.002
2.20(S) 10.10(T)	.008	.239		.247
2.60(S) 3.70(T)	.014	.005		.020
3.60(S) 13.10(T)	.049	.613		.662
3.20(S) 10.60(T)	.032	.286		.317
3.25(S) 12.25(T)	.033	.481		.515
2.70(S) 12.45(T)	.017	.510		.527
1.50(S) 2.90(T)	.002	.002		.004
2.75(S) 3.40(T)	.018	.004		.022
2.30(S) 3.20(T)	.009	.003		.013
1.90(S) 2.80(T)	.005	.002		.007
2.30(S) 5.00(T)	.009	.016		.026
2.00(S) 2.60(T)	.006	.002		.007

1.70(S) 3.80(T)	.003	.006		.009
2.50(S) 7.40(T)	.013	.075		.088
2.10(S) 2.70(T)	.007	.002		.009
1.70(S) 6.00(T)	.003	.034		.037
2.50(S) 2.60(T)	.013	.002		.014
2.00(S) 6.40(T)	.006	.043		.049
1.40(S) 4.00(T)	.002	.007		.009
2.30(S) 4.50(T)	.009	.011		.020
3.30(S) 14.00(T)	.035	.780		.815
3.00(S) 4.10(T)	.025	.008		.032
2.30(S) 3.80(T)	.009	.006		.015
2.00(S) 4.00(T)	.006	.007		.013
2.70(S) 4.80(T)	.017	.014		.030
3.30(S) 6.60(S) 11.70(T)	.035	.459	.408	.902
2.30(S) 2.40(S) 5.20(T)	.009	.011	.019	.039
2.50(S) 2.50(S) 10.70(T)	.013	.013	.296	.321
5.00(S) 9.10(T) 9.00(T)	.168	.164	.157	.489
1.70(S) 3.40(T) 3.60(T)	.003	.004	.005	.012
2.60(S) 8.20(T) 6.00(T)	.014	.111	.034	.159
2.20(S) 4.80(T) 4.50(T)	.008	.014	.011	.032
2.20(S) 4.50(T) 4.10(T)	.008	.011	.008	.026
3.00(S) 8.60(T) 10.90(T)	.025	.133	.316	.474
2.10(S) 3.20(T) 2.90(T)	.007	.003	.002	.013
2.50(S) 5.00(S) 8.10(T) 8.05(T)	.013	.168	.106 .103	.390
Number of Trucks = 74				Total ESALs = 12.609
Truck Load Factor = 12.609 / 74 = .170				

Data Source : Urban Infrastructure Rehabilitation and Management Project

2) Bus Load Factor

The bus load factor is estimated also at about 0.17, assuming 2.0 t of front axle load and 5.0 t of rear axle load (both single axles).

3) First Year ESALs and Traffic Growth Rate

The first year ESALs and traffic growth rate are estimated as shown in Table A24.1-2.

Table A24.1-2 Traffic Loading

	Principal Arterial St.	Minor Arterial Street	Collector Street	Local Street
Average Heavy Vehicle Volume in 2004 (veh/day)	1,260	360	200	50
Growth Rate of Heavy Vehicle Volume	3.6% p.a.	5.5% p.a.	5.5% p.a.	12.8% p.a.
ESALs in 2004 *	29,000	14,000	8,000	2,000

* Yearly ESAL = $V \times f_{HV} / NL \times D_L \times 365$

where, V = Heavy vehicle volume (veh/day)

f_{HV} = Weighted average of truck load factor and bus load factor (0.170)

NL = Number of lanes (principal arterial street : 4, other street : 2)

D_L = Lane distribution factor (principal arterial st. : 1.5, other st. : 1.25)

1.2 Time Constraints

1) Life-Cycle Cost Analysis

The life-cycle cost analysis is carried out for the following three alternatives to find the most economical design performance period:

Alternative-1: Pavement with short performance period (about 5 years)

Alternative-2: Pavement with medium performance period (about 12 years)

Alternative-3: Pavement with long performance period (about 20 years)

Assumed pavement structure is shown in Table A24.1-3

Table A24.1-3 Assumed Pavement Structure

	Principal Arterial St.	Minor Arterial St.	Collector Street	Local Street
Alternative-1				
Pavement Structure : Surface Course (thickness)	7.5cm	7.5cm	5cm	5cm
Base Course	20cm	20cm	20cm	15cm
Subbase Course	25cm	20cm	20cm	15cm
Structural Number, SN	2.69	2.54	2.16	1.81
Performance Period	4.3 years	5.9 years	4.4 years	5.1 years
Alternative-2				
Pavement Structure : Surface Course (thickness)	10cm	10cm	7.5cm	5cm
Base Course	25cm	20cm	20cm	20cm
Subbase Course	25cm	25cm	25cm	25cm
Structural Number, SN	3.27	3.08	2.69	2.31
Performance Period	12.1 years	14.6 years	13.6 years	13.0 years
Alternative-3				
Pavement Structure : Surface Course (thickness)	12.5cm	12.5cm	10cm	7.5cm
Base Course	25cm	20cm	20cm	20cm
Subbase Course	25cm	25cm	25cm	25cm
Structural Number, SN	3.65	3.46	3.08	2.69
Performance Period	20.3 years	22.8 years	23.9 years	19.9 years

The major assumptions are as follows:

- Analysis period : 25 years
- Discount rate : 12% p.a.

The costs considered in the analysis as the life-cycle cost are as follows:

- Initial construction cost
- Future rehabilitation cost (5-cm AC overlay)
- Salvage value of the last rehabilitated pavement at the end of the analysis period
- Annual maintenance cost

The analysis is shown in Table A24.1-4. The results of the analysis are summarized in Table A24.1-5.

Table A24.1-5 Summary of Life-cycle Cost Analysis

(Unit : \$1,000/km)

	Principal Arterial St.	Minor Arterial St.	Collector Street	Local Street
Alternative-1				
Initial Construction Cost	767.3	505.7	368.7	275.6
Life-cycle Cost *	1,085.9	695.4	596.0	459.8
Alternative-2				
Initial Construction Cost	878.0	577.8	442.7	311.3
Life-cycle Cost *	1,000.6	653.7	522.6	392.7
Alternative-3				
Initial Construction Cost	986.0	649.8	488.4	359.0
Life-cycle Cost *	1,056.7	694.6	525.4	403.4

For all classes of road, Alternative-2 shows the lowest life-cycle cost and therefore is considered to be the most economical.

Table A24.1-4(1) Life-Cycle Cost Analysis (Principal Arterial Street)

(unit : \$1,000/km)

Year	Alternative-1				Alternative-2				Alternative-3			
	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost
0	767.3		767.3	767.3	878.0		878.0	878.0	986.0		986.0	986.0
1		7.2	7.2	6.4		7.2	7.2	6.4		7.2	7.2	6.4
2		7.2	7.2	5.7		7.2	7.2	5.7		7.2	7.2	5.7
3		7.2	7.2	5.1		7.2	7.2	5.1		7.2	7.2	5.1
4		7.2	7.2	4.6		7.2	7.2	4.6		7.2	7.2	4.6
5	288.1	7.2	295.3	167.6		7.2	7.2	4.1		7.2	7.2	4.1
6		7.2	7.2	3.6		7.2	7.2	3.6		7.2	7.2	3.6
7		7.2	7.2	3.3		7.2	7.2	3.3		7.2	7.2	3.3
8		7.2	7.2	2.9		7.2	7.2	2.9		7.2	7.2	2.9
9		7.2	7.2	2.6		7.2	7.2	2.6		7.2	7.2	2.6
10	288.1	7.2	295.3	95.1		7.2	7.2	2.3		7.2	7.2	2.3
11		7.2	7.2	2.1		7.2	7.2	2.1		7.2	7.2	2.1
12		7.2	7.2	1.8		7.2	7.2	1.8		7.2	7.2	1.8
13		7.2	7.2	1.7	288.1	7.2	295.3	67.7		7.2	7.2	1.7
14		7.2	7.2	1.5		7.2	7.2	1.5		7.2	7.2	1.5
15		7.2	7.2	1.3		7.2	7.2	1.3		7.2	7.2	1.3
16		7.2	7.2	1.2		7.2	7.2	1.2		7.2	7.2	1.2
17		7.2	7.2	1.0		7.2	7.2	1.0		7.2	7.2	1.0
18		7.2	7.2	.9		7.2	7.2	.9		7.2	7.2	.9
19		7.2	7.2	.8		7.2	7.2	.8		7.2	7.2	.8
20		7.2	7.2	.7		7.2	7.2	.7		7.2	7.2	.7
21		7.2	7.2	.7		7.2	7.2	.7	288.1	7.2	295.3	27.3
22		7.2	7.2	.6		7.2	7.2	.6		7.2	7.2	.6
23	288.1	7.2	295.3	21.8		7.2	7.2	.5		7.2	7.2	.5
24		7.2	7.2	.5		7.2	7.2	.5		7.2	7.2	.5
25		7.2	7.2	.4	288.1	7.2	295.3	17.4		7.2	7.2	.4
25	-261.7		-261.7	-15.4	-286.2		-286.2	-16.8	-211.8		-211.8	-12.5
Total	1,369.9	180.0	1,549.9	1,085.9	1,168.0	180.0	1,348.0	1,000.6	1,062.3	180.0	1,242.3	1,056.7

Table A24.1-4(2) Life-Cycle Cost Analysis (Minor Arterial Street)

(unit : \$1,000/km)

Year	Alternative-1				Alternative-2				Alternative-3			
	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost
0	505.7		505.7	505.7	577.8		577.8	577.8	649.8		649.8	649.8
1		5.1	5.1	4.6		5.1	5.1	4.6		5.1	5.1	4.6
2		5.1	5.1	4.1		5.1	5.1	4.1		5.1	5.1	4.1
3		5.1	5.1	3.6		5.1	5.1	3.6		5.1	5.1	3.6
4		5.1	5.1	3.2		5.1	5.1	3.2		5.1	5.1	3.2
5		5.1	5.1	2.9		5.1	5.1	2.9		5.1	5.1	2.9
6	203.5	5.1	208.6	105.7		5.1	5.1	2.6		5.1	5.1	2.6
7		5.1	5.1	2.3		5.1	5.1	2.3		5.1	5.1	2.3
8		5.1	5.1	2.1		5.1	5.1	2.1		5.1	5.1	2.1
9		5.1	5.1	1.8		5.1	5.1	1.8		5.1	5.1	1.8
10		5.1	5.1	1.6		5.1	5.1	1.6		5.1	5.1	1.6
11		5.1	5.1	1.5		5.1	5.1	1.5		5.1	5.1	1.5
12		5.1	5.1	1.3		5.1	5.1	1.3		5.1	5.1	1.3
13	203.5	5.1	208.6	47.8		5.1	5.1	1.2		5.1	5.1	1.2
14		5.1	5.1	1.0		5.1	5.1	1.0		5.1	5.1	1.0
15		5.1	5.1	.9	203.5	5.1	208.6	38.1		5.1	5.1	.9
16		5.1	5.1	.8		5.1	5.1	.8		5.1	5.1	.8
17		5.1	5.1	.7		5.1	5.1	.7		5.1	5.1	.7
18		5.1	5.1	.7		5.1	5.1	.7		5.1	5.1	.7
19		5.1	5.1	.6		5.1	5.1	.6		5.1	5.1	.6
20		5.1	5.1	.5		5.1	5.1	.5		5.1	5.1	.5
21		5.1	5.1	.5		5.1	5.1	.5		5.1	5.1	.5
22		5.1	5.1	.4		5.1	5.1	.4		5.1	5.1	.4
23		5.1	5.1	.4		5.1	5.1	.4	203.5	5.1	208.6	15.4
24		5.1	5.1	.3		5.1	5.1	.3		5.1	5.1	.3
25		5.1	5.1	.3		5.1	5.1	.3		5.1	5.1	.3
25	-0.6		-0.6	.0	-21.3		-21.3	-1.3	-173.9		-173.9	-10.2
Total	912.1	127.5	1,039.6	695.4	760.0	127.5	887.5	653.7	679.4	127.5	806.9	694.6

