THE FEASIBILITY STUDY ON THE TRANSPORT INFRASTRUCTURE DEVELOPMENT PROJECT IN CALCUTTA FINAL REPORT VOLUME I SUMMARY

SEPTEMBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEASIBILITY STUDY ON THE TRANSPORT INFRASTRUCTURE DEVELOPMENT PROJECT IN CALCUTTA

FINAL REPORT VOLUME I

SUMMARY

SEPTEMBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to a request from the Government of India, the Government of Japan decided to conduct a feasibility study on The Transport Infrastructure Development Project in Calcutta and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to India a study team headed by Dr. Juro Kodera, Yachiyo Engineering Co., Ltd., two times between September, 1991 and September, 1992.

The team held discussions with the officials concerned of the Government of India, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of India for their close cooperation extended to the team.

September, 1992

Kensuke Yanagiya
President
Japan International Cooperation Agency

THE FEASIBILITY STUDY
ON
THE TRANSPORT INFRASTRUCTURE DEVELOPMENT PROJECT
IN
CALCUTTA

FINAL REPORT

VOLUME I : SUMMARY
VOLUME II : MAIN REPORT
VOLUME III : TECHNICAL REPORT
VOLUME IV : DRAWINGS

CONTENTS

CHAPTER 3 FIELD SURVEY

CHAPTER 4 TRAFFIC SURVEYS AND FUTURE TRAFFIC ESTIMATES

CHAPTER 5 TRANSPORT INFRASTRUCTURE IMPROVEMENT ALTERNATIVES

CHAPTER 6 ASSESSMENT OF INTERSECTION IMPROVEMENT PLANS USING TRAFFIC FLOW SIMULATION

CHAPTER 7 PRELIMINARY DESIGNS

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 1 INTRODUCTION

1.1 Background and Objectives

In response to the request of the Government of India and the Government of West Bengal, the Government of Japan decided to conduct the feasibility study for "The Transport Infrastructure Development Project in Calcutta". Accordingly, the Japan International Cooperation Agency (JICA) has carried out the Study in close cooperation with the authorities concerned of the Government of India and the Government of West Bengal.

The initial request of the Government of India was to conduct a comprehensive study in order to formulate a "Transportation Master Plan". Since the traffic situation in Calcutta requires very urgent attention, it was agreed that the study would be changed to that of a feasibility study of designated infrastructure improvements to be completed within a shorter time period.

The objectives were to conduct a feasibility study on the following projects (refer Figure 1.1.1) for the alleviation of traffic congestion in the study area;

(i) Construction of vehicular flyovers at ten designated intersections in Calcutta,
(ii) Construction of multi-storied car parking structures at BBD. Bag and the Esplanade,
(iii) Other transport infrastructure improvement measures including an elevated pedestrian plaza from Sealdah to BBD Bag, pavement improvements and traffic signal improvements.

The Study was carried out in four phases over a total of ten calendar months. As part of the Study, soil investigations, topographical survey and underground utilities survey were carried out at each of the study intersections. Comprehensive traffic studies such as origin - destination surveys were not undertaken, but a limited O-D survey was carried out for cross-river traffic to assist in the assignment of vehicles after the opening of the second Hooghly Crossing.

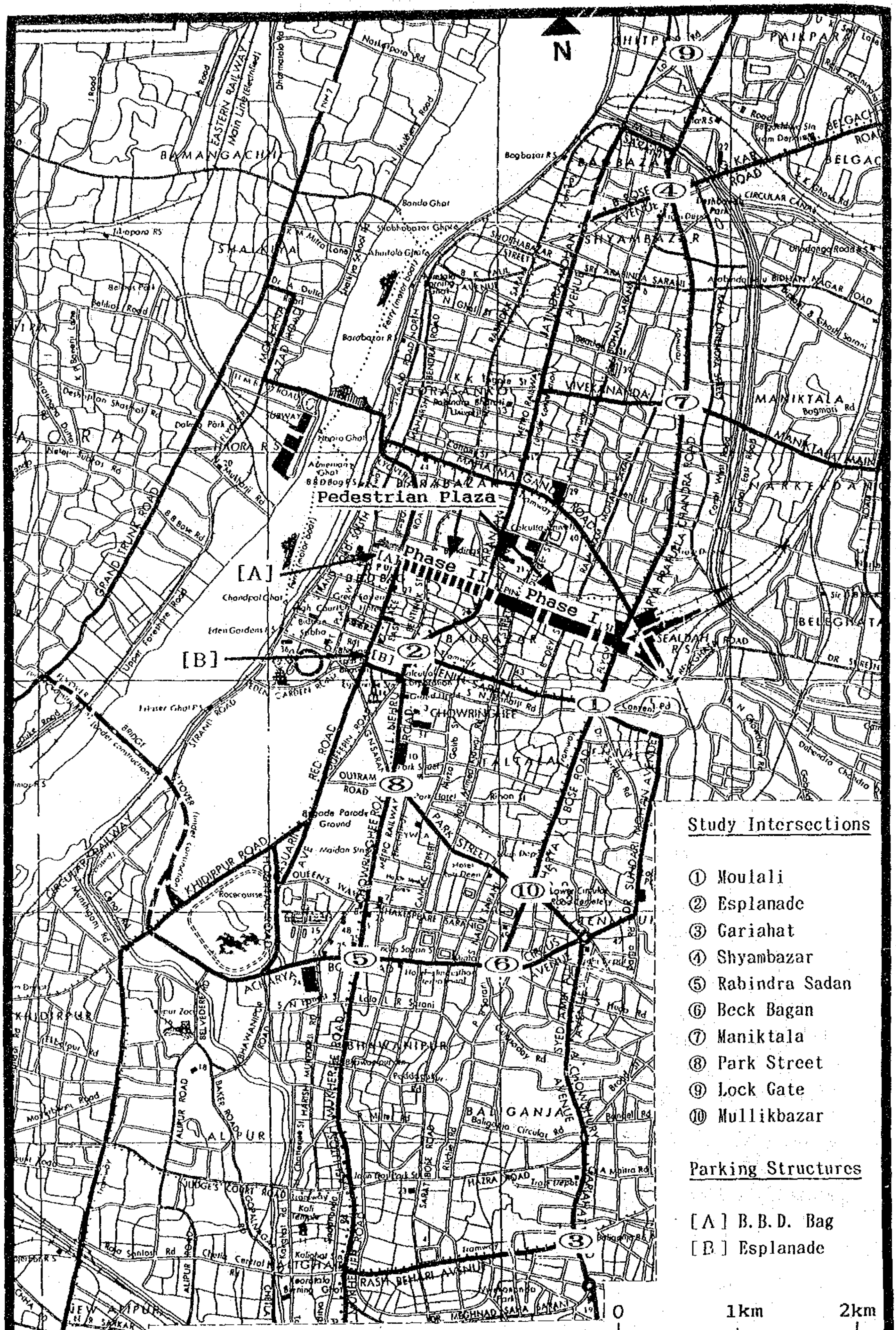


Figure 1.1.1 Project Locations

1.2 Study Organization

The Study has been jointly executed by a Study Team dispatched by JICA and a Counterpart Team organized by the West Bengal Government. JICA also established an Advisory Committee to supervise the progress of the Study.

1.2.1 Counterpart Team

The Counterpart Team consisted of the members listed below;

1. Mr. A.K. Bandopadhyaya	Counterpart Team Leader Chief Traffic & Transportation Planner/Engineer, Transport Department
2. Mr. S. Mukherjee	Deputy Commissioner of Police (Traffic) Calcutta
3. Mr. N.K. Sinha	Superintending Traffic & Transportation Planner, Transport Department
4. Mr. B.K. Sadhu	Executive Traffic and Transportation Engineer, Transport Department
5. Mr. S. Sanyal	Executive Engineer (Drainage) Calcutta Municipal Corporation
6. Mr. T. Mukherjee	Executive Engineer (Water Supply) Calcutta Municipal Corporation
7. Mr. A. Maikap	Senior Economic Planner Development and Planning (T & CP) Department
8. Mr. R. Chowdhury	Deputy Director (Planning & Design) Hooghly River Bridge Commission

9. Mr. D.K. Biswas	Executive Engineer (Roads) Calcutta Municipal Corporation
10. Mr. S. Roy	Executive Engineer (Roads) Calcutta Municipal Corporation
11. Mr. A.K. Bagchi	Senior Engineer Calcutta Tramways Company - Coordinator

The Counterpart team also arranged for necessary discussions to be held with the following important officials.

1. Mr. D. Rudra	Secretary Transport Dept. GOWB
2. Mr. B.K. Saha	Commissioner of Police Calcutta
3. Mr. Sumantra Chowdhury	Special Secretary Transport Dept. GOWB
4. Mr. M. Mandel	Chief Municipal Engineer (Civil) Calcutta Municipal Corporation
5. Mr. S.K. Roy	Director General (P & D) Calcutta Metropolitan Development Authority
6. Mr. H.S. Verma	Director General (M.D) Calcutta Metropolitan Development Authority
7. Mr. A.K. Ganguly	Principal Chief Engineer Metro Railway, Calcutta

1.2.2 Advisory Committee, Japanese Government

Dr. Hirotake Koike	Professor of Civil Engineering Utsunomiya University
Mr. Seiichiro Akimura	Ministry of Construction
Mr. Hiroo Ikemoto	The City of Yokohama

1.2.3 Study Team

The Study Team consisted of the following members;

Dr. Juro Kodera	Team Leader
Mr. Hiroo Takeda	Transportation Planning
Mr. Tetsuo Horie	Traffic Survey & Traffic Estimation
Mr. Katsunori Fuse	Structure Engineering
Mr. Yasuo Nabeshima	Traffic Facility Planning
Mr. John Hamilton	Cost Estimation and Construction Methods
Mr. Mahmoud-Saleh Riad	Natural Condition Survey
Mr. Kenici Ando	Underground Utility Survey
Mr. Takao Nakaoka	Economic Evaluation

CHAPTER 2 BACKGROUND INFORMATION

2.1 Project Area and Administrative Organizations

Calcutta Metropolitan District (CMD) occupies an area of about 1,400 km^2 and has been designated for planning and development purposes. Responsibility for urban development within most of CMD is vested with the Calcutta Metropolitan Development Authority (CMDA), an organization under the Ministry of Urban Development which was set up in 1970. CMDA liaises with the other State Government Departments or local authorities to coordinate development schemes and to prepare land use and development plans. The State Government, through the State Planning Board of the Development and Planning Department, prepares development perspectives, policy and funding programs for development of the State.

Development planning, funding and implementation of transportation projects within the CMD is shared between the national, state and local governments. The National Government is sometimes also involved with major projects such as the 2nd Hooghly Bridge. Indian Railways is responsible for the entire railway system including the Metro. The Public Works Department, the Transport Department of the State Government and Municipal Corporation undertake the funding and implementation of transportation projects.

The Department of Transport of the Government of West Bengal is the nodal Department for all transportation functions and is responsible for the administration and control of road, tram and inland waterway transport, including the corporations/companies which run the public sector buses, trams and ferries. Under the control of the Department, private operators can run transport services.

Within the CMD there are many administrative units at the local government level;

(a) 3 Municipal Corporations (Calcutta, Howrah and Chandannagar)
(b) 31 Municipalities
(c) 3 Notified Areas
(d) 70 Non-Municipal Urban Units
(e) 390 Rural Mouzas

The city of Calcutta is located within the Calcutta Municipal Corporation (CMC) area. It has no administrative function, but is often adopted for transportation planning since it contains the most heavily developed areas of Calcutta and Howrah and the most serious transportation problems occur within this core area.

2.2 Socioeconomic Conditions

2.2.1 Population

Table 2.2.1 shows the population growth trends for India, West Bengal, Calcutta Metropolitan District (CMD) and Calcutta City.

The growth in population of the city of Calcutta has been significantly slower than in the CMD, particularly between 1951 and 1981. The growth between 1971 and 1981 was very small, indicating that saturation may be occurring.

Table 2.2.1 - Population growth during 1921 - 81
(population in millions)

Year	India	W Bengal	CMD	Calcutta City
1921	251.32	17.47	2.25	1.05
	(100)	(100)	(100)	(100)
1931	279.00	18.90	2.54	1.22
	(111)	(108)	(113)	(116)
1941	318.66	23.23	4.31	2.17
	(127)	(133)	(192)	(207)
1951	361.09	26.30	5.14	2.70
	(144)	(150)	(228)	(257)
1961	439.24	34.93	6.83	2.93
	(175)	(200)	(304)	(279)
1971	548.16	44.31	8.22	3.15
	(218)	(254)	(365)	(300)
1981	685.18	54.58	9.98	3.31
	(273)	(312)	(444)	(315)

source: A Perspective Plan for Calcutta: 2011

For estimation of future population the projections prepared in the 1990 report "A PERSPECTIVE PLAN FOR CALCUTTA:2011 (draft)" by the State Planning Board, Development and Planning Department of the Government of West Bengal have been adopted. The population projections were made after considering migration rates, fertility rates and mortality rates. The final projections are shown in Table 2.2.2.

Table 2.2.2. Estimate of Future Population
(population in millions)

year	West Bengal	CMD	Calcutta Municipal Corporation (CMC)
1981	54.58	9.98	4.13
1991	67.42	12.07	4.52
2001	84.2	14.58	5.03
2011	103.46	17.09	5.42
2021	124.08	19.65	5.94

source: A Perspective Plan For Calcutta:2011

2.2.2 Land Use Composition

Table 2.2.3 shows the land use composition within the CMD in 1961 and 1981, the former being surveyed by CMPO. There are certain trends in land use patterns which have emerged in the metropolitan district over the two decades. Changes in residential land use are most apparent and usage increased from 15.5% in 1961 to 32.10% in 1981. Other important land uses such as Industrial, Commercial and Recreational increased only slightly. Transportation categories occupied 5.1% and 6.36% of CMD land in 1961 and 1981 respectively; both values are low compared to other major cities. The remaining area of land within CMD recorded under non-urban use and consisting of arable, forest and wasteland including water bodies and marshes still represents more than half of CMD but showed a marked decrease, falling from 72.3% to 52.5% during the period under consideration.

Table 2.2.3. Land Use Composition of CMD

Land Use Category	1961 Area(sq.km)	1961 %	1981 Area(sq.km)	1981 %
Residential	203.80	15.50	420.89	32.01
Industrial	55.22	4.20	62.19	4.73
Commercial	9.20	0.70	9.34	0.71
Recreational	9.20	0.70	10.52	0.80
Transportation	67.06	5.10	83.63	6.36
Institutional	19.72	1.50	38.26	2.91
Sub-Total	364.20	27.70	624.83	47.52
Vacant	950.66	72.30	690.03	52.48
Total	1,314.86	100.00	1,314.86	100.00

source: A Perspective Plan for Calcutta:2011

2.2.3 State Domestic Product and Per Capita Income

The State Domestic Product of West Bengal in 1988-89 was 124,208.6 million Rs. at 1980-81 prices and made up 7.47% of the Net National Product of India which was 1,662,000 million Rs. This percentage has decreased slightly since 1980-81 when it was 8.04%. Table 2.2.4 shows the State Domestic Product of West Bengal by industry of origin at 1980-81 prices. This Table also shows the Per Capita Income for West Bengal.

