CHAPTER 24

URBAN STREETS IMPROVEMENT PLAN

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24.1 OBJECTIVES OF THE PROJECT

As described in Chapter 5, the surface condition of the urban streets is very poor. At present, 32% of arterial streets, 59% of collector streets and 81% of local streets are in bad or very bad condition, causing inefficient operation such as reduced speed and capacity as well as high vehicle operating cost, economic loss due to reduction in vehicle service life and damage of cargo, deterioration of environment due to dust, etc. The grave condition of the lower class of streets in particular brings about the concentration of traffic on arterial streets and the resultant increase in travel distance. This situation, if not improved, might be a hindrance to the realization of the bus favored policy. To cope with such problems, the urban streets improvement project is essential.

The direct objectives of the project are as follows:

- Saving of vehicle operating cost
- Reduction of travel time and increase of road capacity
- Prolongation of vehicle service life and decrease of damage of cargo
- Improvement of driving comfort and safety
- Improvement of roadside environment reducing dust and exhaust gas

The indirect objectives of the project are as follows:

- Proper distribution of traffic onto the arterial and local streets giving a shorter travel distance, and thus improvement of the road network efficiency as a whole
- Satisfaction of a basic condition for the bus favored policy to be realized
- Promotion of tourism industry. The riverside area forms a tourist belt.
- Enhancement of community development in depressed areas due to better accessibility.

24.2 IMPLEMENTATION PRIORITY OF IMPROVEMENT

The implementation priority is evaluated from various points of view, i.e. engineering, traffic, functional, developmental and environmental points. Table 24.2-1 shows the prioritization criteria set up for each class of roads. The criteria proposed in Chapter 14 were modified to make the criteria in Table 24.2-1. The criteria of Table 24.2-1 is tailored for pavement improvement of urban streets.

Table 24.2-1 Improvement Priority Criteria

Item	Evaluation Indicator/Method	Road Class		
		Principal & Minor Arterial Street	Collector Street	Local Street
Engineering Requirement	• Necessity/urgency of improvement, evaluated based on present road surface condition	Fair, bad or very bad condition	Bad or very bad condition	Bad or very bad condition
Traffic Requirement	• Traffic demand, evaluated based on forecasted AADT* in 2005	AADT* 400 pcu or more	AADT* 200 pcu or more	-
Functional Requirement	• Role of the road in the road network • Effect on facilitation of bus operation	-	-	Road supplementing the arterial street for decongestion and facilitation of bus operation, being parallel thereto
Developmental Requirement	• Promotion of tourism industry	Given priority to the roads leading to tourist spots	-	-
Environmental Requirement (Social)	• Avoidance of negative social impact, especially resettlement of residents • Effect on community development	No additional ROW** acquisition required	No additional ROW** acquisition required	No additional ROW** acquisition required Road contributing to the community development
Environmental Requirement (Physical)	• Dust prevention effect for roadside residents, evaluated by presently paved/unpaved	-	-	Unpaved

* AADT : Annual Average Traffic Volume ** ROW : Right of Way

By applying these criteria, the following arterial and collector streets are proposed to be improved.

No.	Name of Street
Arterial	
1	Norodon / France Blvd.
2	Sisovath / Sothearos Blvd.
3	Ang Duong St.
22	Mao Tse Toung Blvd.
Collector	
4	Ang Eng St.
5	Khemarak Phomin St.
6	Ang Yukhantor St.
7	Pasteur St.
8	Hing Penh Bassac St.
9	Keo Chea / Theamak Lethetouk St.
10	Tchecoslovaquie
11	St. 163
12	St. 167
13	Trasac Paem St. (southern end section)

Pavement of these arterial/collector streets are fair or worse. All these streets also satisfy other requirements of Table 24.2-1.

The arterial and collector streets which are not listed above are either in good condition, currently being improved or to be improved in the near future.

Among local streets, the following streets are proposed to be improved.

No.	Name of Street
14	St. 109 (northern section)
15	St. 107 (southern section)
16	Samdach Pan St.
17	St. 230
18	St. 310
19	St. 105 (southern section)
20	St. 432
21	Nhek Tioulong St.

These streets are unpaved and are parallel to arterial streets and expected to contribute to reducing traffic congestion on the arterial streets.

The streets proposed for improvement are shown in Figure 24.2-1 and summarized in Table 24.2-2.

Table 24.2-2 Proposed Roads for Improvement

(km)

Class of Road	Total Road Length	Roads Requiring Improvement	Priority Roads		Other Roads
			Ongoing/planned by Government	Proposed in this study	Future Project
Principal Arterial Street	27.2	16.3	11.1	5.2	-
Minor Arterial Street	26.8	22.0	14.7	5.6	1.7
Collector Street	26.0	19.6	5.2	12.3	2.1
Local Street	230.9	227.2	1.1	8.7	217.4
Total	310.9	285.1	32.1	31.8	221.2

