(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.

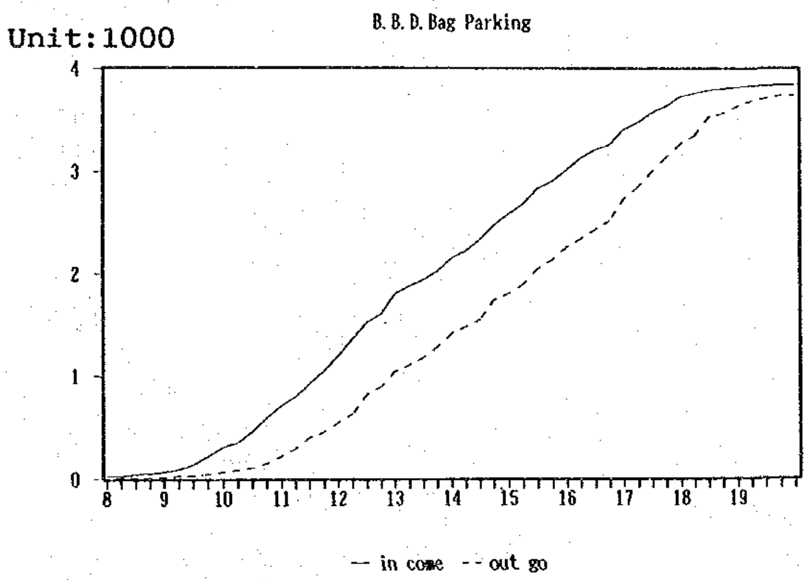


Figure 7.3.1 Parking Characteristics of B.B.D.Bag

(2) Structure plan

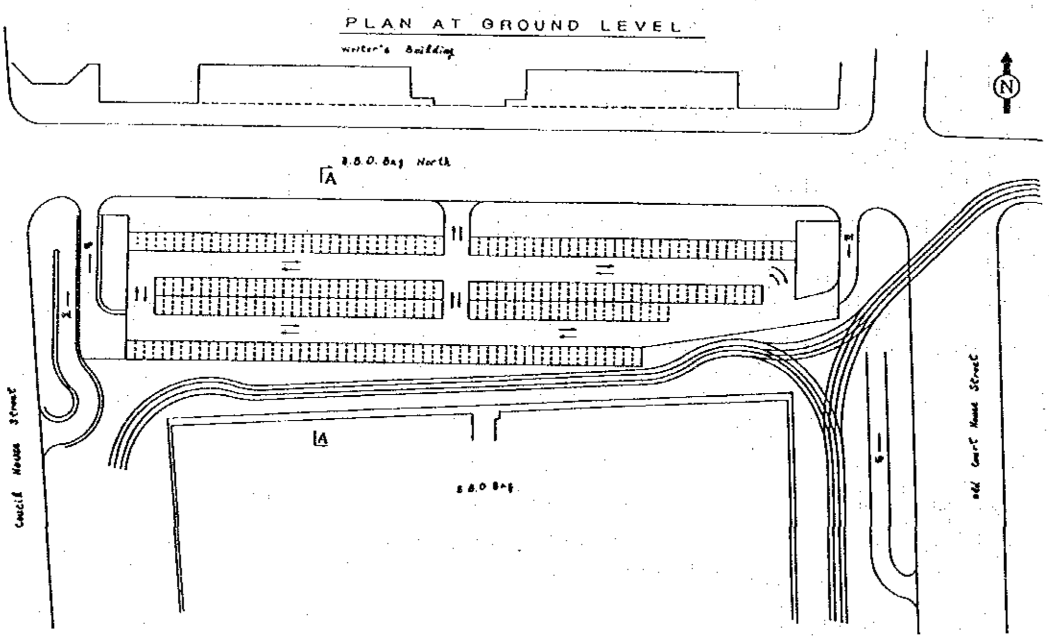
The following parameters have been adopted for the structure;

- 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)

Plan



Section A-A

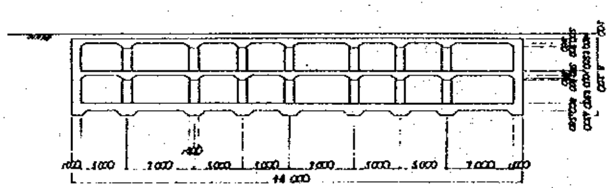


Figure 7.3.2 B.B.D.Bag North Parking

7.3.2 Esplanade Parking Facility

As described in Chapter 5.4.3, 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.

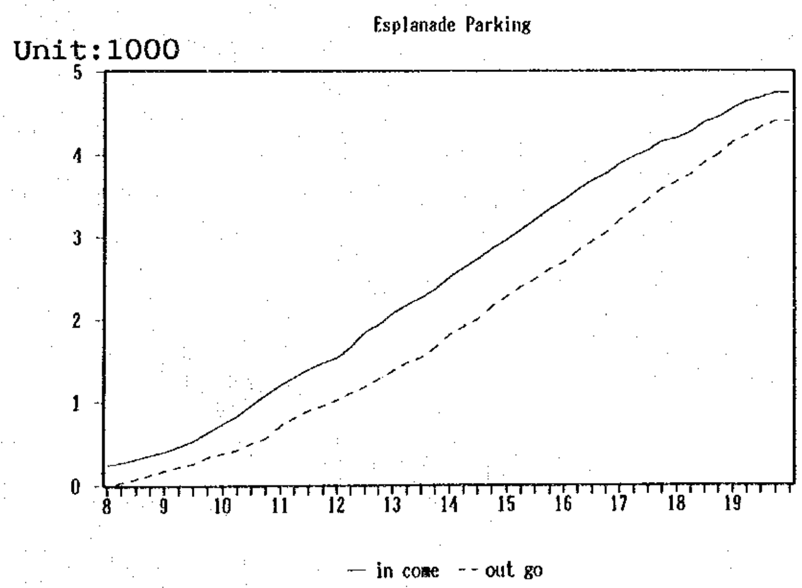


Figure 7.3.3 Parking Characteristics of Esplanade

(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

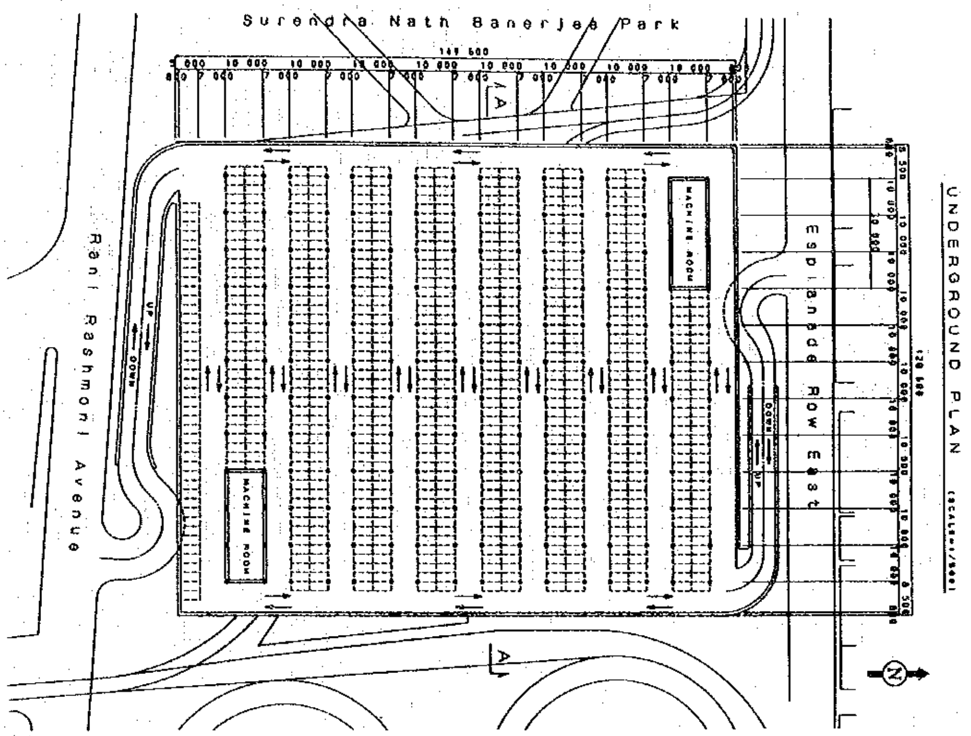
The structure will comprise a reinforced concrete slab, girders and columns. The foundations will be cast-in-place reinforced concrete piles.

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

b. Underground proposal

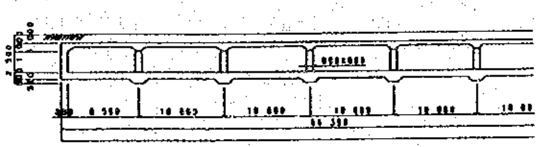
The structure type and excavation method will be the same as those adopted for the B.B.D. Bag North Parking facility.

Plan



Section

Underground proposal



Above ground proposal

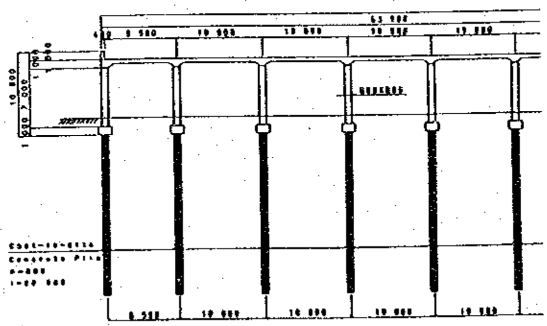


Figure 7.3.4 Esplanade Parking

CHAPTER 8

CONSTRUCTION AND COSTING

CHAPTER 8 CONSTRUCTION AND COSTING

8.1 Construction Methods

8.1.1 Flyovers

The form of construction and construction material proposed for each flyover have been described in Chapter 7.2. This section of the report describes in general terms the most appropriate method of construction given the existing situation and constraints in Calcutta. The limitations on construction space available at most of the Study Intersections are such that it is inevitable that there will significant effects on existing traffic flows during construction. The method of construction adopted must minimize the construction time and the disruption to traffic during the construction period. Two main types of flyover have been proposed and construction methods for each are described below.