2.2.4 Motor Vehicle Registration

Figure 2.2.1 shows the growth in the number of registered motor-vehicles in Calcutta. The number of cars and jeeps increased by a factor of 2.136 in the last decade, corresponding to an average annual growth rate of 7.88%. The corresponding increases for total vehicles in the same period were 2.743 and 10.62% respectively.

Table 2.2.4

Estimate of State Domestic Product of West Bengal by Industry of Origin (at 1980-81 prices)

(Rs. in million)

Industry	1980-81 (P)	1984-85 (P)	1985-86 (P)	1986-87 (P)	1987-88 (P)	1988-1989 (Q)
1. Agriculture	24,776.40	29,869.50	31,452.40	33,185.90	36,455.00	40,348.60
2. Forestry	716.00	754.70	704.10	468.40	424.80	443.80
3. Fishery	2,883.40	3,055.70	3,183.30	3,466.90	3,727.50	3,872.00
4. Mining and Quarrying	1,642.10	777.50	792.70	816.00	814.50	871.50
5. Manufacturing	2,1967.80	21,698.80	25,414.20	26,619.90	27,158.50	28,801.30
5.1. Registered	12,453.80	11,287.70	14,721.40	15,686.40	15,575.50	16,332.90
5.2. Unregistered	9,514.00	10,411.10	10,692.80	10,933.50	11,583.00	12,468.40
6. Construction	4,227.40	3,815.00	3,666.50	3,757.50	4,452.50	5,120.40
7. Electricity, Gas and Water Supply	806.30	1,110.80	1,297.00	1,315.30	1,432.90	1,561.10
8. Transport, Storage and communications	4,147.70	4,561.20	4,656.20	5,141.60	5,234.80	5,339.70
8.1. Railways	495.60	495.80	641.10	752.60	826.80	892.90
8.2 Transport by other means and storagee	3,117.10	3,460.40	3,437.10	3,805.30	3,838.20	3,871.30
8.3 Communications	535.00	605.00	578.00	583.70	569.80	575.50
9. Trade, Hotels and Restaurants	9,157.20	10,256.90	10,558.50	10,872.10	11,192.00	11,521.30
10. Banking and Insurance	4,018.80	4,848.70	4,837.10	5,006.00	5,038.90	5,215.30
11. Real Estate, Ownership of Dwellings and Business Services	6,754.20	7,280.70	7,406.40	7,526.80	7,640.20	7,741.20
12. Public Administration	3,077.50	4,241.30	4,693.80	5,242.00	6,290.40	7,548.50
13. Other Services	4,838.00	5,227.70	5,342.30	5,489.60	5,648.90	5,823.90
Total	89,012.80	97,498.50	104,004.50	108,908.00	115,510.90	124,208.60
Per Capita Income (Rupees)	1,612.00	1,631.00	1,707.00	1,755.00	1,828.00	1,930.00

P = Provisional

Q = Quick

Source: Bureau of Applied Economics and Statistics,
Government of West Bengal.

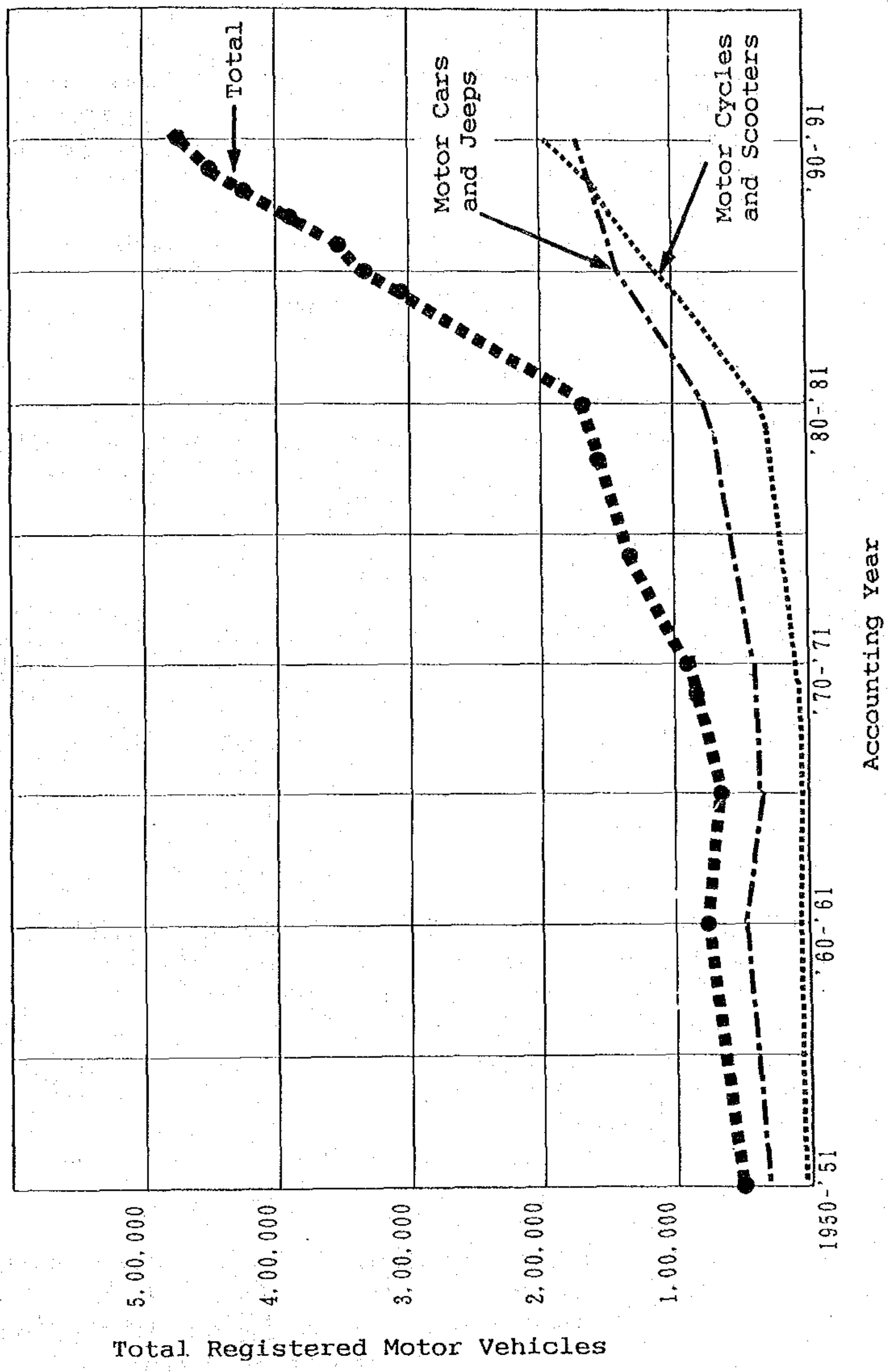


Figure 2.1.1 Motor Vehicle Ownership

2.3 Mass Transportation Systems

Public Transport systems in Calcutta are of vital importance in Calcutta because there are relatively few private vehicles. In 1989, around 10 million passengers per day were carried by public transport.

The transit modes under the control of the Transport Department, ie. public and private buses, trams and ferries carried about 7.47 million passengers per day as shown in Table 2.3.1.

Table 2.3.1 Transit Data for Calcutta and Howrah in 1989

Mode	No of fleet daily on road	No. of Passengers per day (millions)	% of total
CSTC Buses	621	.733	9.82
Private Buses	2726	4.871	65.22
Mini-buses	1541	.896	11.99
Chartered Buses	600	.240	3.20
Trams	310	.550	7.37
Ferry Services		.180	2.40
total		7.470	100.00

source: A Handbook On Transport

In addition to the number of passengers in the above Table, 2.3 million passengers per day were carried by the suburban rail system and Metro Rail is predicted to carry 1 million passengers per day when the section now under construction is opened. The main features of each transit mode are described below.

2.3.1 Railway

The railways have a major role in the transportation system of CMD and the railways networks on both banks of the river Hooghly have contributed significantly to the development of the present linear pattern of the urban structure.

There are a total of 10 railways, with about 230 km of long distance passenger services, suburban passenger services and goods transportation lines. There are 105 stations within CMD at an average spacing of 2 to 2.5 km.

The most important passenger terminals within CMD are the Sealdah and Howrah Stations. A large volume of suburban commuter traffic is channeled through these two stations. The number of suburban trains operating from Howrah Station on an average week day in 1987 was 362. From Sealdah Station about 488 suburban passenger trains were operated on an average week day in the same year. The number of passengers using these two stations on an average weekday was found to have increased by a factor of more than three since 1965 as shown in Table 2.3.2.

Table 2.3.2 Number of Passengers (in thousands)

	1965	1981	1988
Howrah Station	221	624	722
Sealdah Station	314	730	934
Total	535	1,354	1,656

source: A Handbook on Transport

2.3.2 Metro

A Metro Railway comprising north - south and east - west lines was proposed in the "Traffic And Transportation Plan 1966-1986". Construction of the 16.5 km long north - south Metro Railway from Dum Dum to Tollygunge commenced in 1972 along one of the major road corridors.

The cut and cover method with diaphragm walls and piles was adopted. At the northern section crossing Circular Canal the driven shield tunneling method was adopted.

The southern section of the line from Esplanade to Bhowanipur (3.42 km) and from Bhowanipur to Tollygunge (4.24 km) began operation on 24 October 1984 and 28 April 1986 respectively. The northern section from Dum Dum to Belgachia (2.15 km) was opened on 12 November 1984. The remainder of the section is expected to be completed within the next three (3) years.

2.3.3 Trams

The tram is one of the oldest modes of passenger transport in Calcutta, and is operated by Calcutta Tramways Company (CTC). The tram service operates on 36 routes within the metro core area on a route length of 70.42km, 24.85km of which is on reserved track.

A total number of 310 tram cars carried 550,000 passengers in 1989. The average operating speed can be as low as 6 zkm/h, but on the reserved sections it is higher, reaching 32 to 40 km/h.

The tramways have been criticized in the past as inefficient and not a very effective use of public funds but the trams nevertheless carry a substantial number of passengers and are an important component in the public transport system.

2.4 Highway and Street Network

The most important factor that has influenced the configuration of the major highway and road system is the topography. The CMD is divided into two halves by the Hooghly River, and the difficulty and expense in providing adequate river crossings have led to the development of independent road systems on either side of the river.

Furthermore, substantial portions of the area are prone to flooding so that development has been concentrated in a strip along the higher ground along each side of the river. This strip type development coupled with the limited number of river crossing facilities is the main reason behind the north-south oriented street and highway pattern.

The major roads in CMD are shown in Figure 2.4.1 (source: Plan for Metropolitan Development 1990-2015).

2.4.1 National Highways

National highways, along with state highways and district roads, form the regional road system serving CMD. The national highways are the principal roadway connections between CMD and the rest of the Indian sub-continent. National Highways (NH) extend for 1,631 km in CMD and include the following;

a) NH 2
b) NH 6
c) NH 3
d) NH 35

2.4.2 State and District Roads

State highways and district roads provide regional roadway connections between Calcutta and its immediate hinterland within the State of West Bengal. There are 3,455 km of State Highway, 2,784 km of Major District Roads and 3,819 km of Other District Roads in West Bengal.

The most important roads in this category are as follows;

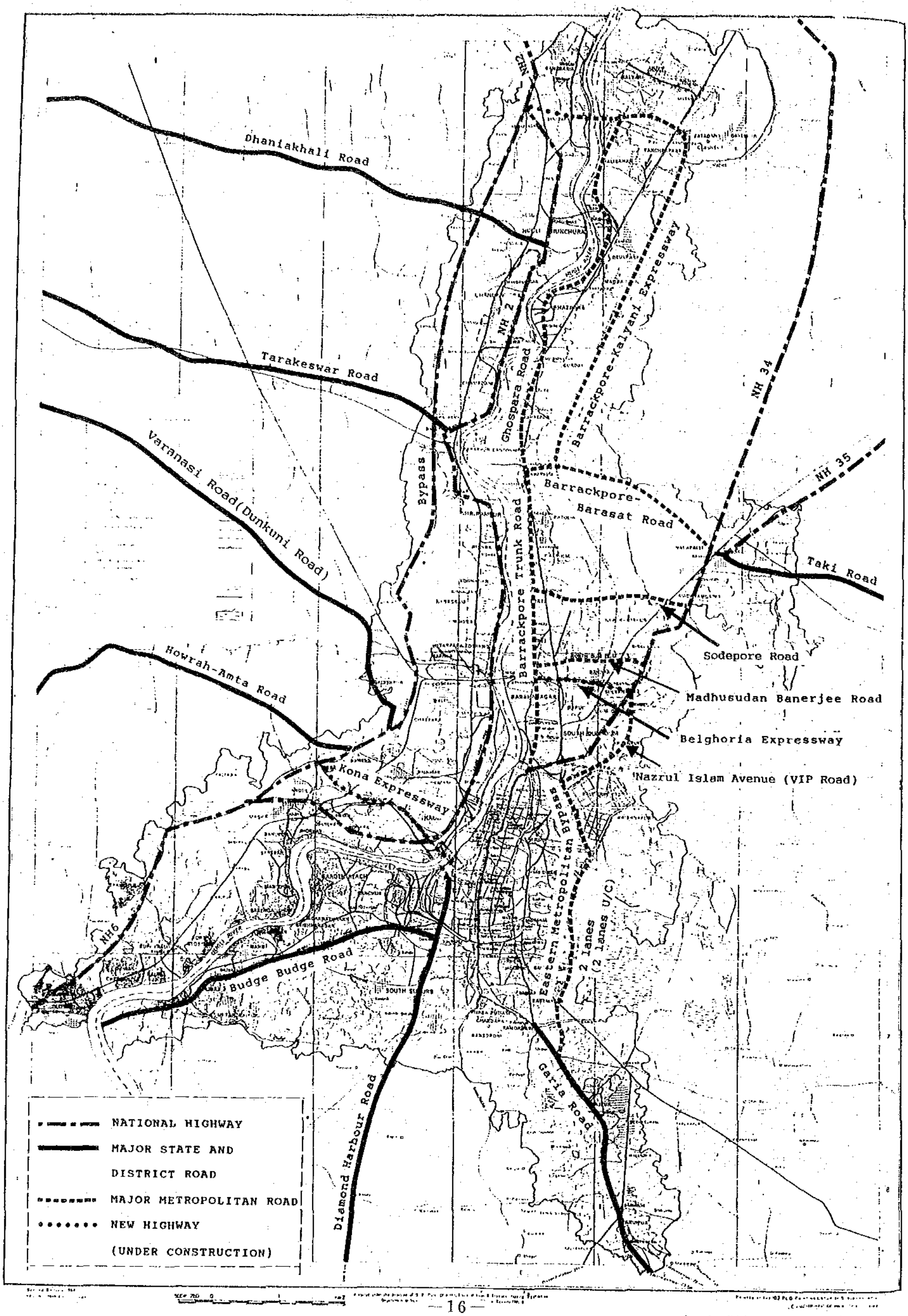
a) Diamond Harbour Road
b) Taki Road
c) Garia Road
d) Howrah - Amta Road
e) Varanasi Road
f) Tarakeswar Road
g) Dhaniakhali Road
h) Budge Budge Road

2.4.3 Metropolitan Road System

(1) Major Roads

There are several metropolitan roads within the CMD area not classified as state highways or district roads since their main function is to serve the metropolitan area. The major metropolitan roads existing or under construction are shown in Fig. 2.4.1. The current metropolitan road system consists of the national and state highways listed above, plus regional or metropolitan roads.