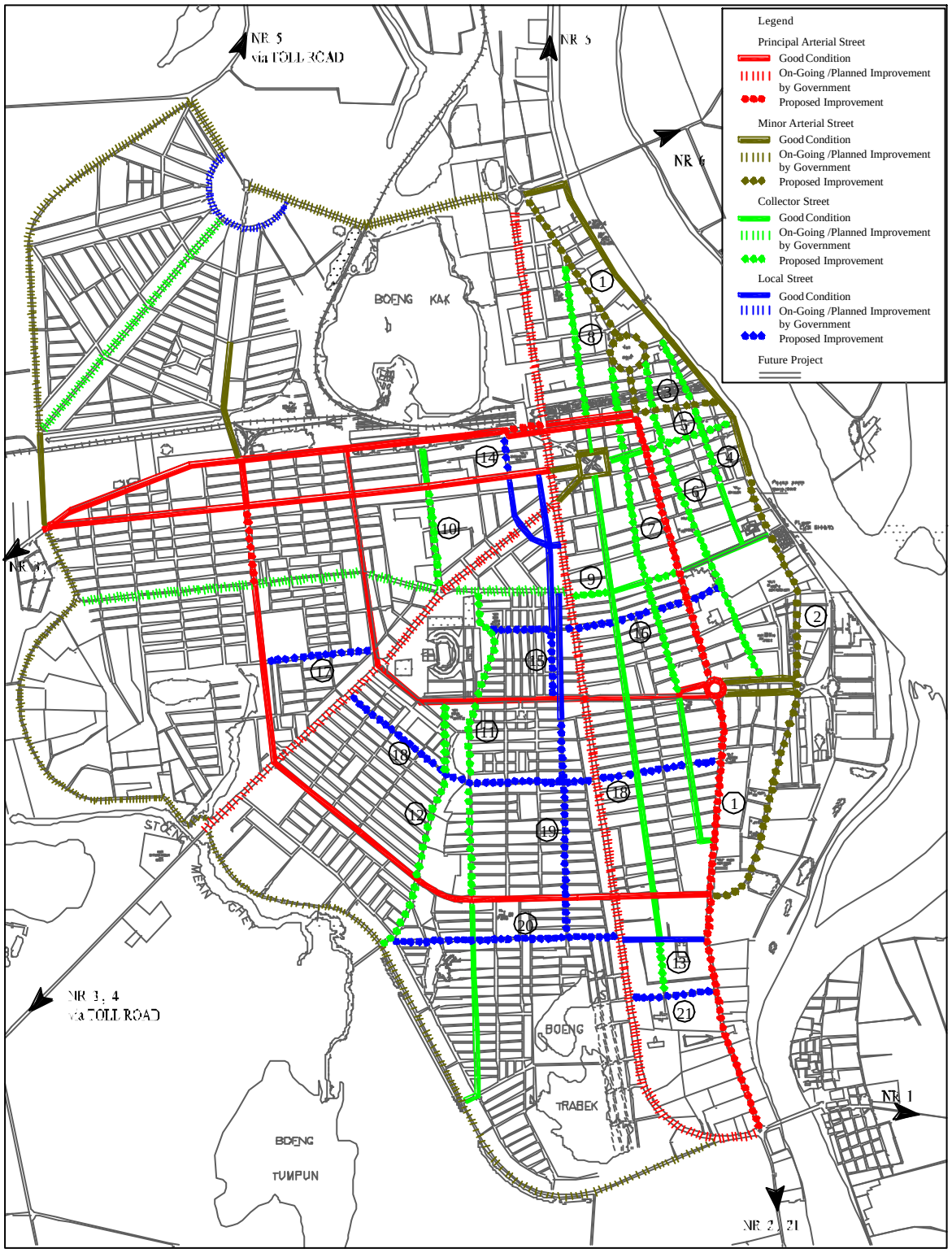

Figure 24.2-1 Proposed Roads for Improvement

*Note: the number in the circle is corresponding to the list of the street to be improved in pages 24-2 & 24-3

24.3 STANDARD PAVEMENT DESIGN AND COST ESTIMATE

The AASHTO Guide for Design of Pavement Structures, 1993, is the most widely used design manual in the world, and is applied to the pavement design in this study.

24.3.1 Basic Design Equation and Design Inputs

(1) Basic Design Equation

The basic design equation for flexible pavement is as follows:

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

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,
?PSI	=	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.
* kip	=	kilo pound (1,000 pounds)
** psi	=	pound per square inch.

SN is given as follows:

$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$

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

(2) Design Inputs

The design inputs assumed in the design are summarized in Table 24.3-1. Detailed discussion thereof is given in Appendix 24-1.

Table 24.3-1 Assumed Design Inputs for Standard Design

Item	Description		
1. Design Variables			
Time Constraints			
- Performance Period	Target performance period of initial pavement structure : 12 years		
- Analysis Period	Period of life-cycle cost analysis and economic evaluation : 25 years		
Traffic*			
- First Year ESALs(18-kip Equivalent Single Axle Loads)	Principal arterial street	:	29,000
	Minor arterial street	:	14,000
	Collector street	:	8,000
	Local street	:	2,000
	Principal arterial street	:	3.6% p.a.

- Traffic Growth Rate	Minor arterial street	: 5.5% p.a.
	Collector street	: 5.5% p.a.
	Local street	: 12.8% p.a.
Reliability	Reliability of traffic prediction and performance prediction : 50% ($Z_R = 0$)	
Environment Impacts - Roadbed Swelling	Not considered	
2. Performance Criteria		
Serviceability		
- Initial Design Serviceability Index, P_o	$P_o = 4.2$	
- Design Terminal Serviceability Index, P_t	$P_t = 2.5$ (Principal & minor arterial streets) $P_t = 2.0$ (Collector and local streets)	
3. Material Properties for Structural Design		
Effective Roadbed Soil Resilient Modulus	CBR = 2.3% (replacement with sand and laterite of 50cm and 20cm respectively in thickness) $M_R = 3{,}450$psi	
Layer Coefficients		
- Surface Course	0.39 (asphalt concrete)	
- Base Course	0.125 (mechanically stabilized)	
- Subbase Course	0.095 (granular)	
4. Pavement Structural Characteristics		
Drainage	Drainage coefficient = 0.8	

* Average ESALs and traffic growth rate are assumed for standard design of each class of roads. As individual roads vary in traffic condition, their performance periods will somewhat deviate from the standard value, or pavement designs will have to be adjusted.

24.3.2 Selection of Improvement Method

Applicable improvement methods are as follows:
- Reconstruction
- Overlay
- Other method like full/partial depth repair, crack sealing, surface treatment, etc.

Of the above, the ' other method ' is considered as maintenance work. Therefore, either reconstruction or overlay with asphalt concrete is proposed for the selected project roads.

Japan Road Association proposes that the selection criteria of the rehabilitation method is based on cracking index and deflection by Benkelman Beam Test. (A similar method is used in many countries including the US and European Countries). However, due to absence of such technical data, the following criteria are applied in this study:

- Conditions to warrant reconstruction
  - Unpaved.
  - Paved, but serious distress as shown below are developed:
    - Highly developed alligator or fatigue cracking
    - Deformation caused by deterioration of base course
    - Deformation caused by softening of subbase course due to infiltration of water
    - Deformation due to weak subgrade
    - Pumping
- Conditions to warrant overlay

Other than above.

Generally, overlay is applicable to roads in fair condition and reconstruction is required for roads in bad or very bad condition.

The improvement method proposed for individual project roads is shown in Figure 24.3-1 and summarized in Table 24.3-2.

Table 24.3-2 Total Length of Project Roads by Improvement Method

(km)

	Reconstruction	Overlay	Total
Principal Arterial Street	0.4	4.8	5.2
Minor Arterial Street	1.0	4.6	5.6
Collector Street	12.3	-	12.3
Local Street	8.7	-	8.7
Total	22.4	9.4	31.8

24.3.3 Design of Pavement Structure

Standard cross-sections are shown in Figure 24.3-2.
Design calculation is given in Appendix 24-2. Calculation results are summarized in Table 24.3-3.

Table 24.3-3 Summary of Design of Pavement Structure

Item	Principal Arterial	Minor Arterial	Collector	Local
Reconstruction				
Pavement Structure				
Surface Course Thickness	10cm	10cm	7.5cm	5cm
Base Course Thickness	25cm	20cm	20cm	20cm
Subbase Course Thickness	25cm	25cm	25cm	25cm
Structural Number, SN	3.27	3.08	2.69	2.31
Serviceability				
Initial Design Serviceability Index, P_o	4.2	4.2	4.2	4.2
Design Terminal Serviceability Index, P_t	2.5	2.5	2.0	2.0
Traffic	29,000	14,000	8,000	2,000
Initial Year ESALs	3.6% p.a.	5.5% p.a.	5.5% p.a.	12.8% p.a.
Traffic Growth Rate	431,100	300,200	155,300	58,800
Total ESALs during the Performance Period, W_{18}	12.1 years	14.6 years	13.6 years	13.0 years
Performance Period				
Overlay				
Pavement Structure				
Effective Structural Number of Existing Pavement, SN_{eff} (assumed)	1.69	1.69	1.69	1.69
Overlay Thickness	10cm	10cm	7.5cm	5cm
Structural Number of Overlaid Pavement, SN_f	3.23	3.23	2.67	2.29
Serviceability				
Initial Design Serviceability Index, P_o	4.2	4.2	4.2	4.2
Design Terminal Serviceability Index, P_t	2.5	2.5	2.0	2.0
Traffic	29,000	14,000	8,000	2,000
Initial Year ESALs	3.6% p.a.	5.5% p.a.	5.5% p.a.	12.8% p.a.
Traffic Growth Rate	400,100	400,100	148,000	55,600
Total ESALs during the Performance Period, W_{18}	11.4 years	17.6 years	13.1 years	12.6 years
Performance Period				