(1) Steel Main Spans with PC Approach Spans

In view of the need to minimize construction times this form of construction has been proposed for most flyovers. The structures consist of;

a) Approach sections comprising piled retaining walls, earth fill and pavement.
b) Central steel spans, details of which vary according to the span length;
   - Span 20m to 25m: Steel plate girders and concrete deck;
   - Span 26m to 45m: Steel plate girders with steel deck;
   - Span over 46m: Steel box girder with steel deck.
c) Approach spans of precast concrete beams with cast in-situ concrete deck.

The main steps during construction would be as follows;

a) Relocate utilities and tram lines to the sides, clear of the flyover construction works, and construct a minimum pavement width of 5m on each side of the flyover after allowing sufficient construction clearance. In some cases a temporary roadway in part of the footpath may be necessary. Usually however the pavement can remain as part of the permanent works after the flyover is complete.

b) Transfer trams and vehicular traffic to this pavement as a one way flow on each side of the proposed flyover. After allowing for construction clearances there will in most cases only be sufficient width for one lane on each side of the flyover and this lane will be shared by all vehicles including trams. The central construction works area would be fenced off, leaving openings for the main cross roads and also for minor cross roads where feasible.

c) Construct the approach section at each end of the flyover, comprising the piled retaining walls, earth fill, pavement and the abutments.

d) Commence work on the piled foundations and piers, working from the abutments towards the centre.

e) Establish a casting area on each of the completed approaches and commence the forming, reinforcing, casting and stressing of the standard PC beams. Alternatively a separate central precasting yard could be established at a convenient site.

f) After the piers nearest the abutments are completed the first PC beams can be erected and the deck formed, reinforced and poured while working primarily from the deck level. The construction of the PC spans would continue in this manner.

g) Steel piers would be fabricated, painted and transported in two segments, i.e. the vertical column and the horizontal crosshead. First the vertical column would be erected to suit the time of completion of the piles and pile caps, then the horizontal crosshead would be connected at the top of the column.

h) Fabrication and painting of the steel beams would take place in the factory prior to trucking to site. The standard 20m beams would be fabricated, transported and erected in one piece. Beams more than

20m long would be fabricated and transported in shorter lengths for ease of transport and erection. Temporary piers would be necessary for erection in this case. The beam sections would be lifted onto the temporary piers, the connections would be made above ground and the temporary supports would then be removed. The temporary piers and the erection works would be scheduled for nights or weekends to minimize the disruption to traffic. The deck (steel or concrete) would be added to the steel spans while working from deck level, allowing traffic to operate underneath.

i) Pavement works at ground level plus ancillary works such as traffic signals and lighting would be completed once the structural works at ground level are completed.

The sequence of works is shown in the Figure 8.1.1 below;

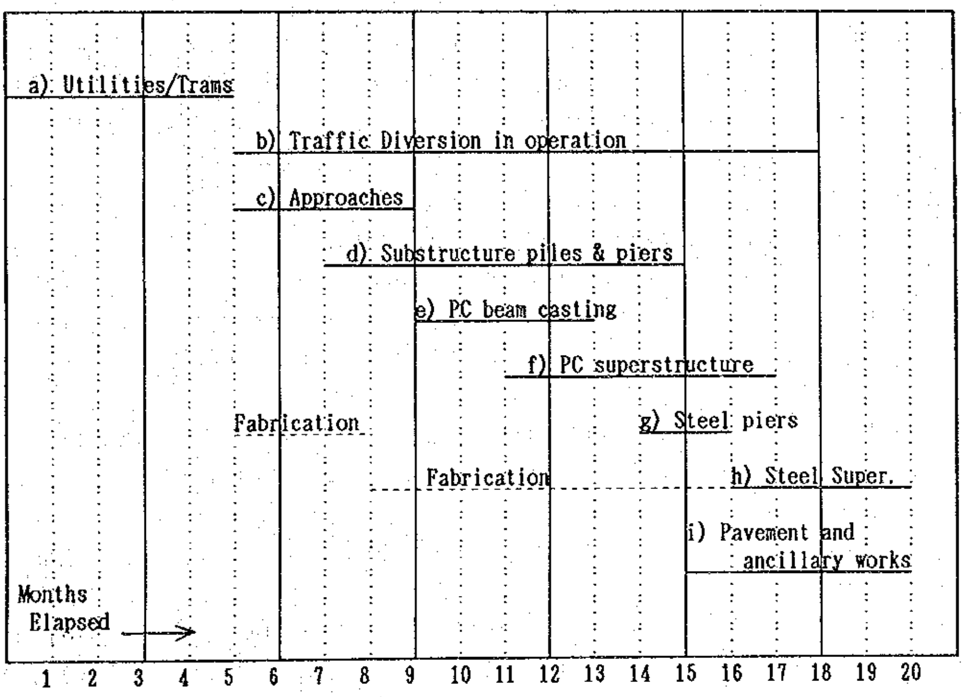


Figure 8.1.1 Typical Flyover Construction Sequence

(2) Concrete Box Main Spans with PC Approach Spans

At Intersection No. 8 there is sufficient space for the main traffic flow to be diverted and at this location concrete box girders have been proposed for the main spans, not steel as proposed elsewhere, to take advantage of the lower cost of concrete box girder construction.

The sequence of construction would be similar to that shown above but the staging (falsework), forming and stressing etc of the box girders will add to the overall construction time. It is estimated that the total construction time would be about 3 months longer than shown above.

That two main spans would be constructed one at a time. This is necessary to allow for the diversion of traffic on the intersecting roadways to the alternate span during the time the scaffolding is in place.

8.1.2 Carparking Structures

The structural features of the proposed carpark structures have been described in Chapter 7.3.

The proposed construction method for the underground structure at BBD Bag Square is to first excavate and construct a reinforced concrete diaphragm wall around the perimeter of the underground structure. The main excavation would then be carried out as steel bracing is progressively placed to support the diaphragm wall. The excavation would be carried out by machine where possible in order to reduce the construction time but some hand excavation will be necessary in areas that are inaccessible to machines.

Temporary closure of part of BBD Bag north roadway will be required and of course the existing surface level carpark must be closed. The structure would be clear of the tram lines and the trams could continue to operate during the construction works.

The proposed above ground parking structure at the Esplanade would be a conventional reinforced concrete structure and would be supported on piles. The structure is on the site of the existing tram terminal and terminus operations would be seriously disrupted during the 2 years necessary for construction. It might be possible to stage the works to allow limited terminus operation but costs and construction time would increase.

8.2 Preliminary Cost Estimation

8.2.1 Methodology and Assumptions

Project costs have been estimated considering the following cost components;

(1) Direct construction cost comprising labour, materials and equipment costs.
(2) Indirect cost including temporary and preparatory work, diversion and control of traffic, measures needed for environmental protection, administration of site office and an allowance for head office overheads and profit.
(3) Engineering services cost including detail design and supervision.
(4) Contingency allowance for unexpected costs.
(5) Land acquisition and compensation costs.

The above costs are added and combined according to the cost estimation process shown in Figure 8.2.1. The costing details for each of the above cost components are described in the respective sections beginning 8.2.2 below.

The project cost estimates have been prepared on the basis of the following assumptions;

(1) Contract Method

The estimates are based on the assumption that the major construction works will be awarded to a general contractor by international tendering. Similar projects have been implemented in the past by local tendering or direct execution by Government Departments. The majority of the works under consideration are well within the capabilities and experience of the major local contractors but there are some aspects where the support of a foreign contractor would be desirable. For example the construction must be completed within a short time frame and requires technical expertise in medium span steel bridges where there is limited direct experience in Calcutta. It has therefore been assumed for the

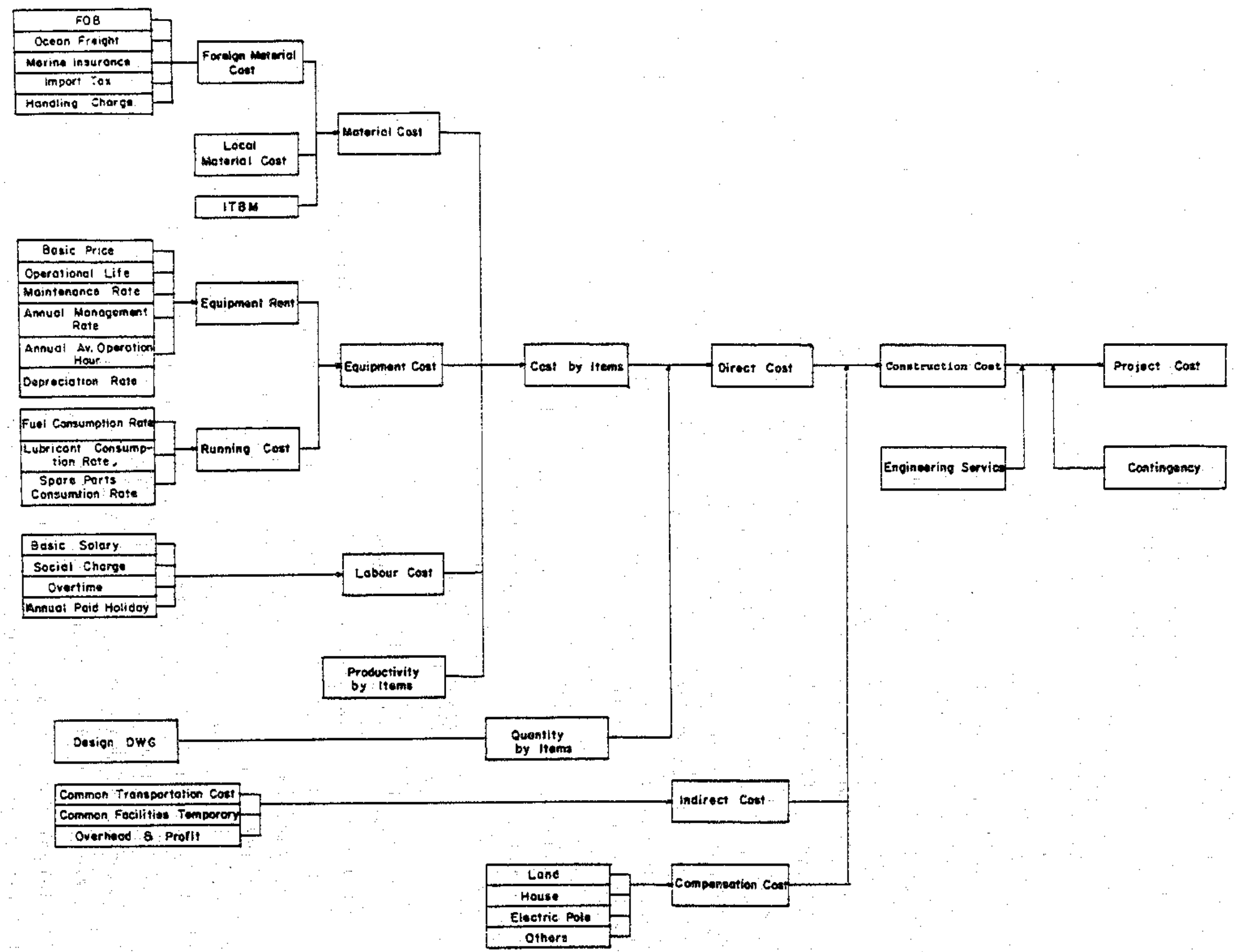


Figure 8.2.1 Cost Estimation Process

purpose of the present cost estimation that the subject projects will be awarded through international tendering.

