7.3 Off-Street Parking Facilities

Design standards for parking facilities in India and Japan are summarized below. Various features such as car size and minimum turning radius affect these elements. The Indian standards are basically applied except for design car length, where the Japanese standard for length of 5.8m was adopted.

DESIGN STANDARDS FOR PARKING FACILITIES

Item	Japan	India
design car	5.8 x 2.0	5.0 x 2.5 (Indian) 6.5 x 2.5 (large)
head room	2.3	2.5
min.turning radius	5.0	6.5
min.width of circulation	3.5 (one way) 5.5 (two way) 6.7	6.0 (common) 90 deg. 7.6 (large) 90 deg. 5.5 (driveway) 3.0 (ramp) 5.5 (access ramp)
entrance ramp grade	below 12.5%	12.5%
exit ramp grade		10.0%
anti fire block	every 1,500 sq.m	
ventilation	10 air changes per hour	

7.3.1 B.B.D. Bag North Parking Facility

In Chapter 5.3.1, three alternatives were put forward for this parking facility. Alternative A was found to provide less than the number of parking spaces required (732 min.) unless the facility was extended slightly under B.B.D. Bag North (Alternative C). Alternative B was rejected because of the adverse effects it would have on the adjacent Writers Building. Hence preliminary designs and costing have been prepared for an underground parking facility with two underground levels and which extends approximately 5m into the area beneath the B.B.D. Bag North road. The total capacity is 794 cars. The ground level area is currently used as a parking facility and will be extended at ground level to match the underground facility. Two entrance/exits will be provided on B.B.D. Bag North Rd, an entrance on Council House St and an exit on Old Court House St.

(1) Parking Characteristics

In line with the present parking characteristics of Sector 9 of the Study Area, and described in Chapters 4 and 5, the following assumptions have been made.

Capacity ..... 794 units
Average parking time ..... 120 min
T/O 4.5
Total number of units using the facility 3,840

These conditions are illustrated in Fig. 7.3.1.

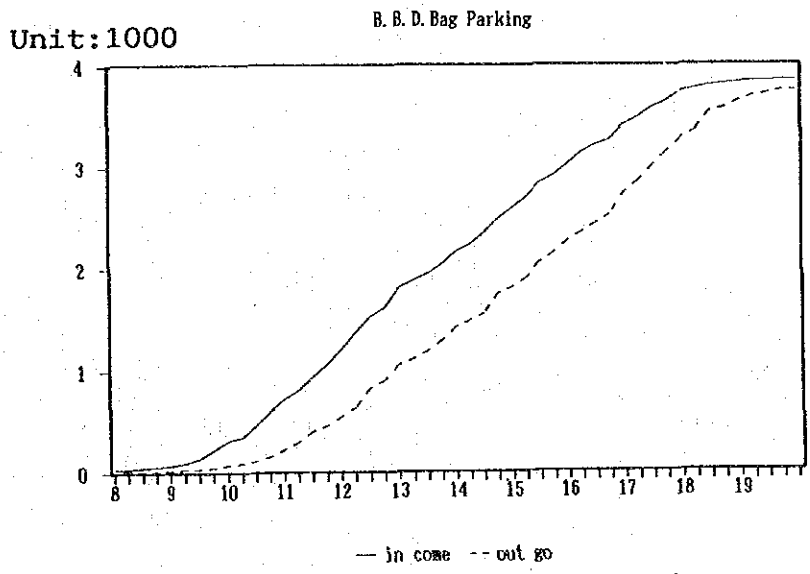


Figure 7.3.1 Parking Characteristics of B.B.D.Bag

(2) Structure plan

The following parameters have been adopted for the structure;

- Target vehicles ..... Passenger vehicles (excluding buses)
- Parking dimensions .. 2.5m wide x 5.0m long
- Ceiling height 2.5m
- Lane width ..... Lanes opening on to the parking space 7.0m
  Lanes not opening on to the parking space 6.0m
- Ramp gradient 8%
- Live load ..... 550kg/m^2

A reinforced concrete structure will be used for the walls, slabs, girders and columns. The foundations will be direct foundations. The mechanical services rooms (pumping systems, ventilation, etc) will all have structural walls.

Before excavation, a diaphragm wall will be constructed along the peripheral of the project site and temporary strutting and beams will be arranged. Upon completion of excavation, construction of the structure will be carried out. Facilities will be installed upon completion of the construction. (Ref. Figure 7.3.2)

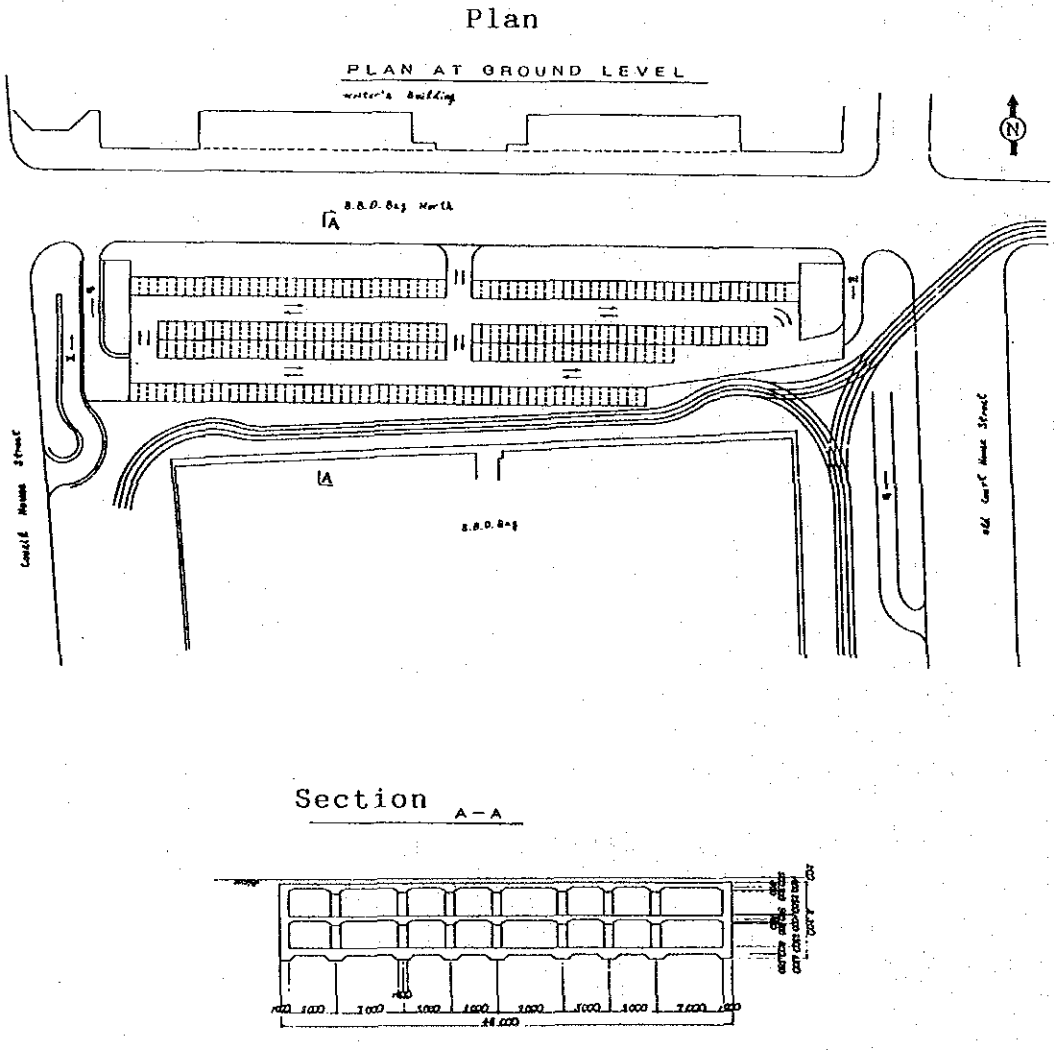


Figure 7.3.2 B.B.D.Bag North Parking

7.3.2 Esplanade Parking Facility

As described in Chapter 5.3.2, two alternative parking facilities have been considered at this location. The alternatives utilize space either above or below the existing tram terminus, but not the ground level area on which the existing terminus operates. Since the tram terminus occupies quite a large area, the necessary parking demand can be met with a single level facility. Gates, used for both exit and entrance will be located on Esplanade Row East and Rani Rashmori Ave.

(1) Parking Characteristics

In line with the present parking characteristics of Sector 8 of the Study Area, and described in Chapters 4 and 5, the following assumptions have been made.

Capacity ..... 799 units (above ground)
759 units (underground)
Average parking time ..... 99 min
T/O 6.1
Total number of units using the facility
..... 4,570 (ground level)
4,453 (underground)

These conditions are illustrated in Fig. 7.3.3.