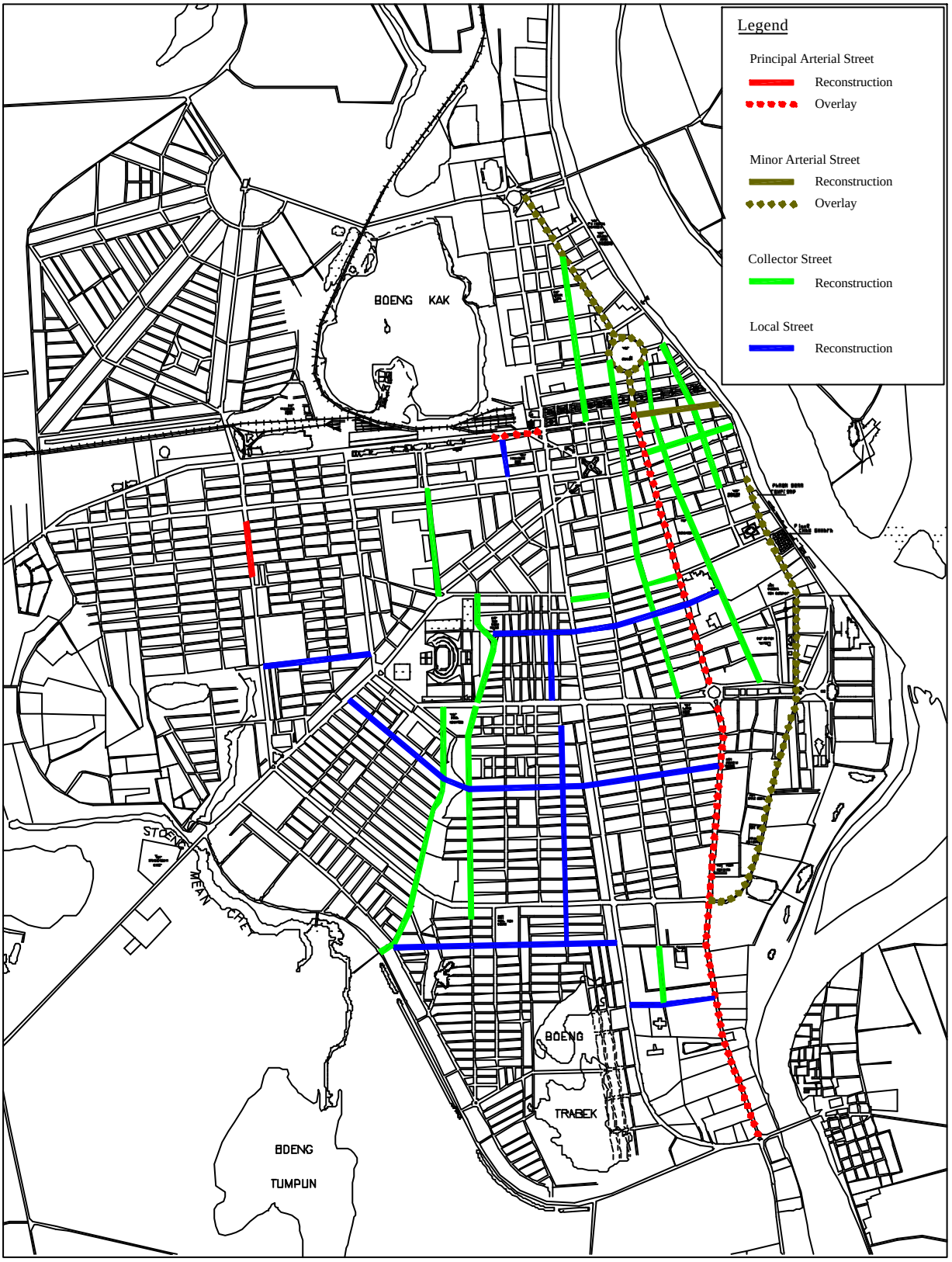

Figure 24.3-1 Proposed Type of Improvement

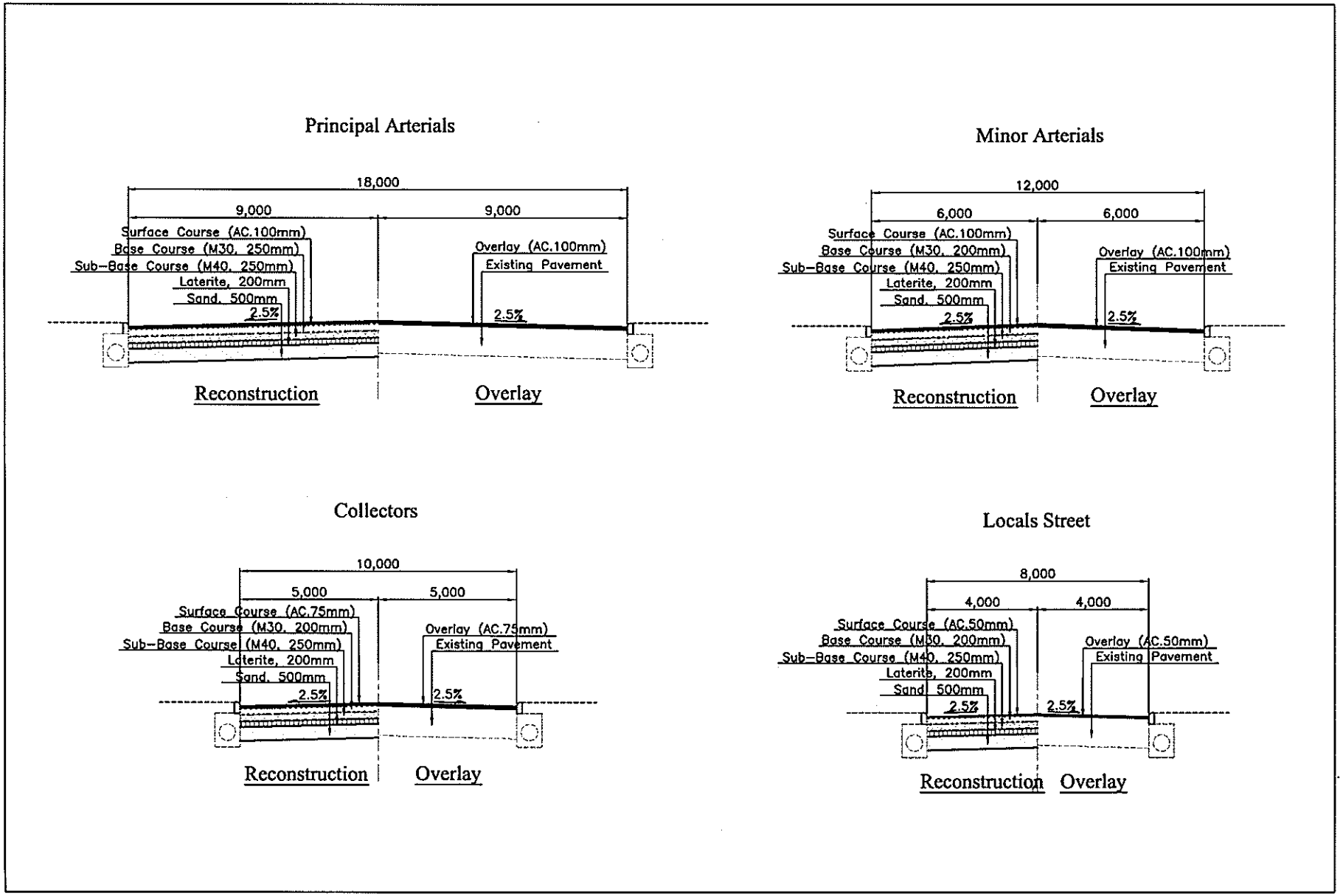

Figure 24.3-2 Standard Cross-Section

Figure 24.3-2 Standard Cross-Sections

24.3.4 Cost Estimate

The cost analysis is given in Appendix 24-3. Table 24.3-4 summarizes the unit costs of standard pavements.