(2) Construction Methods

It is necessary to complete the works within a relatively short period and the scale of the works will justify greater usage of mechanized equipment than is usually the case in Calcutta. However, the constricted working areas, the need to consider existing traffic and pedestrians flows, and the risk of damaging existing utilities will still require labour intensive methods in some areas. The estimates assume the use of mechanized equipment to reduce construction times to the extent possible given the above constraints.

(3) Base Year for Cost Estimation

Cost calculations of materials, labour, and machinery, are based on the prices prevailing in January 1992.

(4) Foreign and Local Currency Portions

The proportion of the total cost which is in foreign currency and local currency has also been estimated. The foreign component has been expressed in Rupiah at the governing exchange rates in January 1992, ie US$1 = 130Yen = Rs26. Classification into foreign and local currency components is based on the following principles:

(a) Foreign currency
- Wages of foreign personnel;
- Overheads and profit of foreign firms;
- Imported equipment, materials and supplies;
- Part of the cost of domestic materials of which India is a net importer, such as cement, steel and oil products.

(b) Local currency
- Domestic equipment, materials and supplies of which India is a net exporter;
- Wages of local personnel;
- Overhead and profit of local firms;
- Managing and maintenance costs of equipment; and
- Taxes.

(5) Economic Costs

To assist in the economic evaluation of the project, economic costs have also been estimated from the local currency portion by subtracting all transfer costs, taxes, etc.

8.2.2 Direct Construction Costs

Following normal cost estimation methods, the cost estimation process involved deriving unit costs for each construction work item by combining the material, machinery and labour cost components with productivity rates. Quantities were estimated from the preliminary designs and direct construction costs were then estimated as the product of unit costs and quantities. The methodology used to derive the unit costs is described below.

(1) Labour Costs

For cost estimating purposes labour was classified into five categories, foreman, operator (plant and equipment), driver (normal trucks and dump trucks), skilled labour (carpenters, steel riggers, masons, steel fixers etc) and unskilled labour. The average unit wage for each category was obtained from private companies and government agencies in Calcutta.

It is necessary to include in addition to the labour wage cost, allowances for social security, bonuses, vacations, public holidays, rain interference, and overtime costs.

(a) Social Security and Overheads

Rates as a percentage of the of the basic labour cost have been estimated assuming a 6 day week and an 8 hour day as the base condition.

Table 8.2.1 Social Security and Overheads

Description	Rate of Salary (%)	Comments
1. Social Security	15%	Allowance for workers compensation, health insurance, retirement benefits/pension etc.
2. Bonuses	15%	-
3. Public Holidays	4%	13 days per year
4. Vacation	4%	12 days per year
5. Wet Weather	10%	30 days per year
6. Overtime	22%	3 hours per day (except for 3, 4, & 5 above) at 100% above normal rates
TOTAL OVERHEADS	70%	

Source: Study Team enquiries.

(b) Effective Labour Costs

The effective labour costs have been derived from the basic wage rates and the overheads in (a) above as shown in the following Tables 8.2.2.

Table 8.2.2 - Effective Labour Costs

Category	Unit	Wage Rate (Rs)	Overheads Allowance (%)	Effective Wage Rate (Rs./hr)
Foreman	hour	12	70	20
Plant/Equip Operator	hour	10	70	17
Driver	hour	10	70	17
Skilled Labour	hour	8	70	14
Unskilled Labour	hour	5	70	8.5

Source: Study Team enquiries.

(2) Material Costs

All of the basic materials required for the project are produced in India and material costs are based on market prices in Calcutta.

In determining the Foreign currency portion for the basic materials the amount of imports and exports for each material has been considered. Where India is a net importer (eg. cement , steel and oil products) a higher foreign currency proportion has been assumed.

For materials in which India is a net exporter some foreign currency proportion has also been assumed. In the course of extraction, transport or production some raw materials, fuel and production plant and equipment would have been imported.

The unit costs and assumed foreign and local currency portions for the major materials are shown in Table 8.2.3 below.

Table 8.2.3 Unit Costs of Basic Materials

Material	Unit	Unit Cost(Rs)	Foreign Portion (%)	Local Portion (%)
Cement	tonne	2100	50%	50%
Sand	m3	300	-	100%
Crushed Agg.	m3	400	-	100%
Filler	m3	1375	50%	50%
Softwood	m3	5000	-	100%
Hardwood	m3	7000	-	100%
Asphalt	tonne	4100	50%	50%
Structural Steel	tonne	15000	50%	50%
Prestressing Cable	tonne	22000	50%	50%

Source: Study Team enquiries.

A detailed list of all construction materials and the costs adopted for the cost estimation is provided in Table 8.2.4.

(3) *Equipment Costs*

An assessment of hourly equipment costs has been made for the plant likely to be used during construction of the works. The hourly costs are derived from the hourly direct cost and the operation cost.

Direct cost can be equated to rental cost if the equipment is hired and includes allowance for the price of the equipment, operating life, residual value, annual operating costs, management costs and maintenance costs. Direct costs have been based on the equipment costs in Calcutta and are calculated as follows:

Table 8.2.4 Material Costs

Material Name	Unit	Price	Material Name	Unit	Price
Asphalt 80-100	TON	4,100	PVC Conduit	LM	80
Asphalt Emulsion-2	Litre	6	Reinforcement	ton	12,000
Cement	TON	2,100	Release Material	Litre	50
Conc. Admixture	Kg	55	Sand	CUM	300
Crusher Run	CUM	400	Scaffolding	PCS	263
Curing Mat	SQM	36	Screened Crusher	CUM	450
Curing Material	L	80	Soft Wood	CUM	5,000
Filler	CUM	1,375	Steel Form 0.3*1.5	PCS	675
Hard Wood	CUM	7,000	Structural Steel	ton	15,000
PC Anchor	PCS	1,200	Steel Wire #10	ton	25,000
PC Sheath D65	LM	35	Wire Mesh	SQM	50
PC Steel D12.7	ton	22,000			

Table 8.2.5 Equipment Costs

Equipment Name	Basic Price	Cost/hour (Rs)	Equipment Name	Basic Price	Cost/hour (Rs)
Agg. Spreader 2.3m	500,000	459	Hand Hammer 1.1m3	50,000	23
Apron Feeder 30t	250,000	54	Hydro-Shovel 0.6m3	3,000,000	704
Asphalt Plant 60t	7,000,000	27,613	Mac. Roller 12t	1,500,000	322
Asp. Finisher 3m	2,500,000	1,249	Motor Grader 3.7m	2,500,000	529
Batching Plant	2,500,000	1,218	PC Jack	200,000	43
Belt Con. 0.35*10m	125,000	191	Road Sweeper 1.8m	500,000	190
Belt Con. 0.6*15m	200,000	164	Soil Compactor 0.05t	100,000	41
Bulldozer 11t	2,100,000	458	Soil Compactor 0.2t	200,000	81
Compressor 4.6m3	250,000	92	Sprayer 0.3kl	30,000	12
Compressor 9.6m3	800,000	234	Surf. Vibrater 1.5*3	50,000	44
Concrete Cutter 0.3m	50,000	35	Tandem Roller 10t	1,500,000	344
Conc. Breaker 30kg	100,000	63	Tire Roller 15t	1,500,000	323
Conc. Bucket	20,000	12	Truck 5t	500,000	169
Conc.Finisher 5.5m	2,000,000	959	Truch 8t	600,000	206
Conc. Spreader 2.3m	2,000,000	954	Truch Crane 11t	2,000,000	451
Crawlor Crane 35t	5,000,000	1,020	Truck Crane 16t	4,500,000	1,002
DMC Pile Excavator	500,000	88	Truck Crane 5t	800,000	188
Distributor 4kl	500,000	275	Truck Mixer 3m3	1,000,000	318
Dump Truck 11t	800,000	233	Vibrater	5,000	2
Dump Truck 2t	200,000	90	Vib-Roller 3.5t	400,000	116
Dump Truck 6t	800,000	224	Watering Cart 5.5kl	600,000	244
Engine Pump 4in	70,000	41	Wheel Loader 1.4m3	2,000,000	415
Grout Mixer	40,000	38	Truck Crane 40t	12,000,000	2,614
Grout Pump	90,000	81	Truck Crane 70ton	18,000,000	3,907

$$\text{Direct Cost} = BP \left[\frac{DR + M}{T} + Mg \right] \frac{1}{Hr}$$

Where BP: Basic price
DR: Depreciation rate
M : Maintenance rate
Mg: Annual management rate
T : Operational life in years
Hr: Annual operating hours

The operating life of equipment and annual operating hours have been increased above those normally adapted in Japan in recognition of local economic conditions. A 10% residual value has been assumed for all equipment.

Operating costs include fuel consumption and lubricants and are also based on costs in Calcutta.

Table 8.2.5 shows the total equipment costs per hour of operation. The estimation method adopted reflects actual operating costs and allows the use of the equipment for more than one project.