Table A24.1-4(3) Life-Cycle Cost Analysis (Collector Street)

(unit : \$1,000/km)

Year	Alternative-1				Alternative-2				Alternative-3			
	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost
0	368.7		368.7	368.7	442.7		442.7	442.7	488.4		488.4	488.4
1		4.4	4.4	3.9		4.4	4.4	3.9		4.4	4.4	3.9
2		4.4	4.4	3.5		4.4	4.4	3.5		4.4	4.4	3.5
3		4.4	4.4	3.1		4.4	4.4	3.1		4.4	4.4	3.1
4		4.4	4.4	2.8		4.4	4.4	2.8		4.4	4.4	2.8
5	176.5	4.4	180.9	102.6		4.4	4.4	2.5		4.4	4.4	2.5
6		4.4	4.4	2.2		4.4	4.4	2.2		4.4	4.4	2.2
7		4.4	4.4	2.0		4.4	4.4	2.0		4.4	4.4	2.0
8	176.5	4.4	180.9	73.1		4.4	4.4	1.8		4.4	4.4	1.8
9		4.4	4.4	1.6		4.4	4.4	1.6		4.4	4.4	1.6
10		4.4	4.4	1.4		4.4	4.4	1.4		4.4	4.4	1.4
11		4.4	4.4	1.3		4.4	4.4	1.3		4.4	4.4	1.3
12		4.4	4.4	1.1		4.4	4.4	1.1		4.4	4.4	1.1
13		4.4	4.4	1.0		4.4	4.4	1.0		4.4	4.4	1.0
14		4.4	4.4	.9	176.5	4.4	180.9	37.0		4.4	4.4	.9
15		4.4	4.4	.8		4.4	4.4	.8		4.4	4.4	.8
16		4.4	4.4	.7		4.4	4.4	.7		4.4	4.4	.7
17	176.5	4.4	180.9	26.3		4.4	4.4	.6		4.4	4.4	.6
18		4.4	4.4	.6		4.4	4.4	.6		4.4	4.4	.6
19		4.4	4.4	.5		4.4	4.4	.5		4.4	4.4	.5
20		4.4	4.4	.5		4.4	4.4	.5		4.4	4.4	.5
21		4.4	4.4	.4	176.5	4.4	180.9	16.7		4.4	4.4	.4
22		4.4	4.4	.4		4.4	4.4	.4		4.4	4.4	.4
23		4.4	4.4	.3		4.4	4.4	.3		4.4	4.4	.3
24		4.4	4.4	.3		4.4	4.4	.3	176.5	4.4	180.9	11.9
25		4.4	4.4	.3		4.4	4.4	.3		4.4	4.4	.3
25	-74.8		-74.8	-4.4	-120.3		120.3	-7.1	-155.6		-155.6	-9.2
Total	823.4	110.0	933.4	596.0	675.4	110.0	785.4	522.6	509.3	110.0	619.3	525.4

Table A24.1-4(2) Life-Cycle Cost Analysis (Minor Arterial Street)

(unit : \$1,000/km)

Year	Alternative-1				Alternative-2				Alternative-3			
	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost	Const./Rehab./Salvage Cost	Maintenance Cost	Total Cost	Dis'd Total Cost
0	275.6		275.6	275.6	311.3		311.3	311.3	359.0		359.0	359.0
1		3.7	3.7	3.3		3.7	3.7	3.3		3.7	3.7	3.3
2		3.7	3.7	2.9		3.7	3.7	2.9		3.7	3.7	2.9
3		3.7	3.7	2.6		3.7	3.7	2.6		3.7	3.7	2.6
4		3.7	3.7	2.4		3.7	3.7	2.4		3.7	3.7	2.4
5		3.7	3.7	2.1		3.7	3.7	2.1		3.7	3.7	2.1
6	146.0	3.7	149.7	75.8		3.7	3.7	1.9		3.7	3.7	1.9
7		3.7	3.7	1.7		3.7	3.7	1.7		3.7	3.7	1.7
8		3.7	3.7	1.5		3.7	3.7	1.5		3.7	3.7	1.5
9	146.0	3.7	149.7	54.0		3.7	3.7	1.3		3.7	3.7	1.3
10		3.7	3.7	1.2		3.7	3.7	1.2		3.7	3.7	1.2
11		3.7	3.7	1.1		3.7	3.7	1.1		3.7	3.7	1.1
12		3.7	3.7	.9		3.7	3.7	.9		3.7	3.7	.9
13		3.7	3.7	.8	146.0	3.7	149.7	34.3		3.7	3.7	.8
14		3.7	3.7	.8		3.7	3.7	.8		3.7	3.7	.8
15	146.0	3.7	149.7	27.3		3.7	3.7	.7		3.7	3.7	.7
16		3.7	3.7	.6		3.7	3.7	.6		3.7	3.7	.6
17		3.7	3.7	.5		3.7	3.7	.5		3.7	3.7	.5
18		3.7	3.7	.5	146.0	3.7	149.7	19.5		3.7	3.7	.5
19		3.7	3.7	.4		3.7	3.7	.4		3.7	3.7	.4
20		3.7	3.7	.4		3.7	3.7	.4	146.0	3.7	149.7	15.5
21		3.7	3.7	.3		3.7	3.7	.3		3.7	3.7	.3
22		3.7	3.7	.3		3.7	3.7	.3		3.7	3.7	.3
23		3.7	3.7	.3		3.7	3.7	.3		3.7	3.7	.3
24	146.5	3.7	149.7	9.9		3.7	3.7	.2		3.7	3.7	.2
25		3.7	3.7	.2		3.7	3.7	.2	146.0	3.7	149.7	8.8
25	-131.7		-131.7	-7.7	-0.8		-8	.0	-142.2		-142.2	-8.4
Total	727.9	92.5	820.4	459.8	602.5	92.5	695.0	392.7	508.8	92.5	601.3	403.4

- 2) Performance Period
Based on the life-cycle cost analysis, 12-year performance period is used in the design.
- 3) Analysis Period
The analysis period is set at 25 years.

1.3 Reliability

The reliability of traffic prediction and performance prediction is assumed to be 50% (standard normal deviate, $Z_R = 0$).

1.4 Environmental Impacts

Roadbed swelling is not considered in the design.

2. PERFORMANCE CRITERIA

2.1 Initial Design Serviceability Index, P_o

Based on the AASHO Road Test, P_o is assumed to be 4.2.

2.2 Design Terminal Serviceability Index, P_t

The AASHTO Guide for Design of Pavement Structures, 1993 suggests the design terminal serviceability index of 2.5 or 3.0 for major highways and 2.0 for highways with a lower classification. The following values of P_t are used in this study:

- 2.5 for principal arterial and minor arterial streets.
- 2.0 for collector and local streets.

3. MATERIAL PROPERTIES FOR STRUCTURAL DESIGN

3.1 Effective Roadbed Soil Resilient Modulus, M_R

The roadbed soil is designed to be replaced with sand of 50cm in thickness and laterite of 20cm in thickness. The combined CBR value of the roadbed is assumed using the equation given in the Asphalt Pavement Manual, Japan Road Association, as shown in Figure A24.1-1.

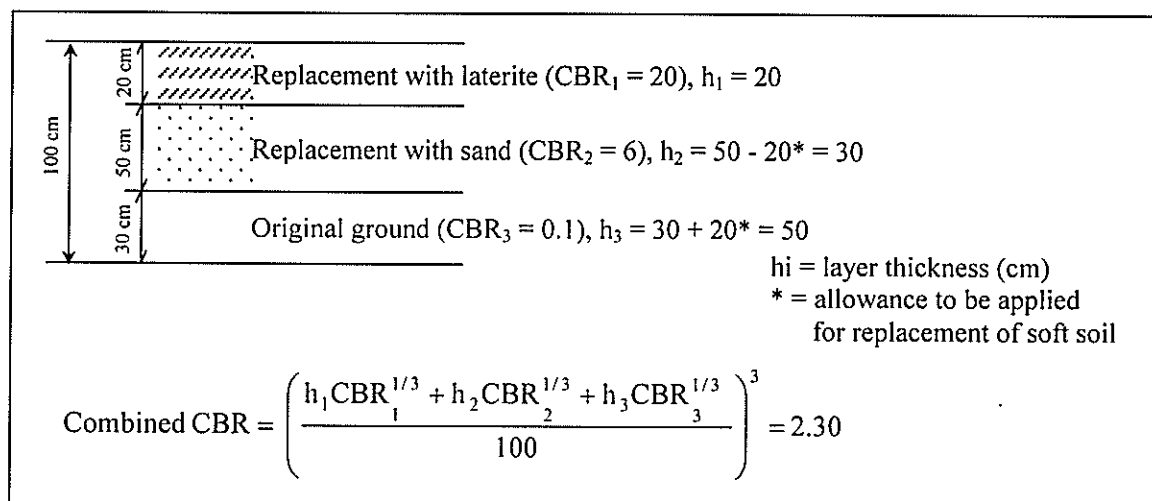


Figure 24.1-1 Combined CBR of Improvement Roadbed

The resilient modulus, M_R is estimated using the Heukelom and Klomp report introduced in the AASHTO Guide, as follows:

$$M_R (\text{psi}) = 1,500 \times \text{CBR} = 1,500 \times 2.3 = 3,450$$

3.2 Layer Coefficients

The layer coefficients are assumed as shown in Table A24.1-6.

A24.1-6 Layer Coefficient

Layer	Property	Layer Coefficient
Surface Course	Asphalt Concrete Elastic Modulus, $E_{AC} = 350,000\text{psi}$	0.39
Base Course	Mechanically stabilized (CBR = 40, R-value = 70)	0.125
Subbase Course	Granular (CBR = 20, R-value = 55)	0.095

4. PAVEMENT STRUCTURAL CHARACTERISTICS

4.1 Drainage Coefficient

The AASHTO Guide classifies the quality of drainage as shown in Table A24.1-7 and recommends the drainage coefficients for use in the design as shown in Table A24.1-8.

Table A24.1-7 Quality of Drainage

Quality of Drainage	Water Removed Within
Excellent	2 hours
Good	1 day
Fair	1 week
Poor	1 month
Very poor	(water will not drain)

Table A24.1-8 Recommended m_i Values for Modifying Structural Layer Coefficients of Untreated Base and Subbase Materials in Flexible Pavements

Quality of Drainage	Percent of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation			
	Less Than 1%	1-5%	5-25%	Greater Than 25%
Excellent	1.40-1.35	1.35-1.30	1.30-1.20	1.20
Good	1.35-1.25	1.25-1.15	1.15-1.00	1.00
Fair	1.25-1.15	1.15-1.05	1.00-0.80	0.80
Poor	1.15-1.05	1.05-0.80	0.80-0.60	0.60
Very poor	1.05-0.95	0.95-0.75	0.75-0.40	0.40

In this study, the layer coefficient is estimated to be 0.8, assuming that the quality of drainage is fair and the pavement structure is exposed to moisture levels approaching saturation for more than 25% of time.