Table 24.3-4 Unit Construction Cost of Standard Pavement

(Unit = US$)

Road Class	Carriage-way width (m)	Cost per km				Cost per m²
		Foreign Component	Local Component	Tax	Total	
Reconstruction						
Principal Arterial Street	18	616,217	162,172	99,608	877,997	48.78
Minor Arterial Street	12	406,058	106,588	65,192	577,838	48.15
Collector Street	10	299,710	91,169	51,789	442,668	44.27
Local Street	8	200,325	72,763	38,202	311,290	38.91
Overlay						
Principal Arterial Street	18	387,107	48,434	42,216	477,757	26.54
Minor Arterial Street	12	264,039	36,329	29,609	329,977	27.50
Collector Street	10	181,360	32,620	22,137	236,117	23.61
Local Street	8	105,644	25,924	14,480	146,048	18.26

24.4 IMPLEMENTATION SCHEDULE AND FINANCIAL REQUIREMENT

(1) Project Cost

The project cost is summarized in Table 24.4-1 (see also Appendix 24-3)

Table 24.4-1 Project Cost

	Improvement Length (Km)			Cost (US$1,000)		
	Reconst-ruction	Overlay	Total	Reconst-ruction	Overlay	Total
Construction Cost						
Principal Arterial St.	0.4	4.8	5.2	334.8	2,238.8	2,573.6
Minor Arterial St.	1.0	4.6	5.6	678.4	1,575.8	2,254.2
Collector Street	12.3	-	12.3	4,920.1	-	4,920.1
Local Street	8.7	-	8.7	2,939.1	-	2,939.1
Total	22.4	9.4	31.8	8,872.4	3,814.6	12,687.0
Detailed Design Cost (5%)						634.4
Construction Supervision Cost (7%)						888.1
Total						14,209.5

(2) Implementation Schedule

The urban streets improvement project is divided into the following three parts:

(i) Principal/minor arterial and collector streets with high priority, which are being improved or planned to be improved by the Government.

(ii) Principal/minor arterial, collector and major local streets with high priority, which are proposed to be improved under the proposed project in this Study. To encourage and sustain the benefits of the project, it is proposed to include the post-construction engineering services as a component of the project. The said services will include technology transfer for traffic management and safety and road maintenance.

(iii) Other streets consisting mainly of local streets and the remaining principal/minor arterial and collector streets, which are proposed to be improved as future projects.

A proposed implementation schedule is shown in Table 24.4-2.

Table 24.4-2 Implementation Schedule

	Length (km)	Cost (1,000$)	Year 2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1. Ongoing/Planned Project by Government													
2. Proposed Project	31.8												
Detailed Design		634											
Construction Supervisor		888											
Construction		12,687											
Post-construction Engineering Services		300											
3. Future Projects													

(3) Fund Resource

Since the proposed project is urgently needed but its economical feasibility is not so high, as described in Section 24.7, it is recommended to apply for extending the grant aid to implement the project.

The future projects are proposed to be funded from various combined resources including local fund, grant aids and loans from international and bilateral lending institutions.

24.5 IMPLEMENTING AGENCY AND ORGANIZATION

The implementing agency will be the Department of Public Works and Transport (DPWT) of the Municipality of Phnom Penh (MPP). It is recommended to establish a new Project Management Unit (PMU) for this project to provide the overall management. The counterpart bodies in the post-construction engineering services will be the Transport Office for traffic management and safety and the Road and Bridge Division for road maintenance.

If grant aid is extended to the project, the project will be implemented in the following steps:

(i) Project Arrangement Study to confirm the background, objectives and benefits of the project, evaluate the appropriateness of the project, prepare a basic design and estimate the cost.
(ii) Detailed Design including preparation of tender documents.
(iii) Construction.
(iv) Implementation of post-construction engineering services as a soft component.

The project organization of each step is shown in Figure 24.5-1.

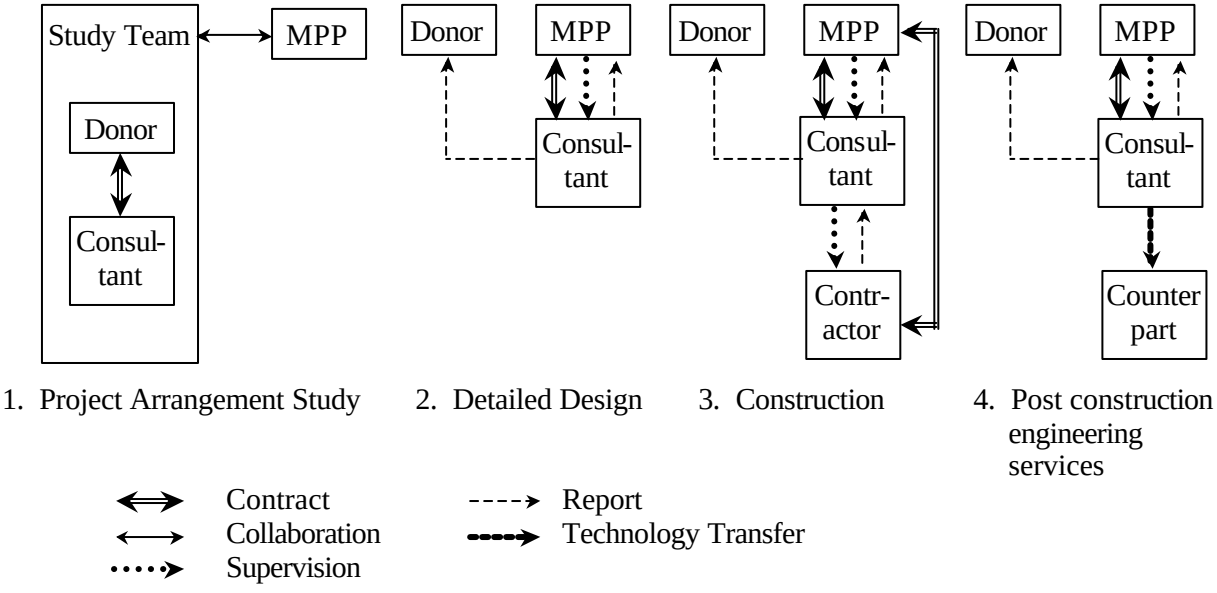

Figure 24.5-1 Project Organizations in Japan's Grant Aid Scheme

24.6 ENVIRONMENTAL IMPACT ASSESSMENT

The Urban Street Improvement Project under the plan is expected to have some environmental impact on both social aspects and pollution levels. Comprehensive surveys and analysis are conducted under this task, and a summary for the main results is presented in the following sections.

24.6.1 Impact on Social Activities

The social impact to be generated by the road improvement project in the urbanized area of Phnom Penh was assessed through a social survey by interviewing affected people in addition to other field surveys. Expectations of interviewed people are based on considerable increase in traffic volumes after improvement. Main results of the survey on people living at unpaved and recently paved streets are summarized in Table 24.6-1.