(4) Unit Cost for Construction Works

Unit costs were developed from the labour, material and equipment costs as described in (1), (2) and (3) above. Unit costs are on three levels; plant products, site products and work items.

Plant products are materials produced and delivered by field plant, asphaltic concrete for example. Plant products, in conjunction with other materials, equipment and/or labour form site products. Asphaltic concrete for example is a plant product which is placed, compacted and finished to form an asphaltic surface course which is a site product.

Work items have been developed for construction items which can be conveniently measured from the preliminary design proposals. They are derived from the unit costs for plant products as well as from the unit costs for site products, materials, equipment and labour as appropriate. Pavement for example is a work item consisting of several site products; aggregate sub-base course, prime coat, tack coat, asphaltic surface courses etc.

Since there will be many areas where the use of heavy equipment will not be possible, greater dependence on manual labour has been assumed in deriving the unit costs for some items. In the case of pavement works for example, a separate work item has been developed for pavement constructed mainly by hand.

The major plant products, site products and work items and their corresponding unit costs are shown in Table 8.2.6.

The unit price for each work item, such as cost per m^2 in the case of pavement, is multiplied by the quantity calculated from the preliminary designs to arrive at the estimates for direct construction costs.

8.2.3 Indirect Costs

Indirect Costs are costs not directly related to a particular work item. They include mobilization and demobilization costs, installation and removal of temporary facilities such as power supply and other utilities, temporary diversion and control of traffic, safety facilities, quality and progress control, and environmental protection. Site administration costs covering support staff wages, office supplies, office maintenance and other general site office running expenses are also included in this category. Other significant indirect costs are a portion of the contractor's head office expenses plus an allowance for the contractor's profit.

Table 8.2.6 Unit Costs (Rs)

(a) Plant Products

Description	Unit	Total Financial	Description	Unit	Total Financial
Asphalt Concrete	CUM	2,580	Grout Mortar	cum	6,746
BT Aggregate	CUM	2,308	Lean Concrete	CUM	1,334
Concrete	CUM	1,395	PC-Concrete	CUM	1,708
Fabricated Steelwork	TON	33,121	Screened Aggregate	CUM	705
Foundation Concrete	CUM	1,359			

(b) Site Products

Description	Unit	Total Financial	Description	Unit	Total Financial
Agg. Subbase Cource	CUM	836	Main-D400mm	LM	1,434
Approach Filling	CUM	50	Main-D600mm	LM	1,828
Asphalt Surface	CUM	2,813	Main-D800mm	LM	3,366
BT Base Cource	CUM	2,551	Pipe-D1000	LM	3,850
Conc. Curing	SQM	20	Pipe-D1200	LM	5,252
Concrete Pavement	CUM	2,153	Pipe-D2000	LM	10,604
Cutting	CUM	40	Pipe-D400	LM	1,302
Equip. Backfill	CUM	18	Pipe-D600	LM	1,697
Erection 16t	ton	637	Pipe-D800	LM	2,840
Erection 40t	ton	1,638	PC Concreting	CUM	1,954
Erection 70t	ton	2,600	Prestressing	ton	43,407
Grouting	LM	30	Prime Coating	SQM	12
Hand Agg. Subbase	CUM	808	Reinforcing	ton	14,891
Hand Asphalt Surf.	CUM	2,777	Staging	CUM	173
Hand BT Base Cource	CUM	2,492	Steel Forming	SQM	139
Hand Backfill	CUM	18	Structure Excavation	CUM	86
Hand Excavation	CUM	106	Strutting	Ton	17,249
Main-D1000mm	LM	4,376	Tack Coating	SQM	24
Main-D1200mm	LM	3,677	Wood Forming	SQM	94
Main-D2000mm	LM	14,549	Structure Concreting	CUM	1,627

(c) Work Items

Description	Unit	Total Financial	Description	Unit	Total Financial
Asphalt Pavement A-1	SQM	998	PC Superstr. 4L*20m	Item	2,229,050
Asphalt Pavement A-2	SQM	742	Steel Piers	Ton	34,760
Bored Piling D800	LM	2,186	Steel Superstructure	TON	34,760
PC Superstr. 2L*20m	Item	1,231,890	Concrete Pavement 20	SQM	558
PC Superstr. 3L*20m	Item	1,824,670			

Unlike direct construction costs, these indirect costs can vary substantially from one contractor to another. For the purpose of the preliminary cost estimate, the indirect costs have been assumed to be 30% of the direct costs.

8.2.4 Engineering Services Cost

The costs of final design and construction supervision has been estimated assuming that such work will be contracted out. Based on previous experience the engineering services costs are estimated at 10% of the total of direct and indirect costs.

8.2.5 Contingency

A contingency allowance has been included in the total cost to allow for unexpected costs identified in the detail design and construction. Since this project requires work in congested urban areas such unexpected difficulties are more likely to arise and an allowance of 10% has been included as a physical contingency. Cost escalation is considered separately in the financial analysis.

8.2.6 Land Acquisition and Compensation Costs

Land acquisition has been kept to an absolute minimum as requested but there are some options where acquisition would be necessary. In these cases cost allowances must be made for land acquisition, building restoration and compensation. Regulations covering the acquisition of land for public works are in force but limited information was available on land acquisition and compensation costs.

The cost of the land alone is relatively low compared to the civil works costs and on the basis of discussions with government agencies, land costs of 10 lakhs/katta (14,000 Rs/m2) and 5 lakhs/katta (7,000 Rs/m2) have been assumed for land in central and suburban areas respectively.

The reconstruction/compensation costs are much more difficult to estimate since there are many factors which must be considered in each case. The at-grade improvements at Intersection No.2 is the only location where acquisition of private land would be required. For this alternative an allowance of Rs 100 million is included for land acquisition/reconstruction/compensation costs. This figure is intended as an order of cost only and is based on the cost of the land plus the cost of building reconstruction to provide floor space equivalent to that which now exists.

It has been assumed that land acquisition and compensation costs need not be included in the costs for public land such as right of way for roads and railways and for public land in BBD Bag Square, Esplanade tram terminus area or in the Maidan adjacent to Intersection No. 8.

8.2.7 Results of Preliminary Cost Estimation

(1) Project Costs

Construction cost estimates were made for each subproject 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 8.2.7. This table also shows the estimated economic cost of each subproject as discussed in (2) below.

More detailed cost breakdowns for the recommended options are shown in Tables 8.2.8, 8.2.9 and 8.2.10 for the flyovers, at grade improvements and parking structures respectively.

(2) *Currency Portioning and Economic Costs*

As well as estimating the total financial cost of each option, estimates of the foreign currency portion and the economic cost have also been made.

Estimation of the foreign currency portion and the economic cost requires many assumptions for projects in India where foreign currency and some domestic goods may be in short supply. The local prices of some items which are produced locally and also imported are subsidized in some cases and the import of goods is strictly controlled. In these circumstances a foreign currency portion for some domestic goods should be assumed and economic costs should be adjusted to take into account any government subsidies.

A thorough investigation of these economic considerations was not carried out as part of this Study but conservative assumptions were made on the basis of available information. For example, the assumed foreign and local currency portions for the major materials are shown in Table 8.2.3. The resulting ratio of the foreign currency portion to the total project cost varies according to the sub-project but averages around 60%. The actual foreign currency portion is likely to be considerably less than this provided that good supplies of domestic materials and equipment are available.

The assumption of a relatively high foreign currency portion is conservative at the feasibility evaluation stage of the project since the resulting B/C ratio and the IRR are slightly lower than they would be with a lower foreign currency portion. The reason for this is that taxes are deducted from the local currency portion only when determining the economic costs, hence the economic cost would have been slightly reduced if a higher local currency portion had been assumed.

8.2.8 Maintenance Costs

Maintenance costs are necessary for the financial and economic analysis of the project. Maintenance works include routine maintenance (electricity for lighting, maintenance of traffic signals, cleaning of road surface, drainage facilities, signs etc) and periodic maintenance works (patching, overlays, painting of steelwork, renewal of lane markings etc.).

Based on available data and study team enquiries it has been assumed that maintenance costs for the flyovers and the at grade improvements will average 4% of the initial construction cost for each year of the life of the project.

For the carpark structures, annual maintenance costs of 2% for underground structures and 1% for overhead structures have been assumed. Annual operating costs of 1% for underground structures and 0.5% for overhead structures have also been adopted.

Table 8.2.7(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 8.2.7(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 8.2.7(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 8.2.8(a) Flyover Cost at Intersection No.1

Intersection No. 1 (4 Lanes, 636m)

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
SUPERSTRUCTURE				
Steel Superstructure	Item	-	43,047,000	43,047,000
PC 20m Spans	No.	8	2,229,050	17,832,400
SUBSTRUCTURE				
Concrete Piers	Item	-	2,159,815	2,159,815
Steel Piers	Ton	426	34,760	14,807,803
Pilecaps	Item	-	6,972,420	6,972,420
Pier Piles	LM	7,664	2,186	16,749,672
Abutments	Item	-	862,406	862,406
Abutment Piles	LM	896	2,186	1,958,217
APPROACHES				
Walls and Pavement	Item	-	5,832,970	5,832,970
Piles	LM	1,600	2,186	3,496,816
OTHERS				
PAVEMENT IMPROVEMENTS	SQM	6,118	742	4,537,721
TRAFFIC SIGNALS	Item	-	1,000,000	1,000,000
TRAM TRACK RELOCATION	LM	820	10,000	8,200,000
MAJOR UTILITIES	Item	-	5,051,230	5,051,230
LIGHTING	LM	636	3,000	1,908,000
Sub-total				134,416,469
OTHER UTILITIES	%	5		6,720,823
DRAINAGE	%	5		6,720,823
Total Direct Cost				147,858,116
INDIRECT COST	%	30		44,357,435
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				192,215,551
ENGINEERING SERVICES	%	10		19,221,555
CONTINGENCY	%	10		19,221,555
Project Cost				230,658,661

Table 8.2.8(b) Flyover Cost at Intersection Nos.5&6 (combined)

Intersection No. 5&6 (3 Lanes, 2290m)