Figure 2.4.1 EXISTING REGIONAL HIGHWAY LINKAGES OF CALCUTTA METROPOLITAN DISTRICT



The major metropolitan roads within CMD are;

a) Madhusudan Banerjee Road
b) Sodepore Road
c) Barrackpore-Barasat Road
d) Barrackpore Trunk Road - Ghoshpara Road
e) Eastern Metropolitan Bypass
f) Barrackpore-Kalyani Expressway

The northern section of the Eastern Metropolitan Bypass is currently being widened from 2 lanes to 4 lanes. The Barrackpore Expressway is completed with the exception of the final section connecting to National Highway No. 2.

Two new highways are now under construction;
a) Belghoria Expressway
b) Kona Expressway - 2nd Hooghly Bridge to NH6

(2) Bridges across the Hooghly River

The only Hooghly River bridge in the study area is the Howrah Bridge which was completed in 1943. This bridge has tram tracks in the median and a 3 lane roadway on either side. Traffic volume was 61,000 vehicles per day, the highest in the study area. Some 8 km to the north is Vivekananda bridge which has a railway in the center and a 2 lane roadway on either side. Further north is Kalyani bridge, opened to traffic in 1989. It will eventually link the Barrackpore-Kalyani expressway with NH2 but the connection to NH2 is not yet complete and the traffic volume using the bridge is still very low.

The Second Hooghly Bridge is under construction and is planned to be opened in 1992. The approaches to the bridge on the eastern side include an interchange which is designed to disperse traffic into three directions by con necting to three different routes. A.J.C. Bose road will play an important role as a bridge feeder road.

2.5 Parking Facilities

Traffic problems in the CBD are to some extent common to other large metropolitan areas in the world but a problem unique to Calcutta is the scarcity of off street parking facilities and the overflow of pedestrians onto the roadway.

The number of parking facilities in the study of 1962 and 1975 is shown in Table 2.5.1. The corresponding sectors are shown in Figure 2.5.1. The total number of 3,385 on-street vehicle spaces in 1962 increased to 5,027 by 1975. This was achieved by providing on-street parking in streets which were not considered so important for handling traffic, or by converting streets from parallel parking to perpendicular parking to meet parking demand pressures.

Table 2.5.1. Parking Facilities

	1962 study			1975 study(on-street)		
Sector No.	On-str.	Off-str.	total	fee	free	total
5	268	49	317	13	795	808
7	152	2	154	203	588	791
8	256	158	414	56	273	329
9	506	141	647	142	85	227
10	1,148	125	1,273	1,048	338	1,386
11	322		322	87	678	765
12	733	340	1,073	523	198	721
total	3,385	815	4,200	2,072	2,955	5,027

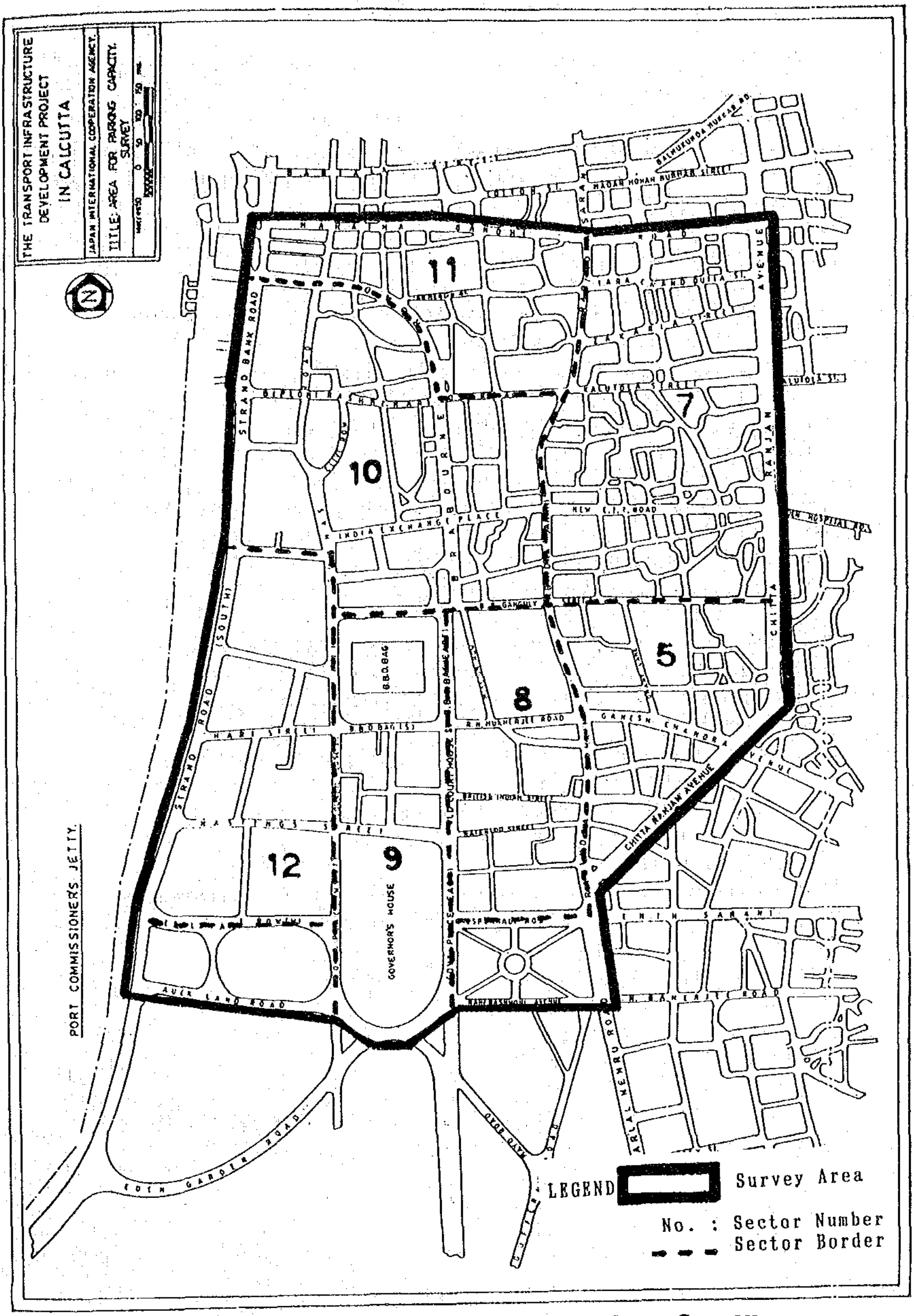


Figure 2.5.1 Area for Parking Volume Survey

2.6 Transportation Projects Under Implementation or Committed

Transportation projects which are either under construction or committed are listed below and are shown in Figure 2.6.1.

1) Durgapur Bridge Reconstruction
2) Garia Bridge Reconstruction
3) Widening of Eastern Metropolitan Bypass to 4 lanes
4) Widening 2-lane Bridge No. 4 to 4 lanes
5) Addition of 3 lane underpass adjoining 2 lane underpass on Ultadanga Main Road below railway line
6) Improvement of Foreshore Road in Howrah
7) Circular Canal Road
8) Improvement of Canal West Road
9) Extension of Canal West Road to Govinda Khatic Road
10) Widening and improvement of C.I.T.Road, Moulali
11) Improvement of A.P.C.Roy Road-A.J.C.Bose Road north and south of Sealdah Flyover
12) Improvement of Chowringhee Road
13) Improvement of a large number of road junctions
14) Signalization of a number of road junctions
15) Flyover on G.T. Road at Salkia, Howrah
16) Long distance bus terminal at Ultadanga
17) Re-sectioning of roads and road junctions with tram lines
18) Jadavpur Road Flyover over rail lines
19) Lake Garden Flyover
20) Bandal Gate Flyover
21) A number of traffic management and safety measures
22) A number of pedestrian overpasses at congested road junctions
23) Truck Terminal at Kona
24) Kona Expressway
25) Belghoria Expressway
26) 2nd Hooghly Bridge
27) New Khidirpur Bridge
28) Link road between Strand Road and 2nd Hooghly Bridge
29) Improvement of Andul Road

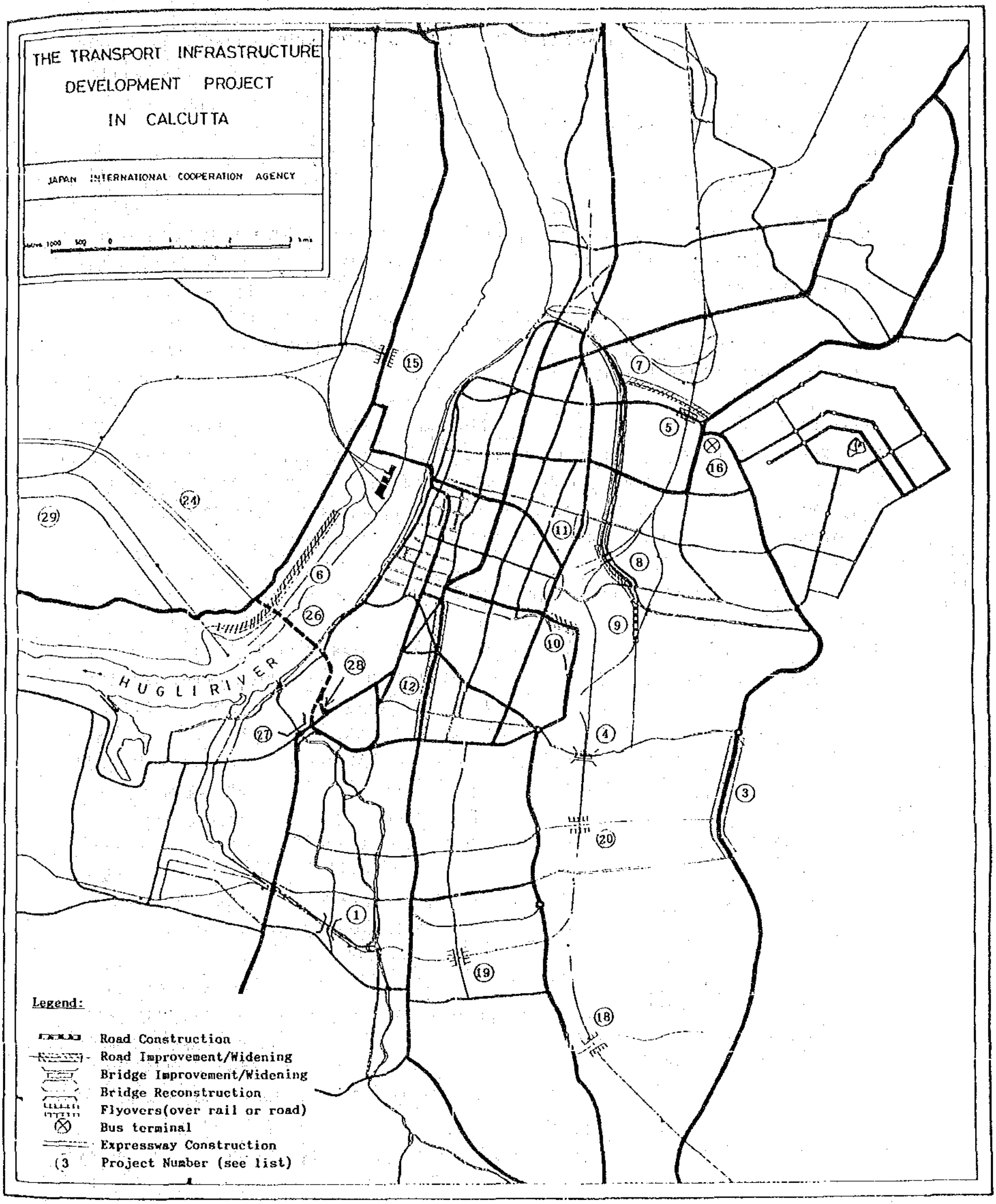


Figure 2.6.1 Transport Infrastructure Projects Committed or Under Construction

CHAPTER 3 FIELD SURVEY

3.1 Soil Investigation

(1) Field Survey

The field survey was conducted at the ten Study intersections in order to obtain a preliminary understanding of the sub-soil conditions. Such an understanding is essential for selecting the most economical and technically suitable flyover structure at the surveyed intersections, should a flyover be deemed necessary.

One bore hole, of diameter 150 mm and depth 40.0 meters below ground level, was executed at each of the locations. Standard penetration tests were conducted at each hole at one-meter intervals, undisturbed samples collected, and laboratory tests of soil samples were executed.

(2) Collection and Review of Previous Reports

Previous soil reports for bore holes executed in Calcutta by reliable authorities were collected to supplement the field survey carried out under this Study. Reports prepared on the soil conditions along the metro project route in 1970 and 1973 were very helpful in determining the soil conditions for the Study intersections No.2, 4, 5 and 8.

The reports collected and reviewed were as follows;

a. Geology and Groundwater Resources of the Greater Calcutta Industrial Area, prepared by Geological Survey of India in 1964.
b. Calcutta Mass Transit Study, prepared in 1970-1971, by the Governmental commission set up for studying the metro report.
c. Metropolitan Transport Project, Rapid Transit System, prepared in 1973, for the design and execution of the metro project.

3.2 Topographic Survey

(1) Survey Locations

The topographic field survey conducted under the Study covered the ten intersections where there are proposals to construct flyovers or execute at-grade intersection improvement projects.

(2) Survey Methodology

The sequence under which this survey was implemented is described hereafter;

a. Collection of available maps

Through the assistance of the Counterpart Team, maps were collected for some of the Study intersections, of varying levels of detail. From these maps, for each intersection a base map was prepared to be used on site and verified.

b. Execution of the field survey

The heavily congested traffic conditions at nine of the ten intersections undermined any possibility that field surveys could be executed during the daytime, and consequently the surveys were done during the hours of 11 PM to 5 AM of the following morning. The survey was executed by the theodolite traversing, offsetting and plane table method.

c. Preparation of preliminary maps and field check

Upon the preparation of the preliminary topographic maps for the intersections, these drawings were taken to site for checking of the accuracy of measurements and for confirmation that all necessary information was recorded on the maps.

d. Finalization of maps

The final maps were prepared using a CAD system and plotters.