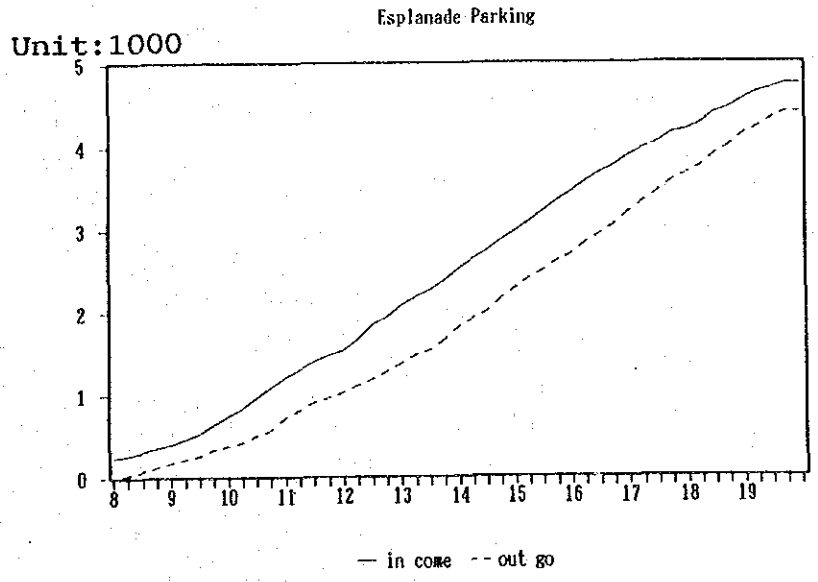


Figure 7.3.3 Parking Characteristics of Esplanade

(2) Structure plan

The structure plan is based on the same conditions as for the B.B.Bag North Parking facility. (Ref. Figure 7.3.4)

a. Above Ground proposal

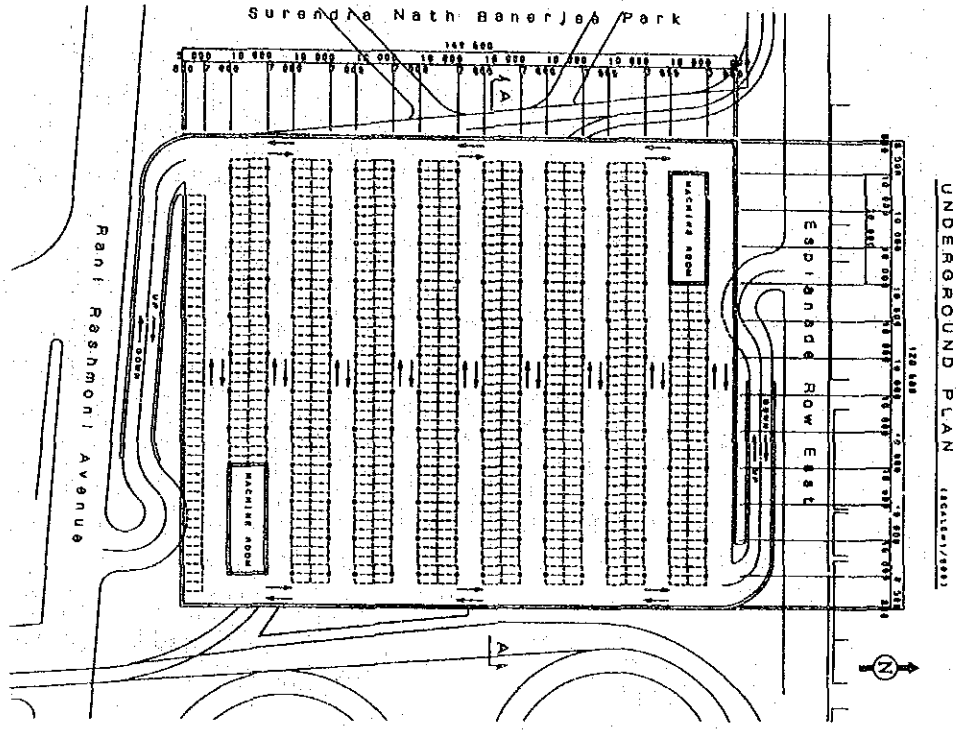
The structure will comprise a reinforced concrete slab, girders and columns. The foundations will be cast-in-place reinforced concrete piles.

The construction will commence with the removal of the trams, execution of the pile works and followed by the main structure.

b. Underground proposal

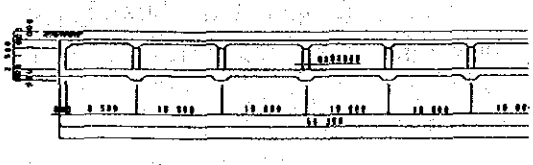
The structure type and excavation method will be the same as those adopted for the B.B.D. Bag North Parking facility.

Plan



Section

Underground proposal



Above ground proposal

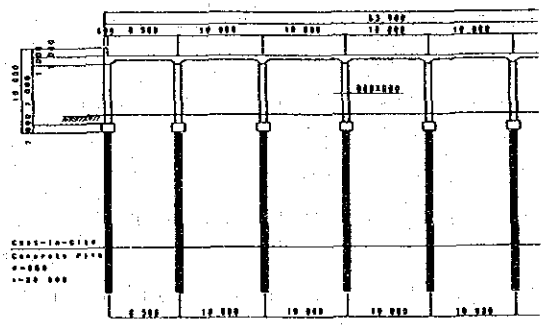


Figure 7.3.4 Esplanade Parking

7.4 Other Transport Infrastructure Improvements

7.4.1 Overhead Pedestrian Plaza

The volume of pedestrians using the east-west axis in downtown Calcutta from Sealdah and Howrah Railway Stations to the CBD is very high. Pedestrian counts were carried out as part of the Study and the results showed that volumes decreased with distance from Sealdah Station and that the flow was strongly directional. The highest volume was 152,000 in 12 hours on B.B. Ganguly Street near Sealdah Station.

The Study concluded that pedestrian numbers were sufficient to justify construction of an elevated pedestrian plaza between Sealdah Station and Chittaranjan Avenue only.

Extension of the facility to B.B.D. Bag (Phase-II), is likely to become necessary after completion of the Metro but further study of the increase in pedestrian volumes is required. Connection to the approach to Howrah Bridge could also be considered as part of a future pedestrian facility network.

Pedestrians in Calcutta suffer from insufficient sidewalk widths, frequent obstructions, poorly paved surfaces and inadequate facilities at road crossings. The proposed facility will help to improve the safety and convenience for pedestrians in the core area of Calcutta.

7.4.2 Concrete Pavements

The Study Team was provided with a list of seven road sections totaling 88 lane.kilometers for consideration as roads where high maintenance costs could perhaps be reduced by the addition of a concrete surface.

A preliminary technical review of the road sections indicated that the high maintenance costs are most likely related to high moisture levels in the sub-grade. Improvements in pavement drainage would be difficult to achieve and since concrete roads are better able to tolerate higher foundation moisture levels and variations in the water table they should, if properly designed and constructed, be able to provide a relatively maintenance free pavement even under the conditions experienced in Calcutta.

An economic comparison between concrete and asphalt confirmed that concrete roads, despite their higher initial cost, had lower overall costs after maintenance costs for the conventional asphalt pavements were considered over the life of the concrete road.

However, concrete roads have the disadvantages of longer construction times, and major services must be relocated in advance. Existing and proposed utilities must be carefully identified before deciding to proceed with any concreting proposals, since the economic comparison did not include the cost of any utility relocations prior to concreting.

7.4.3 Traffic Signal Improvements

Most intersections in Calcutta are operated under manual traffic control by policemen. This method is inefficient and significant improvements in traffic and pedestrian flow could be achieved by implementation of a traffic signalization plan based on the road network system previously described.

The traffic signalization proposal includes a combination of the three basic methods of signal control, namely, area traffic control (ATC) in the CBD, arterial intersection control on the major arterials and isolated intersection control for other intersections where signals are necessary. The proposed system, shown on Figure 7.4.1, would include;

- 33 intersections for the ATC system within the CBD.
- 47 intersections for the Arterial Intersection Control System on A.J.C Bose Rd and Chowringhee Rd.
- 36 intersections for the Isolated Intersection Control System.

If the proposal cannot be implemented in total as one project, the following order of priority is recommended:

Priority 1: Arterial Intersection Control,
Priority 2: ATC System for the CBD Area,
Priority 3: Isolated Control for Other Intersections.

A traffic education program should also be carried out so that maximum benefits are achieved from the new facilities and operations.