APPENDIX 24-2 DESIGN OF PAVEMENT STRUCTURE

1. DESIGN CRITERIA TO BE ADOPTED

AASHTO Guide for Design of Pavement Structures, 1993

2. BASIC DESIGN EQUATION FOR FLEXIBLE PAVEMENT

$$\log_{10}(W_{18}) = Z_R \times S_O + 9.36 \times \log_{10}(SN + 1) - 0.20 + \frac{\log_{10} \left[\frac{\Delta PSI}{4.2 - 1.5} \right]}{0.40 + \frac{1094}{(SN + 1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Where, W_{18} = predicted number of 18-kip equivalent single axle load applications
 Z_R = standard normal deviate,
 S_O = combined standard error of the traffic prediction and performance prediction,
 ΔPSI = difference between the initial design serviceability index, p_o , and the design terminal serviceability index, p_t ,
 M_R = resilient modulus (psi), and
 SN = structural number indicative of the total pavement thickness required.

SN is given as follows:

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

a_i = i^{th} layer coefficient,
 D_i = i^{th} layer thickness (inches), and
 m_i = i^{th} layer drainage coefficient.

3. DESIGN OF RECONSTRUCTION

3.1 Pavement Structure

1) Principal Arterial Street

Layer	Thickness in cm (D)	Layer Coefficient (a)	Drainage Coefficient (m)	Structural Number (aDm/2.54)
Surface Course	10	0.39	-	1.54
Base Course	25	0.125	0.8	0.98
Subbase Course	25	0.095	0.8	0.75
Total	60			3.27

2) Minor Arterial Street

Layer	Thickness in cm (D)	Layer Coefficient (a)	Drainage Coefficient (m)	Structural Number (aDm/2.54)
Surface Course	10	0.39	-	1.54
Base Course	20	0.125	0.8	0.79
Subbase Course	25	0.095	0.8	0.75
Total	55			3.08

3) Collector Street

Layer	Thickness in cm (D)	Layer Coefficient (a)	Drainage Coefficient (m)	Structural Number (aDm/2.54)
Surface Course	7.5	0.39	-	1.15
Base Course	20	0.125	0.8	0.79
Subbase Course	25	0.095	0.8	0.75
Total	52.5			2.69

4) Local Street

Layer	Thickness in cm (D)	Layer Coefficient (a)	Drainage Coefficient (m)	Structural Number (aDm/2.54)
Surface Course	5	0.39	-	0.77
Base Course	20	0.125	0.8	0.79
Subbase Course	25	0.095	0.8	0.75
Total	50			2.31

3.2 Performance Period

		Principal Arterial St.	Minor Arterial St	Collector Street	Local Street
Inputs	Z _R x S _o	0	0	0	0
	ΔPSI (= P _o - P _t)	1.7(=4.2-2.5)	1.7(=4.2-2.5)	2.2(=4.2-2.0)	2.2(=4.2-2.0)
	M _R (psi)	3,450	3,450	3,450	3,450
	SN	3.27	3.08	2.69	2.31
W ₁₈ (from the Basic Equation)		431,100	300,200	155,300	58,800
Inputs	Initial Year ESALs	29,000	14,000	8,000	2,000
	Traffic Growth Rate p.a.(%)	3.6	5.5	5.5	12.8
Performance Period (Year)*		12.1	14.6	13.6	13.0

* Performance period is calculated from the following equation:

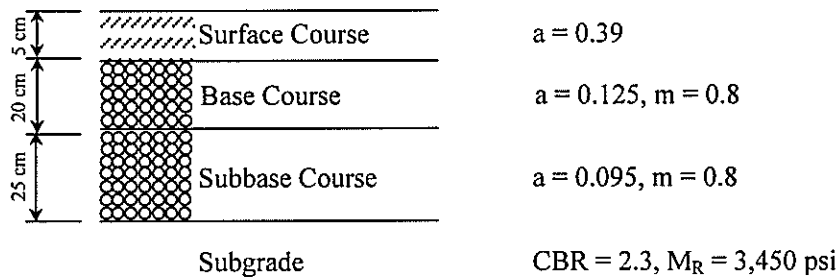
$$W_{18} = \frac{(1 + \text{TGR}/100)^Y - 1}{\text{TGR}/100} E$$

Where, TGR = traffic growth rate p.a. (%)
 E = first year ESALs
 Y = performance period (year)

4. DESIGN OF OVERLAY

4.1 Assumption and Evaluation of the Existing Pavement

1) Existing Pavement Structure (Assumption)



Original Structural Number, SN_o

	Thickness in cm (D)	Layer Coefficient (a)	Drainage Coefficient (m)	Structural Number (aDm/2.54)
Surface Course	5	0.39	-	0.77
Base Course	20	0.125	0.8	0.79
Subbase Course	25	0.095	0.8	0.75
Total	50			2.31

2) Effective Structural Number, SN_{eff}

	Principal & Minor Arterial St.	Collector St. & Local St.
Original Structural Number : SN_o	2.31	2.31
Total traffic to date : N_p^*	53,200	58,800
Total traffic to pavement failure : $N_{1.5}^{**}$	63,600	63,600
Remaining life in % : $RL = 100(1 - N_p/N_{1.5})$	16	8
Condition factor : CF (from Figure A24.2-1)	0.73	0.66
Effective Structural Number : $SN_{eff} = CF \times SN_o$	1.69	1.52

* Serviceability indices of principal/minor arterial streets and collector/local streets at the time of overlaying are assumed to be 2.5 and 2.0 respectively.
 N_p is the estimated total number of 18-kip ESALs from the time of initial construction up to the time the serviceability reaches 2.5/2.0.

** $N_{1.5}$ is the estimated total number of 18-kip ESALs from the time of initial construction up to the time the serviceability reaches 1.5.

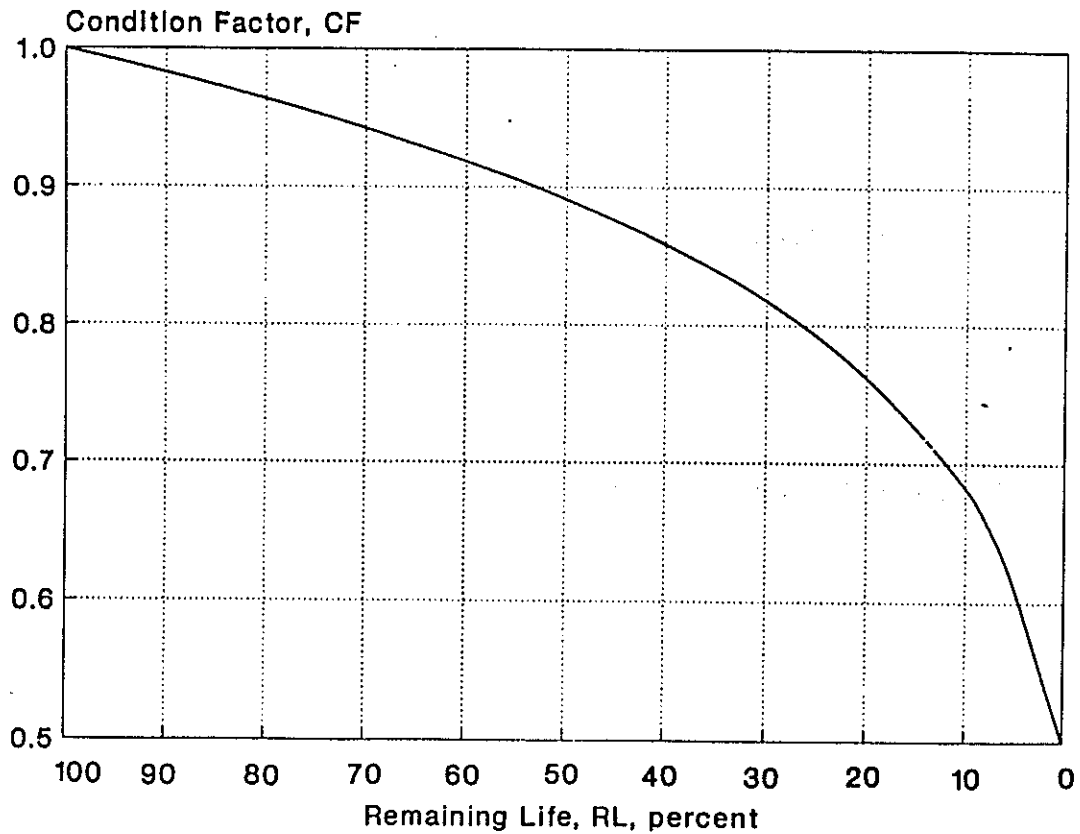


Figure A24.2-1 Relationship of Condition Factor to Remaining Life

4.2 Structural Number of Overlaid Pavement, SN_f

	Principal Arterial St.	Minor Arterial St.	Collector Street	Local Street
SN_{eff}	1.69	1.69	1.52	1.52
Overlay : thickness in cm (D)	10	10	7.5	5
layer coefficient (a)	0.39	0.39	0.39	0.39
aD	1.54	1.54	1.15	0.77
$SN_f = SN_{eff} + aD$	3.23	3.23	2.67	2.29

4.3 Performance Period

		Principal Arterial St.	Minor Arterial St.	Collector Street	Local Street
Inputs	$Z_R \times S_o$	0	0	0	0
	$\Delta PSI (= P_o - P_f)$	1.7(=4.2-2.5)	1.7(=4.2-2.5)	2.2(=4.2-2.0)	2.2(=4.2-2.0)
	M_R (psi)	3,450	3,450	3,450	3,450
	SN_f	3.23	3.23	2.67	2.29
W_{18} (from the Basic Equation)		400,100	400,100	148,000	55,600
Inputs	Initial Year ESALs	29,000	14,000	8,000	2,000
	Traffic Growth Rate p.a.(%)	3.6	5.5	5.5	12.8
Performance Period (Year)		11.4	17.6	13.1	12.6

Appendix 24-3 CONSTRUCTION COST OF THE URBAN STREETS IMPROVEMENT PROJECT

1. Unit Cost

1) Excavation

Per 100 m³

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Backhoe 0.6m ³	0.33	day	220.02	72.61	36.30	25.41	10.89
Dump Truck 10t.	1.70	day	183.41	311.79	155.90	109.13	46.77
Traffic Control Man (4/3000m ³ X 100m ³)	1.30	M day	7.00	9.10	0.00	9.10	0.00
Total				393.50	192.20	143.64	57.66
Unit Price /m³				3.94	1.92	1.44	0.58

2) Sand (t=50cm)

Per 1300 m²

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Sand	812.00	m ³	4.00	3,248.00	1,624.00	1,136.80	487.20
Skilled Labour	2.00	M day	7.00	14.00	0.00	14.00	0.00
Motor Grader 3.1m	1.00	day	181.65	181.65	90.83	63.58	27.25
Macadam Roller 10-12t.	2.00	day	140.63	281.25	140.63	98.44	42.19
Tire Roller 8 -20 t.	2.00	day	164.07	328.14	164.07	114.85	49.22
Water Lorry 5.5 ~ 6.5m ³	2.00	day	48.21	96.42	48.21	33.75	14.46
Total				4,149.46	2,067.73	1,461.41	620.32
Unit Price /m²				3.19	1.59	1.12	0.48

3) Laterite (t=20cm)