3.3 Underground Utilities Survey

The objective of the survey was to identify the types and locations of subsurface utilities at the ten Study intersections. The following surveys were undertaken by the Study Team.

(1) Interview Survey and Mapping
(2) Subsurface Radar Survey
(3) Excavation of test pits for verification of utility locations detected by Radar

The execution methods of these surveys and their results are reviewed in the Technical Report.

Through the cooperation of the Counterpart Team, the following authorities and companies were contacted to collect data and available maps related to the Study intersections;

a. Calcutta Municipal Corporation
   Water supply and drainage
b. Metro Railway
   Information on extent of utilities diversionary works executed during the metro construction
c. Calcutta Electric Supply Corporation (CESC)
   Electric power supply network
d. Calcutta Telephones
   Telephone network
e. Greater Calcutta Gas Supply Corporation
   Gas supply network
f. Calcutta Metropolitan Development Authority (CMDA)
   Water supply and drainage network
g. Calcutta Investment Trust (CIT)
   Various available utilities mapping at some of the Study intersections

CHAPTER 4 TRAFFIC SURVEYS AND FUTURE TRAFFIC ESTIMATES

4.1 Surveys

The Study Team carried out the following traffic surveys to allow a better understanding of the present traffic conditions in Calcutta.

- Traffic Volume Surveys
- Roadside Origin-Destination Survey on Howrah Bridge
- Travel Speed Survey
- Parking Survey
    - Parking Interview Survey
    - Parking License Plate Survey
    - Parking Volume Count
- Pedestrian Survey on B.B. Ganguly Street and M.G. Road

Various relevant traffic reports and traffic surveys which were conducted by West Bengal or other organizations were collected with the assistance of the Counter-part Team and reviewed for possible utilization in the Study.

The results of the surveys are shown in the following tables and figures.

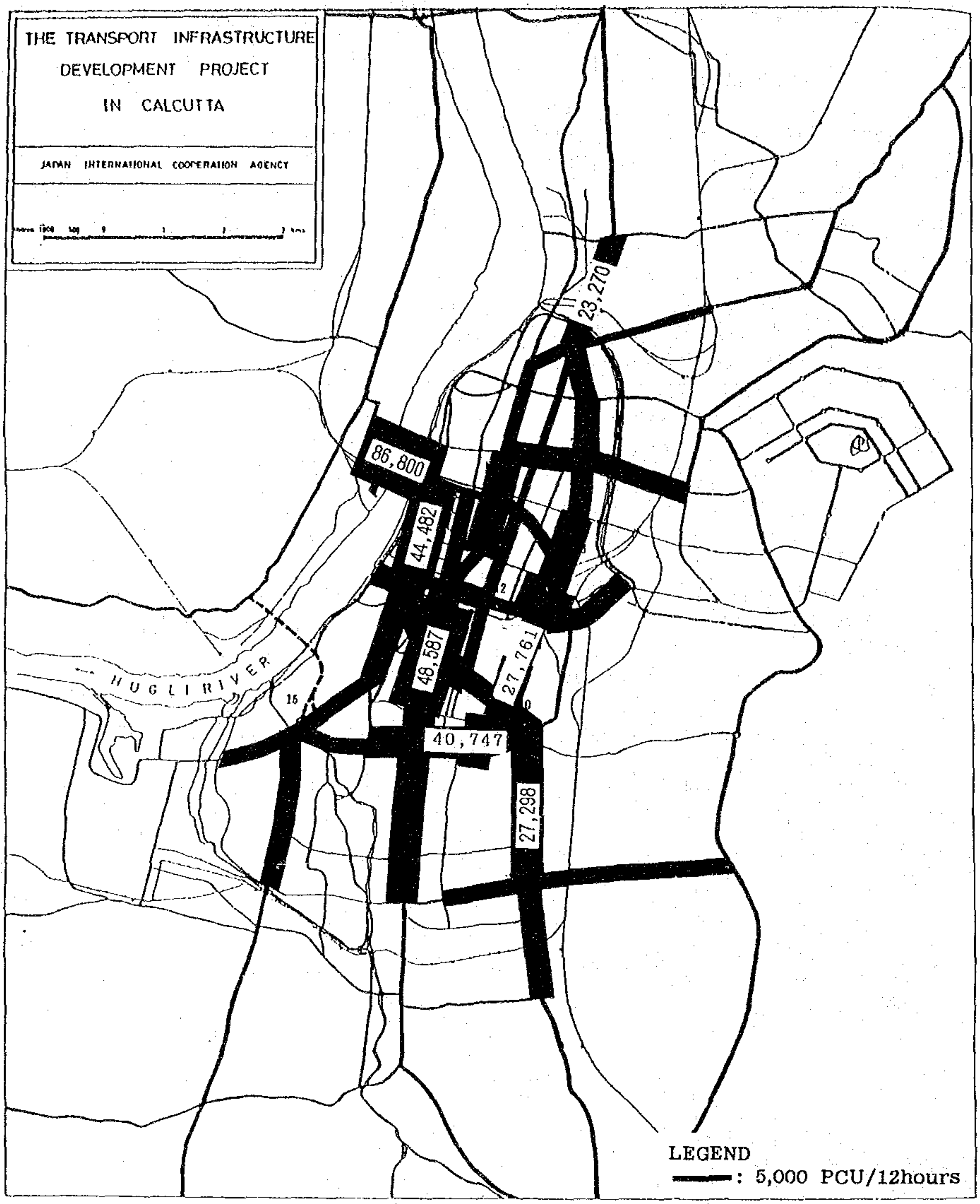


Figure 4.1.1 Traffic Volume by PCU/12 hours in 1991

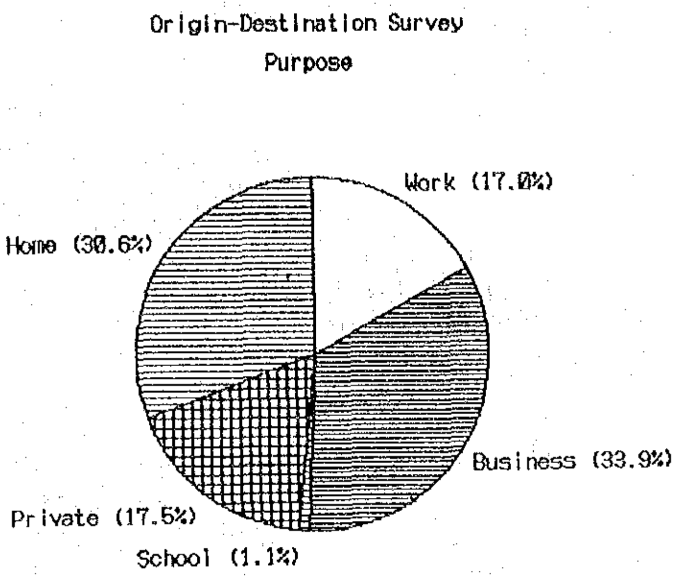


Figure 4.1.2 Trip Purpose

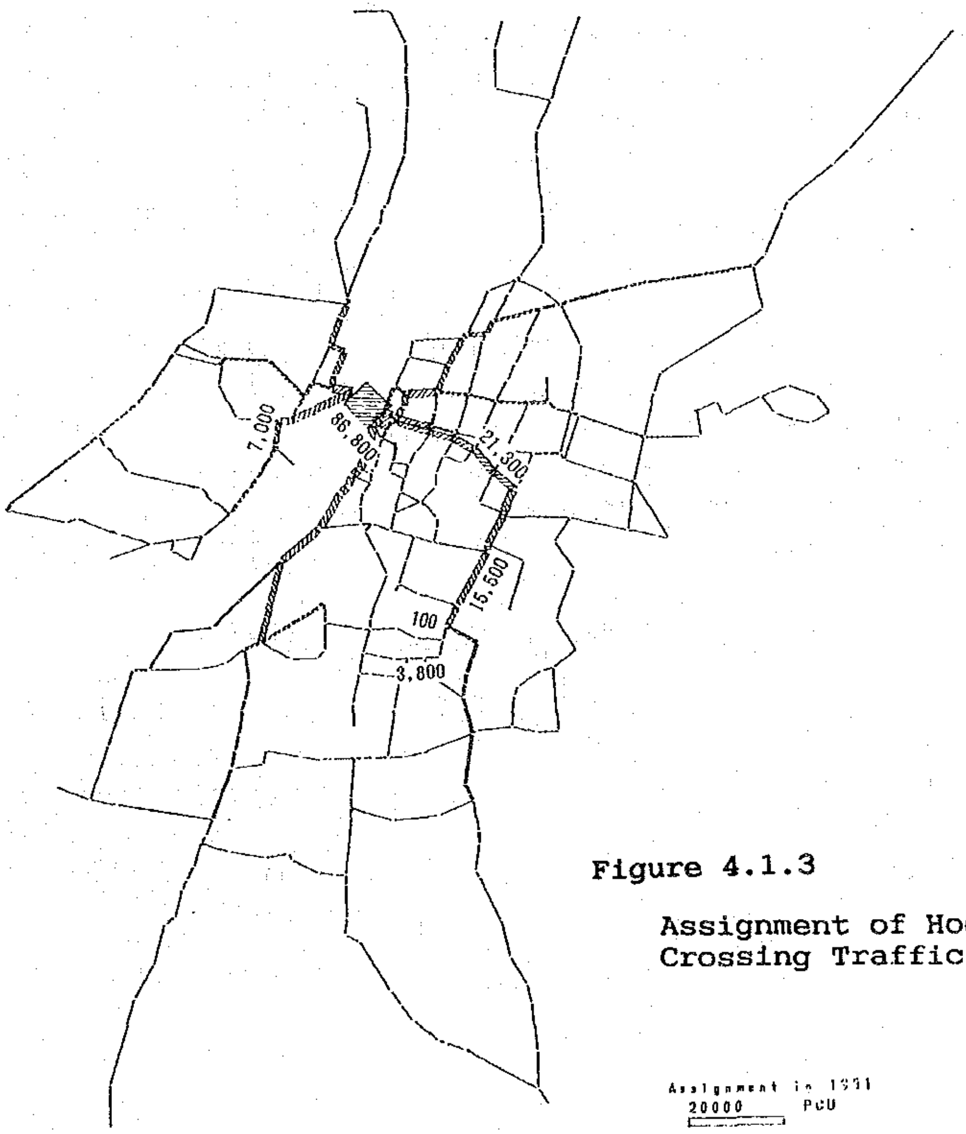


Figure 4.1.3

Assignment of Hooghly River Crossing Traffic in 1991

Table 4.1.1 Travel Time by Corridor

Corridor	Direc -tion	Distance (km)	Average Time (min.'sec.")	Average Speed (km/h)
1 Deshpran Sasmal Rd.				
-S.P.Mukherjee Rd.	1 South	15.5	88'30"	10.51
-A.T.Mukherjee Rd.	-North			
-J.L.Nehru Rd.				
-C.R.Avenue				
-J.M.Avenue	2 North	15.5	87'15"	10.66
-Bhupen Bose Rd.	-South			
-R.G.Kar Rd.				
-Raja Manindra Rd.				
2 Diamond Harbour Rd.	1 South	17.0	86'26"	11.80
-A.J.C.Bose Rd.	-North			
-A.P.C.Roy Rd.	2 North	17.4	75'04"	13.91
-Bidhan Sarani	-South			
-B.T.Rd.				
3 Gariahat Rd.	1 North	6.5	25'24"	15.35
-Syed Amir Ali	-South			
-Park Street	2 South	6.5	34'25"	11.33
	-North			
4 Howrah Bridge	1 West	3.9	20'19"	11.52
-M.G.Rd.	-East			
(Part of one way)				
5 Lenin Sarani	1 West	3.8	23'23"	9.75
-Convent Lane	-East			
(Part of one way)				
6 Najrul Islam Ave.	1 East	5.7	22'31"	15.19
-Manicktala Main Rd.	-West			
-Vivekananda Rd.	2 West	5.7	21'43"	15.75
	-East			
7 Circus Avenue	1 West	0.5	2'07"	14.20
	-East			
	2 East	0.5	2'03"	14.69
	-West			

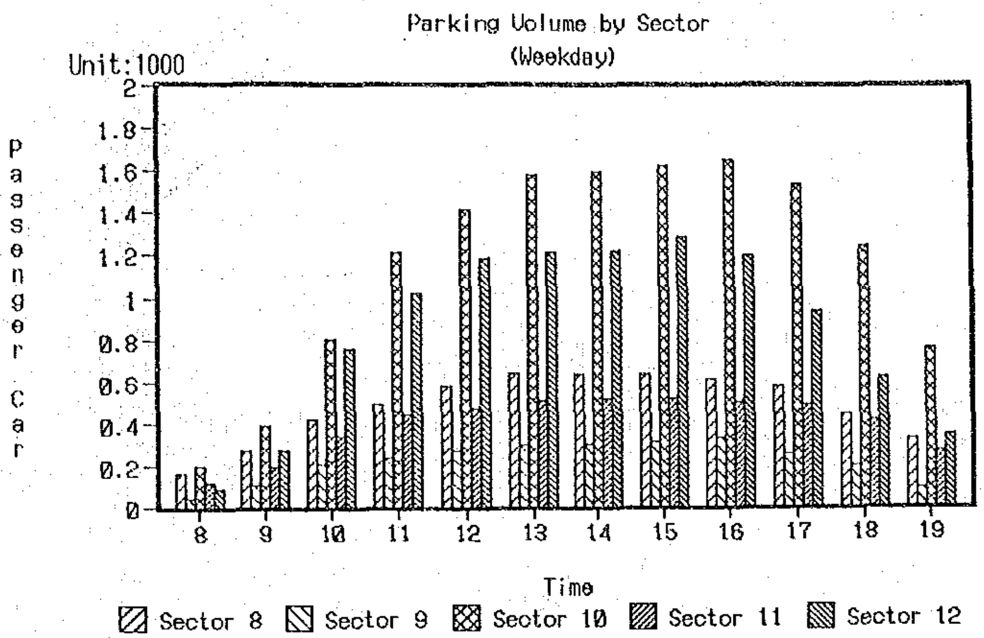


Figure 4.1.4 12 hours Parking Volume by Sectors

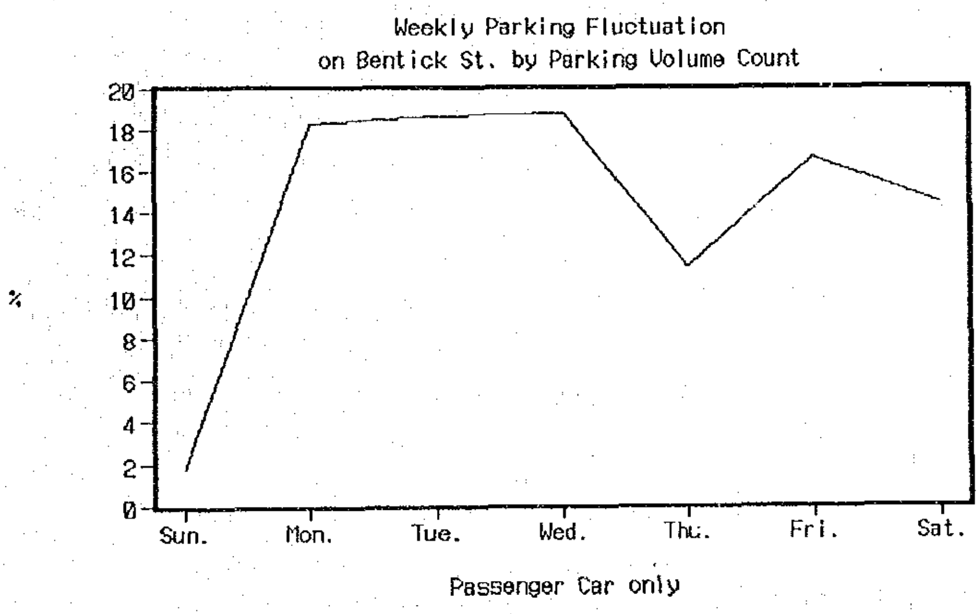


Figure 4.1.5 Parking Weekly Fluctuation on Bentinck St.