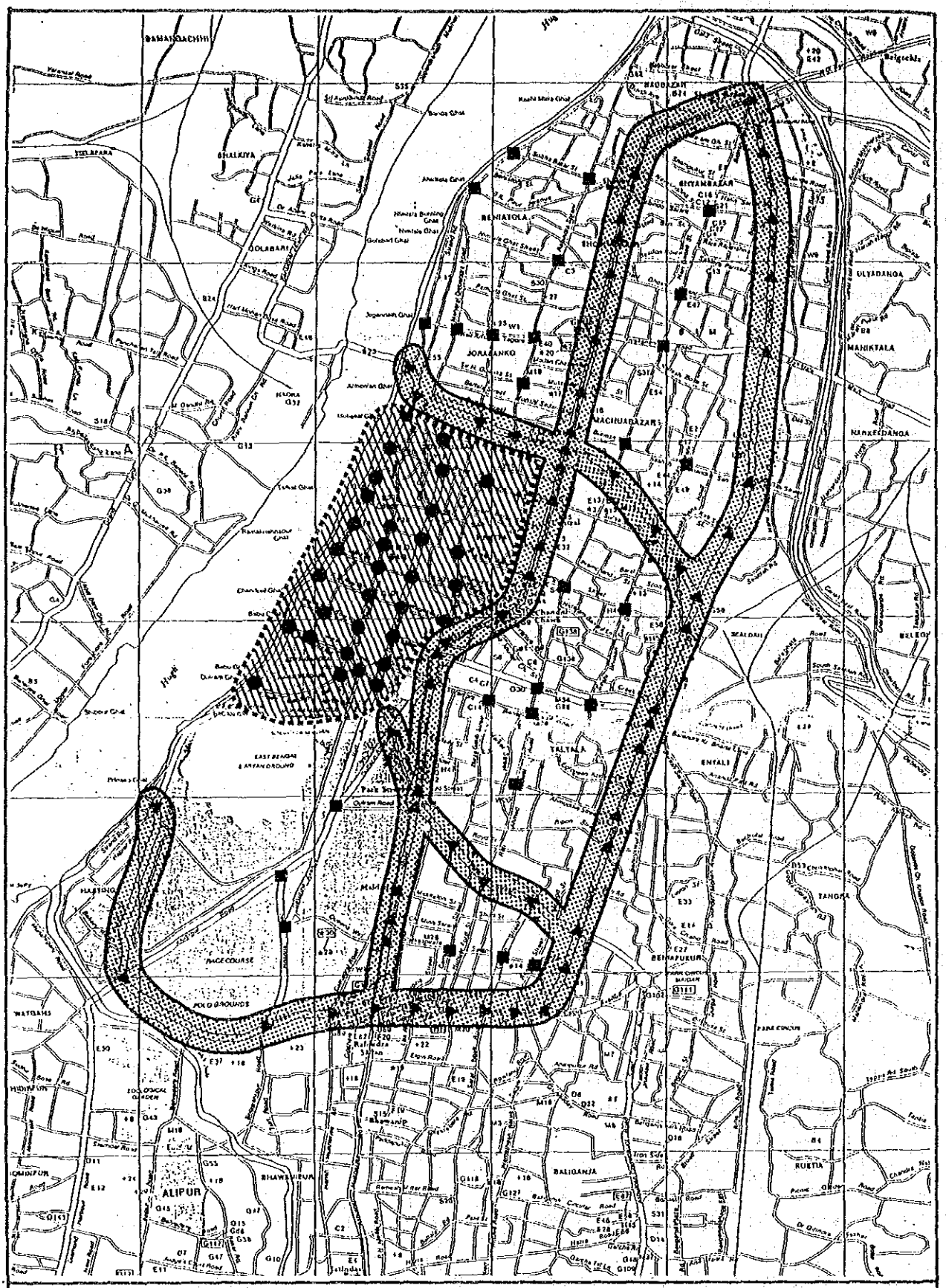


Figure 7.4.1 Proposed Traffic Signalization Plan

Legend

Area Traffic Control

Arterial Control

Isolated Control

CHAPTER 8 COST ESTIMATION

(1) Project Costs

Construction cost estimates were made for each sub-project based on the quantities estimated in the preliminary design, the unit prices for work items and the estimated indirect cost and land acquisition cost. An allowance for engineering services and contingencies was then added to give the total project cost.

The results for all flyovers, at grade improvements and parking structures are summarized in Table 8.1.1. This table also shows the estimated economic cost of each sub-project.

Table 8.1.1(a) Summary of Cost of Flyovers

Item	unit	INTERSECTION No.					
		NO.1	NO.2	NO.3	NO.4	NO.5	NO.6
Total length	m	636.0	838.0	575.0	558.0	765.0	880.0
Flyover Length	m	437.0	648.0	379.0	355.0	580.0	671.0
Approach length	m	199.0	190.0	196.0	203.0	185.0	209.0
No. of Lanes	No.	4.0	4.0	4.0	3.0	2.0	2.0
Total Financial Cost	Mill.Rs	230.7	433.3	172.5	157.6	153.5	184.4
Total Economic Cost	Mill.Rs	208.1	390.9	155.3	142.7	138.2	165.9

Item	unit	INTERSECTION No.				
		NO.5&6	NO.7	NO.8	NO.9	NO.10
Total length	m	2,290.0	704.0	568.0	633.0	474.0
Flyover Length	m	1,987.0	492.0	356.0	430.0	277.0
Approach length	m	303.0	212.0	212.0	203.0	197.0
No. of Lanes	No.	3.0	4.0	4.0	4.0	2.0
Total Financial Cost	Mill.Rs	675.5	252.7	160.7	174.2	91.1
Total Economic Cost	Mill.Rs	609.1	229.0	143.9	156.0	82.3

Table 8.1.1(b) Summary of Cost of At Grade Improvements

Item	unit	Intersection No.						
		NO. 2	NO. 3	NO. 4	NO. 7	NO. 8(3-L)	NO. 8(4-L)	NO. 10
Total Pavement	SQM	24, 500. 00	11, 940. 00	9, 410. 00	11, 050. 00	19, 800. 00	23, 000. 00	9, 100. 00
New Pavement	SQM	3, 000. 00	140. 00	110. 00	50. 00	9, 300. 00	12, 500. 00	0. 00
Reconstructed Pavement	SQM	21, 500. 00	11, 800. 00	9, 300. 00	11, 000. 00	10, 500. 00	10, 500. 00	9, 100. 00
Total Financial Cost	Mill. Rs	175. 5	21. 6	31. 0	20. 3	* 58. 0	* 70. 3	29. 2
Total Economic Cost	Mill. Rs	140. 6	15. 8	25. 8	14. 9	46. 7	56. 9	24. 1

* Cost would be reduced by about 17.5 Mill. Rs if tram track relocation is not required.

Table 8.1.1(c) Summary of Cost of Parking Structures

Item	unit	Esplanade		BBD Bag
		Over-head	Underground	Underground
Capacity	Cars	799. 0	759. 0	794. 0
Total Financial Cost	Mill. Rs	193. 5	557. 5	587. 9
Total Economic Cost	Mill. Rs	175. 1	517. 3	544. 6

Table 8.1.2 Cost of Underground Parking Structure at BBD Bag

BBD underground parking

Item	Unit	Quan-tity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
STRUCTURE				
Concrete Piers	CUM	25, 718	1, 627	41, 839, 071
Steel forming	SQM	28, 748	139	3, 982, 460
Reinforcing	TON	2, 572	14, 891	38, 299, 266
Excavation	CUM	89, 459	86	7, 723, 890
Hand Excavation	CUM	5, 000	106	531, 300
Backfill	CUM	4, 972	18	89, 745
Piles	LM	0	2, 186	0
Diaphragm wall	SQM	4, 902	4, 500	22, 059, 000
Strutting	TON	1, 694	17, 249	29, 219, 637
Electrical Services	SQM	19, 886	1. 000	19, 886. 000
Mechanical Services	SQM	19, 886	4, 500	89, 487. 000
Finishing	SQM	19, 886	4, 500	89, 487. 000
TRAM TRACK RELOCATION	LM	0	10, 000	0
MISCELLANEOUS	%	10		34, 260, 437
Total Direct Cost				376, 864, 806
INDIRECT COST	%	30		113, 059, 442
Construction Cost				489, 924, 248
ENGINEERING SERVICES	%	10		48, 992, 425
CONTINGENCY	%	10		48, 992, 425
Project Cost				587, 909, 097

Table 8.1.3 Cost of At Grade Improvements at Intersection No.2

Intersection No. 2 (At-Grade)

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
Pavement				
Asphalt Pavement A-1	SQM	3,000	998	2,993,580
Asphalt Pavement A-2	SQM	21,500	742	15,946,550
OTHERS				
TRAFFIC SIGNALS	SET	2	1,000,000	2,000,000
TRAM TRACK RELOCATION	LM	600	10,000	6,000,000
LIGHTING	LM	400	3,000	1,200,000
Miscellaneous	%	25		7,035,033
Total Direct Cost				35,175,163
INDIRECT COST	%	30		10,552,549
LAND ACQUISITION	SQM	750	14,000	10,500,000
-REBUILD/COMPENSATION	ITEM	-	-	90,000,000
Construction Cost				146,227,711
ENGINEERING SERVICES	%	10		14,622,771
CONTINGENCY	%	10		14,622,771
Project Cost				175,473,254

Table 8.1.4 Cost of Overhead Parking Structure at Esplanade

Esplanade Overhead Parking

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
STRUCTURE				
Concrete Piers	CUM	13,941	1,627	22,679,776
Steel forming	SQM	23,514	139	3,257,394
Reinforcing	TON	2,091	14,891	31,136,767
Excavation	CUM	3,848	86	332,236
Backfill	CUM	3,272	18	59,060
Piles	LM	5,400	2,186	11,801,754
Diaphragm wall	SQM	0	4,500	0
Strutting	TON	0	17,249	0
Electrical Services	SQM	5,000	1,000	5,000,000
Mechanical Services	SQM	2,000	4,500	9,000,000
Finishing	SQM	5,000	4,500	22,500,000
TRAM TRACK RELOCATION	LM	700	10,000	7,000,000
MISCELLANEOUS	%	10		11,276,699
Total Direct Cost				124,043,687
INDIRECT COST	%	30		37,213,106
Construction Cost				161,256,793
ENGINEERING SERVICES	%	10		16,125,679
CONTINGENCY	%	10		16,125,679
Project Cost				193,508,152

CHAPTER 9 FEASIBILITY ASSESSMENT AND EVALUATION

9.1 Technical Evaluation of Intersection Improvements

9.1.1 Alternative I

Future traffic volumes at proposed intersections are predicted to exceed their capacity at-grade. From the traffic simulation, the proposed improvement in the form of flyover construction at these intersections will be very effective in mitigating the expected future traffic congestion and delays.

If the proposed flyovers at Intersections No.5 and 6 are connected, it is possible to design it as a 3 lane roadway. The operation of such a flyover would designate the central lane as a reversible lane, assigned to the heavier traffic stream according to the flow conditions. To operate it effectively and safely, overhead signs should be installed showing the current operational directions of these lanes. Safety cones should also be placed along the lane markings for the reversible lane. The public should be well informed of such traffic operation through the mass media.

If such an operation can be carried out safely and effectively, considerable improvement to the intersection capacities can be expected even with a 3 lane roadway. The congestion at those minor intersections between No.5 and No.6 will also decrease, since they will be loaded only with local traffic.

At Intersection No.1 which fronts a religious property, the present deficiency in traffic capacity will be improved by the proposed flyover. Traffic flow for the north-south stream will be substantially improved. Lenin Sarani and S.N. Banerjee, a pair of one-way operation roads at this intersection, will also acquire higher capacities, since conflicts with the north-south through traffic are greatly reduced.

A flyover at Intersection No.2 would have to be constructed on top of the Metro box. Such a structure would not only be costly but also difficult to construct. A feasible alternative solution is to improve the intersection at-grade. This would involve widening of the roadway, and sidewalks would also be widened to accommodate piers and stairways for any pedestrian bridges to be installed in the future.

At Intersection No.8, the flyover will reduce traffic congestion by separating the north-south traffic from the east-west traffic stream at the intersection complex.

9.1.2 Alternative II

In addition to the flyovers proposed for Alternative I, Alternative II also includes flyovers proposed at Intersections No.4, No.7 and No.10. An additional sub-option considered in Alternative II was the construction of a flyover on Lock Gate Road above the railway line (Intersection No.9) to replace flyovers at Intersections No.4 and No.7.