Per 1300 m²

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Laterite	286	m ³	5.00	1,430.00	715.00	500.50	214.50
Skilled Labour	1.00	M day	7.00	7.00	0.00	7.00	0.00
Motor Grader 3.1m	1.00	day	181.65	181.65	90.83	63.58	27.25
Macadam Roller 10-12t.	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Water Lorry 5.5 ~ 6.5m ³	1.00	day	48.21	48.21	24.10	16.87	7.23
Total				1,971.56	982.28	694.59	294.68
Unit Price /m²				1.52	0.76	0.53	0.23

4) Sub-Base Course(t=20cm)

Per 1300 m²

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Crushed Stone M-40	325.00	m ³	16.00	5,200.00	2,600.00	1,820.00	780.00
Skilled Labour	4.00	M day	7.00	28.00	0.00	28.00	0.00
Motor Grader 3.1m	1.00	day	181.65	181.65	90.83	63.58	27.25
Macadam Roller 10-12t.	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Water Lorry 5.5 ~ 6.5m ³	1.00	day	48.21	48.21	24.10	16.87	7.23
Total				5,762.56	2,867.28	2,035.09	860.18
Unit Price /m²				4.43	2.20	1.57	0.66

5) Sub-Base Course(t=25cm) Per 1300 m2

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Crushed Stone M-40	406.00	m3	16.00	6,496.00	3,248.00	2,273.60	974.40
Skilled Labour	4.00	M day	7.00	28.00	0.00	28.00	0.00
Motor Grader 3.1m	1.00	day	181.65	181.65	90.83	63.58	27.25
Macadam Roller 10-12t.	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Water Lorry 5.5 ~ 6.5m ³	1.00	day	48.21	48.21	24.10	16.87	7.23
Total				7,058.56	3,515.28	2,488.69	1,054.58
Unit Price /m2				5.43	2.70	1.91	0.82

6) Base Course (t=20cm) Per 1200 m2

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Crushed Stone M-30 (1200m3 x 0.20 x 1.25)	300.00	m3	18.00	5,400.00	2,700.00	1,890.00	810.00
Skilled Labour (2 x 2)	4.00	M day	7.00	28.00	0.00	28.00	0.00
Motor Grader 3.1m (1 x 1 layer)	1.00	day	181.65	181.65	90.83	63.58	27.25
Macadam Roller 10-12t (1 x 1 layer)	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Water Lorry 5.5 ~ 6.5m ³ (1 x 1 layer)	1.00	day	48.21	48.21	24.10	16.87	7.23
Total				5,962.56	2,967.28	2,105.09	890.18
Unit Price /m2				4.97	2.47	1.75	0.75

7) Base Course (t=25cm) Per 1200 m2

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Crushed Stone M-40 (1200m3 x 0.25 x 1.25)	375.00	m3	18.00	6,750.00	3,375.00	2,362.50	1,012.50
Skilled Labour (2 x 2)	4.00	M day	7.00	28.00	0.00	28.00	0.00
Motor Grader 3.1m (1 x 1 layer)	1.00	day	181.65	181.65	90.83	63.58	27.25
Macadam Roller 10-12t (1 x 1 layer)	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Water Lorry 5.5 ~ 6.5m ³ (1 x 1 layer)	1.00	day	48.21	48.21	24.10	16.87	7.23
Total				7,312.56	3,642.28	2,577.59	1,092.68
Unit Price /m2				6.09	3.03	2.15	0.91

8) Binder Course (t=4.5cm) Per 1900 m2

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Asphalt Concrete (1900m3 x 0.045 x 2.35 x 1.08)	217.00	ton	60.00	13,020.00	6,510.00	4,557.00	1,953.00
Prime Coat (1900m2 x 1.26Lt./m2)	2.40	ton	490.00	1,176.00	1,093.68	0.00	82.32
Foreman	1.00	M day	24.00	24.00	0.00	24.00	0.00
Special Worker	6.00	M day	12.00	72.00	0.00	72.00	0.00
Skilled Labour (2 x 2)	12.00	M day	7.00	84.00	0.00	84.00	0.00
Asphalt Finisher 4.5m	1.00	day	267.27	267.27	133.63	93.54	40.09
Macadam Roller 10-12t	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Sand Spray	9.00%		2,158.92	194.30	0.00	194.30	0.00
Misceraneous Cost	5.00%		2,158.92	107.95	0.00	107.95	0.00
Total				15,250.21	7,889.66	5,239.44	2,121.11
Unit Price /m2				8.03	4.15	2.76	1.12

9) Binder Course (t=5cm) Per 1900 m2

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Asphalt Concrete (1900m3 x 0.05 x 2.35 x 1.08)	241.00	ton	60.00	14,460.00	13,447.80	0.00	1,012.20
Prime Coat (1900m2 x 1.26Lt./m2)	2.40	ton	490.00	1,176.00	1,093.68	0.00	82.32
Foreman	1.00	M day	24.00	24.00	0.00	24.00	0.00
Special Worker	6.00	M day	12.00	72.00	0.00	72.00	0.00
Skilled Labour (2 x 2)	12.00	M day	7.00	84.00	0.00	84.00	0.00
Asphalt Finisher 4.5m	1.00	day	267.27	267.27	133.63	93.54	40.09
Macadam Roller 10-12t	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Sand Spray	9.00%		2,158.92	194.30	0.00	194.30	0.00
Misceraneous Cost	5.00%		2,158.92	107.95	0.00	107.95	0.00
Total				16,690.21	14,827.46	682.44	1,180.31
Unit Price /m2				8.78	7.80	0.36	0.62

10) Wearing Course (t=3cm) Per 1000 m2

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Asphalt Concrete (1000 x 0.03 x 2.35 x 1.08)	76.00	ton	60.00	4,560.00	4,240.80	0.00	319.20
Tack Coat (1000m2 x 0.43Lt./m2)	0.43	ton	450.00	193.50	179.96	0.00	13.55
Foreman	1.00	M day	24.00	24.00	0.00	24.00	0.00
Special Worker	6.00	M day	12.00	72.00	0.00	72.00	0.00
Skilled Labour (2 x 2)	12.00	M day	7.00	84.00	0.00	84.00	0.00
Asphalt Finisher 4.5m	1.00	day	267.27	267.27	133.63	93.54	40.09
Macadam Roller 10-12t	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Sand Spray	9.00%		2,158.92	194.30	0.00	194.30	0.00
Misceraneous Cost	4.00%		2,158.92	86.36	0.00	86.36	0.00
Total				5,786.13	4,706.74	660.85	418.54
Unit Price /m2				5.79	4.71	0.66	0.42

11) Wearing Course (t=5cm) Per 1000 m²

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Asphalt Concrete (1000 x 0.05 x 2.35 x 1.08)	127.00	ton	60.00	7,620.00	7,086.60	0.00	533.40
Tack Coat (1000m ² x 0.43Lt/m ²)	0.43	ton	450.00	193.50	179.96	0.00	13.55
Foreman	1.00	M day	24.00	24.00	0.00	24.00	0.00
Special Worker	6.00	M day	12.00	72.00	0.00	72.00	0.00
Skilled Labour (2 x 2)	12.00	M day	7.00	84.00	0.00	84.00	0.00
Asphalt Finisher 4.5m	1.00	day	267.27	267.27	133.63	93.54	40.09
Macadam Roller 10-12t	1.00	day	140.63	140.63	70.31	49.22	21.09
Tire Roller 8 -20 t.	1.00	day	164.07	164.07	82.03	57.42	24.61
Sand Spray	9.00%		2,158.92	194.30	0.00	194.30	0.00
Misceraneous Cost	4.00%		2,158.92	86.36	0.00	86.36	0.00
Total				8,846.13	7,552.54	660.85	632.74
Unit Price /m ²				8.85	7.56	0.66	0.63

12) Concrete Curb Per 100 m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Material							
Crushed Stone (0.3 x 0.1 x 100m x 1.1)	3.30	m ³	16.00	52.80	26.40	18.48	7.92
Lean Concrete (0.3 x 0.1 x 100m x 1.1)	3.20	m ³	55.00	176.00	88.00	61.60	26.40
Concrete Curb Stone (0.4 x 0.2 x 1m)	100.00	Nos.	8.00	800.00	400.00	280.00	120.00
Installation							
Foreman (1.67 x 1)	1.67	M day	24.00	40.08	0.00	40.08	0.00
Mason (1.67 x 2)	3.34	M day	15.00	50.10	0.00	50.10	0.00
Skilled Labour (5 x 2)	10.00	M day	7.00	70.00	0.00	70.00	0.00
Excavation / Backfilling	100.00	m	2.00	200.00	0.00	200.00	0.00
Form Work	20.00	m ²	4.00	80.00	40.00	28.00	12.00
Misceraneous Cost					0.00	0.00	0.00
Total				1,468.98	554.40	748.26	166.32
Unit Price /m				14.69	5.54	7.48	1.67

13) Road Marking Per 1 m²

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Road Marking	1.00	m ²	14.00	14.00	7.00	4.90	2.10
Total				14.00	7.00	4.90	2.10
Unit Price /m ²				14.00	7.00	4.90	2.10

14) Pot Hole Repairing Per 25 m2

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Labour							
Foreman	1	M day	24.00	12.00	0.00	12.00	0.00
Skilled Labour	20	M day	7.00	140.00	0.00	140.00	0.00
Traffic Controller	4	M day	7.00	28.00	0.00	28.00	0.00
Material							
Crushing Stone	9.80	m3	18.00	176.40	88.20	61.74	26.46
Equipment							
Asphalt Cutter	1.00	day	24.43	24.43	12.22	8.55	3.67
Backhoe 0.4m3	1.00	day	145.97	145.97	72.98	51.09	21.89
Dump Truck 10 ton	1.00	day	183.41	183.41	91.70	64.19	27.51
Tamper 60-100kg	2.00	day	7.69	15.38	7.69	5.38	2.31
Vibrator Roller 3-4 ton	1.00	day	77.88	77.88	38.94	27.26	11.68
Total				803.47	311.74	398.22	93.52
Unit Price /m2				32.14	12.47	15.93	3.74

15) Cleaning Mud on Pavement Per 1 m2

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign	Local	Tax
Cleaning Mud	1.00	m2	0.50	0.50	0.00	0.50	0.00
Total				0.50	0.00	1.00	0.00
Unit Price /m2				0.50	0.00	0.50	0.00

16) Summary of Unit Cost

Unit Price	unit	USD./Unit	Cost Component		
			Foreign	Local	Tax
1 Excavation	m3	3.94	1.92	1.44	0.58
2 Sand (t= 50cm)	m2	3.19	1.59	1.12	0.48
3 Laterite(t= 20cm)	m2	1.52	0.76	0.53	0.23
4 Sub-Base Course(t=20cm)	m2	4.43	2.20	1.57	0.66
5 Sub-Base Course(t=25cm)	m2	5.43	2.70	1.91	0.82
6 Base Course(t=20cm)	m2	4.97	2.47	1.75	0.75
7 Base Course(t=25cm)	m2	6.09	3.03	2.15	0.91
8 Binder Course(t=4.5cm)	m2	8.03	4.15	2.76	1.12
9 Binder Course(t=5.0cm)	m2	8.78	7.80	0.36	0.62
10 Wearing Course(t=3.0cm)	m2	5.79	4.71	0.66	0.42
11 Wearing Course(t=5.0cm)	m2	8.85	7.56	0.66	0.63
12 Concrete Curb	m2	14.69	5.54	7.48	1.67
13 Road Marking	m2	14.00	7.00	4.90	2.10
14 Pot Hole Repairing	m2	32.14	12.47	15.93	3.74
15 Cleaning Mud on Pavement	m2	0.50	0.00	0.50	0.00