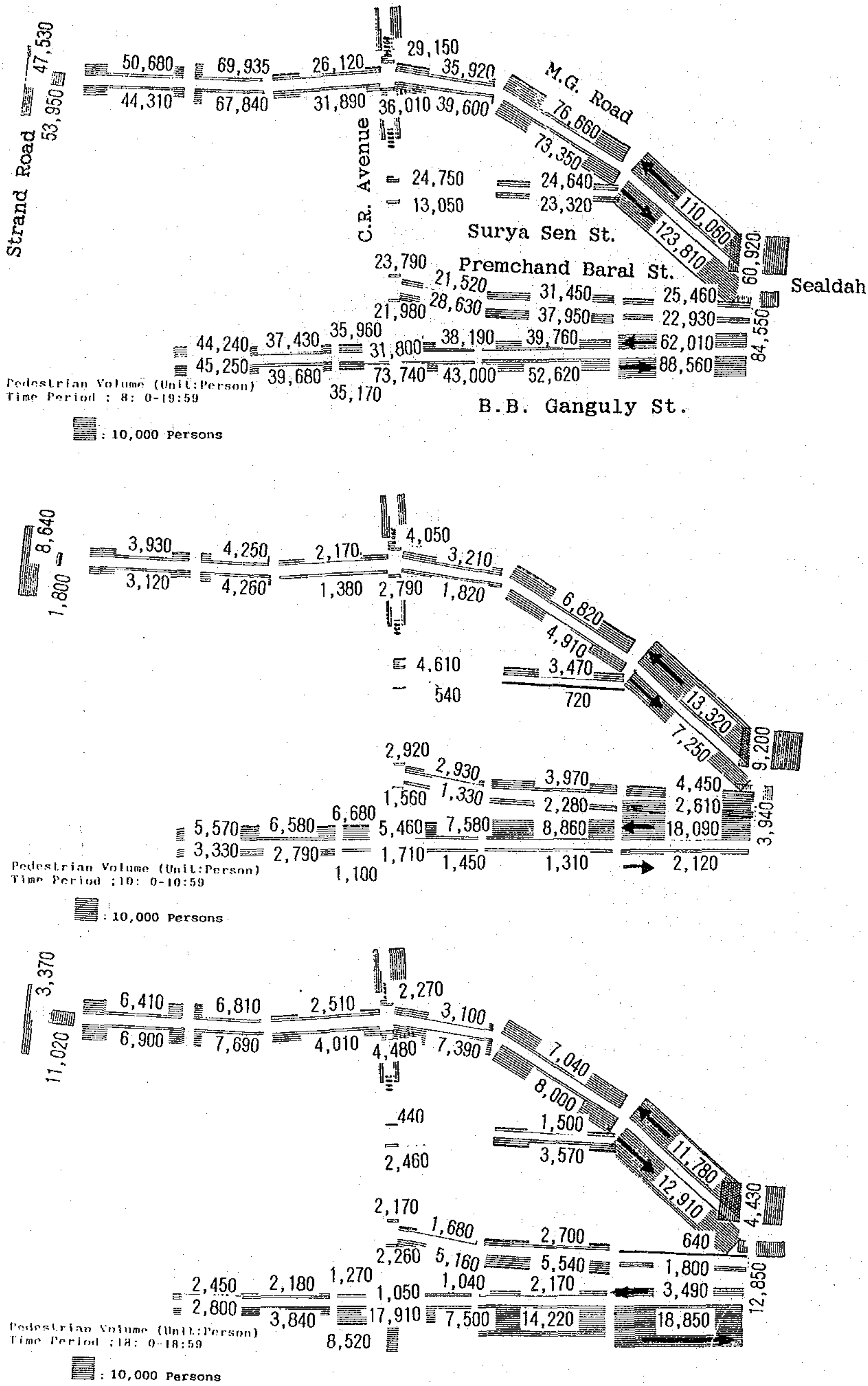


Figure 4.1.6 Pedestrian Volumes in 1991

4.2 Estimation of Future Traffic Demand

(1) Growth Estimation for Future Traffic

The future traffic volumes were estimated using growth ratios based on previous trends. The growth ratios were calculated using the previous traffic volumes surveyed on the screen-lines established in the 1971 survey in the study titled "TRAFFIC STUDY FOR PROPOSED RAPID TRANSIT SYSTEM AND SUBURBAN DISPERSAL LINE IN CALCUTTA", the 1981 study titled "RECORDED CLASSIFIED TRAFFIC VOLUMES ON CALCUTTA ROADS 1978" and those for 1991. The 1991 traffic volume figures were produced from surveys executed under this Study and from figures obtained from the Transport Department, West Bengal Government. Table 4.2.1 shows the growth ratios adopted for intersections in the urban and suburban area.

Table 4.2.1 Traffic Growth Ratios

	Ints.No.1,2 11 & 18 (Urban Area)	Other Intersections (Suburban Area)
Ratio between 1991 and 1998	1.252	1.283
Ratio each year	1.033 (3.3%)	1.036 (3.6%)

Future traffic volumes (prior to adjustments) were estimated by applying the relevant growth ratio for each intersection to the 1991 traffic volumes.

(2) Future Traffic Generated by 2nd Hooghly Bridge Opening

The completion of the 2nd Hooghly bridge is expected to promote increased usage of vehicles for cross-river trips and will also promote development in the surrounding areas, particularly on the west bank. Therefore the river crossing traffic in 1998 will be more than the value which would be predicted from Table 4.2.1.

The growth ratio in registered vehicles between 1980 and 1990 was 7.9% annually, so it would be reasonable to assume that the growth rate in cross-river traffic volume would be 8.0% per annum after the new bridge opens. This growth rate would give a cross-river volume of around 20,000 more vehicles per day by 1998 than the value estimated using an growth rate of 3.6% annually from Table 4.2.1. The additional volume increase has therefore been assumed to be 20,000 vehicles per day in 1998.

Table 4.2.2 shows the cross-river traffic volume in PCU/day in 1991 and 1998.

Table 4.2.2 - 1998 Cross-River Traffic Volume (PCU/day)

Year	Case	Growth Ratio 98/91	River Crossing Volumes
1991	A. Existing	-	86,824
1998	B. Growth at 3.6% per year (Table 4.2.1)	1.283	111,410
1998	C. Adopted 1998 Vol. (Case B plus 20,000 vehicles/day	1.655	143,724

The future cross-river traffic volume for 1998 estimated from sections (1) and (2) above has been distributed to the future road network with the 2nd Hoogly Bridge open to traffic, as shown in Figure 4.2.1.

Figure 4.2.2 shows the future forecast traffic volume at each intersection.

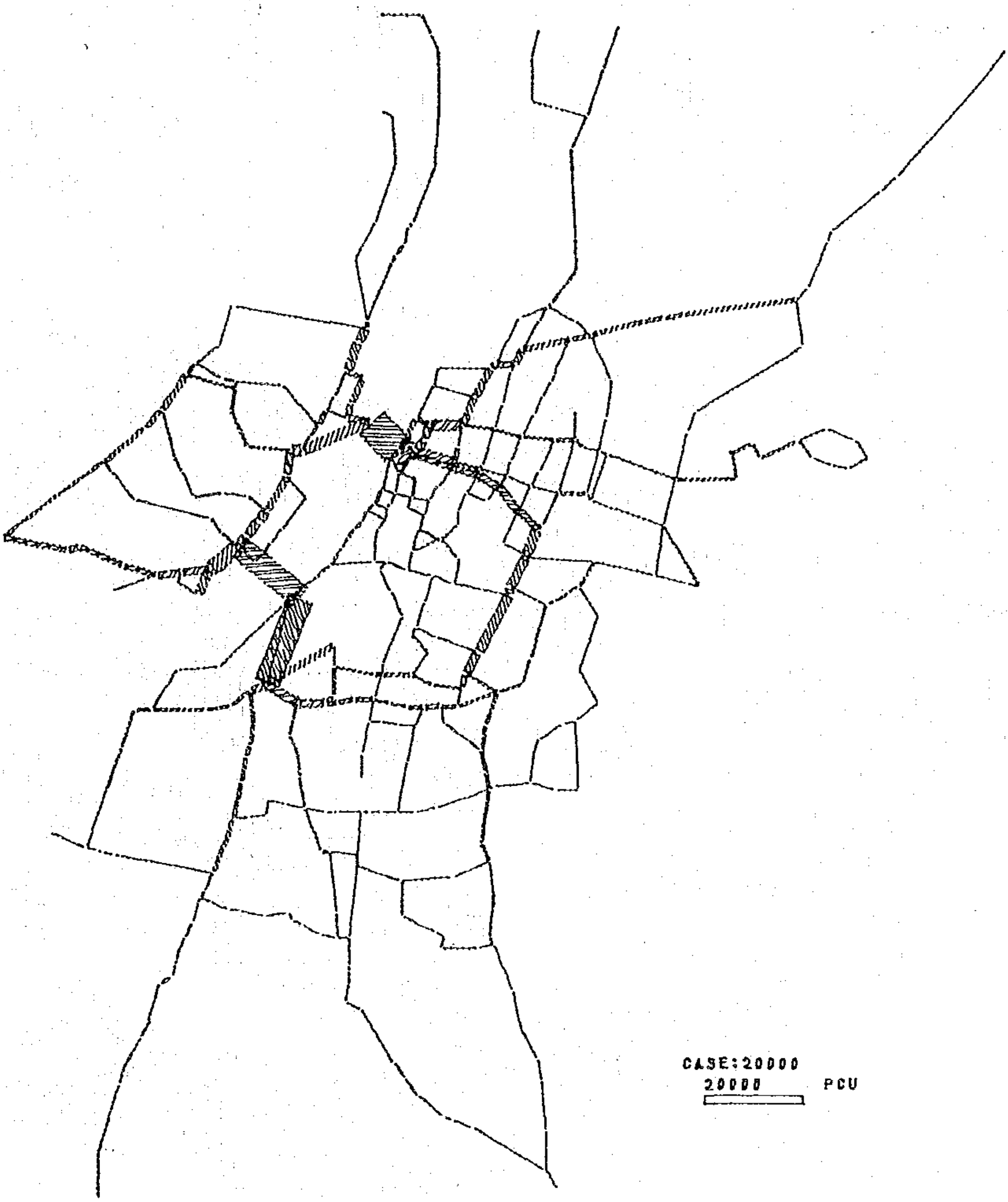


Figure 4.2.1 Assignment of Hooghly River Crossing Traffic in 1998 (2nd Hooghly Bridge construction completed ; Including additional 20,000 vehicles/day ; Case C)

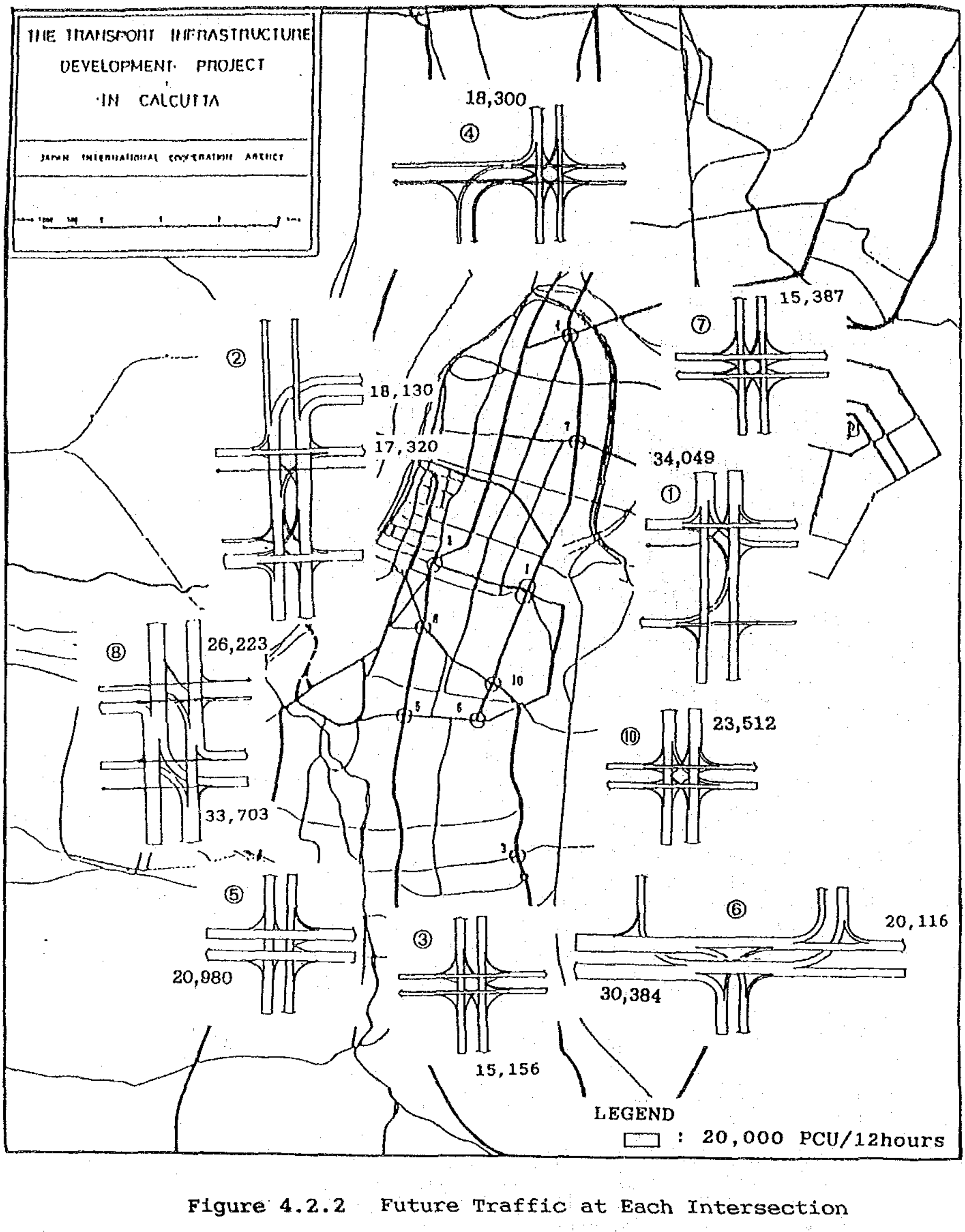


Figure 4.2.2 Future Traffic at Each Intersection

CHAPTER 5 TRANSPORT INFRASTRUCTURE IMPROVEMENT ALTERNATIVES

5.1 Conditions at Study Intersections

5.1.1 Location and Conditions

Figure 1.1.1 shows the locations of the Study intersections. Intersections No.2, No.5 and No.8 are situated along the north-south corridor of Chowringhee/Jawaharlal Nehru Roads. Intersection No.2 is located at the fringe of the CBD area.