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
SUPERSTRUCTURE				
Steel Superstructure	Item	-	150,558,400	150,558,400
PC 20m Spans(3L,2L)	No.	16		22,081,340
SUBSTRUCTURE				
Concrete Piers	Item	-	2,573,260	2,573,260
Steel Piers	Ton	2,238	34,760	77,807,008
Pilecaps	Item	-	29,046,500	29,046,500
Pier Piles	LM	17,718	2,186	38,722,866
Abutments	Item	-	787,359	787,359
Abutment Piles	LM	594	2,186	1,298,193
APPROACHES				
Walls and Pavement	Item	-	7,678,480	7,678,480
Piles	LM	1,650	2,186	3,606,092
OTHERS				
PAVEMENT IMPROVEMENTS	SQM	19,673	742	14,591,093
TRAFFIC SIGNALS	Item	2	1,000,000	2,000,000
TRAM TRACK RELOCATION	LM	0	10,000	0
MAJOR UTILITIES	Item	-	36,034,300	36,034,300
LIGHTING	LM	2,290	3,000	6,870,000
Sub-total				393,654,891
OTHER UTILITIES	%	5		19,682,745
DRAINAGE	%	5		19,682,745
Total Direct Cost				433,020,380
INDIRECT COST	%	30		129,906,114
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				562,926,494
ENGINEERING SERVICES	%	10		56,292,649
CONTINGENCY	%	10		56,292,649
Project Cost				675,511,792

Table 8.2.8(c) Flyover Cost at Intersection No.8

Intersection No. 8 (4 Lanes, 568m)

Item	Unit	Quan-tity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
SUPERSTRUCTURE				
Steel Superstructure	Item	-	18,126,640	18,126,640
PC 20m Spans	No.	9	2,229,050	20,061,450
SUBSTRUCTURE				
Concrete Piers	Item	-	3,519,140	3,519,140
Steel Piers	Ton	156	34,760	5,436,480
Pilecaps	Item	-	4,832,220	4,832,220
Pier Piles	LM	5,280	2,186	11,539,493
Abutments	Item	-	862,406	862,406
Abutment Piles	LM	616	2,186	1,346,274
APPROACHES				
Walls and Pavement	Item	-	5,940,300	5,940,300
Piles	LM	1,100	2,186	2,404,061
OTHERS				
PAVEMENT IMPROVEMENTS	SQM	4,984	742	3,696,633
TRAFFIC SIGNALS	Item	-	1,187,500	1,187,500
TRAM TRACK RELOCATION	LM	1,210	10,000	12,100,000
MAJOR UTILITIES	Item	-	892,745	892,745
LIGHTING	LM	568	3,000	1,704,000
Sub-total				93,649,341
OTHER UTILITIES	%	5		4,682,467
DRAINAGE	%	5		4,682,467
Total Direct Cost				103,014,276
INDIRECT COST	%	30		30,904,283
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				133,918,558
ENGINEERING SERVICES	%	10		13,391,856
CONTINGENCY	%	10		13,391,856
Project Cost				160,702,270

Table 8.2.8(d) Flyover Cost at Intersection No.9

Intersection No. 9 (4 Lanes, 633m)

Item	Unit	Quan-tity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
SUPERSTRUCTURE				
Steel Superstructure	Item	-	14,277,190	14,277,190
PC 20m Spans	No.	19	2,229,050	42,351,950
SUBSTRUCTURE				
Concrete Piers	Item	-	6,537,730	6,537,730
Steel Piers	Ton	0	34,760	0
Pilecaps	Item	-	5,668,610	5,668,610
Pier Piles	LM	6,216	2,186	13,585,130
Abutments	Item	-	862,406	862,406
Abutment Piles	LM	588	2,186	1,285,080
APPROACHES				
Walls and Pavement	Item	-	5,766,710	5,766,710
Piles	LM	1,100	2,186	2,404,061
OTHERS				
PAVEMENT IMPROVEMENTS	SQM	6,020	742	4,465,034
TRAFFIC SIGNALS	Item	-	0	0
TRAM TRACK RELOCATION	LM	0	0	0
MAJOR UTILITIES	Item	-	2,439,030	2,439,030
LIGHTING	LM	633	3,000	1,899,000
Sub-total				101,541,931
OTHER UTILITIES	%	5		5,077,097
DRAINAGE	%	5		5,077,097
Total Direct Cost				111,696,124
INDIRECT COST	%	30		33,508,837
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				145,204,961
ENGINEERING SERVICES	%	10		14,520,496
CONTINGENCY	%	10		14,520,496
Project Cost				174,245,954

Table 8.2.8(e) Flyover Cost at Intersection No.10

Intersection No. 10 (2 Lanes, 474m)

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
SUPERSTRUCTURE				
Steel Superstructure	Item	-	8,677,800	8,677,800
PC 20m Spans	No.	8	1,231,887	9,855,096
SUBSTRUCTURE				
Concrete Piers	Item	-	1,126,364	1,126,364
Steel Piers	Ton	81	34,760	2,829,472
Pilecaps	Item	-	1,942,420	1,942,420
Pier Piles	LM	2,572	2,186	5,621,132
Abutments	Item	-	463,078	463,078
Abutment Piles	LM	512	2,186	1,118,981
APPROACHES				
Walls and Pavement	Item	-	4,102,060	4,102,060
Piles	LM	1,600	2,186	3,496,816
OTHERS				
PAVEMENT IMPROVEMENTS	SQM	1,939	742	1,438,156
TRAFFIC SIGNALS	Item	-	1,000,000	1,000,000
TRAM TRACK RELOCATION	LM	830	10,000	8,300,000
MAJOR UTILITIES	Item	-	1,689,669	1,689,669
LIGHTING	LM	474	3,000	1,422,000
Sub-total				53,083,044
OTHER UTILITIES	%	5		2,654,152
DRAINAGE	%	5		2,654,152
Total Direct Cost				58,391,349
INDIRECT COST	%	30		17,517,405
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				75,908,753
ENGINEERING SERVICES	%	10		7,590,875
CONTINGENCY	%	10		7,590,875
Project Cost				91,090,504

Table 8.2.9(a) 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 8.2.9(b) Cost of At-Grade Improvements at Intersection No.3

Intersection No. 3 (At-Grade)

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
Pavement				
Asphalt Pavement A-1	SQM	140	998	139,700
Asphalt Pavement A-2	SQM	11,800	742	8,752,060
OTHERS				
TRAFFIC SIGNALS	SET	1	1,000,000	1,000,000
TRAM TRACK RELOCATION	LM	0	10,000	0
LIGHTING	LM	400	3,000	1,200,000
Miscellaneous	%	25		2,772,940
Total Direct Cost				13,864,701
INDIRECT COST	%	30		4,159,410
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				18,024,111
ENGINEERING SERVICES	%	10		1,802,411
CONTINGENCY	%	10		1,802,411
Project Cost				21,628,933

Table 8.2.9(c) Cost of At-Grade Improvements at Intersection No.4

Intersection No. 4 (At-Grade)

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
Pavement				
Asphalt Pavement A-1	SQM	110	998	109,765
Asphalt Pavement A-2	SQM	9,300	742	6,897,810
OTHERS				
TRAFFIC SIGNALS	SET	1	1,187,500	1,187,500
TRAM TRACK RELOCATION	LM	620	10,000	6,200,000
LIGHTING	LM	500	3,000	1,500,000
Miscellaneous	%	25		3,973,769
Total Direct Cost				19,868,843
INDIRECT COST	%	30		5,960,653
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				25,829,496
ENGINEERING SERVICES	%	10		2,582,950
CONTINGENCY	%	10		2,582,950
Project Cost				30,995,395

Table 8.2.9(d) Cost of At-Grade Improvements at Intersection No.7

Intersection No. 7 (At-Grade)

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
Pavement				
Asphalt Pavement A-1	SQM	50	998	49,893
Asphalt Pavement A-2	SQM	11,000	742	8,158,700
OTHERS				
TRAFFIC SIGNALS	SET	1	1,000,000	1,000,000
TRAM TRACK RELOCATION	LM	0	10,000	0
LIGHTING	LM	400	3,000	1,200,000
Miscellaneous	%	25		2,602,148
Total Direct Cost				13,010,741
INDIRECT COST	%	30		3,903,222
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				16,913,964
ENGINEERING SERVICES	%	10		1,691,396
CONTINGENCY	%	10		1,691,396
Project Cost				20,296,756

Table 8.2.9(e) Cost of At-Grade Improvements at Intersection No.8
(3 lanes each way on J.L. Nehru Road)

Intersection No. 8 (3 Lane At-Grade)

Item	Unit	Quan-tity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
Pavement				
Asphalt Pavement A-1	SQM	9,300	998	9,280,098
Asphalt Pavement A-2	SQM	10,500	742	7,787,850
OTHERS				
TRAFFIC SIGNALS	SET	1	1,187,500	1,187,500
TRAM TRACK RELOCATION	LM	1,000	10,000	10,000,000
LIGHTING	LM	500	3,000	1,500,000
Miscellaneous	%	25		7,438,862
Total Direct Cost				37,194,310
INDIRECT COST	%	30		11,158,293
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				48,352,603
ENGINEERING SERVICES	%	10		4,835,260
CONTINGENCY	%	10		4,835,260
Project Cost				58,023,124

Table 8.2.9(f) Cost of At-Grade Improvements at Intersection No.8
(4 lanes each way on J.L. Nehru Road)

Intersection No. 8 (4 Lane At-Grade)

Item	Unit	Quan-tity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
Pavement				
Asphalt Pavement A-1	SQM	12,500	998	12,473,250
Asphalt Pavement A-2	SQM	10,500	742	7,787,850
OTHERS				
TRAFFIC SIGNALS	SET	1	1,187,500	1,187,500
TRAM TRACK RELOCATION	LM	1,000	10,000	10,000,000
METRO ENTRANCE MODIF.	ITEM	-	-	3,125,000
LIGHTING	LM	500	3,000	1,500,000
Miscellaneous	%	25		9,018,400
Total Direct Cost				45,092,000
INDIRECT COST	%	30		13,527,600
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				58,619,600
ENGINEERING SERVICES	%	10		5,861,960
CONTINGENCY	%	10		5,861,960
Project Cost				70,343,520

Table 8.2.9(g) Cost of At-Grade Improvements at Intersection No.10

Intersection No. 10 (At-Grade)

Item	Unit	Quantity	Unit Price (Rs.) Total Financial	Cost (Rs.) Total Financial
Pavement				
Asphalt Pavement A-1	SQM	0	998	0
Asphalt Pavement A-2	SQM	9,100	742	6,749,470
OTHERS				
TRAFFIC SIGNALS	SET	1	1,000,000	1,000,000
TRAM TRACK RELOCATION	LM	600	10,000	6,000,000
LIGHTING	LM	400	3,000	1,200,000
Miscellaneous	%	25		3,737,368
Total Direct Cost				18,686,838
INDIRECT COST	%	30		5,606,051
LAND ACQUISITION	SQM	0	14,000	0
Construction Cost				24,292,889
ENGINEERING SERVICES	%	10		2,429,289
CONTINGENCY	%	10		2,429,289
Project Cost				29,151,467

Table 8.2.10(a) 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
Hand Excavation	CUM	0	106	0
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
Erectrical 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

Table 8.2.10(b) 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

CHAPTER 9

FEASIBILITY ASSESSMENT AND EVALUATION

CHAPTER 9 FEASIBILITY ASSESSMENT AND EVALUATION

9.1 Technical Evaluation of Intersection Improvements

This section discusses the effect on traffic flow patterns of the proposed intersection improvement plans as set up in Section 5.3.4. This technical evaluation of the alternative plans is based mainly on results from the traffic simulation, and other information such as road widths obtained from actual surveys.