Due to the limited right-of-way width at the five-legged Intersection No.4, the proposed flyover must be a 3-lane roadway. This proposal will improve the traffic flow at this intersection to a great extent. The operation of such a flyover would be the same as the continuous flyover proposed at Intersections No.5 and No.6.

At Intersection No.7, the merit of having a flyover over the narrow roadway is to increase the intersection capacity in handling the north-south through traffic.

In the case of improving Lock Gate Road (Intersection No.9) by constructing a flyover over the railway tracks, traffic coming from B.T. Road in the north will divide between Lock Gate Road and Shyambazar. With a reduced volume of traffic coming to APC Roy Road, Intersection No.4 will be able to handle the demand if at-grade improvements are carried out to this five-legged intersection, such as removal of the monument to streamline the traffic flows. The flyover at Lock Gate Road will therefore have similar effects as having flyovers at Intersections No.4 and No.7. Prior to opening the Lock Gate flyover however, improvements to Kasipur Road, including provision of a connection to the southern end of Lock Gate Road, and improvements at the Lock Gate Road/Barakpur Road intersection would be necessary.

At Intersection No.10, the right-of-way widths both in the north-south and east-west directions are not sufficient to accommodate a 3 or 4-lane flyover. Considering the high potential demand for east-west traffic with improved access

to the Eastern Metropolitan Bypass, an east-west 2-lane flyover will be able to improve future traffic conditions. The operation of this flyover will be reversible one-way according to the time of day as applied to the full length of Park Street.

9.1.3 Alternative III

Alternative III examines the feasibility of constructing flyovers at all the 10 study intersections.

Simulation has shown that additional flyovers at Intersections No. 3, No.4 and No.7 will only produce marginal benefits above the plan having flyovers at Intersections No.1, 2, 5, 6, 8, 9 and 10. The construction of flyovers at Intersections No.4 and No.7 at the same time as a flyover at Intersection No.9 has been shown to be unnecessary before 1998.

At Intersection No.3, the future traffic volume up to 1998 will not exceed the capacity of an at-grade intersection. The construction of a flyover here is therefore not necessary up to 1998.

9.2 Economic Evaluation

9.2.1 Economic Analysis of Intersection Improvements

An economic analysis has been carried out to determine the economic feasibility of the alternative intersection improvement plans. The economic indicators used for this analysis are:

1. IRR (internal rate of return)
2. B/C Ratio (benefit-cost ratio) and
3. NPV (net present value).

(1) Alternative I

The options of having independent flyovers against a continuous flyover at Intersections No.5 and No.6 and the options of having a flyover at Intersection No.2 against at-grade im provements are evaluated using the computed economic indicators below:

Table 9.2.1 Comparison of Alternative I Options

No.	Option (Flyover Nos)	Project Economic Cost (in Rs.mill)	Benefit (in Rs. mill)	IRR (%)	B/C	NPV (in Rs. mill)
I-1	No.1, 2, 5, 6, 8	1,188	1,258	12.9	1.1	70
I-2	No.1, 2, 5-6, 8	1,535	1,491	11.5	1.0	-44
I-3	No.1, 2(G), 5-6, 8	1,292	1,462	14.0	1.1	170

Note: 1. No.5-6 : No.5,No.6 continuous flyover
2. No.2(G): No.2 at grade improvement
3. All Options include at-grade improvements at Intersections No.3, No.4, No.7 and No.10

Comparing options Alt I-1 and Alt I-2, the economic indictors of Alt I-2 are slightly lower than those of Alt I-1. This is mainly due to the high costs of constructing a continuous flyover at No.5 and No.6.

Comparing options Alt I-2 with Alt I-3, however, Alt I-3 has higher economic indicators. These indicators are also higher than those for Alt-1, indicating that construction cost savings from having at-grade improvements at Intersection No.2 are more than able to offset the additional cost of having a continuous flyover at No.5 and No.6.

(2) Alternative II

For this alternative plan, the additional benefit of adding a flyover at Intersection No.10 to Alternative I and whether a flyover at Intersection No.9 is more beneficial than flyovers at No.4 and No.7 were analyzed. The result of the analysis are shown in Table 9.2.2.

Table 9.2.2 Comparison of Alternative II Options

No.	Option (Flyover Nos)	Project Economic Cost (in Rs.mill)	Benefit (in Rs. mill)	IRR (%)	B/C	NPV (in Rs. mill)
II-1	As in I-2, and No.4,7,3(G)	1,809	1,871	12.6	1.0	62
II-2	As in I-2, and No.4,7,10,3(G)	1,866	2,132	14.2	1.1	266
II-3	As in I-2, and No.9,10, 3(G),4(G),7(G)	1,723	2,204	16.0	1.3	481
II-4	As in I-3, and No.9,10, 3(G),4(G),7(G)	1,474	2,176	18.4	1.5	702

Note 1. All Alt.II Options include No.5-6 continuous flyover.
2. No.2 at-grade improvements included in Option II-4.
3. 3(G) = at-grade improvements at Intersection No.3 etc.

Comparing options Alt II-1 and Alt II-2, Alt II-2 generates higher economic indicators, implying that more benefits can be obtained from having the additional flyover at Intersec-

tion No.10 due to its relatively low cost of construction.

Comparing the economic indicators of Alt II-2 and Alt II-3, those of Alt II-3 are higher showing that construction of the flyover at Intersection No.9 will be more beneficial than construction of flyovers at Intersections No.4 and No.7. This is because of the lower cost of one flyover at Intersection No.9 than the total cost of two flyovers at Intersections No.4 and No.7, with the effects on improving traffic flow about the same.

Alt II-4 consists of flyover proposals as in Alt I-3 (No.1, No.2 at grade improvement, No.5 and No.6 continuous, No.8), and an additional two flyovers at Intersections No.9 and No.10. The economic indicators of this option are the highest among the four options. This option thus is the most recommendable plan.

(3) Alternative III

Intersection improvements at all the 10 study intersections are included in this alternative. The results are shown in Table 9.2.3.

Table 9.2.3 Comparison of Alternative III

No.	Option (Flyover Nos)	Project Economic Cost (in Rs.mill)	Benefit (in Rs. mill)	IRR (%)	B/C	NPV (in Rs. mill)
III-1	As in II-3, and No.3, 4, 7	2,124	2,212	12.7	1.0	88

The economic indicators of this alternative plan are not as high as those in Alt II-2, Alt II-3 or Alt II-4. This is mainly due to the high construction cost of additional flyovers while the increased benefits are not substantial.

9.2.2 Economic Analysis of Parking Facilities

A simplified economic evaluation of the parking structures has been carried out to assist in the project evaluation. The principle used for the evaluation is similar to that adopted for the flyovers, but the benefits will accrue to road users in the vicinity of the parking structures. By removing parked vehicles and vehicles looking for parking spaces from the streets in the central area, the road capacity will be increased while congestion and travel times will be reduced. The estimated reduction in travel times can be converted into time savings using the parameters adopted in Chapter 9.2.1.

The traffic flow on the central area roads could in theory be simulated to take into account the attraction of vehicles to the improved street system. Insufficient data was available to carry out such a simulation so the effects of a possible increase in traffic volume due to attraction from other areas have not been included. The travel time savings have been based on existing traffic volumes and assumed average travel speeds. From the travel speed survey described in Chapter 4 an average speed of 10 km/hr has been adopted as representative under existing conditions in conjested areas. After construction of the carparks, it has been assumed that travel speeds will increase to an average of about 13 km/hr.

Other benefits such as improved intersection capacity, fewer accidents, improved flow of pedestrians will accrue but are difficult to quantify and have not been included in the economic benefits.

The expected time savings due to the assumed difference in travel speeds are estimated in Table 9.2.4 below.

Table 9.2.4 Estimated Time Savings

B.B.D.Bag Parking

No.	name of streets	length(m)	T(min.)	volume	v. min
1	B.B.D. Bag North	230	0.28	18,000	5,040
2	B.B.D. Bag East	230	0.28	40,000	11,200
3	N.S.Rd.	490	0.60	30,000	18,000
4	R.N. Mukerjee	270	0.32	25,000	8,000
5	B.B.D. Bag South	510	0.61	25,000	15,250
6	Brabourne	200	0.24	40,000	9,600
	total				67,090

Esplanade Parking

No.	name of streets	length(m)	T(min.)	volume	v. min
7	Esplanade Row East	280	0.34	13,900	4,726
8	Esplanade Row West	370	0.44	10,000	4,400
9	Govt.Palace East	560	0.67	44,000	29,480
10	Govt.Palace West	560	0.67	30,000	20,100
11	A.S.Roy & G.P.N.	580	0.70	20,000	14,000
	total				72,706

These time savings were converted to benefits using the time values adopted elsewhere, and the economic indicators have been calculated and are shown below;

Table 9.2.5 Economic Indicators for Carpark Structures

Carpark Structure	Economic Cost (mill.Rs)	Benefits (mill.Rs)	IRR (%)	B/C	NPV (mill.Rs)
Esplanade (overhead)	183	157	9.8	0.9	-26
Esplanade (underground)	556	144	-	0.3	-412
B.B.D. Bag (underground)	550	120	-	0.2	-429

The underground parking structures in particular are clearly not economically feasible. The overhead parking structure at the Esplanade is more promising but still has a B/C ratio of less than one (1) and a NPV less than zero (0), so in purely economic terms this structure is also not feasible.

9.2.3 Economic Analysis of Pedestrian Facilities

The construction of the first phase of the pedestrian plaza will result in benefits for pedestrians in terms of safety, convenience and reduced travel times. At the same time, vehicular traffic will also benefit from increased travel speeds and improved safety. Safety and convenience cannot easily be quantified but an economic analysis has been carried out considering the time savings for vehicular traffic and pedestrians.

In the absence of sufficient data on the likely increase in traffic volumes in the eastern section of B.B. Ganguly Street, it was not possible to carry out a traffic simulation. It has been assumed that the average speed of vehicles on B.B. Ganguly Street will increase from 10 to 13 km/hr and that the volume will increase to 20,000 vehicles per day after completing the pedestrian plaza and the roadworks at the eastern end, it has also been assumed that pedestrian travel times will be reduced by about 10% on average.