2. Unit Cost of Reconstruction

1) Principal Arterial Street (18m Wide)

Cost Per 1,000m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign (US\$)	Local (US\$)	Taxes (US\$)
Direct Cost							
Excavation	21,600.00	m3	3.94	85,104	40,850	31,488	12,766
Sand (50cm)	18,000.00	m2	3.19	57,420	28,710	20,097	8,613
Laterite (20 cm)	18,000.00	m2	1.52	27,360	13,680	9,576	4,104
Subbase Course(25cm)	18,000.00	m2	5.43	97,740	48,870	34,209	14,661
Base Course(25cm)	18,000.00	m2	6.09	109,620	54,810	38,367	16,443
Binder Course(5cm)	18,000.00	m2	8.78	158,040	140,656	6,322	11,063
Wearing Course(5cm)	18,000.00	m2	8.85	159,300	136,998	11,151	11,151
Concrete Curb	2,000.00	m	14.69	29,380	11,164	14,984	3,232
Road Marking	550.00	m2	14.00	7,700	3,850	2,695	1,155
Total of Direct Costs				731,664	479,588	168,889	83,187
Indirect Cost (20%)				146,333	0	131,700	14,633
Gross Total				877,997	479,588	300,588	7,820
Unit Cost Per M2				48.78	26.65	16.70	5.43

2) Minor Arterial Street (12m Wide)

Cost Per 1,000m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign (US\$)	Local (US\$)	Taxes (US\$)
Direct Cost							
Excavation	13,800.00	m3	3.94	54,372	26,099	20,118	8,156
Sand (50cm)	12,000.00	m2	3.19	38,280	19,140	13,398	5,742
Laterite (20cm)	12,000.00	m2	1.52	18,240	9,120	6,384	2,736
Subbase Course(25cm)	12,000.00	m2	5.43	65,160	32,580	22,806	9,774
Base Course(20cm)	12,000.00	m2	4.97	59,640	29,820	20,874	8,946
Binder Course (5cm)	12,000.00	m2	8.78	105,360	93,770	4,214	7,375
Wearing Course(5cm)	12,000.00	m2	8.85	106,200	91,332	7,434	7,434
Concrete Curb	2,000.00	m	14.69	29,380	11,164	14,984	3,232
Road Marking	350.00	m2	14.00	4,900	2,450	1,715	735
Total of Direct Costs				481,532	315,475	111,927	54,130
Indirect Cost (20%)				96,306	0	86,676	9,631
Gross Total				577,838	315,475	198,603	63,760
Unit Cost Per M2				48.15	26.29	16.55	5.31

3) Collector Street (10m Wide)

Cost Per 1,000m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign (US\$)	Local (US\$)	Taxes (US\$)
Direct Cost							
Excavation	11,500.00	m3	3.94	45,310	21,749	16,765	6,797
Sub-Grade Sand (50cm)	10,000.00	m2	3.19	31,900	15,950	11,165	4,785
Sub-Grade Laterite (20cm)	10,000.00	m2	1.52	15,200	7,600	5,320	2,280
Sub-base Course(25cm)	10,000.00	m2	5.43	54,300	27,150	19,005	8,145
Base Course(20cm)	10,000.00	m2	4.97	49,700	24,850	17,395	7,455
Binder Course (4.5cm)	10,000.00	m2	8.03	80,300	41,756	27,302	11,242
Wearing Course(3cm)	10,000.00	m2	5.79	57,900	47,478	6,369	4,053
Concrete Curb	2,000.00	m	14.69	29,380	11,164	14,984	3,232
Road Marking	350.00	m2	14.00	4,900	2,450	1,715	735
Total of Direct Costs				368,890	200,147	120,020	48,723
Indirect Cost	20.00	%		73,778	0	66,400	7,378
Gross Total				442,668	200,147	186,420	56,101
Unit Cost Per M2				44.28	20.02	18.65	5.61

4) Local Street (8m Wide)

Cost Per 1,000m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign (US\$)	Local (US\$)	Taxes (US\$)
Direct Cost							
Excavation	9,200.00	m3	3.94	36,248	17,399	13,412	5,437
Sand (50cm)	8,000.00	m2	3.19	25,520	12,760	8,932	3,828
Laterite (20cm)	8,000.00	m2	1.52	12,160	6,080	4,256	1,824
Subbase Course(25cm)	8,000.00	m2	5.43	43,440	21,720	15,204	6,516
Base Course(20cm)	8,000.00	m2	4.97	39,760	19,880	13,916	5,964
Wearing Course(5cm)	8,000.00	m2	8.85	70,800	60,888	4,956	4,956
Concrete Curb	2,000.00	m	14.69	29,380	11,164	14,984	3,232
Road Marking	150.00	m2	14.00	2,100	1,050	735	315
Total of Direct Costs				259,408	150,941	76,395	32,072
Indirect Cost (20%)				51,882	0	46,693	5,188
Gross Total				311,290	150,941	123,088	37,260
Unit Cost Per M2				38.91	18.86	15.39	4.66

3. Unit Cost of Overlay

1) Principal Arterial Street (18m Wide)

Cost Per 1,000m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign (US\$)	Local (US\$)	Taxes (US\$)
Direct Cost							
Pot Hole Repairing	1,080.00	m2	32.14	34,711	13,537	17,008	4,165
Binder Course(5cm)	18,000.00	m2	8.78	158,040	140,656	6,321	11,063
Wearing Course(5cm)	18,000.00	m2	8.85	159,300	136,998	11,151	11,151
Concrete Curb	2,000.00	m	14.69	29,380	11,164	14,984	3,232
Road Lane marking	550.00	m2	14.00	7,700	3,850	2,695	1,155
Cleaning Mud on Pavement	18,000.00	m2	0.50	9,000	0	9,000	0
Total of Direct Costs				398,131	306,205	61,159	30,766
Indirect Cost (20%)				79,626	0	71,664	7,963
Gross Total				477,757	306,205	132,823	38,729
Unit Cost Per M2				26.54	17.01	7.38	2.15

2) Minor Arterial Street of 12m Wide

Cost Per 1,000m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign (US\$)	Local (US\$)	Taxes (US\$)
Direct Cost							
Pot Hole Repairing	720.00	m2	32.14	23,141	9,025	11,339	2,777
Binder Course(5cm)	12,000.00	m2	8.78	105,360	93,770	4,215	7,375
Wearing Course(5cm)	12,000.00	m2	8.85	106,200	91,332	7,434	7,434
Concrete Curb	2,000.00	m	14.69	29,380	11,164	14,984	3,232
Road Lane marking	350.00	m2	14	4,900	2,450	1,715	735
Cleaning Mud on Pavement	12,000.00	m2	0.5	6,000	0	6,000	0
Total of Direct Costs				274,981	207,742	45,686	21,553
Indirect Cost (20%)				54,996	0	49,496	5,500
Gross Total				329,977	207,742	95,182	27,053
Unit Cost Per M2				27.50	17.31	7.94	2.25

3) Collector Street (10m Wide)

Cost Per 1,000m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign (US\$)	Local (US\$)	Taxes (US\$)
Direct Cost							
Pot Hole Repairing	600.00	m2	32.14	19,284	7,521	9,449	2,314
Binder Course(4.5cm)	10,000.00	m2	8.03	80,300	41,756	27,302	11,242
Wearing Course(3cm)	10,000.00	m2	5.79	57,900	46,899	6,948	4,053
Concrete Curb	2,000.00	m	14.69	29,380	11,164	14,984	3,232
Road Lane marking	350.00	m2	14	4,900	2,450	1,715	735
Cleaning Mud on Pavement	10,000.00	m2	0.5	5,000	0	5,000	0
Total of Direct Costs				196,764	109,790	65,398	21,576
Indirect Cost (20%)				39,353	0	35,418	3,935
Gross Total				236,117	109,790	100,816	25,511
Unit Cost Per M2				23.61	10.98	10.08	2.55

4) Local Street (8m Wide)

Cost Per 1,000m

Item	Q'ty	Unit	Unit Price (US\$)	Total (US\$)	Cost Component		
					Foreign (US\$)	Local (US\$)	Taxes (US\$)
Direct Cost							
Pot Hole Repairing	480.00	m2	32.14	15,427	6,017	7,559	1,851
Wearing Course(5cm)	8,000.00	m2	8.85	70,800	60,888	4,956	4,956
Concrete Curb	2,000.00	m	14.69	29,380	11,164	14,984	3,232
Road Lane marking	150.00	m2	14	2,100	1,050	735	315
Cleaning Mud on Pavement	8,000.00	m2	0.5	4,000	0	4,000	0
Total of Direct Costs				121,707	79,119	32,234	10,354
Indirect Cost (20%)				24,341	0	21,907	2,434
Gross Total				146,048	79,119	54,141	12,788
Unit Cost Per M2				18.26	9.89	6.77	1.60

Construction Cost

1) Principal Arterial Streets

Road Name & Number	Road Length (km)	Road Length (m)				Carriage way Width (m)	Unit Cost (US\$/m ²)		Pavement Area (m ²)		Cost (US\$)	
		good (m)	Reconstruction (m)	Overlay (m)	Total (m)		Reconstruction	Overlay	Reconstruction	Overlay	Reconstruction	Overlay
1 Preah Norodom Blvd.(41)	~ St. 110 (Km 0.3)		0	50	50	16.00	48.78	26.54	0	800	0	21,232
	~ Foreign Trade Bank (Km 0.35)		0	1650	1650	15.00	48.78	26.54	0	24,750	0	656,865
	~ Preah Suramarith Blvd. (Km 2.0)		0	350	350	18.00	48.78	26.54	0	6,300	0	167,202
	~ St. 294 (Km 2.35)		0	1150	1150	19.70	48.78	26.54	0	22,655	0	601,264
	~ Mao Tse Toung Blvd. (Km 3.5)		0	1500	1500	18.50	48.78	26.54	0	27,750	0	736,485
	~ Kbal Thnal Roundabout (Km5.0)		0	4700	4700				0	82,255	0	2,183,048
	Sub-Total	0	0									
2 Russian Blvd. (110)	Preah Monivong Blvd. (Km 0.0)		0	0	0	9.40	48.78	26.54	0	0	0	0
	~Total Petroleum Station (km 0.10)	100	0	0	100	9.40	48.78	26.54	564	0	27,512	0
	~ Train Station (Km 0.16)		60	0	60	15.00	48.78	26.54	0	2,100	0	55,734
	~ St. 109 (Km 0.30)		490	0	490	15.00	48.78	26.54	0	0	0	0
	~ St. 169 (Km 0.79)		590	60	140	790			564	2,100	27,512	55,734
	Sub-Total	590	60	140	790				564	2,100	27,512	55,734
3 Mao Tse Toung Blvd. (245)	Russian Blvd. (Km 0.0)		0	0	0	18.00	48.78	26.54	0	0	0	0
	~ St. 134 (Km 0.40)	400	0	0	400	18.00	48.78	26.54	6,300	0	307,314	0
	~ St. 160 (Km 0.75)		350	0	350	18.00	48.78	26.54	0	0	0	0
	~ (Km 1.55)	800	0	0	800	18.00	48.78	26.54	0	0	0	0
	Sub-Total	1200	350	0	1550				6,300	0	307,314	0
Total		1,790	410	4,840	7,040				6,864	84,355	334,826	2,238,782
									91,219	2,573,608		