9.1.1 Alternative I

This alternative improvement plan proposes the construction of flyovers at intersections along the southern and eastern sections of A.J.C. Bose Road (Intersections No.5, No.6, and No.1), and along J.L. Nehru Road that runs through the central area of Calcutta City (Intersections No.2 and No.8).

Future traffic volumes at these five 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.

At Intersections No.5 and No.6, separate flyovers would be restricted to 2-lanes maximum due to the limited right-of-way widths. These flyovers will therefore be one-way and would each operate as a reversible facility according to the time of day.

As the traffic pattern at Intersection No.5 has no obvious peak, the traffic stream not using the flyover will probably face congestion on the roadway at grade. This is because only 2 lanes can be provided on the frontage road and they will not be sufficient to accommodate the main traffic flow.

There are still a few minor intersections between separate flyovers at Intersections No.5 and 6. Through traffic from the flyovers will come into conflict with local traffic turning right and left at these minor intersections and congestion will occur. The effectiveness of the flyovers will therefore be reduced by the existence of these minor intersections.

However, 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.

This entrance point to the city is an important access to the north, particularly Barrackpore and Kalyani areas which are undergoing rapid urban growth. Presently, the low traffic capacity at Shyambazar actually acts as a restraint on traffic demand, diverting traffic to other routes. If Lock Gate Road is improved, actual traffic demand may result in a rapid increase in traffic volume at this point. To meet such a demand from the northern parts of the CMD, improvement measures recommended in the Study as well as other measures such as widening the bridges on Central Canal and developing a ring road along the Hooghly river will 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.

Traffic is dynamic and fluctuation of demand is more a rule than an exception. Congestion therefore may occur sometimes at Intersections No.3, No.4 and No.7 but the level does not justify the construction of flyovers before 1998. Rather, at grade intersection improvement measures including upgrading the tram tracks are recommended.

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).

For the computation of these economic indicators, the following conditions are applied:

1.	Project Cost	The economic cost of alternative plans as estimated in Chapter 8, equally divided into the construction period.
2.	Construction Period	Construction periods of alternative improvement plans are given in Section 9.6.
3.	Project Life	20 years
4.	Maintenance cost	4% of direct cost
5.	Benefit from Time Savings	Savings in total delay time by alternative improvement plans converted to monetary terms
6.	Benefit from Fuel Savings	Savings in fuel consumption due to increase in travel speed.
7.	Discount Rate	12%

One of the most important factors in any economic analysis is the unit time value adopted for the study area. The unit time value for this study is adopted from "Manual of Economic Evaluation of Highway Projects in India", but updated to 1992 using indices from the trend in per capita GRP in West Bengal State. The unit time value was 8.21 Rs/hour in 1984 for passengers of car and taxi. Unit time values have been increased according to increases since 1984 in per capita income, and it has been assumed that the same growth rate will apply in the future.

(1) Alternative I

This alternative includes improvements at Intersection No.1, 2, 5, 6 and 8. 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 improvements 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 Intersection 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.

(4) Sensitivity Analysis

The conditions which were adopted for the economic analysis are subject to change. In order to analyze the sensitivity of the economic indicators to changes in conditions, cost and traffic volume were both selected as variables to be changed.

Increases and decreases of 5% in these variables were applied for Alternative II-4 which has the highest IRR in Section 9.2.1. The results are shown in Table 9.2.4.

Table 9.2.4 Results of Sensitivity Analysis

		IRR traffic volume			B/C traffic volume		
		+5%	N/C	-5%	+5%	N/C	-5%
cost	+5%	17.1		21.2	1.4		1.7
	N/C		18.4			1.5	
	-5%	18.9		23.2	1.5		1.9

N/C = No change to traffic volume or cost for Alt II-4.

According to the Table the indicators are less sensitive to cost than to traffic volume. Regarding traffic volume, an increase in the traffic volume reduces the indicators while a decrease in volume increases the indicators, but to a larger degree.

Under the most favorite combination i.e. 5% decrease of both of the variables, the indicators show a considerable increase. But, even in the worst combination i.e. 5% increase of both the cost and the traffic volume, Alternative II-4 is still feasible with an IRR of 17.1% and a B/C ratio of 1.4.

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 9.2.5 below.

Table 9.2.5 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

Using these time savings, the economic costs of the parking structures from Chapter 8, and other parameters from Chapter 9.2.1, the economic indicators have been calculated and are shown below;

Table 9.2.6 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 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 and the costs from Chapter 10, an economic evaluation has been carried out. The results are shown in Table 9.2.7 below.

Table 9.2.7 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 Section 10.1.

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.

For the financial analysis of the proposed parking facilities, 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.

To explore the financial feasibility of the parking facilities, the following types of financing have been considered:

1. Grant - Up to 50% of the Project Cost
2. Long Term Loan - at 8% interest with a grace period of 5 years for repayment of loan and a repayment period of 20 yrs
3. Subsidy - Yearly operational subsidy from Govt.

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.

9.3.3 Conclusions

* Underground car parks in Calcutta are not economically feasible (Chapter 9.2.3) and are not financially feasible as long as revenues are confined to parking charges only.

* The above-ground car park facility at the Esplanade was found to be marginal in terms of economic feasibility. It would be 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 (in thousand rupee)
Long Term Loan at 8% Interest Rate

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.

Other possible positive effects of improved traffic flow, other than those considered in the economic analysis, are very difficult to quantity but include:

a. travel time of all trips, be it social, work and recreational trips in the city will become more predictable with the improved traffic flow and speed.

b. the necessity to observe lane markings on the flyovers will produce positive side-effects in better driver behaviour.

c. the provision of designated pedestrian crossing facilities below the flyovers will help in training better pedestrian behavior at other cross walks.

d. Traffic accidents, including those involving pedestrians, will be reduced.

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)

The effectiveness of the flyovers and at-grade improvements listed below in alleviating traffic congestion have been clearly demonstrated and are supported by the economic analysis of the alternatives. In the case of the continuous flyover at Intersections No.5 and No.6 only, another alternative (separate flyovers) showed higher returns but the continuous flyover is recommended for traffic reasons as previously described and also because a continuous flyover is likely to be necessary in any case to cope with traffic volume increases beyond 1998. Converting two separate flyovers to one continuous flyover would be difficult and expensive. Therefore the recommended list of intersection improvements is as follows;

(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 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.

9.5.3 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, as described in Chapter 10.1, 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 Implementation Plan

The target year for completion of the recommended works is the beginning of 1998. Allowing for design and tendering, the construction should take place during 1994 to 1997 inclusive, a period of 4 years.

The time frame is quite short for the amount of work required but completion is quite achievable provided that the required funding is available. There are however two aspects which must be given careful consideration in scheduling the works and where strong support at the government level will be required;

a) Utilities and Tram Tracks

At virtually all of the intersections major works involving the relocation of tram tracks and/or utilities will be required. Completion of these works will be necessary prior to commencement of the main works at the site.

The usual practice in Calcutta is for the main contractor to pay the relevant government agency to undertake the diversion works. After the main contract is awarded the main contractor must obtain from the government agencies the final cost estimates for the diversion works and then forward the required funds to the agency. On receipt of funds the agency can carry out the works but they must be scheduled around other works the agency has in hand. For the projects under consideration, adoption of this method could delay the overall program during the funding, approval, mobilization and implementation of the relocation works. Delay costs could be high if the main contractor is denied possession of site at the prearranged date.

The total time required could be reduced if the relocation works were either included in the main contract and carried out by the main contractor to the approval of the relevant agencies or if separate arrangements were made with the agencies in advance so that the utility diversion works can be completed in advance of the main contract and are not on the critical path for overall contract completion. Another advantage in having this work carried out in advance would be that unexpected works related to utility diversions could be identified and implemented without delaying the main contract.

b) Land Acquisition

Land acquisition requirements have been kept to a minimum but are required for some of the options. The only option requiring the acquisition of private land is the at-grade option at Intersection No. 2 where some land acquisition is required opposite the mosque. The acquisition would involve several holdings and partial demolition and reconstruction of existing buildings would be required. It will be necessary for the land acquisition and compensation, as well as the actual demolition works, to be carried out in advance so that the main contract for pavement widening and intersection reconstruction can proceed on schedule. The negotiations and legal procedures could take some time and must be given a high priority if the at-grade option for Intersection No. 2 is adopted.

At Intersection No. 8 the flyover option would require temporary usage of government land in the Maidan for the diversion of north-south traffic away from the construction of the concrete box girders and approaches. Early negotiations will be required to ensure that the necessary approvals can be achieved in advance of the proposed construction works. The adoption of the at grade improvements for Intersection No. 8 would require the permanent acquisition of Government owned land in the same area.