Using this assumptions, an economic evaluation has been carried out. The results are shown in Table 9.2.6 below.

Table 9.2.6 Economic Evaluation of Overhead Pedestrian Plaza (Phase I)

Project	Economic Cost (Mill.Rs)	Benefits (Mill.Rs)	IRR (%)	B/C	NPV (Mill.Rs)
Overhead Pedestrian Plaza Phase I 1.5 km	170	136	8.7	0.8	-34

On the basis of this evaluation, the pedestrian plaza is not economically feasible. However, Phase I has been recommended on the basis of safety and convenience for pedestrians as described in Chapter 9.5.3.

9.3 Parking Facilities Evaluation

9.3.1 Basic Conditions

A financial analysis of the proposed parking facilities has been carried out assuming that the facilities are financed, constructed and operated by one organization with independent accounting procedures. The following conditions and assumptions have been adopted:

Item	Esplanade		BBD.BAG
	Above Grd. (Case 1)	Under Grd. (Case 2)	Under Ground (Case 3)
Parking Capacity	779	759	784
Turnover Rate	6.1	6.1	4.8
Parking/day	4,552	4,630	3,763
Period of Const.	2 years	3 years	4 years
Project Life	25 years	25 years	25 years
Operation & Maintenance Cost *	1.5%	3.0%	3.0%
Inflation	3%/yr	3%/yr	3%/yr

*: Percent of total construction cost.

The parking charges in Calcutta vary between 1-2 Rupee per hour. In order to investigate the financial feasibility of the proposed carpark structures, the future parking charges are assumed as follows:

Period	Charge Per Hour
1996-2000	2.5 Rupee
2001-2005	3.0 Rupee
2006-2010	4.0 Rupee
2011-2015	5.5 Rupee
2016 -	7.5 Rupee

The project costs are estimated and given in the previous chapter. Project costs for the proposed parking facilities do not include land costs.

9.3.2 Results of Financial Evaluation

(1) Case 1: Above Ground Parking Facility at Esplanade

For the proposed above ground parking facility at Esplanade, a cashflow analysis shows that if 50% of the total construction cost is funded by a grant, while the remaining 50% is financed by a loan at an interest rate of 8%, the facility will be financially feasible with a profit showing on the 21st year after the facility is operational.

If the grant cannot be secured during the 2 years of the construction period, a subsidy of an equivalent sum spread over 20 years would also render the project financially feasible even with a loan repayment starting from the operational year. The facility will generate a profit on the 20th year after it is opened. (Table 9.3.1)

(2) Case 2: Under Ground Parking Facility at Esplanade

A similar cashflow analysis shows that parking facility proposed as underground structure at Esplanade is not financially viable even with a grant as high as 70%. The project cost is 2.9 times higher than Case 1. The annual revenue from parking alone would be too low to even cover the operating and maintenance costs of such a structure.

For the underground proposal at Esplanade to be financially feasible, a 50% grant of the total project cost during the construction period, together with a yearly subsidy of 30 million rupees for the project life would be necessary (Table 9.3.2).

An above ground parking facility is therefore recommended at Esplanade. To further increase the revenue of such an urban infrastructure investment, it is also recommended that incorporation of other commercial functions be considered. As the proposed site is very near to the shopping district of Calcutta, incorporating some commercial space into the parking building would generate additional revenues and render

the project more feasible. Such a project, however, could result in the loss of part of the recreational park adjacent the proposed site.

(3) Under Ground Parking Facility at BBD. Bag

The underground parking facility proposed for BBD. Bag is not feasible even with a large (70%) grant. The project would therefore require further yearly subsidies to cover losses due to the high operational and maintenance costs. Initial computation indicates that a 50% grant for the project cost and a yearly subsidy of 35 million rupees for the entire project life would be required to render the facility feasible to operate.

To implement this facility with less burden to the government, a possible solution would be to cross-subsidize this facility from profit made in the Esplanade facility, assuming more revenues are generated at the latter from additional commercial space and are sufficient to cover operational deficits at the BBD. Bag Facility.

(4) Conclusions

* Underground car parks in Calcutta are not financially feasible projects as long as revenues are confined to parking charges only.

* The above-ground car park facility is financially feasible only with a grant (up to 50% of project cost), either in the form of a yearly subsidy or a lump sum.

* To improve the financial feasibility of the proposed car parking facilities, other forms of revenue generators must be considered, such as incorporating commercial rental spaces into the facilities.

Table 9.3.1 Cashflow Analysis for Parking Facility Case 1

Case: Esplanade Above Ground

Year	Revenue	Operation/ Maintenance Outlays	Construc Cost	Net Revenue	Loan Taken	Grant/ Subsidy	Total Inflow	Loan Repay- ment	Interest	Total Outflow	Balance At Year	Cumulative Balance
1994			96760	-96760	48,380	4,838	-43542	0	3,870	3,870	-47412	-47412
1995			96760	-96760	48,380	4,838	-43542	0	7,741	7,741	-51283	-98695
1996	8,672	2,419		6253		4,838	11091	4,838	7,741	12,579	-1487	-100183
1997	8,672	2,492		6181		4,838	11019	4,838	7,354	12,192	-1173	-101356
1998	8,672	2,566		6106		4,838	10944	4,838	6,967	11,805	-861	-102216
1999	8,672	2,643		6029		4,838	10867	4,838	6,580	11,418	-551	-102767
2000	8,672	2,723		5950		4,838	10788	4,838	6,193	11,031	-243	-103010
2001	10,407	2,804		7603		4,838	12441	4,838	5,806	10,644	1797	-101213
2002	10,407	2,888		7518		4,838	12356	4,838	5,419	10,257	2100	-99113
2003	10,407	2,975		7432		4,838	12270	4,838	5,032	9,870	2400	-96712
2004	10,407	3,064		7343		4,838	12181	4,838	4,644	9,482	2698	-94014
2005	10,407	3,156		7251		4,838	12089	4,838	4,257	9,095	2993	-91021
2006	13,876	3,251		10625		4,838	15463	4,838	3,870	8,708	6755	-84266
2007	13,876	3,348		10527		4,838	15365	4,838	3,483	8,321	7044	-77222
2008	13,876	3,449		10427		4,838	15265	4,838	3,096	7,934	7331	-69892
2009	13,876	3,552		10323		4,838	15161	4,838	2,709	7,547	7614	-62278
2010	13,876	3,659		10217		4,838	15055	4,838	2,322	7,160	7895	-54383
2011	19,079	3,769		15311		4,838	20149	4,838	1,935	6,773	13375	-41008
2012	19,079	3,882		15198		4,838	20036	4,838	1,548	6,386	13649	-27358
2013	19,079	3,998		15081		4,838	19919	4,838	1,161	5,999	13920	-13438
2014	19,079	4,118		14961			14961	4,838	774	5,612	9349	-4089
2015	19,079	4,242		14838			14838	4,838	387	5,225	9613	5523
2016	26,017	4,369		21648			21648		0	0	21648	27171
2017	26,017	4,500		21517			21517		0	0	21517	48689
2018	26,017	4,635		21382			21382		0	0	21382	70071
2019	26,017	4,774		21243			21243		0	0	21243	91314
2020	26,017	4,917		21100			21100		0	0	21100	112414
Total	390,258	88,195	193,520	108,543	96,760	96,760	302,063	96,760	92,890	189,650	112,414	

(in thousand rupee)

Note: Grant at 50% of Project Cost

Long Term Loan at 8% Interest Rate for 50% of the Project Cost

Table 9.3.2 Cashflow Analysis for Parking Facility Case 2

Case: Esplanade Under Ground

Year	Revenue	Operation/ Maintenance Outlays	Constru Cost	Net Revenue	Long Term Loan	Grant/ Subsidy	Total Inflow	Loan Repay- ment	Interest	Total Outflow	Balance At Year	Cumulativ Balance
1994			185,852	-185852	92,926	92,926	0	0	7,434	7,434	-7434	-7434
1995			185,852	-185852	92,926	92,926	0	0	14,868	14,868	-14868	-22302
1996			185,852	-185852	92,926	92,926	0	0	22,302	22,302	-22302	-44604
1997	8,450	13,939		-5489		30,000	24511	13,939	22,302	36,241	-11730	-56335
1998	8,450	14,357		-5907		30,000	24093	13,939	21,187	35,126	-11033	-67368
1999	8,450	14,788		-6338		30,000	23662	13,939	20,072	34,011	-10349	-77717
2000	8,450	15,231		-6782		30,000	23218	13,939	18,957	32,896	-9677	-87395
2001	8,450	15,688		-7239		30,000	22761	13,939	17,842	31,781	-9019	-96414
2002	10,140	16,159		-6019		30,000	23981	13,939	16,727	30,666	-6685	-103099
2003	10,140	16,644		-6504		30,000	23496	13,939	15,612	29,550	-6055	-109153
2004	10,140	17,143		-7003		30,000	22997	13,939	14,496	28,435	-5439	-114592
2005	10,140	17,657		-7518		30,000	22482	13,939	13,381	27,320	-4838	-119430
2006	10,140	18,187		-8047		30,000	21953	13,939	12,266	26,205	-4253	-123682
2007	13,520	18,733		-5213		30,000	24787	13,939	11,151	25,090	-303	-123986
2008	13,520	19,295		-5775		30,000	24225	13,939	10,036	23,975	250	-123736
2009	13,520	19,874		-6354		30,000	23646	13,939	8,921	22,860	786	-122949
2010	13,520	20,470		-6950		30,000	23050	13,939	7,806	21,745	1305	-121644
2011	13,520	21,084		-7564		30,000	22436	13,939	6,691	20,630	1806	-119838
2012	18,589	21,716		-3127		30,000	26873	13,939	5,576	19,514	7359	-112479
2013	18,589	22,368		-3778		30,000	26222	13,939	4,460	18,399	7822	-104657
2014	18,589	23,039		-4449		30,000	25551	13,939	3,345	17,284	8266	-96391
2015	18,589	23,730		-5141		30,000	24859	13,939	2,230	16,169	8690	-87700
2016	18,589	24,442		-5852		30,000	24148	13,939	1,115	15,054	9093	-78607
2017	25,349	25,175		174		30,000	30174		0	0	30174	-48433
2018	25,349	25,930		-581		30,000	29419		0	0	29419	-19014
2019	25,349	26,708		-1359		30,000	28641		0	0	28641	9627
2020	25,349	27,510		-2160		30,000	27840		0	0	27840	37466
2021	25,349	28,335		-2986		30,000	27014		0	0	27014	64481
Total	380,239	508,202	557,556	(685,519)	278,778	1,028,778	622,037	278,778	278,778	557,556	64,481	