The metro runs underneath this corridor and construction has already been completed in the section adjoining intersections No.5 and No.8. Construction works are still proceeding at Intersection No.2. Some improvement plans were implemented at both Intersections No.5 and No.8 at the time of executing restoration projects after the completion of the Metro works.

Any improvement plans for these three intersections must take into consideration the importance of the area. Chowringhee Road is one of the city's landmarks, made so by the architecture splendor of the buildings surrounding it such as the National Museum, Geological Survey of India, Grand Hotel and Tippsultan Mosque, among others. The open and green area of Maidan to the west of the road is very important to the city's environment.

Intersections No.4, No.7, No.1, No.10 and No.6 are all located along the city's other major north-south corridor and ring road; A.J.C. Bose/A.P.C. Roy Roads. Metro construction is still under way at intersection No.4, the northernmost of these five intersections. Intersections No.7 and No.1 lie to the north and south of Sealdah Station respectively, a very important and busy railway station serving the city. Intersections No.4, No.7 and No.1 are located in rather old areas of the city, however, in the western area of the southernmost Intersection No.6, new office and residential buildings have developed.

Intersection No.3 lies south of the metro core area and it plays an important role connecting the city to the Eastern Metropolitan Bypass located to the east. The area between this intersection and the bypass is expected to develop further in the future. Intersection No.9, where Lock Gate Road is divided by the railway tracks is located north of the metro core, in a mostly underdeveloped bustee area.

5.1.2 Problems at Each Study Intersection

The problems observed at each of the study intersections are described below and are summarised on Table 5.1.1, a matrix showing the observed transport problems at each of the study intersections.

Table 5.1.1 Matrix of Transport Problems Observed at Study Intersections

Problems \ Intersection	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9 *	No.10
1.Intersection Geometrics/ Layouts	●	●		●	●	○		●		
2.Tram Turning Movements	●	●	○	●			○	○		○
3.Buses Stopping in Intersection	○	○	●	●	●		●	●		○
4.Hawking at Intersection	●	●	●	●			●			○
5.Very High % of Bus and Trucks	●	●	●	●	●	○	●	○		○
6.Manual Traffic Control and Related Problems	●	●	○	○	○	○	●	●		○
7.Parking at/near Intersections				●			○			○
8.Very High Pedestrian Movements	●	●	●	●	○		●	○		○
9.Traffic Signal Not Working			○	○		○	○			
10.Poor Pavement Conditions	○		○	○			○	○	○	
11.Poor Pavement Markings	○	○	○	○	○	○	○	○	○	○
12.Poor Traffic Signing	○	○	○	○	○		○	○		○
13.Metro Construction Underway		○		○						

○ Moderate Problem
● Severe Problem

Note: * Intersection No.9 is a T junction at present.

5.2 Improvement Options for each Study Intersection

5.2.1 Basic Policy

The basic policy for improving the traffic situation of the study intersections is to increase the traffic capacity of these intersections to meet the expected future traffic demand. If the expected future demand exceeds the capacity of present facilities, some kinds of improvements will be required. Construction of a flyover will be considered necessary, if at-grade improvement measures alone are deemed inadequate to meet the increased future demand.

Land acquisition required to accommodate any proposed infrastructure at the intersections shall be kept to a minimum in this Study. Efforts will be made to utilize the existing facilities and right-of-way as much as possible. If marginal acquisition of intersection corners for example becomes inevitable in order to increase the capacity and correct the intersection geometric problems, it will be assumed that such marginal acquisition is possible and could be taken up by the State Government of West Bengal.

5.2.2 Selection Criteria for Improvement Options

(1) Volume Capacity Ratio

A flyover will be considered at intersections where present or target year traffic volume exceeds the limit that can be handled by the at-grade intersection.

At an intersection, the right-of-way time is shared by the main road and the crossing road, allocated by means of traffic control devices, such as traffic signals. The volume exceeds the theoretical capacity of an at-grade intersection when the sum of the volume/capacity (v/c) ratios of the main and crossing roads becomes greater than 1.0. This concept is illustrated in Figure 5.2.1 below.

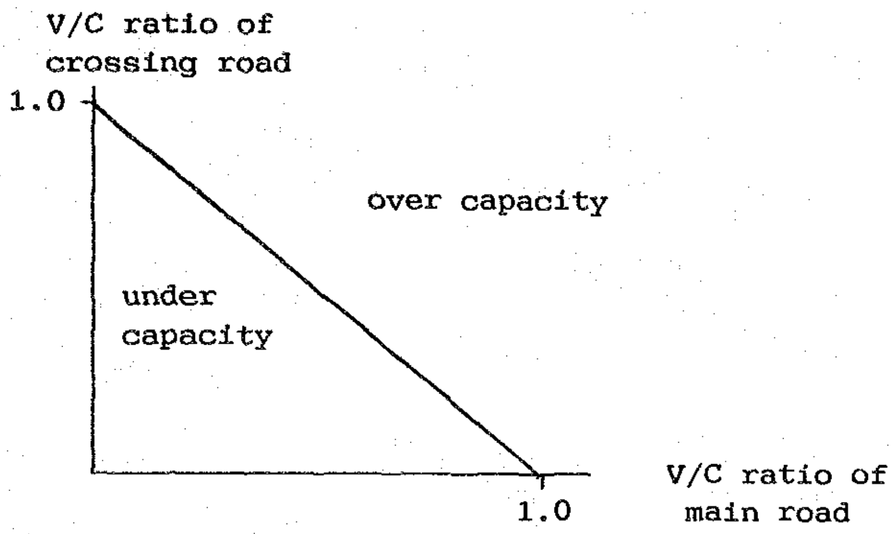


Figure 5.2.1 Volume/Capacity Relationship at Intersections

In this analysis, a capacity of 1,200 pcu/per hour of effective green time/lane was used based on the results of the supplementary survey shown in the Technical Report.

Figure 5.2.2(a) shows the V/C ratios for the present traffic volume at all the study intersections, while Figure 5.2.2(b) shows the V/C ratios for the estimated future traffic volumes.

(2) Delay

Delay is a good indicator of operating conditions at intersections. Computation of the hourly average delay from data collected by traffic surveys indicated that Intersections No.2, No.8 and No.1 have a delay of more than 3,000 veh. hours for the 8 hour period between 8-12 and 16-20 hours. Those with delays between 2,000-3,000 veh.hours for the same time period are Intersections No.4 and No.5.

Recommendations for construction of a flyover as a grade-separated improvement measure will be proposed partly based on the analysis of this delay time at the Study intersections. Higher priority will be given to intersections with higher delay times.

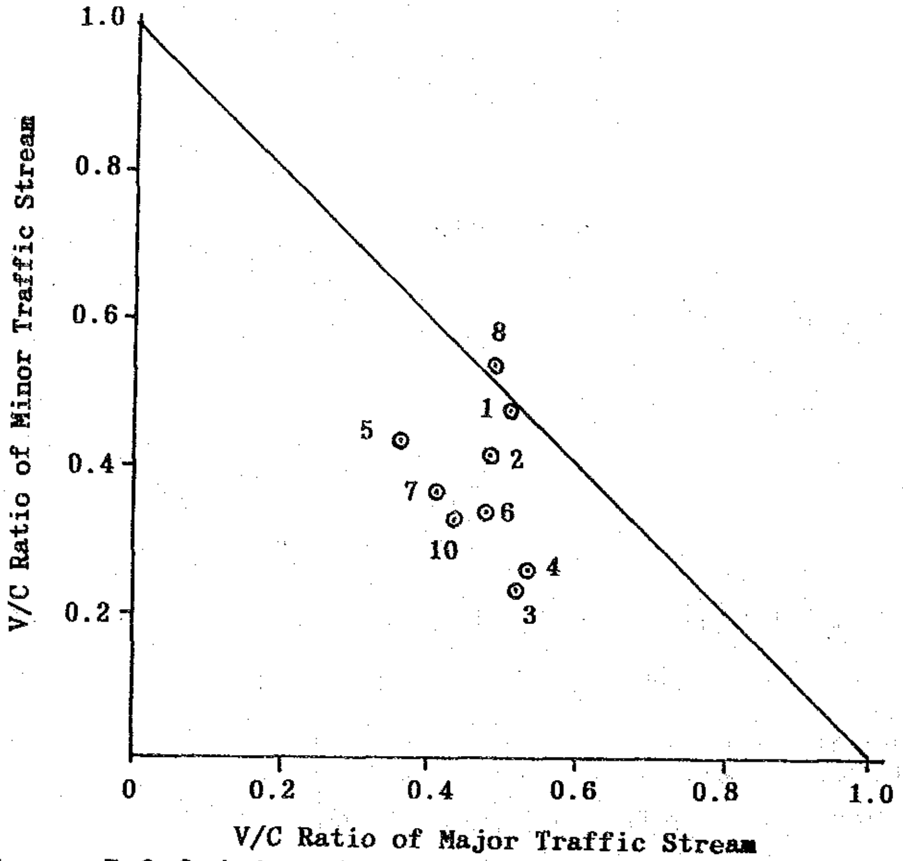


Figure 5.2.2 (a) V/C Ratio of Study Intersection Under Existing Traffic Demand Conditions

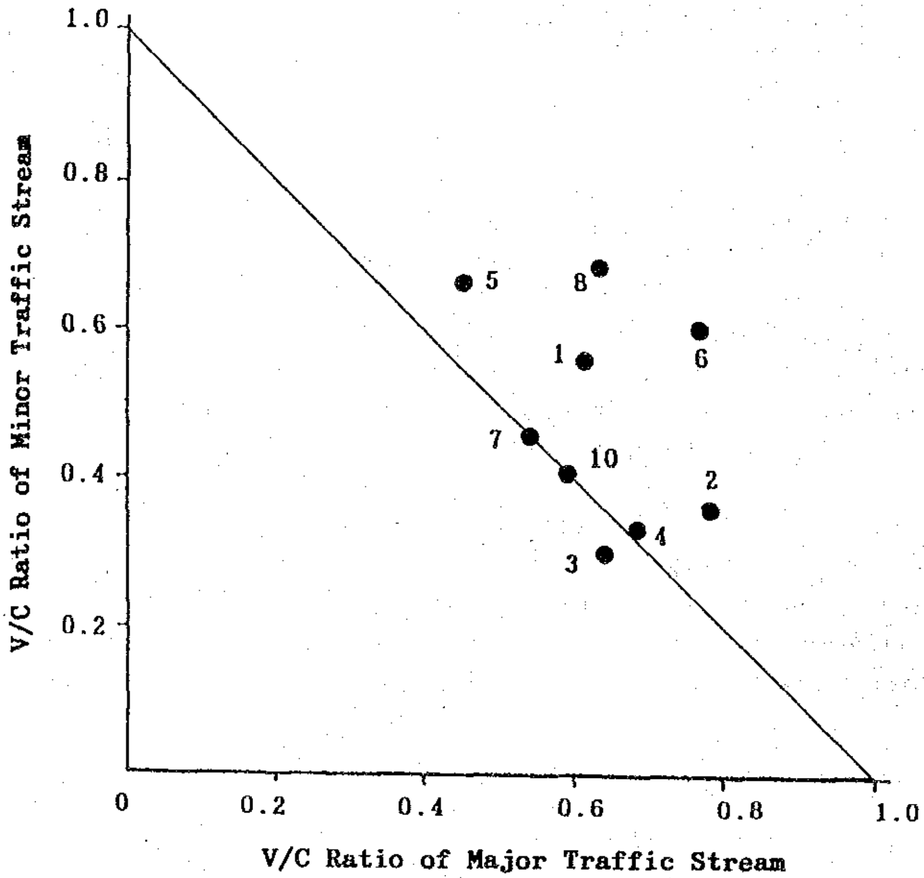


Figure 5.2.2 (b) V/C Ratio of Study intersection Under Future Traffic Demand Conditions

5.2.3 Alternative Intersection Improvement Proposals for Feasibility Assessment

Table 5.2.1 shows the ranking of the severity of traffic conditions at the study intersections in terms of delay and V/C ratio. The higher ranking for the future V/C ratio compared to the present V/C ratio at Intersections No.5 and No.6 is caused by the additional traffic flow from the 2nd Hooghly Bridge.

Table 5.2.1 Priority Ranking of Intersections

Ranking Parameter	Priority Ranking								
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Delay	2	8	1	4	5	6	7	3	10
V/C Present	8	1	2	6	4	5	7	10	3
V/C Future	6	8	5	1	2	4	7	10	3

Based on the future traffic demands and physical conditions at each intersection, alternative package improvements have been formulated as shown in Table 5.2.2.

Table 5.2.2 Alternatives for Feasibility Assessment

Alternative	Flyover Construction	At-grade Improvement
Alt. I	No.1, No.2, No.5, No.6, No.8	No.3, No.4, No.7, No.10
Alt. II	No.1, No.2, No.4, No.5, No.6, No.7, No.8, No.10	No.3
Alt. III	All study intersections	-

An additional sub-option will be included in Alt.I and Alt.II in which the at-grade improvement option is assumed at No.2. Sub-options will also be considered in Alt.I and Alt.II in which at-grade improvements replace the flyover at No.8, provided that at-grade improvements can be shown to have sufficient capacity. For No.5 and No.6 an additional sub-option in which a continuous flyover is constructed between No.5 and No.6 will be studied. Also included in Alt.II is an additional sub-option in which construction of a flyover at No.9 will replace the flyovers at No.4 and No.7.

5.3 Parking Facilities Improvements

In the CBD, many government offices are still located in buildings more than 100 years old. Preservation of historic buildings has restricted the construction of high rise buildings and is likely to continue to do so. Therefore, parking characteristics and demands are unlikely to change much in the future.

Also, it is estimated that the generation rate of parking per unit area will not increase, although there is no available supporting data. Even so, substantial parking facilities would be required to accommodate all parking demands in the CBD. The exclusion of parked vehicles from streets which are considered to be important from the view point of traffic circulation is the primary objective of the Study. For this purpose two parking facilities have been proposed.