In addition to the above, the Implementation Schedule should give consideration where possible to the particular effects of the local climate. The most productive period of the year for construction activity in Calcutta is from October to May inclusive when rainfall is low. Works during the months of June to September inclusive are slow due to the high rainfall during this period. During these four months piling works can be carried out but foundation and pavement works should be avoided if possible. The construction schedule can be adjusted to some extent to take timing of the monsoon rains into consideration but the overall time frame is too short to give much flexibility.

Based on the above 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.

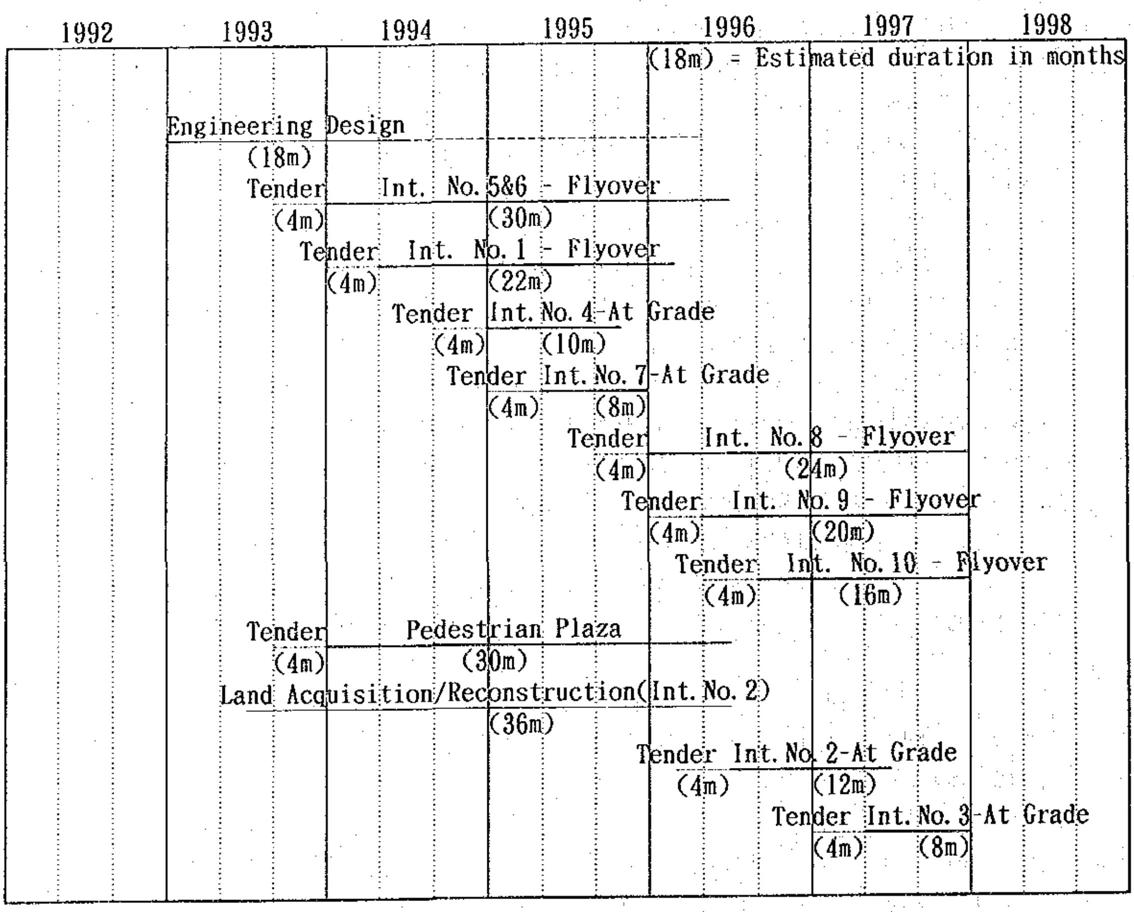


Figure 9.6.1 Implementation Schedule

9.7 Disbursement 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 9.7.1 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 9.7.1 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.

CHAPTER 10

OTHER TRANSPORT INFRASTRUCTURE IMPROVEMENTS

CHAPTER 10 OTHER TRANSPORT INFRASTRUCTURE IMPROVEMENTS

In addition to the feasibility assessment of the intersection improvements and the parking structures, a preliminary feasibility assessment has been carried out for additional projects put forward by the Department of Transport. The additional projects are:

a) Pedestrian facility between Sealdah Station and BBD Bag;
b) Concreting of some road sections;
c) Traffic signal improvements.

The results of the preliminary feasibility assessments are described below.

10.1 Pedestrian Facilities

There is a huge volume of pedestrians using the east-west axis in downtown Calcutta from Sealdah and Howrah Railway Stations to the CBD. The pedestrians are suburban rail commuters who prefer to continue their trips to their place of work on foot rather than by the often congested trams or buses.

As the level of service for surface traffic has deteriorated, operating speeds of mass transport systems have correspondingly worsened in recent years. Usage of mass transport systems therefore may level off or decrease. This implies that pedestrian traffic on this east-west axis is likely to increase in the near future. Unless there are significant improvements in the bus and tram systems.

10.1.1 Pedestrian Traffic Along B.B. Ganguly Street

A pedestrian survey was conducted along B.B. Ganguly Street from 8:00 to 20:00 hours. Pedestrian volumes and operating conditions on the road were surveyed according to the sections shown in Figure 10.1.1 and described below:

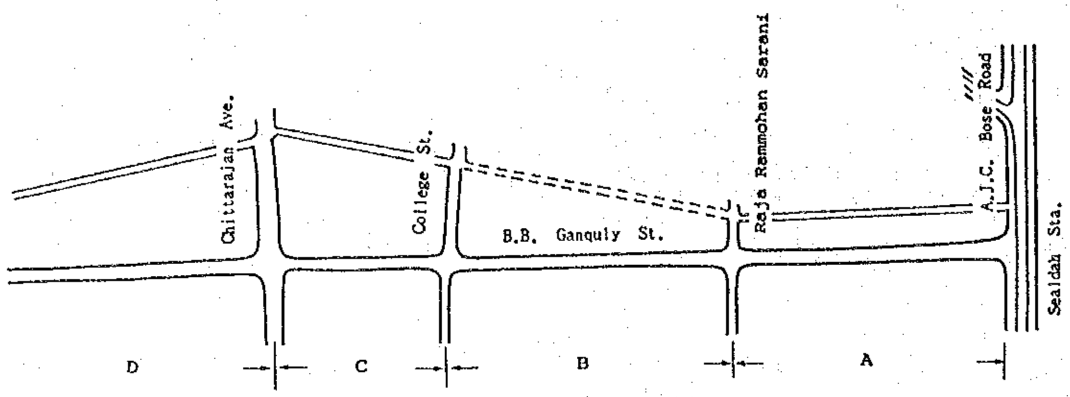


Figure 10.1.1 B.B. Ganguly St. by Section

(a) Section A: Sealdah Railway Station to Raj Rammohan Sarani

This section of B.B. Ganguly Street is relatively wide in comparison to other sections. The eastern end of this section is occupied by green grocers in the mornings and pedestrian volume here is the highest with 20,000 in the morning peak (10:00-11:00), 22,500 in the evening peak (18:00-19:00) and 152,000 over twelve hours. As expected, 90% of the pedestrians traffic in the morning are west bound while 85% in the evening are east bound at this section.

At present, vehicular traffic volume along this section is very low as the frontage roads beside Sealdah Flyover are too congested by hawkers, thus allowing few left-turning or right-turning vehicles from A.J.C Bose Road. A high volume of pedestrians thus overflow onto the street. In the morning and evening peak hours, it is observed that this section of B.B. Ganguly Street is fully occupied by pedestrians.

In the future, vehicular traffic is expected to increase significantly in this section when planned roadworks at the eastern end of B.B. Ganguly Street near Sealdah Station are implemented.

(b) Section B : From Raj Rammonhan Sarani to College Street

The pedestrian volume decreases from Section A as pedestrians begin to disperse to other streets while vehicle traffic begin to increase. Trams also run on this section as they turn from Rammonhan Sarani. Pedestrian volume in the morning peak is 10,300 pedestrians per hour and 16,300 in the evening peak. For 12 hours, the volume is 92,000 as compared to 152,000 in Section A.

(c) Section C : From College Street to Chittarajan Avenue

Pedestrian volume along this section is further reduced to only about 9,000 in the morning peak and 8,500 in the evening peak, as more are dispersed to other streets. Although vehicular traffic has increased with more vehicles entering from College Street, this increase is manageable with the present one-way operation. Curb side parking however should be prohibited to improve vehicular flow.

(d) Section D : From Chittarajan Avenue to CBD

Pedestrian traffic along this section is no longer unique with no distinct directional flow but typical of a busy CBD district.

Pedestrian volumes along this section are likely to increase substantially following the opening of the Metro expected in 1994, but no detailed projections are available.

10.1.2 Pedestrian Facility Improvements

The basic policy should be to utilize the existing pedestrian provisions to the maximum extent possible. In many areas this would ideally involve clearing the full width of sidewalk for pedestrian flow.

However, as mentioned above pedestrian flow on B.B. Gangly Street is tremendously large and a facility to segregate pedestrian flow from vehicular traffic should be considered, especially if the street is required to cater for an increasing volume of vehicular traffic. In order to effectively feed the facility, segregation of pedestrian and vehicular traffic below Sealdah flyover must be ensured.

The basic concept for the elevated Pedestrian Plaza is to construct an elevated pedestrian deck above the existing roadway to segregate the pedestrian traffic from the vehicular traffic. This pedestrian deck could be constructed above existing B.B. Ganguly Street which has sufficient width of 15-17 meters. At intersections, the pedestrian deck would branch out to connect all corners of the intersection together by the provision of stairways.

The most recommendable section, as shown in Figure 10.1.2 below, can be considered as Phase-I and would be from Sealdah station to just beyond Chittarajan Avenue, as the pedestrian volume is relatively high and has a homogeneous direction. This section would also function as a pedestrian corridor between the major railway station, Sealdah station, and Metro Central station.