Note: Grant at 50% of Project Cost, and Yearly Subsidy at 30 million
Long Term Loan at 8% Interest Rate

(in thousand rupee)

Table 9.3.3 Cashflow Analysis for Parking Facility Case 3

Case: BBD Bag Under Ground

Year	Revenue	Operation/ Maintenance Outlays	Constru Cost	Net Revenue	Long Term Loan	Grant/ Subsidy	Total Inflow	Loan Repay- ment	Interest	Total Outflow	Balance At Year	Cumulativ Balance
1994			146,994	-146994	73,497	73,497	0	0	5,880	5,880	-5880	-5880
1995			146,994	-146994	73,497	73,497	0	0	11,760	11,760	-11760	-17639
1996			146,994	-146994	73,497	73,497	0	0	17,639	17,639	-17639	-35279
1997			146,994	-146994	73,497	73,497	0	0	23,519	23,519	-23519	-58798
1998	6,867	14,699		-7832		35,000	27168	14,699	23,519	38,218	-11050	-69848
1999	6,867	15,140		-8273		35,000	26727	14,699	22,343	37,042	-10315	-80163
2000	6,867	15,595		-8727		35,000	26273	14,699	21,167	35,866	-9594	-89757
2001	6,867	16,062		-9195		35,000	25805	14,699	19,991	34,691	-8885	-98642
2002	6,867	16,544		-9677		35,000	25323	14,699	18,815	33,515	-8191	-106833
2003	8,241	17,041		-8800		35,000	26200	14,699	17,639	32,339	-6138	-112972
2004	8,241	17,552		-9311		35,000	25689	14,699	16,463	31,163	-5474	-118445
2005	8,241	18,078		-9837		35,000	25163	14,699	15,287	29,987	-4824	-123269
2006	8,241	18,621		-10380		35,000	24620	14,699	14,111	28,811	-4191	-127460
2007	8,241	19,179		-10938		35,000	24062	14,699	12,935	27,635	-3573	-131033
2008	10,988	19,755		-8767		35,000	26233	14,699	11,760	26,459	-226	-131259
2009	10,988	20,347		-9359		35,000	25641	14,699	10,584	25,283	358	-130901
2010	10,988	20,958		-9970		35,000	25030	14,699	9,408	24,107	923	-129978
2011	10,988	21,587		-10599		35,000	24401	14,699	8,232	22,931	1470	-128507
2012	10,988	22,234		-11246		35,000	23754	14,699	7,056	21,755	1999	-126509
2013	15,108	22,901		-7793		35,000	27207	14,699	5,880	20,579	6628	-119880
2014	15,108	23,588		-8480		35,000	26520	14,699	4,704	19,403	7117	-112763
2015	15,108	24,296		-9187		35,000	25813	14,699	3,528	18,227	7585	-105178
2016	15,108	25,025		-9916		35,000	25084	14,699	2,352	17,051	8032	-97146
2017	15,108	25,775		-10667		35,000	24333	14,699	1,176	15,875	8458	-88688
2018	20,602	26,549		-5946		35,000	29054		0	0	29054	-59634
2019	20,602	27,345		-6743		35,000	28257		0	0	28257	-31377
2020	20,602	28,166		-7563		35,000	27437		0	0	27437	-3940
2021	20,602	29,010		-8408		35,000	26592		0	0	26592	22652
2022	20,602	29,881		-9278		35,000	25722		0	0	25722	48374
Total	309,036	535,928	587975	(814,867)	293,988	1,168,988	648,108	293,988	305,747	599,735	48,374	

Note: Grant at 50% of Project Cost, and Yearly Subsidy at 35 million
Long Term Loan at 8% Interest Rate

(in thousand rupee)

9.4 Social and Environmental Effects

There will be some social and environmental effects resulting from the construction of flyovers. These are discussed below:

9.4.1 Social Effects

The proposed projects will create employment opportunities. A large number of workers will be needed for construction of the proposed flyovers and intersection improvement works. Also, local contractors will get jobs. This will have a positive impact on the local economy.

Secondly, the properties adjacent to the flyovers will benefit by the orderly use of street elements such as carriageways and sidewalks. The utilization of space beneath the flyovers as parking lots, for example, could provide additional parking and aid in solving the shortage of parking spaces. The construction of the flyovers may encourage other investments in rebuilding many of the dilapidated old town areas.

9.4.2 Environmental Effects

Calcutta is facing a serious air pollution problem. The proposed project will help in preventing the worsening of air pollution, albeit in a small way, by the reduction in fuel consumption due to the decrease of traffic congestion, delay and improved travel speed. The annual fuel consumption saving is estimated at 20 mill. litres per year in 1998. Secondly, the emission rate of pollutants will decrease with higher travel speeds.

The slope of the proposed flyovers are set at 4% following the IRC design standard, except for a few locations where 5% is adopted due to the prevailing physical constraints. These gradients are low when compared to similar facilities in other countries. The gradients are relatively mild and additional fuel needed for climbing will be negligible.

As for noise nuisance, the prevailing main noise source is from the honking of vehicles and not from engine noise or tire attrition noise. With more orderly flow of traffic, the need to honk will decrease, thus contributing to reduced noise nuisance.

9.5 Selection of Transport Infrastructure Development Projects

Based on the above Sections, implementation of the following projects prior to 1998 is recommended:

9.5.1 Intersection Improvements (Alt.II-4)

(1) Intersection No.1 - N-S Flyover
(2) Intersection No.2 - At Grade Improvements
(2) Intersection No.3 - At Grade Improvements
(2) Intersection No.4 - At Grade Improvements
(3) Intersection No.5&6 - Continuous Flyover
(2) Intersection No.7 - At Grade Improvements
(4) Intersection No.8 - N-S Flyover
(5) Intersection No.9 - N-S Flyover
(5) Intersection No.10 - E-W Flyover

The proposed at-grade improvements at Intersections No.2, No.3, No.4 and No.7 will be sufficient until 1998 at least, but the construction of flyovers at Intersections No.3, No.4 and No.7 is likely to become necessary beyond 1998.

9.5.2 Parking Structures

The Study has shown that there is a chronic shortage of off-street parking spaces in the central area of Calcutta. The shortage causes traffic congestion, slows public transport, increases pollution, hampers pedestrian movement, and generally impairs living and working conditions in the CBD.

However, the Study has also shown that off-street parking structures are not economically feasible and are also not financially feasible given the low parking charges currently acceptable unless construction is funded by a substantial grant. Therefore, inclusion of the car parking structures as separate dedicated facilities in the list of recommended works is not proposed.

In view of the urgent need for measures to be taken to alleviate the parking shortage it is recommended instead that the option of incorporating car parking facilities as part of redevelopments including commercial office and retail space should be further considered. In this way the cost of constructing and operating the parking structure could be offset against more profitable activities. The Esplanade site obvi-

ously has potential in this regard because of the location and land value, and there may be other potential sites.

9.5.3 Overhead Pedestrian Plaza

Preliminary costing and feasibility evaluation of this facility has been carried out as part of this study and the first stage of the pedestrian plaza project, has been included in the list of recommended projects. As with the parking facilities, this sub-project cannot be recommended from the results of the economic evaluation but inclusion as requested by the Government of West Bengal can be recommended on the basis of the following considerations;

- Pedestrian volumes are extremely high and there will be substantial benefits to pedestrians in the form of convenience and safety.

- B.B. Ganguly St. carries heavy tram and bus volumes, west of Raja Rammohan Sarani in particular, and with many pedestrians on the overhead walkway the public transport will flow more freely at ground level.

- It is understood from discussions with the Government of West Bengal that improvements will be made to the eastern end of B.B. Ganguly St. near Sealdah Station and that vehicle usage of B.B. Ganguly St. is likely to increase substantially as a result. The separation of the high pedestrian volume from vehicles therefore assumes higher importance.

- The opening of Metro Central Station, due 1994, will add to the concentration of pedestrians on B.B. Ganguly St.

9.6 Disbursement Schedule and Implementation Schedule

Using the costs from Chapter 8 the annual expenditure for each sub-project has been estimated for the project timings and durations shown in the Implementation Schedule. The results are shown in Table 9.6.1 below. The total annual expenditure is in excess of recent budget allocations for Calcutta and it is evident that other sources of funding will be required if the works are to be completed within the given time frame.

Table 9.6.1 Disbursement Schedule (Rs.millions)

Sub-Project	Annual Disbursement (Rs. millions)					Total Expenditure (Rs. millions)
	1993	1994	1995	1996	1997	
Int. No. 5&6 - Flyover	40.5	304.0	209.4	121.6		675.5
Int. No. 1 - Flyover	13.8	115.3	76.1	25.4		230.7
Int. No. 4 - At Grade Improv.	1.9	0.0	29.1			31.0
Int. No. 7 - At Grade Improv.	1.2	0.0	19.1			20.3
Int. No. 8 - Flyover	9.6	0.0	0.0	80.4	70.7	160.7
Int. No. 9 - Flyover		10.5	0.0	83.6	80.2	174.2
Int. No. 10 - Flyover		5.5	0.0	27.3	58.3	91.1
Pedestrian Plaza - Stage 1	9.7	64.7	55.0	32.3		161.7
Int. No. 2 - Land Acq./Comp.	10.1	20.1	45.2	25.1		100.5
Int. No. 2 - At Grade Improv.	4.5	0.0	0.0	37.5	33.0	75.0
Int. No. 3 - At Grade Improv.		1.3	0.0	0.0	20.3	21.6
Total Annual Disbursement	91.3	521.3	434.0	433.2	262.5	1,742.3

The costs above include all allowances for utility relocations, contractors overheads, engineering design and construction supervision, and a 10% contingency allowance. However, there is no specific allowance for administrative expenses of the Government of West Bengal which would probably include the establishment of an project office for monitoring and coordinating the sub-projects and liaising with other government and semi-government agencies.