Table 24.6-1 Main Results of Social Survey

Item	Unpaved	Paved
Annoyance increase due to traffic noise		
1 Daytime	39.8%	67.9%
2 Nighttime	33.3%	11.3%
3 All day	26,9%	20.8%
Annoyance increase due to gas exhaust		
1 Truck and passenger car	63.2%	50.6%
2 Bus	7.0%	22.6%
3 Motorbike	29.8%	26.8%
Savings in travel time		
1 Average travel time of work trip	25 minutes	12 minutes
2 Average travel time of school trip	21 minutes	11 minutes
3 Average travel time of shopping trip	24 minutes	14 minutes
4 Average travel time of hospital trip	23 minutes	19 minutes
5 Average travel time of religious facility trip	25 minutes	12 minutes
Increase in property value		
1 Average house rental charge	US$30	US$50
2 Average land price of square meter	US$30	US$40
3 Ratio of houses with prices less than US$ 10,000	10.2%	2%
4 Ratio of houses with prices more than US$ 20,000	76.6%	94.7%

As shown in the table, paved roads are expected to improve the living environment and significantly decrease travel time for all types of trips. Other results show that after road improvement, residents are not expected to face any problems related to their daily life. Vendor shops on roadsides are the only group that may face some negative impact or to lose their business if they have to leave their places. The table shows also that land value and price as well as the monthly rental charge of houses are expected to increase by improving adjacent streets. Prices of most of the houses along paved roads are higher than those along unpaved roads. That may produce negative impact on poor community.

As for sales amount, shop owners are expected that more people will use the paved streets that provide more comfort-ability and accessibility to shops and consequently sales will increase. In addition, paved streets, with less dust, attract more customers to open-restaurants on the sidewalks. In addition, implementing this project will result in an increase in the number of shops and businesses along paved streets.

24.6.2 Encroachment and Resettlement Policy

The encroachment problem on the right-of-way of the street network in the urbanized areas of Phnom Penh does not form a major obstacle to implement the Project. There are little areas

occupied by squatters and street vendors as illegal encroachment. In addition, shops are extending their activities on the sidewalks in many commercial streets. An inventory survey for such areas was conducted and a summary of the result is presented in Table 24.6-2 and located in Figure 24.6-1.

Table 24.6-2 Encroachment on urbanized Street Network

Encroachment Type	Number of Locations	Number of Units	Encroachment Length (m)	Encroachment Area (m^2)
Squatter	2	155	360	1,440
Vendor	12	1204	1,450	8,850
Shop-Extension	8	317	1,150	4,600

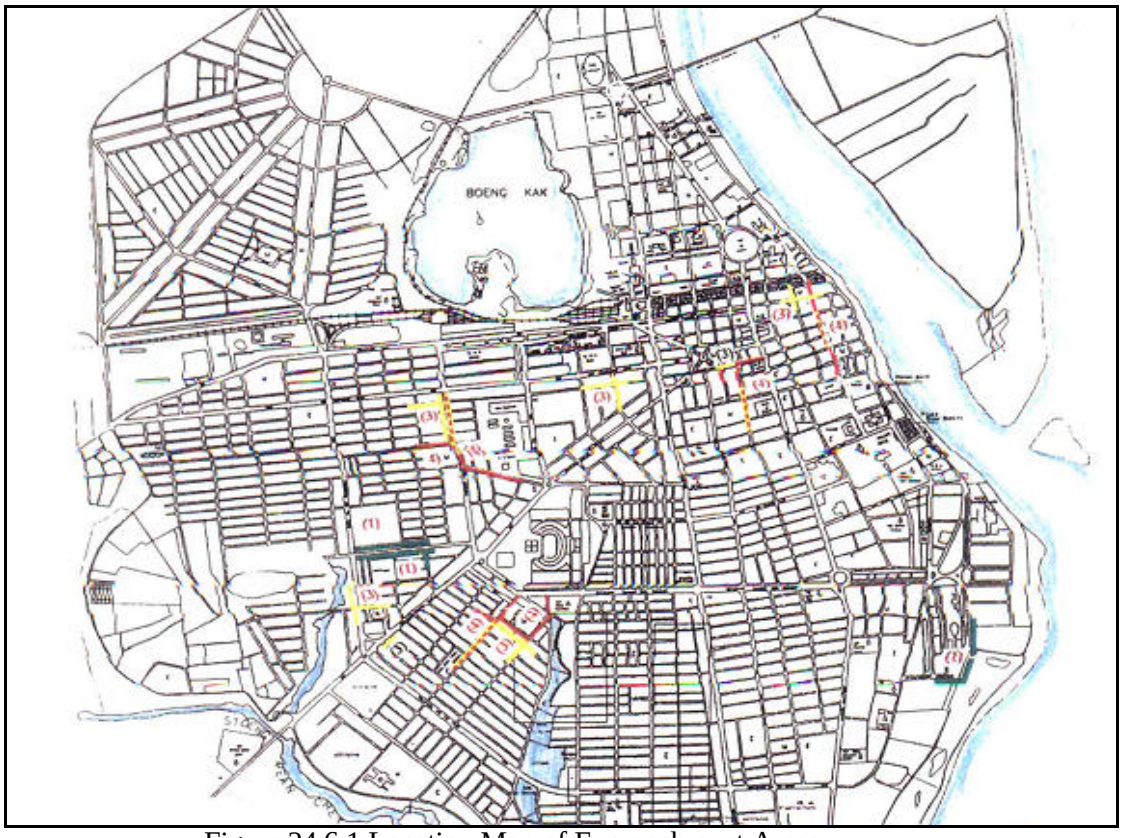

Figure 24.6-1 Location Map of Encroachment Areas

The policy regarding illegal resettlement is basically not existing. An Inter-Ministerial Committee was established in 1999 to setup a national resettlement policy. The committee includes institutions such as: (1) Ministry of Economy and Finance; (2) Ministry of Public Works and Transport; (3) Ministry of Agriculture; (4) Representative of the Council of Ministers, and (5) the Phnom Penh Municipality Council. The main points that addressed by the Committee involve solutions for illegal settlement on national roads where illegal land encroachments are forming critical phenomena in many provinces.

At present, the illegal settlement crisis, according to the past experiences in Phnom Penh, is the responsibility of the Municipality, which provides rural land and loans for re-settlers, but compensations are only for legal settlement cases. Strict enforcement by authorities was the practice applied in the past. Through declarations of time limit of few weeks or months, illegal settlers had to evacuate. The practice was unsuccessful and complaints caused in changing the old policy.

At present, the Municipality has issued announcements and other guidelines for illegal settlements. In collaboration with donors and NGOs, the Municipality is able to provide infrastructure and public service facilities to areas designated for resettlement. Negotiations are done between the

Municipality and communities for mutual understanding and new areas with proper living conditions are provided. Several resettlement schemes are successfully implemented in recent years in new areas containing school, healthcare center, market, well and other necessary infrastructure facilities.

24.6.3 Impact on Pollution

As the proposed F/S projects incorporate road surface pavement activities to improve the functionality of the street network in the urban areas of the municipality, comprehensive pollution surveys of air quality, noise and vibration were conducted at three different locations. The first location is at a high traffic volume section of Nordom Boulevard, which is a paved road with asphalt concrete. The other two stations are located on Laterite surface roads No. 155 and 237. The selection of measuring stations at different road surfaces allows to evaluate forecasted future impact due to road surface improvement through different modeling techniques. Figure 24.6-2 shows the results of data analysis and forecast in which that a reduction in CO is forecasted after the implementation of the Urban Street Improvement Project. This reduction is resulted due to expected increase in travel speed even with the increase in traffic volumes on the street network.