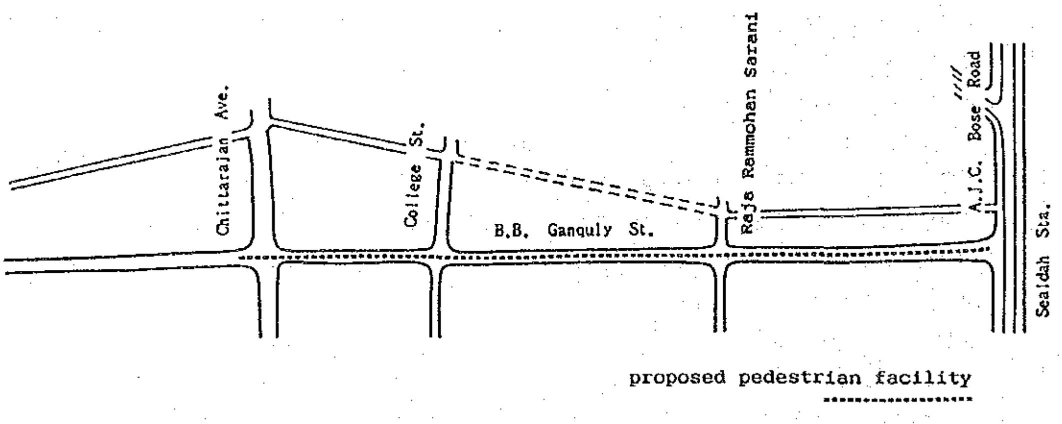


Figure 10.1.2 Pedestrian Facility along B.B.Ganguly St.

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 although there is no detailed information available on likely pedestrian movements along this corridor. The extension of the elevated walkway to B.B.D. Bag (Phase-II) cannot be recommended at this stage since insufficient information is available on predicted pedestrian volumes and destinations.

It is 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 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.

10.1.3 Cost Estimates

Preliminary designs for the Pedestrian Plaza have not been prepared but an order of cost estimate has been provided based on a previous study. In 1990 the Bharat Chamber of Commerce submitted a "Project Profile of Pedestrian Plaza" which included cost estimates and a financial evaluation. Using the quantities and estimates in the above report, and adjusting to current costs using the approach detailed in Chapter 8, the estimated financial cost of Phase I of the Pedestrian Plaza between Sealdah Station and Chittaranjan Ave. would be Rs.162 million, including allowances for indirect costs, engineering services and contingencies.

10.2 Concrete Pavements

10.2.1 Background Information and Project Description

Calcutta Municipal Corporation (CMC) are responsible for the maintenance of 3,400 roads with a total road length of 1,400 km or a total lane length of 4,000 lane-km. The major arterial roads (750 lane-km) are looked after by a central maintenance section. Calcutta is divided into 15 boroughs and the remaining roads are looked after by maintenance units set up for each borough.

CMC have about 1,000 workers available for road maintenance, about 400 at the central level and about 600 (60 gangs of 10 workers) at the borough level. At each level the workers are divided into gangs for recycling/resheeting and gangs for patch repairing.

CMC's annual budget for road maintenance is about 19 crore Rs. (US$7.6 million) and is allocated as follows:

Salary	6 crore
Materials	4 crore
Administration	2 crore
Works	7 crore
Total	19 crore (190 million Rs)

Within this budget there is little scope for major road improvements and maintenance is generally limited to resheeting or recycling existing pavement. Recycling existing asphaltic concrete/bituminous concrete involves removal, and relaying of the pavement surface. Full pavement reconstruction is rarely done. CMC aim for resheeting/recycling at intervals of around 5 years but in practice they cannot usually achieve this. Patch repairing is carried out on a regular basis, and is required in particular after the wet season. As a result of regular resheeting since the beginning of the century, the total thickness of most pavements is substantial.

During discussions with CMC they indicated that the main causes of pavement damage are:

a) Maintenance and repair of underground services. Even when the opening is repaired at the time, subsequent settlement can allow water ingress and damage a larger section of pavement.
b) Leaking underground utilities, especially water mains.
c) Poor tram track foundations which move under the passage of trams, opening up a gap between the rail and the adjacent pavement and allowing water to enter, especially where the rail is lower than the surrounding pavement and the tram track functions as a drainage path.
d) Inundation and/or saturation of pavements during the wet season, causing lifting and separation of the surfacing.
e) Deficiencies in the materials and/or the mixing, transport and placement of asphaltic concrete.

CMC are considering the possible construction of concrete surfacing at some locations in order to help overcome the above problems. CMC consider that the use of concrete surfacing is only appropriate where there are no major services under the road. Minor services should be relocated to the verge/footpath prior to concreting. Providing these preconditions are met, CMC feel that the use of concrete surfacing is appropriate where;

a) There are high volumes of heavy vehicles, and
b) High maintenance costs are being incurred with conventional pavement, as a result of inundation and/or pavement waterlogging during each wet season for example.

Based on these criteria CMC would like to add a concrete surface to several roads and proposals are included in the 8th Five Year Plan. For consideration as part of this Feasibility Study CMC prepared and submitted a list of candidate roads for consideration as possible sites where concrete surfacing (white topping) might be justified. The following candidate roads were identified;

Location		Length in Lane.km
A.	Cossipore Road	12
B.	Strand Road	14
C.	Brabourne Road	6
D.	New Park Street	8
E.	Camac Street	8
F.	Gariahat Road	25.5
G.	M. Gandhi Road	14
	Total	87.5 lane.km

The locations are shown on the attached Figure 10.2.1. With the exception of Camac Street and possibly Cossipore Road all the above roads are arterial roads. All carry heavy volumes of traffic. CMC consider that concreting these roads would allow their limited funds to be allocated more effectively to the remaining roads. CMC confirmed that it would be undesirable to construct concrete roads above any major longitudinal services and advised that the listed roads had been screened to ensure that this was not the case. The Study Team was unable to visit all of the candidate sites, but CMC advised that maintenance costs were high as a result of one or more of the problems described above.

10.2.2 Technical Review

A detailed assessment of pavement conditions was not carried out as part of this Study so this review is based on general impressions from the site and experience elsewhere.

The single major cause of the maintenance problems appears to be moisture related. The effects become most apparent during and after the monsoons when water penetrates through damage or imperfections in the surface layers. Under the passage of heavy vehicles, further damage to the surface then progressively occurs in the form of pot-holing and in the stripping and separation of the surface layers.

Increases in the moisture content of the subsoil may also be weakening the pavement in the monsoon season. The moisture could come through the damaged surface layers or

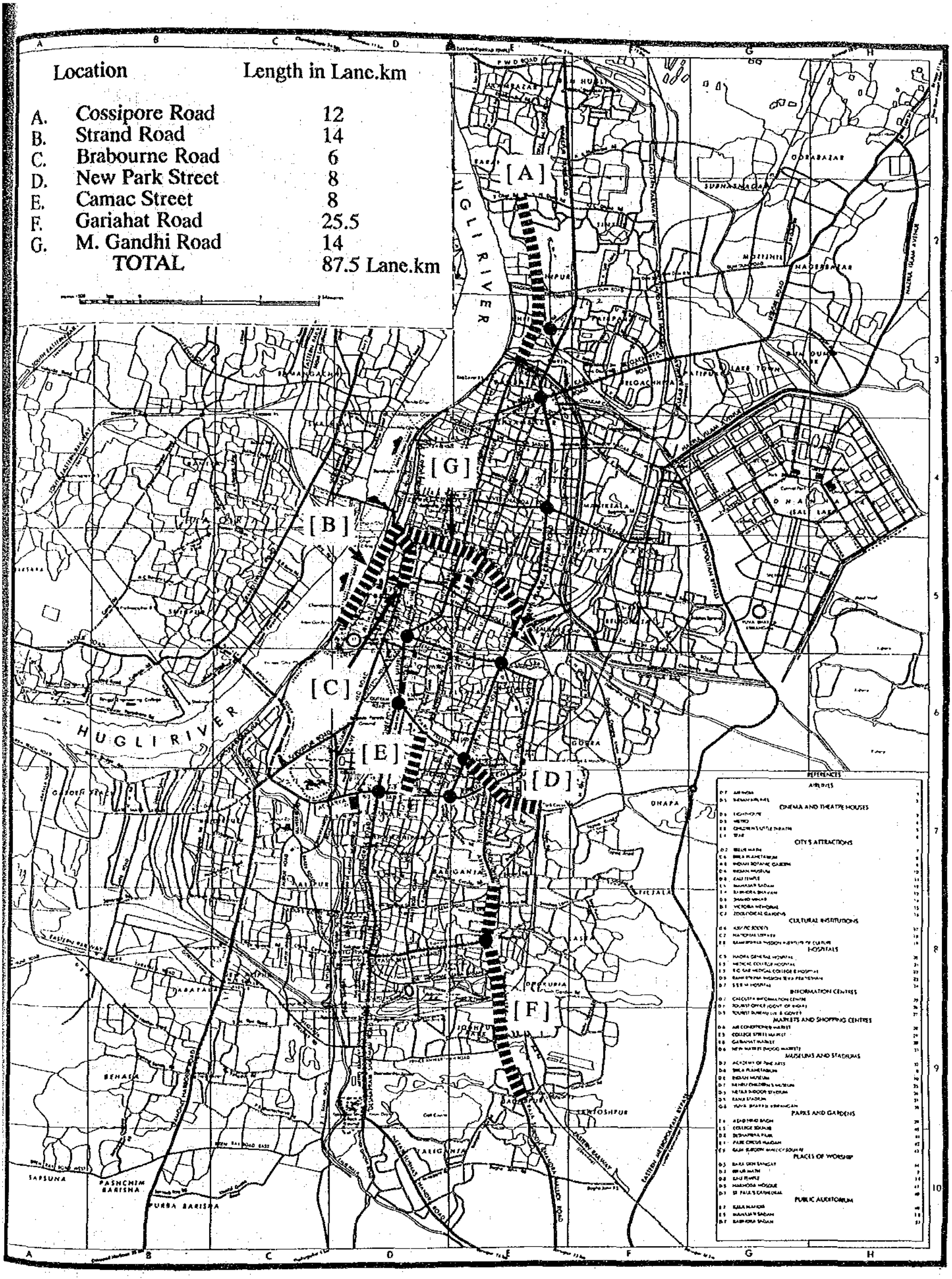


Figure 10.2.1 Candidate Roads for Concrete Surfacing