The proposed Implementation Schedule for the recommended projects is shown in Figure 9.6.1 below. Some adjustments to the work schedule have been made in order to even out the annual expenditure as shown in the Disbursement Schedule.

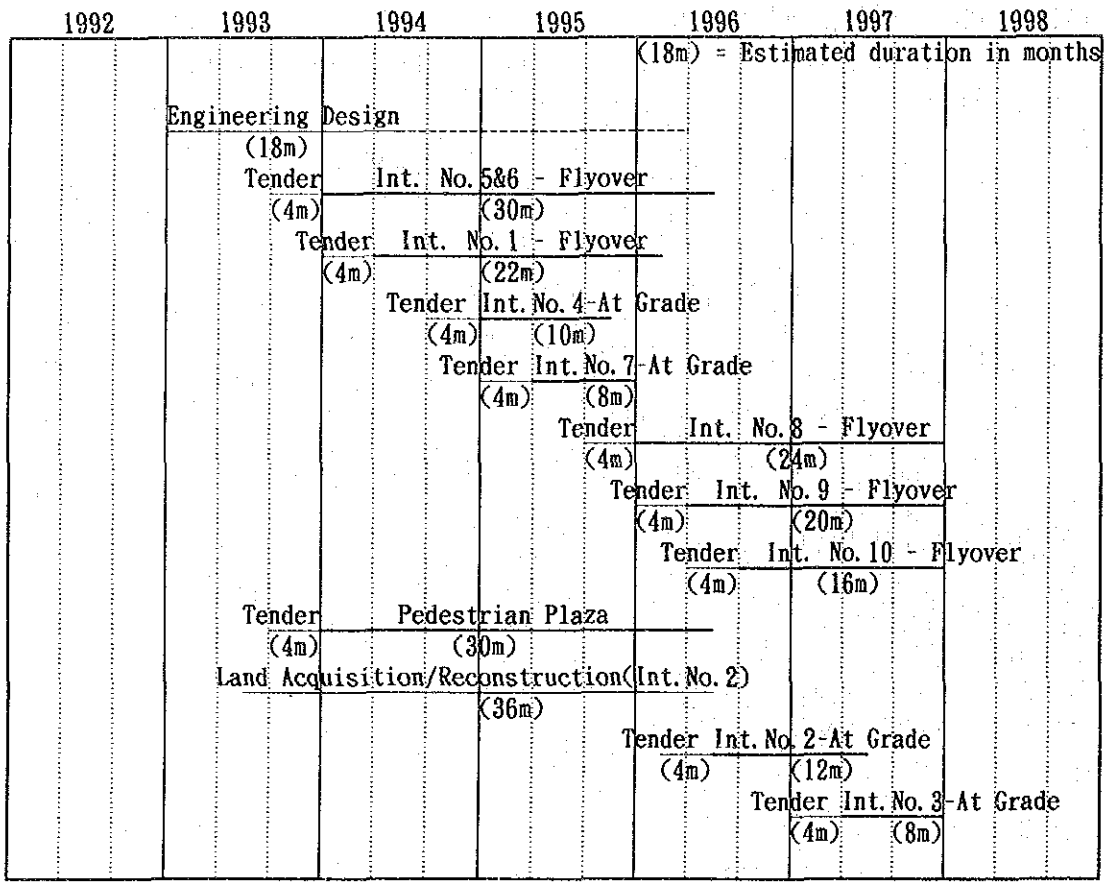


Figure 9.6.1 Implementation Schedule

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

The conclusions reached in this Study and the recommendations derived therefrom, are described in this chapter. Other future studies that may contribute to the improvement of traffic conditions in the city are also briefly considered.

10.1 Intersection Improvements

Based on the findings of this study as described hereafter, the following intersection improvement projects are recommended;

a- Construction of flyovers at each of Intersections No.1, No.8, No.9 and No.10

b- Construction of a continuous flyover linking Intersections No.5 and No.6.

c- Implementation of at-grade intersection improvements at Intersections No.2, No.3, No.4 and No.7.

The economic evaluation of these projects as one package is very favorable, with an IRR of 18.4%.

Intersections No.1, No.5 and No.6 are located along A.J.C. Bose Road, which forms the south-eastern arc of the ring road circling the city core area. The traffic volume demand on this road is expected to grow further with the opening of the new 2nd Hooghly Bridge.

Traffic congestion is extremely heavy at Intersections No.2 and No.8 along J.L. Nehru Rd. and Chowringhee Rd. at present, and improvement plans are urgently required there. At-grade improvement at Intersection No.2, accompanied by widening of the main north-south approach roads is recommended.

Shyambazar Intersection No.4 is an important access to the north, particularly to Barrackpore and Kalyani areas which are undergoing rapid urban growth. On the other hand, upgrading Lock Gate Rd by the construction of a flyover over the railway crossing (No.9) will cause the traffic coming from B.T. Rd in the north to divide between Lock Gate Rd and

Shyambazar. Intersection No.4 would then be able to handle the reduced traffic volume coming to A.P.C. Roy Rd. The flyover at Lock Gate Rd will therefore have similar effects as having flyovers at both Intersections No.4 and No.7. As there is no traffic at Lock Gate Rd, construction works there will be much easier than at other places.

At Intersection No.10, the right-of-way width both in the north-south and east-west directions are not sufficient to accommodate 3 or 4-lane flyovers. Considering the high potential demand for the east-west traffic with improved access to the Eastern Metropolitan Bypass, an east-west 2-lane flyover will have an important role in serving the traffic demand.

Additional flyovers at Intersections No.3, No.4, and No.7 will only produce marginal benefits. At Intersection No.3, the 1998 traffic volume will not exceed the capacity of an at-grade intersection, however the construction of a flyover will become necessary when the traffic volume increases in the future, expected after the target year of this Study. The construction of flyovers at Intersections No.4 and No.7 is also likely to become necessary as the traffic volume on B.T. Road further increases after 1998.

At grade improvements at Intersections No.3, No.4, and No.7 should be implemented prior to 1998 in order to be able to achieve full benefits from the construction of the other flyovers.

10.2 Parking Structures

Construction of multi-level parking facilities for B.B.D. Bag and the Esplanade would eliminate the need for roadside parking on the central area streets which are considered to have an important traffic function. The traffic capacity of these streets, which currently suffer from extreme congestion, would be greatly increased making the implementation of these projects desirable. Other benefits would be improvements in the flow of public transport, reduced pollution, and easier movement of pedestrians, provided that no-parking regulations were introduced and enforced on those important streets.

The economic evaluation of the car parking structures showed that the parking structures are not economically feasible. Moreover, the profitability of multi-level parking lots is highly doubtful. In order to sustain an above ground parking facility, parking charges alone will not be sufficient, 50% of the construction costs should be grants. In the case of an underground parking facility, it would be necessary for all of the construction costs and part of the operation costs to be provided from grants. In order to improve the profitability of the parking structures, redevelopment schemes incorporating off street parking with commercial office and retail space should be further considered. In this way the cost of constructing and operating the parking structure could be offset against more profitable activities.

Therefore, the separate, dedicated car parking structures considered in this feasibility study have not been included in the recommended list of works to be implemented. In view of the urgent need for measures to be taken to alleviate the parking shortage it is recommended instead that further consideration be given to area redevelopment schemes incorporating car parking facilities. The Esplanade site currently occupied by the tram terminus obviously has potential in this regard because of the location and value of the land, and there may be other potential sites.

10.3 Pedestrian Facilities

In Calcutta pedestrians often overflow onto the roadway and cross streets in a disorderly fashion, affecting both pedestrian safety and road effectiveness. Consequently, providing effective and safe countermeasures is an important goal.

When considering and evaluating proposals for improvements in pedestrian facilities, priority should be given to effective utilization of the entire sidewalk width for pedestrian flow. Measures could include footpath improvements, pedestrian crossings and protective barriers where necessary.

Pedestrian flows along B.B. Ganguly St. from Sealdah Station towards B.B.D. Bag, are very high. Although a preliminary economic evaluation of this facility indicated that it was not economically feasible, an overhead pedestrian walkway between Sealdah Station and Chittaranjan Avenue (Phase I) is recommended for inclusion in the list of projects to be implemented. The pedestrian flows along this narrow section are particularly high and vehicular traffic is expected to increase substantially when planned road works at the eastern end of B.B. Ganguly St. are implemented. The walkway will serve to segregate pedestrian flow from vehicular traffic which will continue to use the street level. The detail design should be carried out in such a way as to minimise the visual impact on the old city.

Following the opening of the Metro Central Station, expected in 1994, the movement of pedestrians between Chittaranjan Avenue and B.B.D. Bag is likely to increase substantially and extension of the overhead pedestrian walkway through to B.B.D. Bag (Phase II) is likely to become desirable. At present, pedestrian movements along this link are relatively small and no detailed information is yet available on likely pedestrian movements following the opening of the Metro.

It is therefore recommended that implementation of this second stage should only be carried out after further study of the Metro commuters, including likely pedestrian volumes, their destinations, and the most beneficial walkway route so that the need, the alignment and the width can be decided with more confidence. A connection from B.B.D. Bag to the approach to Howrah Bridge could also be considered as part of a future pedestrian facility network.

10.4 Traffic Signals

With the increase in Calcutta city center traffic, it is necessary to introduce a complete traffic signal system and increase the capacities of intersections and roads to ensure the safety of pedestrians and traffic police.