5.3.1 B.B.D.Bag Parking

The parking facility at B.B.D. Bag should be designed to cater for vehicles now parking on the streets listed in Table 5.3.1. The corresponding minimum number of parking spaces which should be provided is also shown in the Table.

Table 5.3.1 Minimum Capacity of B.B.D. Bag Parking Facility

Street	No. of vehicles
B.B.D.Bag North	184
B.B.D.Bag East	87
Netaji Subhas Road	139
R.N.Mukerjee Road	117
B.B.D.Bag South and Hara Street	122
Brabourne Road	83
TOTAL	732

This parking facility should have a minimum capacity of 730. In addition, assuming that B.B.D.Bag parking will have the same characteristics as Sector 9, the average parking duration time will be 120 minutes and the turnover rate will be 4.5.

The proposed location of this parking facility is at B.B.D. Bag north, facing Writer's Building, as shown on Figure 5.3.1. To achieve the required capacity for an underground carpark, construction under part of B.B.D. Bag North street has been considered. Alternative parking facilities considered are as follows;

(1) Alternative A - Underground facility under B.B.D. Bag between the tank and B.B.D.Bag North Street. Two underground levels for parking would be provided in addition to rearranging the existing parking at ground level.

(2) Alternative B - A single floor above ground level but without a roof is added to alternative A

(3) Alternative C - The facility in Alternative A is extended partially under B.B.D. Bag North.

5.3.2 Esplanade Parking

The proposed parking facility at the Esplanade should be designed to cater for vehicles now parking on the streets listed in Table 5.3.2. The corresponding minimum number of parking spaces which should be provided is also shown in the Table.

Table 5.3.2 Minimum Capacity of Esplanade Parking Facility

Street	No. of vehicles
Esplanade Row East	60
Esplanade Row West	283
Government Place East	72
Government Place West	13
K.S.Roy Road and Government Place North	161
TOTAL	589

This parking facility should have a minimum capacity of 590 vehicles. Assuming that the Esplanade parking will have the same characteristics as Sector 8, it will have a shorter parking duration time of 9.9 minutes and a larger turnover rate of 6.1 compared to the B.B.D. Bag parking facility.

The proposed location of the parking facility is on the tram terminus site adjacent to Surendra Nath Banerjee Park, as shown on Figure 5.3.1. Alternatives considered for this parking facility are as follows;

(1) Alternative A
Underground facility with a single level of parking under the Tram Terminus

(2) Alternative B
Above ground facility with a single level of parking over the Tram Terminus. There would be no roof above the parking level.

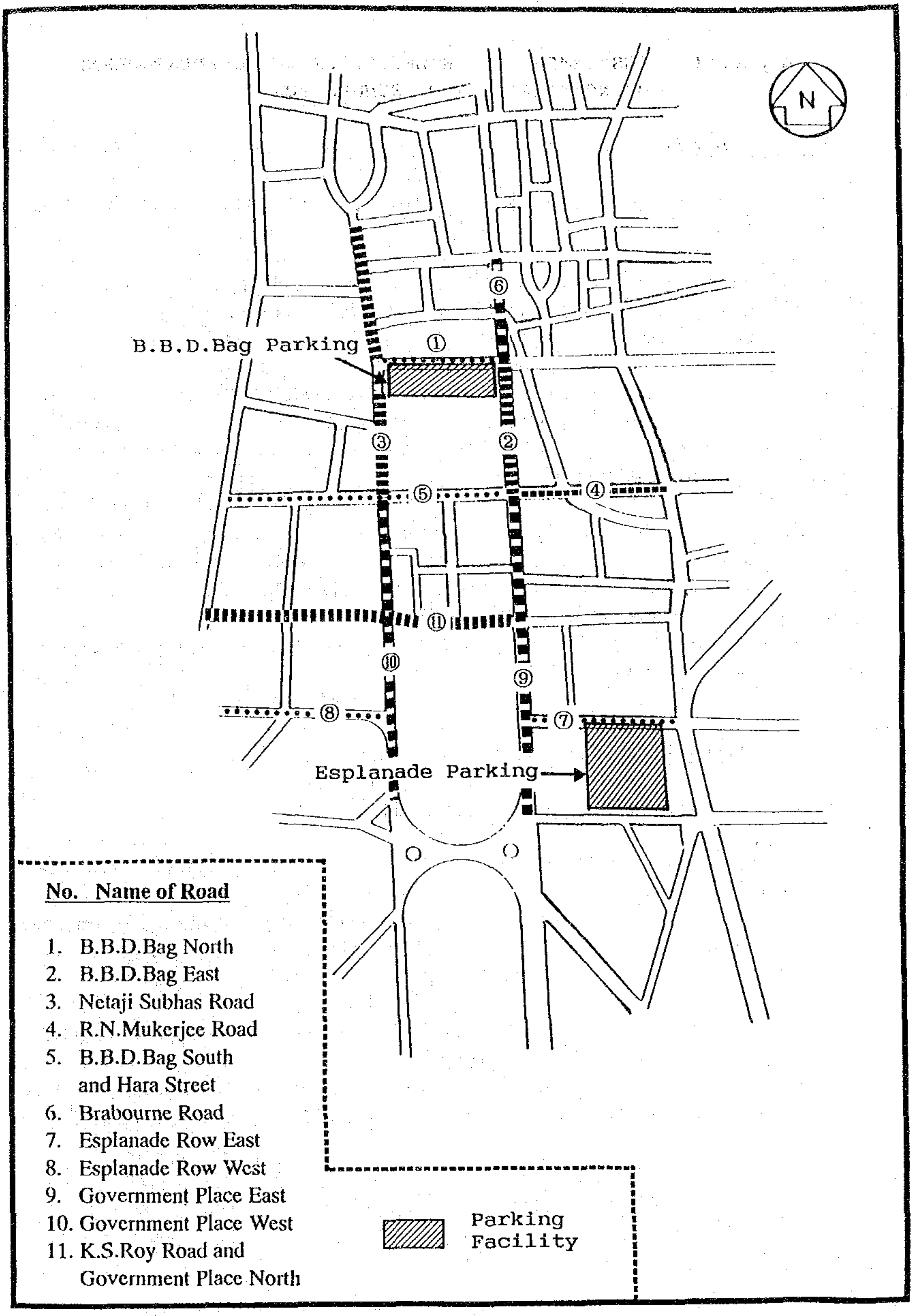


Figure 5.3.1 Location of Parking Facilities and streets

Chapter 6 ASSESSMENT OF INTERSECTION IMPROVEMENT PLANS USING TRAFFIC FLOW SIMULATION

6.1 Purpose

Traffic flow simulation was carried out in this Study for the purpose of:

a. examining the future traffic flow conditions along the study corridors with the present transport infrastructures, and

b. predicting future traffic flow conditions along the study corridors where alternative transport infrastructures are proposed, thus assessing the traffic impacts of these alternative plans.

Results of the traffic simulation are essential for the computation of benefits of the alternative transport infrastructure improvement plans. Savings in delay time for example are converted into quantifiable form which is in turn used for carrying out an economic evaluation of the alternative plans in the Chapter 9.

6.2 Procedure

6.2.1 Selection of Simulation Model

The simulation model selected for this Study is the Input-Output (I/O) Model. This model has the advantages of quickly simulating several intersections simultaneously along a route within the road network for a time period of as long as 24 hours.

The I/O model simulates traffic flow as streams of liquid through channels. The I/O model used in this study is set to simulate traffic flow for 12 hours on the study routes, with an interval scanning function set for 10 minute intervals.

6.2.2 Setting up of Alternative Improvement Plans by Simulation Route

The Study corridors where flyovers are to be proposed are divided into 3 simulating routes. Of the 10 study intersections, 8 are located on these three routes while intersections No. 3 is treated as an isolated intersection. Improvement to Intersection No. 9 will have a great impact on Intersections No. 4 and No. 7. For this reason, Intersection No. 9 is incorporated into Route 2 during simulation.

- Route 1 contains the study intersections No.5,6,10 and 1,
- Route 2 contains the study intersection No.4 and 7,
- Route 3 contains the study intersection No.2 and 8.

6.3 Simulation Results For The Alternative Plans

Simulations were run for the various alternative plans. For each of the simulation runs, the following outputs are generated. These are taken as measures of effectiveness (MOE) of the alternative plans.

- Total entering volumes,
- Total delay in veh.hrs,
- Total vehicle travel distance in veh.km,
- Total vehicle travel time in veh.hrs,
- Average Speed in kph.

The results of simulation for all the alternative plans by route are tabulated using total entering volume, average speed and total delay as indicators and shown in Table 6.3.1.

Table 6.3.1: Simulation Results of Alternative Intersection Improvement Plans

Route	Case	Flyovers	Entering Volume (Veh.)	Average Speed (Kph)	Total Delay (Veh.Hrs)	Total Delay Index*	Delay Reduction Ratio
Route 1	1-1	(Do-Nothing)	245,769	3.2	164,229	6.96	1.00
	1-2	#1,#5, #6	246,899	9.0	53,587	2.27	0.33
	1-3	#1,#56	245,111	14.6	26,890	1.14	0.16
	1-4	#1,#5,#6,#10	233,694	9.9	47,242	2.00	0.29
	1-5	#1,#56,#10	231,906	18.1	18,207	0.77	0.11
Route 2	2-1	(Do-Nothing)	87,726	7.8	32,491	3.36	1.00
	2-2	#4,#7	87,726	32.7	1,472	0.15	0.05
	2-3	#9	79,976	31.3	1,228	0.13	0.04
	2-4	#4,#7,#9	79,976	38.2	1	0.00	0.00
Route 3	3-1	(Do-Nothing)	187,976	3.7	128,458	3.46	1.00
	3-2	#2,#8	161,443	10.5	39,607	1.07	0.31
	3-3	#8	161,443	6.6	68,936	1.85	0.54
	3-4	#8,(#2,4Lane)	161,443	10.0	42,475	1.14	0.33
Isolated	4-1	(Do-Nothing)	49994	38.1	0	-	-
	4-2	#3	49994	38.2	0	-	-

Note: * Index with total delay under existing condition as 1.0
#56 : Continuous flyover bridge from Intersection No.5 to 6

From this analysis of the simulation results, the following conclusions are arrived at:

(a) The construction of a continuous flyover bridge from Intersection No.5 to 6 is more effective in reducing total vehicle delay than the construction of two individual flyovers at No.5 and 6.

(b) The construction of a flyover at Intersection No.2 is equally effective as having a 4-lane at-grade improvement.

(c) The construction of flyover at Intersections No.4 and 7 is as effective as construction of flyover at Intersection No.9.

(d) Construction of a flyover at Intersection No.3 has little impact on traffic flow along the three study routes up to 1998.

CHAPTER 7 PRELIMINARY DESIGNS

7.1 Design Standards

7.1.1 Road Design Standards

(1) Design Standards for Flyovers

Geometric design standards in India are prescribed by Indian Road Congress (IRC), and in designing flyovers in this Study the IRC standards are basically used. Some of the elements used are;

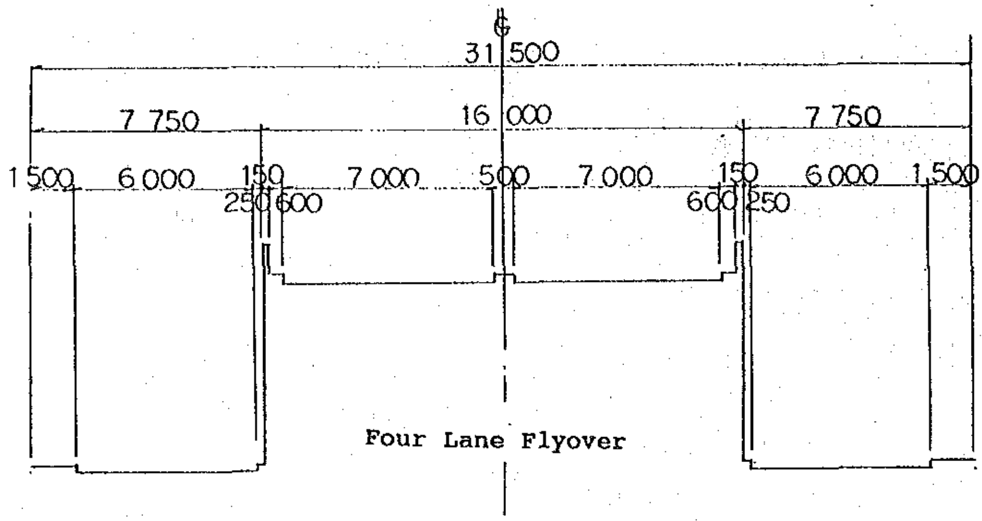
design speed	: 50 km/h
minimum lane width	: 3.5m
curb width	: 0.5m
maximum superelevation	: 7 %
minimum radius	: 100m
steepest grade standard	: 1:25 (4.0 %)
special case	: 1:20 (5.0 %)
minimum vertical curve	: 1,000m radius
vertical clearance	: 5.0m ordinary case
	: 5.4m for tram, 6.7m for train
length for lateral shift	: taper rate 1:10

(a) Minimum Number of Lanes and Carriageway Width

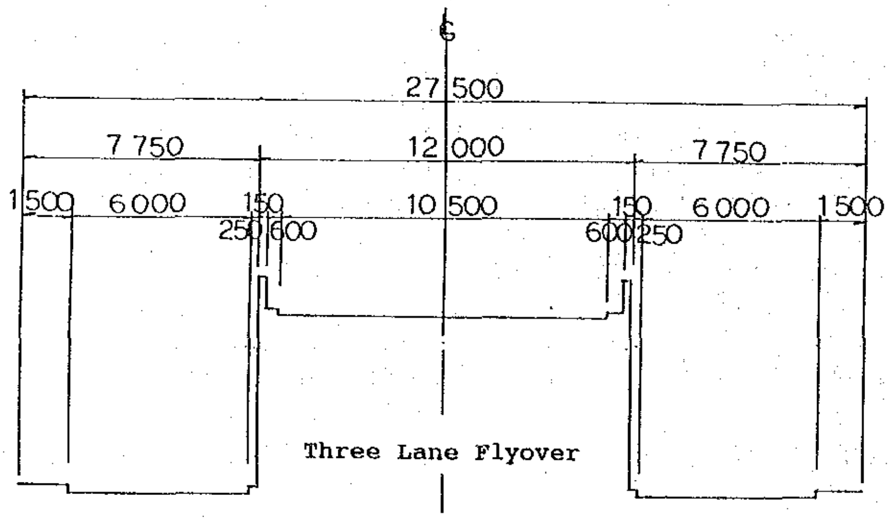
A typical flyover cross section is shown in Figure 7.1.1. The minimum width of a 4-lane flyover is 16.0m. The frontage road carriageway width should be sufficient to enable a large vehicle to pass through beside a parked large vehicle. Thus the minimum right of way width required to accommodate a 4-lane flyover is about 31.0m.