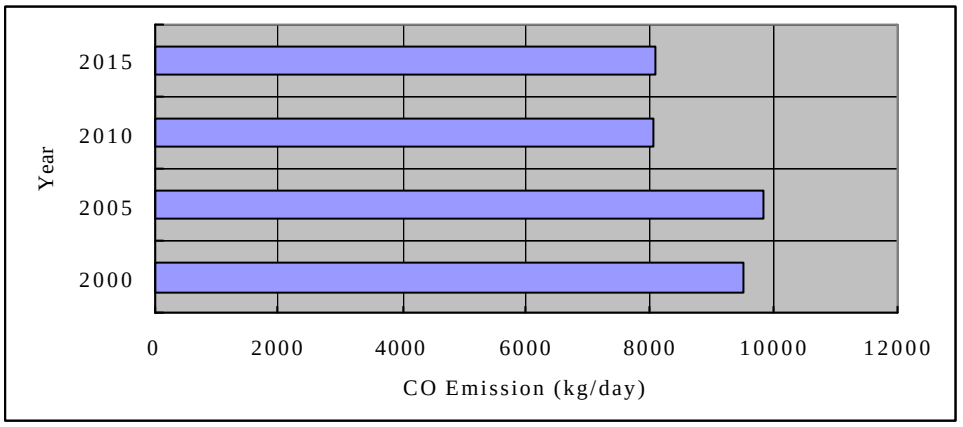

Figure 24.6-2 Reduction in CO Emission

1) Social Environment

The nature of this project is improvement of the existing road surface. Since the project roads have adequate right-of-way, no additional right-of-way acquisition nor resettlement of residents is required. Therefore, no negative social impact is anticipated.

On the contrary, many favorable impacts such as improvement of accessibility, promotion of effective land use, community development, etc. are expected.

2) Natural Environment

Since the project will not change the natural condition, no impact on natural environment is expected.

3) Pollution

In general, improvement of road surface condition significantly decreases dust, exhaust gas, vibration and noise due to vehicle operation.

In addition, traffic volume of the arterial streets is expected to decrease because traffic distribution to the collector/local streets will be improved. Therefore, pollution on the arterial streets will be much reduced.

Traffic volume of the collector/local streets is expected to significantly increase.

Accordingly, pollution thereon may possibly get worse, but the pollution level is considered to be much lower than the tolerable limit because the traffic volume is much lower than that of the arterial streets.

An anticipated problem is the possibility of increasing numbers and severity of traffic accidents due to increase of vehicle running speed. Adequate measures are required to be taken to prevent this from occurring.

4) Nuisance due to construction works
The major problems due to construction works are traffic disturbance during construction and environmental pollution due to improper disposal of excavated soil.

Traffic disturbance during construction should be minimized by:
- Construction on one side with the other side open to traffic (in case of wide street).
- Provision of detour route and clear indication thereof (in case of narrow street).
- Road open to traffic during the period between the completion of one construction stage and commencement of the next construction stage if possible.

Environmental pollution due to disposal of excavated soil should be avoided by dumping at the properly designated area.

24.7 ECONOMIC EVALUATION

The economic evaluation is made for each class of road assuming the average traffic condition and the standard design.

24.7.1 Assumptions

1) Time Frame (Analysis Period)
- Detailed design : 2002
- Construction : 2003
- Operation (benefit generation) : 2004 – 2028 (25 years)

2) Pavement Rehabilitation Plan
- After the performance period passes (when the serviceability index reaches the design terminal serviceability index), AC overlay with a thickness of 5cm is constructed as a rehabilitation work (see Figure 24.7-1).

3) Cost
- Economic cost is used, which is estimated by deducting the tax component from the financial cost.
- Costs considered in the analysis (refer to Figure 24.7-1)
  - Detailed design and construction supervision costs for initial construction.
  - Initial construction cost.
  - Maintenance cost, recurring throughout the analysis period.
  - Future rehabilitation cost.
  - Salvage value at the end of the analysis period (negative cost), which is estimated by SV = C(PP-PE)/PP where SV = salvage value, C = cost of the last rehabilitation, PP = performance period of the pavement after the last rehabilitation, and PE = period after the last rehabilitation until the end of the analysis period.

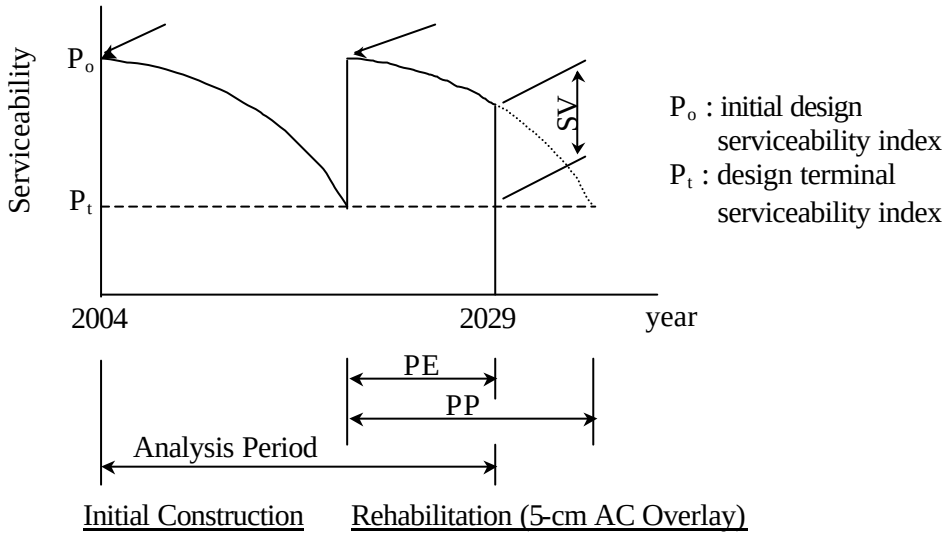

Figure 24.7-1 Pavement Performance

4) Quantified Benefit
   - Traffic cost savings consisting of:
     - Running cost
     - Fixed cost
     - Time cost
   - Road surface condition is as follows:
     - Without case : paved in very poor condition (principal/minor arterial street)
       unpaved in very poor condition (collector or local street)
     - With case : paved in good condition (serviceability index 3.5 or more)
       paved in fair condition (serviceability index 2.5 – 3.5)
       paved in poor condition (serviceability index 2.5 or leas)

5) Discount Rate : 12% p.a.

24.7.2 Results of Evaluation

1) Unit Traffic Cost

Table 24.7-1 shows the unit traffic cost.

Table 24.7-1 Unit Traffic Cost (excluding tax)

Unit : $/km, $/hr

Item \ Vehicle Type	Passenger Car	Motor-cycle	Truck	Bus
Running cost / 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 / hr	0.25	0.01	2.35	3.46
Time Cost / hr	0.25	0.09	-	0.78

2) Traffic Volume

Average traffic volume by road class is shown in Table 24.7-2.

Table 24.7-2 Average Traffic Volume

Unit : vehicle/day

Road Class \ Vehicle Type		Passenger Car	Motor-cycle	Truck	Bus
Principal Arterial	2000	5,664	48,368	643	250
	2005	6,931	46,848	1,003	390
	2010	7,720	45,488	1,163	452
	2015	9,320	49,372	1,424	554
Minor Arterial	2000	1,220	15,472	91	36
	2005	2,268	19,728	294	114
	2010	2,736	20,542	428	167
	2015	3,283	23,242	500	195
Collector Street	2000	743	9,278	81	-
	2005	1,380	12,132	241	-
	2010	1,770	13,802	345	-
	2015	2,242	15,644	398	-
Local Street	2000	349	3,946	27	-
	2005	513	4,096	59	-
	2010	1,083	7,680	147	-
	2015	1,467	9,272	197	-

3) Economic Evaluation

Table 24.7-3 shows the cost and benefit flow for reconstruction of a principal arterial street.

Table 24.7-3 Cost and Benefit Flow (Reconstruction of Principal Arterial Street)

Unit : $1,000/km

Year	Cost				Benefit							Dis'd Cost	Dis'd Benefit
	D/D, C/S	Const., Rehab.	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

Economic Indicators

NPV	$329
B/C Rati	1.38
EIRR	18.0% of 2028.