2) Minor Arterial Streets

Road Name & Number	Road Length (km)	Road Length (m)				Carriage way Width (m)	Unit Cost (US\$/m ²)		Pavement Area (m ²)		Cost (US\$)	
		good (m)	Reconstruction (m)	Overlay (m)	Total (m)		Reconstruction	Overlay	Reconstruction	Overlay	Reconstruction	Overlay
1 Wat Phnom Roundabout	(Km 0.7)		0	700	700	9.00	48.15	27.50	0	6,300	0	173,250
	Sub-Total	0	0	700	700				0	6,300	0	173,250
2 Preah Sotheas Blvd. (3)	St. 154 (Km 0.0)		0	160	160	10.00	48.15	27.50	0	1,600	0	44,000
	~ (Km 0.16)		0	160	160	18.00	48.15	27.50	0	2,880	0	79,200
	~National Museum (Km 0.32)		240	0	240	18.00	48.15	27.50	4,320	0	208,008	0
	~ Royal Palace (Km 0.56)		240	0	240	18.00	48.15	27.50	4,320	0	208,008	0
	~ National Assembly (Km 0.80)		0	320	320	15.00	48.15	27.50	0	4,800	0	132,000
	~ (Km 1.12)		0	480	480	29.00	48.15	27.50	0	13,920	0	382,800
	~ Preah Sihanouk Blvd. (Km 1.60)		0	640	640	9.00	48.15	27.50	0	5,760	0	158,400
~Royal P.P Hotel (Km2.24)		0	760	760	9.00	48.15	27.50	0	6,840	0	188,100	
	~ Preaah Norodom Blvd. (Km 3.0)		0	480	2520	3000			8,640	35,800	416,016	984,500
	Sub-Total	0	480	2520	3000				8,640	35,800	416,016	984,500
3 Preah Norodom Blvd.(41)	Wat Phnom (Km 0.0)		0	300	300	14.00	48.15	27.50	0	4,200	0	115,500
	~ St. 114 (Km 0.3)		0	300	300				0	4,200	0	115,500
	Sub-Total	0	0	300	300				0	4,200	0	115,500
4 France Blvd. (47)	Wat Phnom (Km 0.0)		0	160	160	10.00	48.15	27.50	0	1,600	0	44,000
	~ (Km 0.16)		0	720	720	10.00	48.15	27.50	0	7,200	0	198,000
	~ (Km 0.88)		0	220	220	10.00	48.15	27.50	0	2,200	0	60,500
	~ Junction St.74 (Km 1.1)		0	1100	1100				0	11,000	0	302,500
	Sub-Total	0	0	1100	1100				0	11,000	0	302,500
5 St. Preah Ang Doung (110)	Preah Norodom Blvd. (Km 0.0)		100	0	100	11.00	48.15	27.50	1,100	0	52,965	0
	~St. P Ang Yukanthor19 (Km 0.10)		250	0	250	11.00	48.15	27.50	2,750	0	132,413	0
	~ St. Preah Ang Eng 13 (Km 0.35)		200	0	200	8.00	48.15	27.50	1,600	0	77,040	0
	~ Preah Sisowath Blvd. (Km 0.55)		0	550	0	550			5,450	0	262,418	0.00
	Sub-Total	0	550	0	550				5,450	0	262,418	0.00
Total		5,300	1,030	4,620	10,950				14,090	57,300	678,434	1,575,750
									71,390	2,254,184		

3) Collector Streets

Road Name & Number	Road Length (km)	Road Length (m)				Carriage way Width (m)	Unit Cost (US\$/m ²)		Pavement Area (m ²)		Cost (US\$)	
		good (m)	Reconstruction (m)	Overlay (m)	Total (m)		Reconstruction	Overlay	Reconstruction	Overlay	Reconstruction	Overlay
1 St. Preah Ang Eng (13)	Preah Sisowath Blvd. (Km 0.0)											
	~St. Preah Ang Non(102) (Km 0.3)		300	0	300	8.20	44.28	23.61	2,460	0	108,929	0
	~ St. 106 (Km 0.35)		50	0	50	8.20	44.28	23.61	410	0	18,155	0
	~St. Preah Ang Doung110 (Km 0.5)		150	0	150	15.00	44.28	23.61	2,250	0	99,630	0
	~St. Khemarak Pomin130 (Km 0.7)		200	0	200	11.50	44.28	23.61	2,300	0	101,844	0
	~ St. Decko Damdin154 (Km 1.0)		300	0	300	8.00	44.28	23.61	2,400	0	106,272	0
	~ St. 184 (Km 1.4)		400	0	400	8.00	44.28	23.61	0	0	0	0
Sub-Total		400	1000	0	1400				9,820	0	434,830	0
2 St. Preah Ang Yukanthor (19)	St. Preah Suramarith (Km 0.0)											
	~ St. 240 (Km 0.4)		400	0	400	8.50	44.28	23.61	3,400	0	150,552	0
	~St. Samdech Pann(214) (Km 0.65)		250	0	250	8.50	44.28	23.61	2,125	0	94,095	0
	~St. 178 (Km 1.0)		350	0	350	8.50	44.28	23.61	2,975	0	131,733	0
	St. Decko Damdin(154) (Km 1.25)		250	0	250	8.50	44.28	23.61	2,125	0	94,095	0
	St. Khemarak Poumin130 (Km 1.6)		350	0	350	8.00	44.28	23.61	2,800	0	123,984	0
	St. Preah Ang Doung110 (Km 1.85)		250	0	250	8.00	44.28	23.61	2,000	0	88,560	0
	~ St. 106 (Km 2.0)		150	0	150	10.00	44.28	23.61	1,500	0	66,420	0
	~ St. 102 (km 2.10)		100	0	100	10.00	44.28	23.61	1,000	0	44,280	0
~Wat Phnom Roundabout (Km 2.2)		100	0	100	8.00	44.28	23.61	800	0	35,424	0	
Sub-Total		0	2200	0	2200				18,725	0	829,143	0
3 St. Pasteur (51)	From Wat Phnom Hill (Km 0.0)											
	~ St. 102 (km 0.12)		120	0	120							
	~ St. 106 (Km 0.22)		100	0	100	7.70	44.28	23.61	770	0	34,096	0
	~ St Kramoun Sar(114) (Km 0.44)		220	0	220	8.00	44.28	23.61	1,760	0	77,933	0
	~ St. 118 (km 0.54)		100	0	100	8.00	44.28	23.61	800	0	35,424	0
	~St.Khemarak Pomin130 (Km0.65)		110	0	110	10.00	44.28	23.61	1,100	0	48,708	0
	~ St.Decko Damdin154 (Km0.95)		300	0	300	10.00	44.28	23.61	3,000	0	132,840	0
	~ St. 172 (km 1.15)		200	0	200	11.00	44.28	23.61	2,200	0	97,416	0
	~St. 178 (Km 1.4)		250	0	250	8.00	44.28	23.61	2,000	0	88,560	0
	~ St. 214 (Km 1.6)		200	0	200	8.00	44.28	23.61	1,600	0	70,848	0
	~ Preah Sihanouk Blvd. (Km 2.15)		550	0	550	8.00	44.28	23.61	4,400	0	194,832	0
St. 213 (Km 2.5)	350	0	0	350	11.50	44.28	23.61	0	0	0	0	
~ St. 380 (Km 3.2)	700	0	0	700	11.50	44.28	23.61	0	0	0	0	
Sub-Total		1050	2150	0	3200				17,630	0	780,656	0
4 St. Okha Hing Penn Bassac (61)	Central Market (Km 0.0)											
	~ Preah Ang Doung(110) (Km 0.2)	200	0	0	200	8.00	44.28	23.61	0	0	0	0
	~ St. 106 (Km 0.4)	200	0	0	200	8.00	44.28	23.61	0	0	0	0
	~ St. Daun Penh(92) (Km 0.6)		200	0	200	8.00	44.28	23.61	1,600	0	70,848	0
	~ St. 84 (Km 1.2)		600	0	600	8.00	44.28	23.61	4,800	0	212,544	0
~ France Blvd. (Km 1.3)		100	0	100	8.00	44.28	23.61	800	0	35,424	0	
Sub-Total		400	900	0	1300				7,200	0	318,816	0
5 St. Trasak Phaem (63)	St. 466 (Km 0.0)											
	~ St. 462 (Km 0.08)		80	0	80	8.00	44.28	23.61	640	0	28,339	0
	~ St. 422 (km 0.40)		320	0	320	8.00	44.28	23.61	2,560	0	113,357	0
	~ Mao Tse Toung Blvd. (Km 0.64)	240	0	0	240	10.00	44.28	23.61	0	0	0	0
	~ St. 278 (Km 1.15)	1280	0	0	1280	10.00	44.28	23.61	0	0	0	0
~ Central Market (3.44)	1520	0	0	1520	10.00	44.28	23.61	0	0	0	0	
Sub-Total		3040	400	0	3440				3,200	0	141,696	0
6 St. Khemarak Phoumin (130)	Center Market (Km 0.0)											
	~ St. 51 (Km 0.16)	160	0	0	160	15.50	44.28	23.61	0	0	0	0
	~ Preah Norodom Blvd. (Km 0.25)	90	0	0	90	15.50	44.28	23.61	0	0	0	0
	~ St. 19 (Km 0.32)		70	0	70	11.00	44.28	23.61	770	0	34,096	0
	~ St. Angkor (Km 0.80)		480	0	480	8.00	44.28	23.61	3,840	0	170,035	0
~ Preah Sisowath Blvd.(Km 0.9)		100	0	100	8.00	44.28	23.61	800	0	35,424	0	
Sub-Total		250	650	0	900				5,410	0	239,555	0