As a first phase for this project, installation of an ATC system (33 intersections) for the city center, an arterial intersection control system (57 intersections) along the main trunk roads of A. J. C. Bose Rd, Chowringhee Rd, etc. and isolated intersection control system for other important intersections (36 intersections) is proposed.

Of these intersections it is recommended that signals should first be installed along A.J.C. Bose Rd and Chowringhee Rd., for which there are intersection improvement proposals. This is necessary to increase the traffic capacity on these routes and allow the full benefit to be obtained from construction of the flyovers.
The observance of traffic regulations by drivers and pedestrians is a prerequisite to the success of traffic signal installation, making traffic education an essential part of any signalization program.

10.5 Concrete Pavement

Maintenance costs for concrete pavement are low compared to asphalt pavement and have advantages such as resilience against flooding in times of heavy rain. However the following points must be considered before recommending the conversion of existing flexible pavement to a rigid pavement by addition of a concrete slab.

- Whether there are underground utilities under the pavement or, there are plans for such in the future
- Heavy traffic volumes expected during the pavement life
- The causes of the existing high maintenance costs, eg. poor subgrade drainage, inundation, poor materials, poor placement etc.
- Whether improvements to drainage facilities are necessary
- Review of condition of existing pavements by visual inspection, surface deflection tests, test pits etc.

10.6 Summary of Recommendations

The recommended works to be implemented before 1998 under the Transport Infrastructure Development Project in Calcutta are shown in Figure 10.6.1 and are summarised below;

Location	Sub-Project	Cost (Rs.millions)
a) Int. No.1 -	North-South Flyover	230.7
b) Int. No.2 -	At-Grade Improvements	75.0
-	Land Acquisition and Compensation	100.5
b) Int. No.3 -	At-Grade Improvements	21.6
b) Int. No.4 -	At-Grade Improvements	31.0
c) Int. No.5&6 -	Continuous Flyover	675.5
b) Int. No.7 -	At-Grade Improvements	20.3
d) Int. No.8 -	North-South Flyover	160.7
e) Int. No.9 -	Flyover above railway	174.2
f) Int. No.10 -	East-West Flyover	91.1
g) Ganguly St. -	Overhead Pedestrian Walkway Sealdah to Chitaranjan Ave.	161.7
	Total Cost	1,742.3

Other projects considered or identified during the Study, but not included above, are shown on the list below. The flyovers at Intersections No.3, No.4 and No.7 need not be implemented before 1998.

Location	Sub-Project	Approx. Cost (Rs.millions)	Notes
a) Int. No.3	- North-South Flyover	172.5	After 1998
b) Int. No.4	- North-South Flyover	157.6	After 1998
c) Int. No.7	- North-South Flyover	252.7	After 1998
d) Ganguly St.	- Overhead Pedestrian Walkway Chitaranjan Ave. to BBD Bag	130.0	
e) Esplanade	- Parking Structure	193.5	
f) BBD Bag	- Parking Structure	587.9	
g) Metrocore	- Traffic Signalization	300.0	Order of cost
h) Metrocore	- Concrete Road Surfacing	266.6	Excludes Util.
	Total Cost	2,060.8	

Legend

(1) Recommended Projects included in the Implementation Schedule for completion by 1998

Flyover Construction .....
At-grade Improvements .....
Pedestrian Plaza (Phase I) .....

(2) Other Projects and Studies

Flyover Construction (after 1998) .....
Pedestrian Plaza (Phase II) .....
Parking Facility .....
Urban Development Study .....
Traffic Signalization ...(See Fig.10.3.1)
Concrete Roads .....(See Fig.10.2.1)

Scale
0 0.5 1 1.5 2 km

No. 9 Lock Gate
No. 4 Shyambazar
No. 7 Maniktala
No. 2 Esplanade
No. 1 Moulali
No. 8 Park Street
No. 10 Mullikbazar
No. 5 Rabindra Sadan
No. 6 Beck Bagan
No. 3 Gariahat

Figure 10.6.1 Project Recommendations

10.7 Relevant Future Studies

It is recommended that the following studies be implemented for the bearing they will have on the future Calcutta city traffic improvements.

(1) Esplanade Intersection No.2 is located in the city core area and connected to major transport modes through the adjacent metro station, and bus and tram terminals. It is a central commercial and transport node. However the tram terminal facilities and surrounding buildings (other than historical structures) are too old to support the activities and development associated with this location. At present the overflow of the pedestrians onto the carriageway and the traffic congestion in the vicinity of the intersection are very severe. These conditions cannot be remedied by road improvement alone, and it is considered that an urban renewal plan for the immediate surrounding area of the intersection would be desirable (refer Figure 10.7.1).

This Study considered two plans for the improvement of transport infrastructure in the vicinity of Intersection No.2, firstly at-grade intersection improvements, and secondly a parking facility within the grounds of the tram terminal. Implementation of the intersection improvements has been recommended and will require the widening of approach roads as well as land acquisition and payment of compensation costs, but the parking charges to be levied under the second plan were found to be insufficient to secure the profitability of the parking facility. It may be possible to resolve these problems through a development plan covering the area of the existing tram terminal and bus terminal. Overall costs would be decreased by mainly utilizing public owned land for an integrated terminal and commercial complex. Pedestrians movements could be provided for at the above ground level while bus and tram circulation could be rearranged at ground level.

(2) Calcutta city road traffic is causing serious pollution. As one of the benefits of this project, the reduction in fuel consumption as a result of intersection improvements should lead to a reduction in pollu-

tion. However, further improvements will be necessary and additional pollution countermeasures should be studied. Countermeasures could include improvements to fuel quality and vehicle engines as a first consideration.

(3) The main objective of this Study has been to consider the feasibility of urgent construction of flyovers and parking facilities, and the study has not covered the road network configuration nor the transport facilities needed in association with the future development. Further data collection and study of traffic and transportation in Calcutta is recommended in order to define the policies and strategies for future development. The most suitable time to implement such data collection and study would be after the completion of the two ongoing large-scale transport projects in the city, the 2nd Hooghly bridge and the underground metro, so that their influence can be clearly gauged.

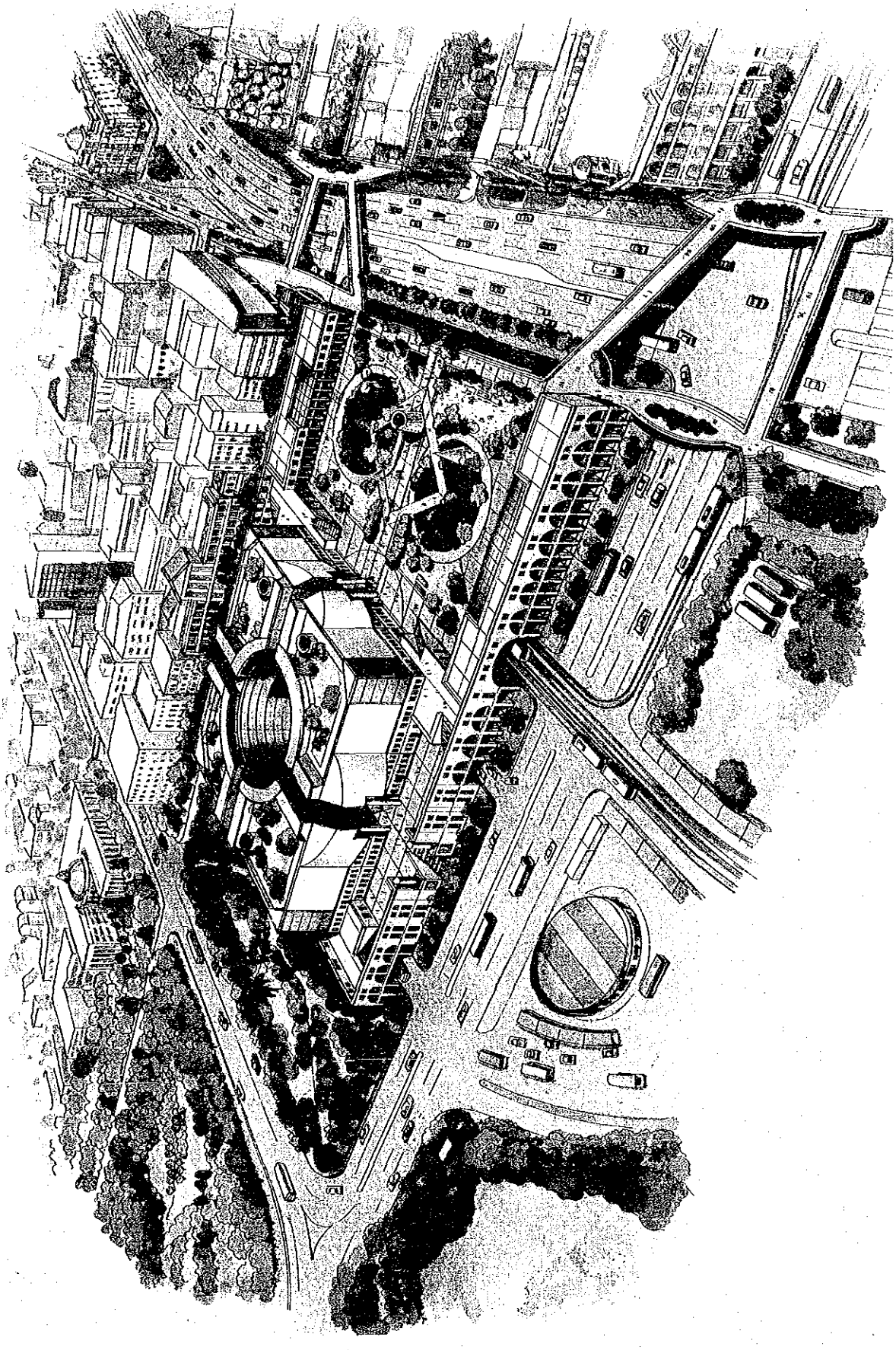


Figure 10.7.1 Possible Esplanade Area Redevelopment