The cost and benefit flow of other class of roads is given in Appendix 24-4. The results of economic evaluation are summarized in Table 24.7-4.

Table 24.7-4 Results of Economic Evaluation (Reconstruction)

Economic Indicator / Road Class	Net Present Value ($1,000/km)	Benefit Cost Ratio	Economic Internal Rate of Return (%)
Principal Arterial St.	329	1.38	18.0
Minor Arterial St.	38	1.07	12.9
Collector Street	-3	0.99	11.9
Local Street	-19	0.94	11.3

The results of economic evaluation show that the reconstruction of all classes of road is economically feasible except for reconstruction of local streets of which the economic internal rate of return is slightly below 12%. Even in the case of local streets, EIRR of close to 12% is considered by many governments and donors to warrant the project.

Sensitivity analysis

To see the influence of deviations in cost and benefit from the assumed conditions, sensitivity analysis was made for the following two cases.

Case 1 : Cost 10% increase, benefit 10% decrease
Case 2 : Cost 10% decrease, benefit 10% increase

The result of analysis is shown in Table 24.7-5.

Table 24.7-5 Result of Sensitivity Analysis

(a) Principal Arterial

Parameter	Base Case	Sensitivity Analysis	
		Case 1	Case 2
B/C Ratio	1.38	1.12	1.67
EIRR (%)	18.0	13.9	22.41
NVP (US$1,000)	329	114	529

(b) Minor Arterial

Parameter	Base Case	Sensitivity Analysis	
		Case 1	Case 2
B/C Ratio	1.07	0.87	1.30
EIRR (%)	12.9	10.1	16.2
NVP (US$1,000)	38	-81	158

(c) Collector

Parameter	Base Case	Sensitivity Analysis	
		Case 1	Case 2
B/C Ratio	0.99	0.81	1.21
EIRR (%)	11.9	9.1	15.0
NVP (US$1,000)	-3	-95	88

(d) Local

Parameter	Base Case	Sensitivity Analysis	
		Case 1	Case 2
B/C Ratio	0.94	0.77	1.16
EIRR (%)	11.3	8.8	13.9
NVP (US$1,000)	-19	-84	47

24.8 CONCLUSION

The project is evaluated as follows:

- Urgency : Very urgent since high priority roads are selected (see Section 24.2).
- Technical aspect : No major technical problems foreseen since a common construction method in Cambodia is applied (see Section24.3).
- Economic aspect : Feasible on condition that the road will be well maintained and the future rehabilitation work will be done timely (see Section 24.7).
- Financial aspect : Financially viable (see Section 24.4).
- Institutional aspect : No problems foreseen with the project arrangement and organization (see Section 24.5).
- Environmental aspect : No significant negative impact except that there is a possibility of increasing traffic accidents due to increase of running speed (see Section 24.6).

Thus, the project is concluded to be urgent and feasible from all aspects except some minor issues such as necessity of maintenance work and possibility of increasing traffic accidents. Therefore, it is highly recommended to implement the project as soon as possible. Furthermore, to solve the minor problems and to encourage and sustain the benefits of the project, it is recommended to include the post-construction engineering services as a component of the project including technology transfer for traffic management and safety and road maintenance.

CHAPTER 25

CONCLUSIONS
AND
RECOMMENDATIONS

CHAPTER 25

CONCLUSIONS AND RECOMMENDATIONS

25.1 CONCLUSION; TRANSPORT MASTER PLAN

(1) Transport System

- A comprehensive transport plan is proposed integrating the development plans and covering all necessary components including road, public transport, traffic management, institution, legislation and finance.

- A bus favored policy aimed at encouraging bus operation, coexisting alongside 2-wheel vehicles, is selected as the most appropriate transport system approach in view of traffic flow condition, system efficiency, environmental impact and social acceptance.

- The bus system is required particularly in the near future when the social and economic activities are revitalized with the economic development and population increase, thus requiring the shift from para-transit oriented public transport system (motodop) to a comprehensive system (bus).

(2) Road Development

- In the urbanized area (inside Inner Ring Road) where the road network is well developed, pavement improvement of existing arterials, collectors and local streets is a very urgent need.

- Improvement of urban streets is indispensable for smooth operation of bus services as well as effective implementation of traffic control measures.

- In the suburban area which will accommodate future development demands, an efficient road network is required to connect development areas and strengthen connections with the national road network, including the improvement of the following;
  - Northern New Trunk Road
  - Southern New Trunk Road
  - Intermediate Ring Road
  - Outer Ring Road

(3) Public Transport

- Bus services are planned to be operated first only on limited high-demand routes (84 kms by the Year 2005) and to be extended in the future based on the demand growth and road network improvement (148 kms by Year 2015). Accordingly, improvement of bus terminals, stops, shelters and depots is greatly required to attract bus passengers.

- Demand for and acceptance of bus services by the general public was demonstrated through the Public Experiment of the Study.

- Other public transport modes such as taxi, motodop, cyclo are proposed to operate in accordance with their characteristics and function, coexisting with the bus services. For example, the cyclo plays a role as an attractive transport means in tourism and heritage areas.

- A policy on such co-existence shall be established including a zone system for motodop and cyclo and regulation of 2-wheel vehicles on major roads.

(4) Traffic Management

- Traffic management is identified as an effective measure, especially in the urbanized area, to be implemented in the short-term with low cost, in order to prevent future deterioration of

traffic condition and traffic nuisance as well as traffic accidents.

- Smooth traffic flow promoted by improved traffic management is expected to help smooth operation of bus services, and as a result, attract more passengers and improve the financial condition of bus operations.

- Measures to be undertaken in the short-term include the provision of traffic signals (33 intersections by Year 2005), improvement of on-street parking facilities, development of accident analysis system and implementation of enforcement and education.

(5) Institution and Capacity Development

- Capacity development for both institution and human resources of DPWT is essential for smooth and effective implementation of the Master Plan.

- Consequently, organizational reform involving establishment of a budget formulation unit, public transport management unit, laboratory and data base formulation unit as well as an urban transport research center is required.

- Human resource capacity is urgently needed to be developed in all fields covering top management and computer operation technique, to be achieved through on-the job training and foreign-assisted training programs.

(6) Legislation and Finance

- The Master Plan requires the sufficient support of legislation and finance. Without a sound legal basis, government agencies, including DPWT and Traffic Police, would lose authority to implement many measures proposed in the Master Plan.

- The sub-decrees and details of present legislation related to transport are recommended to be prepared and promulgated to ensure the transport system, including vehicle registration system, driver license system, among others.

- The fund for the implementation of the Plan is expected to be arranged through local fund, ODA and private participation. The local fund includes fuel tax and vehicle ownership tax, and private participation is highly recommended to be encouraged in all possible ways.

25.2 CONCLUSION; FEASIBILITY STUDY

(1) Overall

(i) Three (3) projects of the Master Plan, namely, bus service implementation, traffic control system and urban street improvement were selected as high-priority projects.

(ii) All these projects should be implemented in a synchronized manner because these projects are indispensable to each other for fully functioning.

(iii) When all three projects are implemented, it gives high economic return with B/C ratio of 1.73, EIRR of 24.6% and NPV of US$126 million (for discount rate of 12% per annum). The result of sensitivity analysis shows that even under a unfavorable condition, the projects yield high economic return.