Road Name & Number	Road Length (km)	Road Length (m)				Carriage way Width (m)	Unit Cost (US\$/m ²)		Pavement Area (m ²)		Cost (US\$)	
		good (m)	Reconstruction (m)	Over-lay (m)	Total (m)		Reconstruction	Overlay	Reconstruction	Overlay	Reconstruction	Overlay
7 St. Republique Populaire De Pologne(163)	Charles De Gaulle Blvd. (Km 0.0)											
	~ St. 182 (Km 0.16)		160	0	160	12.00	44.28	23.61	1,920	0	85,018	0
	~ Roundabout (Km 0.48)		320	0	320	12.00	44.28	23.61	3,840	0	170,035	0
	~ Preah Sihanouk Blvd. (Km 0.96)		480	0	480	8.00	44.28	23.61	3,840	0	170,035	0
	~ St. 310 (km 1.50)		540	0	540	8.00	44.28	23.61	4,320	0	191,290	0
	~ St. 278 (Km 1.70)		200	0	200	8.00	44.28	23.61	1,600	0	70,848	0
	~ St. 360 (Km 1.80)		100	0	100	8.00	44.28	23.61	800	0	35,424	0
	~ Mao Tse Toung Blvd. (Km 2.24)		440	0	440	9.00	44.28	23.61	3,960	0	175,349	0
	~ St. 408 (Km 2.30)		60	0	60	8.80	44.28	23.61	528	0	23,380	0
	~ St. 430 (km 3.63)	1330	0	0	1330	9.80	44.28	23.61	0	0	0	0
~ St. 271 (Km 3.68)	50	0	0	50	10.00	44.28	23.61	0	0	0	0	
Sub-Total	1380	2300	0	3680				20,808	0	921,378	0	
8 Tchecoslovaquie Blvd.(169)	Kang Hing Roundabout (Km 0.0)											
	~ Bak Touk High School (Km0.24)		240	0	240	18.00	44.28	23.61	4,320	0	191,290	0
	~ St. 128 (Km 0.64)		400	0	400	18.00	44.28	23.61	7,200	0	318,816	0
	~ St. 114 (Km 0.96)	320	0	0	320	18.00	44.28	23.61	0	0	0	0
Sub-Total	320	640	0	960				11,520	0	510,106	0	
9 St. 173	Preah Sihanouk Blvd. (Km 0.0)											
	~ St. 284 (Km 0.15)		150	0	150	8.00	44.28	23.61	1,200	0	53,136	0
	~ St. 271 (Km 1.65)		1500	0	1500	8.00	44.28	23.61	12,000	0	531,360	0
Sub-Total	0	1650	0	1650				13,200	0	584,496	0	
10 St. Keo Chea / St. Samdech Theamak Lethet Ouk (184)	Preah Monivong Blvd. (Km 0.0)											
	~ St. Trasak Phaem63 (Km 0.25)		250	0	250	8.00	44.28	23.61	2,000	0	88,560	0
	~ St. Pasteur51 (Km 0.5)	250	0	0	250	8.00	44.28	23.61	0	0	0	0
	~ Preah Norodom Blvd. (Km 0.7)		200	0	200	8.00	44.28	23.61	1,600	0	70,848	0
	St. Preah Ang Yukanthor19(Km 0.9)	200	0	0	200	8.00	44.28	23.61	0	0	0	0
	~ St. Preah Ang Eng13 (Km 1.15)	250	0	0	250	8.00	44.28	23.61	0	0	0	0
~ Preah Sothearos Blvd. (Km 1.3)	150	0	0	150	8.00	44.28	23.61	0	0	0	0	
Sub-Total	850	450	0	1300				3,600	0	159,408	0	
Total		7,690	12,340	0	20,030				111,113	0	4,920,084	0
									111,113	0	4,920,084	0

4) Major Local Streets

Road Name & Number	Road Length (km)	Road Length (m)				Carriage way Width (m)	Unit Cost (US\$.m ²)		Pavement Area (m ²)		Cost (US\$)			
		good (m)	Reconstri- ction (m)	Over- lay (m)	Total (m)		Recons- truction	Overlay	Reconstri- ction	Overlay	Reconstri- ction	Overlay		
1 St. Oknha Nou Kan (105)	St. 432 (Km 0.0)													
	~ Mao Tse Toung Blvd. (Km 0.16)		160	0	160	6.00	38.91	18.26	960	0	37,354	0		
	~ St. 360 (Km 0.80)		640	0	640	6.00	38.91	18.26	3,840	0	149,414	0		
	~ St. 278 (Km 1.44)		640	0	640	12.40	38.91	18.26	7,936	0	308,790	0		
	~ Preah Sihanouk Blvd. (Km 1.60)	160	0	0	160	8.00	38.91	18.26	0	0	0	0		
	~St. 242 (Km 1.76)	160	0	0	160	8.80	38.91	18.26	0	0	0	0		
~ St. 182 (Km 2.32)	560	0	0	560	8.50	38.91	18.26	0	0	0	0			
	Sub-Total	880	1440	0	2320				12,736	0	495,558	0		
2 St. Sok Hok (107)	From St. 118 (Km 0.0)													
	~ St. Tep Phan182 (Km 0.95)	950	0	0	950	10.00	38.91	18.26	0	0	0	0		
	~ St. Yougoslavie214 (Km 1.20)	250	0	0	250	8.00	38.91	18.26	0	0	0	0		
	~ Preah Sihanouk Blvd. (Km 1.65)		450	0	450	8.00	38.91	18.26	3,600	0	140,076	0		
	Sub-Total	1200	450	0	1650				3,600	0	140,076	0		
3 St. Ung Po Kun (109)	From Russian Blvd. (Km 0.0)													
	~Kampuchea Krom Blvd.(Km 0.25)		250	0	250	8.00	38.91	18.26	2,000	0	77,820	0		
	~ Preah Monireth Blvd. (Km 0.58)	330	0	0	330	8.00	38.91	18.26	0	0	0	0		
	~ Preah Monivong Blvd. (Km 0.83)	250	0	0	250	10.00	38.91	18.26	0	0	0	0		
	Sub-Total	580	250	0	830				2,000	0	77,820	0		
4 St. Josep Brozfito (214)	Preah Monivong Blvd. (Km 0.0)													
	~ Pologne 163 (Km 0.45)		450	0	450	8.00	38.91	18.26	3,600	0	140,076	0		
	Sub-Total	0	450	0	450				3,600	0	140,076	0		
4 St. Yougoslavie (214) St. Samdach Pann (214)	~ Preah Monivong Blvd. (Km .00)													
	~ St. Trasak Phaem63 (Km 0.25)		250	0	250	12.00	38.91	18.26	3,000	0	116,730	0		
	~ St. Pasteur51 (Km 0.53)		280	0	280	12.00	38.91	18.26	3,360	0	130,738	0		
	~ Preah Norodom 41 (Km 0.75)		220	0	220	12.00	38.91	18.26	2,640	0	102,722	0		
	~Preah Ang Yukanthor (Km 1.90)		250	0	250	12.00	38.91	18.26	3,000	0	116,730	0		
	Sub-Total	0	1000	0	1000				12,000	0	466,920	0		
5 St. 230	Nerhu Blvd. (km 0.0)													
	~Mao Tse Toung (km 0.5)	0	500	0	500	8.00	38.91	18.26	4,000	0	155,640	0		
	Sub-Total	0	500	0	500				4,000	0	155,640	0		
6 St. 310	Preah Monireth Blvd. (km 0.0)													
	~ St. 173 (km 0.8)		800	0	800	8.00	38.91	18.26	6,400	0	249,024	0		
	~ St. 163 (km 0.9)		100	0	100	8.00	38.91	18.26	800	0	31,128	0		
	St. 105 (km 1.55)		650	0	650	8.00	38.91	18.26	5,200	0	202,332	0		
	~ Preah Monivong Blvd. (Km 1.75)	0	200	0	200	12.00	38.91	18.26	2,400	0	93,384	0		
	~ Preah Norodom Blvd (Km 2.55)	0	800	0	800	8.00	38.91	18.26	6,400	0	249,024	0		
	Sub-Total	0	2550	0	2550				21,200	0	824,892	0		
7 St. 422	Preah Monivong Blvd. (Km 0.0)													
	~ St. 63 (km 0.30)	300	0	0	300	8.00	38.91	18.26	0	0	0	0		
	~ Preah Norodom Blvd. (Km 0.55)	250	0	0	250	8.00	38.91	18.26	0	0	0	0		
	Sub-Total	550	0	0	550				0	0	0	0		
8 St. 432	From St. 173 (Km 0.0)													
	~ Preah Monivong Blvd. (Km 1.45)		1450	0	1450	8.00	38.91	18.26	11,600	0	451,356	0		
	Sub-Total	0	1450	0	1450				11,600	0	451,356	0		
9 Oknha Nhek Tioulong (466)	~ Preah Monivong Blvd. (Km 0.00)													
	~ (Km 0.10)		100	0	100	8.00	38.91	18.26	800	0	31,128	0		
	~ St. Trasak Phaem 63 (km 0.20)	0	100	0	100	8.00	38.91	18.26	800	0	31,128	0		
	~ (km 0.45)		250	0	250	8.00	38.91	18.26	2,000	0	77,820	0		
	~ Preah Nordom Blvd. (km 0.60)	0	150	0	150	8.00	38.91	18.26	1,200	0	46,692	0		
	Sub-Total	0	600	0	600				4,800	0	186,768	0		
Total			3,210	8,690	0	11,900					75,536	0	2,939,106	0
										75,536	0	2,939,106	0	

5. Summary of Construction Cost

Type of Road	Improvement Length (km)			Improvement Cost (US\$)		
	Reconstruction	Overlay	Total	Reconstruction	Overlay	Total
Principal Arterial Street	0.410	4.840	5.250	334,826	2,238,782	2,573,608
Minor Arterial Street	1.030	4.620	5.650	678,434	1,575,750	2,254,184
Collector Street	12.340	0.000	12.340	4,920,084	0	4,920,084
Local Street	8.690	0.000	8.690	2,939,106	0	2,939,106
Total	22.470	9.460	31.930	8,872,450	3,814,532	12,686,982

APPENDIX 24.4 ECONOMIC EVALUATION FOR URBAN STREETS IMPROVEMENT PROJECT

1. TRAFFIC COST

1) Running Cost

Table A24.4-1 Running Cost

Unit: US\$/km

Vehicle Type/Road Condition	Running Cost				Total
	Maintenance	Fuel	Lubricant	Tyres	
Passenger Car					
Paved, Good	0.0013	0.0450	0.0035	0.0031	0.0529
Paved, Fair	0.0016	0.0480	0.0040	0.0035	0.0571
Paved, Poor	0.0021	0.0518	0.0046	0.0045	0.0630
Paved, Very Poor	0.0021	0.0520	0.0051	0.0049	0.0641
Unpaved, Very Poor	0.0027	0.0545	0.0070	0.0097	0.0739
Motorcycle					
Paved, Good	0.0006	0.0120	0.0047	0.0009	0.0182
Paved, Fair	0.0007	0.0128	0.0060	0.0011	0.0206
Paved, Poor	0.0008	0.0138	0.0075	0.0013	0.0234
Paved, Very Poor	0.0008	0.0140	0.0078	0.0016	0.0242
Unpaved, Very Poor	0.0009	0.0145	0.0092	0.0029	0.0275
Truck					
Paved, Good	0.0042	0.1550	0.0056	0.0100	0.1748
Paved, Fair	0.0049	0.1757	0.0067	0.0120	0.1993
Paved, Poor	0.0057	0.2015	0.0082	0.0160	0.2314
Paved, Very Poor	0.0060	0.2117	0.0086	0.0171	0.2434
Unpaved, Very Poor	0.0075	0.2120	0.0110	0.0329	0.2634
Bus					
Paved, Good	0.0119	0.0440	0.0056	0.0067	0.0682
Paved, Fair	0.0143	0.0497	0.0067	0.0080	0.0787
Paved, Poor	0.0173	0.0569	0.0082	0.0100	0.0924
Paved, Very Poor	0.0194	0.0572	0.0086	0.0122	0.0974
Unpaved, Very Poor	0.0287	0.0600	0.0112	0.0222	0.1221

2) Fixed Cost

Table A24.4-2 Fixed Cost

Unit: US\$/hr

Vehicle Type	Fixed Cost				Total
	Depreciation	Salary	Overhead	Capital	
Passenger Car	0.1284	-	-	0.1217	0.2501
Motorcycle	0.0057	-	-	0.0047	0.0104
Truck	1.3664	-	-	0.9882	2.3546
Bus	0.4767	1.56	0.936	0.4903	3.4630

3) Time Cost

Table A24.4-3 Time Cost

Item	Car Owner	Motorcycle Owner	Non Veh. Owner			
Household Income (US\$)	306	115	70			
Number of Earners	4	4	4			
Monthly Working Hours (hr)	192	192	192			
Hourly Income (US\$/hr)	0.40	0.15	0.09			
Time Value (US\$/hr)						
Business Trip	0.40	0.15	0.09			
Other Trip	0.10	0.04	0.02			
Trip Composition						
Business Trip	23.5%					
Other Trip	76.5%					
Travel Time Value (US\$/hr)						
Person Base	0.17	0.06	0.039			
Vehicle Base	Occupancy/Time Cost					
Passenger Car: 0.248	1	0.17	-	2	0.078	
Motorcycle: 0.091	-	-	1	0.06	0.8	0.031
Bus: 0.78	-	-	-	-	20	0.78