Result of Sensitivity Analysis

Parameter	Base Case	Sensitivity Analysis	
		Case 1*	Case 2**
B/C Ratio	1.73	1.42	2.08
EIRR (%)	24.64	19.09	31.46
NVP (US$1,000)	126,171	79,012	170,514

* Case 1 : Cost 10% increase, benefit 10% decrease
** Case 2 : Cost 10% decrease, benefit 10% increase

(2) Bus Service Implementation

(i) The Project aims to introduce bus services, coexisting with the motodop, as the safe, comfortable, reliable and efficient means of transportation and to provide a public transport system which can cope with the future traffic demand and sustainability of urban development.

(ii) The Project is also envisaged to promote the tourism industry by providing a favorable urban environment, and to contribute to the vitalization of urban activities.

(iii) The Project is evaluated to be feasible from both technical and economical aspects with an economic internal rate of return of 21.9% and a benefit-cost ratio of 1.46.

However, the financial internal rate of return is only 1.6% and the benefit-cost ratio is only 0.8, suggesting negative viability in terms of finance.

(iv) Notwithstanding the unfavorable financial condition, the need for bus services is considered to be urgent and justifiable given the high public demand and necessity both at present and in the future as have been demonstrated by the Public Experiment.

It is, therefore, recommended that the Municipality of Phnom Penh shall implement bus services with the following system.

- Executing Agency; Phnom Penh Transport Authority (PPT) under the supervision of Department of Public Works and Transport (DPWT), Municipality of Phnom Penh (MPP).
- MPP Responsibility
  - Procurement of bus fleet.
  - Preparation of necessary land for bus facilities.
- PPT Responsibility
  - Operation of bus services.
  - Self-reliance management including operational, general and administrative expenses.

(v) The stage implementation of bus service operation is recommended in order to avoid the amount of initial investment becoming excessively large.

- Immediate Action Plan ; Expected bus passenger ; 22.900 persons/day
  No. of route ; 4
  No. of bus ; 75
- Short Term Plan ; Expected bus passenger ; 49.500 persons/day
  No. of route ; 9
  No. of bus ; 175

Under the MPP executing system, the profit-loss flow of PPT as the operation entity shows that the immediate action plan is profitable after 2nd Year and the short term plan after 7th Year of bus operation.

(vi) The environmental assessment shows the favorable impact on air pollution and public acceptance of the bus service.

(vii) Based on the above findings, the bus service operation is recommended to be urgently implemented, especially the Immediate Action Plan, under the condition that MPP is the executing agency and PPT as the self-reliance management and operation entity.

(3) Traffic Control System

(i) The Project aims to improve the disorderly traffic flow, increase traffic capacity and minimize traffic accidents at major intersections by providing (up-to-date) traffic signals and improving intersection geometries.

(ii) The Project is expected to promote smooth operation of bus services.

(iii) The Project is also anticipated to reduce noxious gases such as CO, CO_2, NO and NO_X as well as noise and vibration so that the urban environment can be improved and maintained favorably.

(iv) The Project is evaluated on technical, economic and environmental grounds to be feasible with a high economic internal rate of return of more than 10% and a benefit cost ratio more than 4.

(v) The urgency of project implementation is recognized from the present congestion degree at the proposed intersections.

(vi) The environmental assessment shows favorable impacts, especially on air quality level and reductions in noise and vibration.

(vii) Based on the above analysis, the early implementation of the project is recommended with the emphasis that the Project requires a relatively small cost and short time for implementation.

(4) Urban Street Improvement

(i) The Project aims to increase the road capacity, reduce the traffic cost and distribute properly the traffic on the functionally classified roads as well as providing a favorable environment, such as reduction of road dust, enhancement of community development and promotion of tourism industry.

(ii) The Project is also expected to contribute to the realization of the proposed bus service operation by providing high capacity roads for bus and paved roads for motodops which are preferably regulated not to travel on bus routes.

(iii) The Project is justified to be technically and economically feasible.

(iv) The urgency of project implementation is assessed to be very high because of the extent of severely damaged road surface with frequent flood, which is seriously hampering the socioeconomic activity of people.

(v) The environmental assessment indicates a favorable impact, given that only reconstruction of existing roads are planned requiring no new right of way acquisition for road construction.

(vi) It is however noted that there is a tendency of increasing traffic accidents as road surfaces are improved and running speed are increased.

Therefore, it is highly recommended that traffic management and safety measures shall be taken, prior to and simultaneously with the project implementation.

7) Based on the above findings, the Project is recommended to be implemented at the soonest possible time with the special caution on possibility of increasing traffic accidents and on the required countermeasures thereof.

25.3 RECOMMENDATIONS

1) Plan Authorization
   - The Transport Master Plan was formulated for the Phnom Penh Metropolitan Area to the target Year 2015, in order to solve various transport problems and to support sustainable urban development.

   - The Master Plan covers various areas including transport policy, legislation system and financing. It requires positive participation of wide variety of relevant agencies and firm determination of the decision makers.

   - Therefore, it is highly recommended that the Plan be authorized for smooth implementation of recommended projects and measures.

2) Plan Premise
   The Plan was drawn up on the basic premise of development policy established by the Municipality of Phnom Penh;

   - Urbanized Area
     Preserving landscape, cultural heritage and environment as well as easing concentration of population.

   - Suburban Area
     Achieving spatial distribution of urban activities, creating progressive regions with urban structures, high development potentiality with amenity and achieving the planned population growth.

   For this reason, the development policy shall be taken effect immediately prior to the implementation of the Plan.

3) Effective Organization
   - The Plan recommends the implementation of several projects and measures which require huge investments and implementation capacity and therefore effective organization for a systematic approach to implementation and processing is the vital key to the successful realization of the Plan.

   - For these purposes, the recommended organizational reform shall be undertaken so as to be suitable for the characteristics of the projects and measures.

4) Professional Skill
   - Effective organization with skillful administrative and technical staff is the absolute requirement to systematically implement the projects and measures. Such effective organization with skilled professionals shall be established under appropriate institution and legislation.
   - For these purposes, the recommended human resource capacity development programs shall be carried out prior to and during the implementation of the Plan.

5) Fund Preparation
   - The fund required for implementation of the projects and measures is recommended to be prepared through project categorization suitable to the fund characteristics. An example of categorization is;

- Local Finance Type
- Official Development Aid Type
- Government/Private Partner Type
- Private Participation Type

- Attraction of private participation is recommended to be encouraged to execute projects and measures for which high commercial returns are expected.

6) Road Improvement with Land Development
   - Road improvement, which leads to land development by private sector, shall be implemented prior to, or simultaneously with land development so that systematic and controlled land development can be achieved.

   - Some roads with high potentiality for land development are recommended to be improved by private participation interested in land development.

7) On-schedule Implementation
   - Project and measures were composed to help and support each other, and their implementation timings were examined in such a way that they work most efficiently.

   - The Plan should be implemented according to their schedule in order to bring the optimum benefits.

8) Traffic Education
   - The education on traffic rules, regulation, driving manner is an essential element of the Plan, and its importance cannot be neglected. It should be clearly understood that road improvement tends to increase the number and severity of traffic accidents.

   - Prior to, during and after the implementation of any project and measure, the public shall be properly advised that the duty of the Government is to educate the public, and the duty of the public is to control themselves.

9) Early Implementation of Feasibility Study Projects
   - Three (3) projects, namely bus service implementation, traffic control system and urban street improvement, are rationalized to be feasible from technical, economical, financial and environmental aspects as well as the institutional and human capacity viewpoints.

   - The Projects are, therefore, recommended to be implemented immediately with the special attention mentioned in the conclusion.
     - Bus Service Implementation ; Execution by the Government implementation of immediate action plan
     - Traffic Control System ; Installation of up-to-date traffic signal
     - Urban Street Improvement ; Traffic safety measures against possible increase of traffic accident.