4) Summary of Traffic Cost

Table A24.4-4 Traffic Cost

Item \ Vehicle Type	Passenger Car	Motorcycle	Truck	Bus
Running Cost (US\$/km)				
Paved, Good	0.053	0.018	0.175	0.068
Paved, Fair	0.057	0.021	0.199	0.079
Paved, Poor	0.063	0.023	0.231	0.092
Paved, Very Poor	0.064	0.024	0.243	0.097
Unpaved, Very Poor	0.074	0.028	0.263	0.122
Fixed Cost (US\$/hr)	0.2501	0.0104	2.3546	3.463
Time Cost (US\$/hr)	0.248	0.091	-	0.78

2. ECONOMIC EVALUATION

Table A24.4-5 Road Surface Condition (assumed)

	Principal Arterial St.	Minor Arterial St.	Collector Street	Local Street
Without Case	Paved in very poor condition		Unpaved in very poor condition	
With Case	Paved in good condition (serviceability index 3.5 or more)			
	Paved in fair condition (serviceability index 3.5 - 2.5)			
	Paved in poor condition (serviceability index 2.5 or less)			

1) Reconstruction of Principal Arterial Street

Table A24.4-6 Cost and Benefit Flow

Unit: US\$1,000

Year	Cost				Benefit							Dis'd Cost	Dis'd Benefit
	D/D, C/S	Const. Rehab. Salvage	Maint.	Total Cost	Running Cost W/O	Fixed Cost W/O	Time Cost W/O	Running Cost With	Fixed Cost With	Time Cost With	Total Benefit		
2002	39	-	-	39								39	
2003	54	778	-	832								743	
2004	-	-	6	6	665	95	83	511	83	74	175	5	147
2005	-	-	6	6	676	98	84	519	86	74	179	4	127
2006	-	-	6	6	681	100	84	522	88	74	181	4	114
2007	-	-	6	6	686	103	84	526	91	75	181	3	103
2008	-	-	6	6	690	105	85	530	93	75	182	3	92
2009	-	-	6	6	695	108	85	533	96	75	184	3	83
2010	-	-	6	6	700	110	85	599	98	76	122	2	50
2011	-	-	6	6	720	116	88	616	103	78	127	2	46
2012	-	-	6	6	740	121	90	633	108	81	129	2	42
2013	-	-	6	6	760	127	93	649	113	83	135	2	38
2014	-	-	6	6	780	132	96	666	118	85	139	2	35
2015	-	-	6	6	800	138	99	683	123	88	143	1	32
2016	-	255	6	261	820	143	101	700	128	90	146	53	30
2017	-	-	6	6	839	148	104	643	133	93	222	1	41
2018	-	-	6	6	859	154	107	658	138	95	229	1	37
2019	-	-	6	6	879	159	109	673	143	98	233	1	34
2020	-	-	6	6	899	165	112	688	148	100	240	1	31
2021	-	-	6	6	919	170	115	704	153	103	244	1	28
2022	-	-	6	6	939	176	117	801	158	105	168	1	17
2023	-	-	6	6	959	181	120	818	163	107	172	1	16
2024	-	-	6	6	979	187	123	835	168	110	176	0	14
2025	-	-	6	6	999	192	126	852	173	112	180	0	13
2026	-	-	6	6	1,019	197	128	869	178	115	182	0	12
2027	-	-	6	6	1,039	203	131	886	183	117	187	0	11
2028	-	* -	6	6	1,059	208	134	902	188	120	191	0	10
Total	93	1,033	150	1,276	20,801	3,636	2,583	17,016	3,254	2,303	4,447	875	1,203

* No salvage value because the performance period of overlaid pavement is just over at the end of 2028.

Economic Indicators NPV US\$329,000
B/C Ratio 1.38
EIRR 18.0%

2) Reconstruction of Minor Arterial Street

Table A24.4-7 Cost and Benefit Flow

Unit: US\$1,000

Year	Cost				Benefit							Dis'd Cost	Dis'd Benefit
	D/D, C/S	Const. Rehab. Salvage	Maint.	Total Cost	Running Cost W/O	Fixed Cost W/O	Time Cost W/O	Running Cost With	Fixed Cost With	Time Cost With	Total Benefit		
2002	26	-	-	26								26	
2003	36	513	-	549								490	
2004	-	-	5	5	239	28	33	144	28	32	96	4	45
2005	-	-	5	5	255	32	35	153	29	32	108	4	76
2006	-	-	5	5	262	35	37	201	31	32	70	3	44
2007	-	-	5	5	268	39	38	206	33	33	73	3	42
2008	-	-	5	5	275	42	40	211	34	33	79	3	40
2009	-	-	5	5	281	46	42	216	36	33	84	2	38
2010	-	-	5	5	282	50	43	205	38	34	98	2	40
2011	-	-	5	5	297	53	46	228	40	35	93	2	34
2012	-	-	5	5	306	56	49	262	42	36	71	2	23
2013	-	-	5	5	314	59	51	269	43	38	74	1	21
2014	-	-	5	5	323	62	54	277	45	39	78	1	20
2015	-	-	5	5	332	65	56	284	47	40	82	1	19
2016	-	-	5	5	341	69	59	292	49	42	86	1	18
2017	-	-	5	5	350	72	62	299	51	43	91	1	18
2018	-	181	5	186	358	75	64	307	52	44	94	1	15
2019	-	-	5	5	367	78	67	282	54	46	130	30	19
2020	-	-	5	5	376	81	70	288	56	47	136	1	18
2021	-	-	5	5	385	85	72	305	58	48	131	1	16
2022	-	-	5	5	393	88	75	312	60	50	134	1	15
2023	-	-	5	5	402	91	78	319	62	51	139	1	14
2024	-	-	5	5	411	94	80	352	63	52	118	0	10
2025	-	-	5	5	420	97	83	360	65	53	122	0	9
2026	-	-	5	5	429	101	86	367	67	55	127	0	8
2027	-	-	5	5	437	104	88	348	69	56	156	0	9
2028	-	-19	5	-14	446	107	91	382	71	57	134	-1	7
Total	62	675	125	862	8,549	1,709	1,499	6,869	1,223	1,061	2,604	580	618

Economic Indicators NPV US\$38,000
B/C Ratio 1.07
EIRR 12.9%

3) Reconstruction of Collector Street

Table A24.4-8 Cost and Benefit Flow

Unit: US\$1,000

Year	Cost				Benefit							Dis'd Cost	Dis'd Benefit
	D/D, C/S	Const. Rehab. Salvage	Maint.	Total Cost	Running Cost W/O	Fixed Cost W/O	Time Cost W/O	Running Cost With	Fixed Cost With	Time Cost With	Total Benefit		
2002	20	-	-	20								20	
2003	27	391	-	418								373	
2004	-	-	4	4	161	19	23	114	19	23	47	3	36
2005	-	-	4	4	172	21	24	123	21	24	49	3	35
2006	-	-	4	4	180	23	26	128	22	25	54	3	34
2007	-	-	4	4	187	26	27	133	24	26	57	2	33
2008	-	-	4	4	194	28	29	138	25	26	62	2	31
2009	-	-	4	4	201	31	31	143	27	27	66	2	30
2010	-	-	4	4	208	33	32	148	28	28	69	2	28
2011	-	-	4	4	215	35	34	153	29	29	73	1	26
2012	-	-	4	4	222	36	36	176	30	29	59	1	19
2013	-	-	4	4	229	38	37	182	31	30	61	1	18
2014	-	-	4	4	236	40	39	187	32	31	65	1	17
2015	-	-	4	4	243	41	41	193	32	32	68	1	16
2016	-	-	4	4	250	43	42	225	33	32	45	1	9
2017	-	159	4	163	257	45	44	231	34	33	48	30	9
2018	-	-	4	4	264	46	46	187	35	34	100	1	16
2019	-	-	4	4	271	48	47	192	36	35	103	1	15
2020	-	-	4	4	278	50	49	197	37	35	108	1	14
2021	-	-	4	4	285	51	50	202	38	36	110	0	13
2022	-	-	4	4	292	53	52	231	38	36	92	0	9
2023	-	-	4	4	298	55	54	237	39	37	94	0	9
2024	-	159	4	163	305	57	55	275	40	38	64	13	5
2025	-	-	4	4	312	58	57	222	41	39	125	0	9
2026	-	-	4	4	319	60	59	227	42	40	129	0	9
2027	-	-	4	4	326	62	60	232	43	41	132	0	8
2028	-	-106	4	-102	333	63	62	237	44	41	136	-5	7
Total	47	603	100	750	6,238	1,062	1,056	4,713	820	807	2,016	457	455

Economic Indicators NPV US\$-3,000
B/C Ratio 0.99
EIRR 11.9%

4) Reconstruction of Local Street

Table A24.4-9 Cost and Benefit Flow

Unit: US\$1,000

Year	Cost				Benefit							Dis'd Cost	Dis'd Benefit
	D/D, C/S	Const. Rehab. Salvage	Maint.	Total Cost	Running Cost W/O	Fixed Cost W/O	Time Cost W/O	Running Cost With	Fixed Cost With	Time Cost With	Total Benefit		
2002	14	-	-	14								14	
2003	19	273	-	292								261	
2004	-	-	3	3	59	6	10	40	6	9	20	2	16
2005	-	-	3	3	61	8	11	41	8	11	20	2	14
2006	-	-	3	3	73	10	13	49	9	13	25	2	16
2007	-	-	3	3	85	12	16	57	11	14	31	2	17
2008	-	-	3	3	97	15	18	65	13	16	36	2	18
2009	-	-	3	3	109	17	21	73	15	18	41	1	18
2010	-	-	3	3	120	19	23	81	17	20	44	1	18
2011	-	-	3	3	127	22	26	86	18	21	50	1	18
2012	-	-	3	3	133	25	28	90	19	22	55	1	18
2013	-	-	3	3	139	27	31	94	21	23	59	1	17
2014	-	-	3	3	145	30	33	110	22	25	51	1	13
2015	-	-	3	3	152	33	36	114	23	26	58	1	13
2016	-	128	3	131	158	35	38	135	25	27	44	27	9
2017	-	-	3	3	164	38	41	111	26	28	78	1	14
2018	-	-	3	3	170	41	43	115	27	30	82	0	13
2019	-	-	3	3	176	43	46	119	29	31	86	0	13
2020	-	-	3	3	183	46	48	138	30	32	77	0	10
2021	-	128	3	131	189	49	51	161	31	33	64	15	7
2022	-	-	3	3	195	51	53	132	33	34	100	0	10
2023	-	-	3	3	201	54	56	136	34	36	105	0	10
2024	-	-	3	3	208	57	58	141	36	37	109	0	9
2025	-	-	3	3	214	59	61	145	37	39	113	0	8
2026	-	-	3	3	220	62	63	166	38	40	101	0	7
2027	-	-	3	3	226	65	66	171	40	41	105	0	6
2028	-	* -	3	3	233	67	68	199	41	42	86	0	5
Total	33	529	75	637	3,837	891	958	2,769	609	668	1,640	335	317

* No salvage value because the performance period of overlaid pavement is just over at the end of 2028.

Economic Indicators NPV US\$-19,000
B/C Ratio 0.94
EIRR 11.3%