(b) Treatment of Tram Tracks

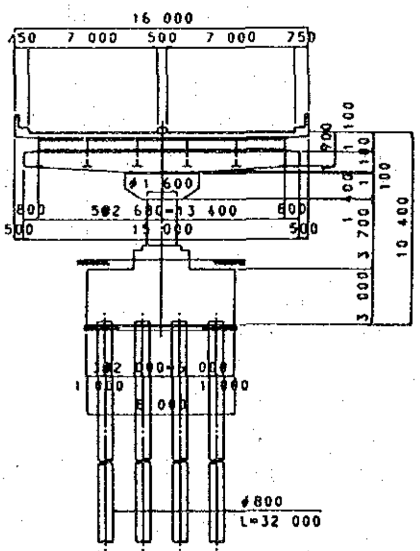
Tram tracks will not be mounted on flyovers as tramcars require gentler slope than automobiles. Tram tracks will basically remain at-grade and will be subject to some rerouting as necessary. Where tram tracks are running parallel to the proposed flyover, the tracks will generally be relocated to either side of the flyover. Any relocation shall be treated carefully during construction of the flyover.



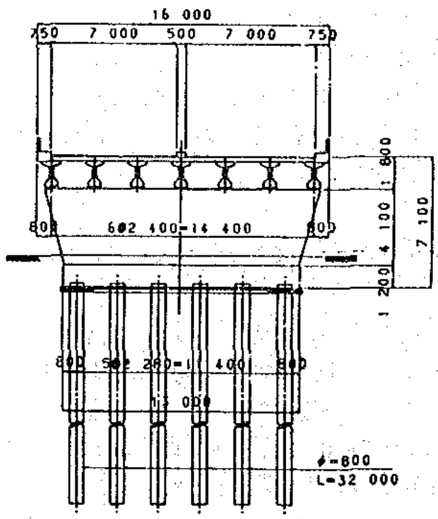
Four Lane Flyover



Three Lane Flyover



(Steel Plate Girder)



(PC Composite Girder)

Figure 7.1.1 Typical Flyover Cross Section

7.1.2 Bridge Type

The bridge structures will be economical and structurally sound with an aesthetically pleasing appearance. The bridges will be economical not just in terms of construction cost, but consideration will also be given to maintenance costs. It goes without saying that the bridges will be safe upon completion but consideration will also be given to safety during the construction period as well.

(1) Superstructure

Superstructures are generally classified into reinforced concrete structure bridges, prestressed concrete structure bridges and steel structure bridges. Reinforced concrete bridges are used for bridges with short spans and prestressed concrete bridges and steel bridges for bridges with short/medium to long spans. Bridge type selection will be made as follows.

(a) For bridge sections over the intersections, steel structure bridges will be used. Because intersections are places of traffic convergence bridge types allowing construction to be completed in the absolute minimum time will be selected.

(b) To allow for right turning traffic lanes, the median needs to be narrow and where the width of concrete piers would create difficulties, steel piers will be used and therefore the superstructure will also be of steel.

(c) For bridge sections that are not near intersections there is little advantage to be gained by having a narrow median and because traffic disruption there will not be as critical as at the intersections it will be economical to use concrete piers and prestressed concrete girders requiring minimum on-site work.

(d) 20m will be used as the standard for the approach section span with consideration given to implementability and economics.

(2) Substructure

A slender shaped bridge is possible because of the low incidence of earthquake occurrence and, in principle, reinforced concrete type piers will be used. However, as discussed in the superstructure paragraph, for sections where the median must be narrow reinforced concrete bridge piers will be difficult and steel bridge piers will be used.

(3) Foundations

According to the results of the geological survey carried out by this Study, at the various survey sites soft silty clay is found at depths ranging from 0.4m to 17m from the ground surface. Under this layer there is medium stiff silty clay with traces of sand at depths ranging from 7.5m to 21m. According to the soil survey results piles will be used in foundation work. Cast in place reinforced concrete piles were adopted in consideration of the kind of piles generally used to date in Calcutta.

In this study 80cm diameter piles were adopted for all bridge sites, as most commonly used in Calcutta. In the detailed design, piles with a larger diameter, such as 1.0m or 1.2m may be used after considering the conditions at the sites.

7.2 Intersection Improvements

7.2.1 Intersection No. 1 - Moulali

Under this Study, only a flyover improvement plan was considered for this intersection. A 4-lane flyover is possible on A. J. C. Bose Rd as the road is sufficiently wide and the flyover will cross both Lenin Sarani and S. N. Banerjee at the same time. The profile is planned so that the area beneath the flyover can be used by traffic, thus providing sufficient clearance in front of the religious facilities located in the vicinity of the intersection.

In order to bring the two-directional trams on Lenin Sarani Rd into line with the one-way vehicular traffic, the westerly direction tram line will be moved to S. N. Banerjee Rd.

As bus traffic volume is large along Lenin Sarani Rd, as much as possible within the site constraints, 3 lanes will be constructed with consideration given to minimizing obstruction to bus and other traffic.

The layout of flyover spans over each of these intersection takes into consideration the tram line relocation plans, and the span over S. N. Banerjee Rd intersection will be 45m while the span overpassing Lenin Sarani Rd will be 32m. The approach section spans will be 20m. The proposed gradient is 4% and the length of the bridge is 437m.

7.2.2 Intersection No. 2 - Esplanade

The Study has considered two options for upgrading this intersection, the construction of a flyover, and secondly an at-grade improvement plan.

A flyover has been considered along J. L. Nehru Rd to overpass the intersections with Bentick St, Lenin Sarani and S.N. Banerjee Rd. To match the proposals at Intersection No. 1, the westbound tram line opposing the one-way traffic flow on Lenin Sarani will be moved to S. N. Banerjee Rd and the eastbound tram line changing lanes in the center of the Lenin Sarani intersection will be modified so that it proceeds through the intersection directly without a lane change.

The alternative to a flyover, the at-grade intersection improvement plan which has also been considered, requires the land acquisition of a small area adjacent to the intersection of Esplanade Row East - Chittarajan Ave in order to provide eight lanes for through traffic, one lane for right turning, and widened sidewalks. The widened sidewalk will create space for the pier and stairway of a future pedestrian overpass.

The flyover substructure design must be adapted to the site conditions which include the underground metro tunnel running along Jawaharlal Nehru Rd.

The main factor governing bridge type selection is the reduction of construction time. Prestressed concrete composite is adopted for the sector on the Park St side, which has a comparatively large works area, and steel girders for the other sectors. The maximum length of span in this flyover is 44m. The gradient for the southern starting point will be 4% while the northern terminal point gradient will be 5% because of the intersection with Ganesh Chandra Ave. The length of the bridge will be 648m.

7.2.3 Intersection No. 3 - Gariahat

Two improvement options have been considered for this intersection, a flyover and at-grade improvement. For the flyover option, a 4-lane flyover in the north-south direction has been selected to best serve the main traffic flow.

The at-grade intersection improvement plan makes maximum use of the current road with 2 lanes allowed on each side of the wide median, even on the south side of Gariahat Rd. This is deemed to be sufficient for handling current and future traffic volume.

The span of the flyover section overpassing the intersection sector is set at 39m because of the intersection traffic flow. A 20m span for the approach sectors has been selected, with emphasis on economy, because there are no large obstructions. The gradient has been set at 4% and with consideration given to tram way and road clearance at the intersection sector the bridge length will be 379m.

The flyover sections over intersection sectors and right turn lane sectors, where the median strip is narrow, will be of steel girder construction while other sections will comprise prestressed concrete girders. The piers will also be of steel construction in sectors where the median strip is narrow and of reinforced concrete construction in other areas.

7.2.4 Intersection No. 4 - Shyambazar

Both at-grade intersection improvements and flyover construction options have been considered at this intersection.

A flyover, limited to three lanes by the right of way constraint, has been studied for the main flow of traffic in the north-south direction.

The at-grade intersection upgrade proposal calls for operating the current 5 leg intersection as a 4 leg intersection. A traffic island will be located such that only left turn movements will be allowed from the Bidhan Sarani approach. The statue in the middle of the intersection will be moved to the nearby square.

The main span of the flyover section over the intersection is set at 35m to allow for the road width of R. G. Kar Rd and the right turn lane on A. P. C. Roy Rd., and to avoid the underground metro tunnel running along R. G. Kar Rd. The spans of the approach sections are set at a standard 20m as there are no particular obstructions. The gradient will be 4% to provide a 5.4m clearance for the tram at the intersection sector, and the bridge length will be 355m.

The flyover section above the intersection shall be of steel girder with a 35m span. In addition, to allow for right turn lanes at the narrow median strip, steel bridge piers for the substructure and a steel superstructure are planned near the intersection sector.

7.2.5 Intersection No. 5 - Rabindra Sadan

Improving this intersection by the construction of a flyover was the option considered under this Study. At this intersection, the approach section to the west of A. J. C. Bose Rd is only 20m wide, which is insufficient to construct a flyover ramp and the flyover must therefore be constructed to pass over H. Mukerjee Rd. as well. Moreover, the right of way width of the eastern approach section is only 25m so that the flyover option for a separate flyover at Intersection No.5 can be two lanes only, thereby limiting the traffic capacity which can be accommodated.

The spans of the flyover sections that overpass Intersection No.5, and the H. Mukerjee Rd. intersection to the west have been set at 32m and 26m respectively, according to the conditions and traffic flow at each intersection. The spans of the approach sections have been set at 20m and the bridge length is planned at 580m. The flyover gradient will be 4% from the starting point west of the intersection, a mild 0.06% between the two intersections, and 5% at the descent east of Intersection No.5.

The width of the existing road is narrow and in order to minimize traffic disruption on the road during construction a steel bridge construction has been selected.

7.2.6 Intersection No. 6 - Beck Bagan

The Study proposes a flyover option as the improvement plan for Intersection No.6. An independent flyover at this intersection is limited to only two lanes, as for Intersection No.5, due to the right of way constraint. The flyover will be along A.J.C. Bose Rd and Park Circus Avenue because the main traffic flow will pass along Park Circus Ave in the future.

As the right of way width of A.J.C. Bose Rd. is narrow, part of the space under the flyover should be used as road space. Furthermore if space for right turn lanes at each intersection is allowed for, the median strip will become very narrow and this will affect the size and location of piers. A steel type flyover is therefore proposed for this intersection. The span lengths of the flyover sections spanning the intersections depend on the conditions at each intersection and will range from 54m to 23m. The gradient will be 4% and the length of the bridge 672m.

7.2.6' Intersections No.5 (Rabindra Sadan) and No.6 (Beck Bagan)

Under this plan a continuous flyover connecting both Intersections No.5 and No.6 is proposed. This proposal allows for the construction of a three lane flyover structure. East of Intersection No.6 the flyover will split into two directions, with two lanes each along A. J. C. Bose Rd. and Park Circus Avenue.

The layout of flyover spans and span lengths depends on the conditions at each intersection and spans will range from 54m to 23m. For flyover sections where there are no large obstructions and the intermediate sections of the flyover, steel construction with span lengths of 20m are adopted. This is in keeping with the need to utilize part of the space under the flyover for road space and the need to minimize traffic hindrance during construction. The flyover gradient will be 4% at the ramps and the length is 2.3 km.

7.2.7 Intersection No. 7 - Maniktala

Two improvement options have been studied for this intersection, the construction of a flyover and at-grade improvements.

As the road width in the vicinity of this intersection is narrow, a north-south 4-lane flyover, with sufficient clearance under the cantilever beam of the pier to allow road traffic, is proposed.

The at-grade improvement plan proposes that the reserved tram lines at this location should be shared by trams and vehicles to provide 3 lanes in the approach sectors.

The flyover ramp gradient will be 4% and the corresponding bridge length will be 492m. The flyover span over the intersection sector will be 32m and the spans of the approach sections 20m each.

For sections where it is difficult to use reinforced concrete bridge piers because of median strip width, steel bridge piers will be used while for other sectors reinforced concrete bridge piers will be adopted.

7.2.8 Intersection No. 8 - Park St.

Both at-grade and flyover construction options have been considered in this Study for Intersection No.8.

The route of the proposed 4-lane flyover is in the north-south direction along J. L. Nehru/Chowringhee Rd. and passes over the intersections with Park St., Outram Rd. and Mayo Rd.

The at-grade improvement plan calls for altering the alignment of Mayo Rd so that it connects to J.L. Nehru Rd. directly opposite Park St. Outram Rd will connect to the realigned Mayo Rd. away from the main intersection. The intersection thus becomes a simple 4 leg intersection. Accordingly the intersection operation will be simplified and the capacity increased.

Prestressed concrete box girders, continuous over 3 spans, have been proposed for the flyover sections spanning the intersection sectors and prestressed concrete simple composite girders have been proposed for the approach sections of the flyover.

The flyover spans over the intersections will be 40m and, as the distance between both intersections is 48m, 2 continuous girders of 24m + 40m + 24m are planned. Standard 20m span will be used for the flyover approach sections because there are no large obstructions. The gradient will be 4% and the bridge length will be 356m.

7.2.9 Intersection No. 9 - Lock Gate

This plan proposes the construction of a flyover at the intersection of Lock Gate Rd and the railway lines. This railway is not a main trunk line but rather runs to factories and yards. At present the north and south portions of Lock Gate Rd end on either side of the railway line. Trains crossing through this area are infrequent, however trains are observed to take a long time to pass through.

The gaps between the 6 tracks are narrow making it impossible to locate bridge piers between tracks. Therefore a sufficient span length to span all the tracks is necessary. Since the main span would be longer if the piers are at right angles to the bridge alignment, it is proposed that the piers should be skewed at 75 degrees to the bridge alignment. With the piers skewed in this manner, the length of the main span is reduced to 50m. The spans for the approach sector do not encounter any large obstructions and are planned at 20m. The gradient is set at 4% with an under bridge clearance of 6.7m for railway and 5.0m for the existing road. The bridge length will be 430m.

For the main 50m span over the railway lines, a steel box girder is adopted. Because the railway cannot be halted during construction, the launching method of construction will be used. The flyover approach sections will be prestressed concrete composite girders as there is no problem with disruption to existing traffic.

7.2.10 Intersection No. 10 - Mullikbazar

At-grade improvement and flyover construction plans are both considered for this intersection.

A.J.C. Bose Rd is a main north-south trunk road but is not sufficiently wide at this location for a 3-lane or 4-lane flyover. With religious facilities and a cemetery adjacent, widening of the right of way is judged to be difficult and a plan for a north-south flyover was not considered feasible. Consequently, an east-west flyover has been proposed. However, the right of way width on the west side of Park St. is also restricted and the flyover will be limited to 2 lanes.

The flyover section over the A.J.C. Bose Rd intersection will have a span of 37m. The approach sections encounter no particular obstructions and the spans will be 20m. There is a 4% gradient planned for the east side ramp but because it is necessary to intersect at ground level with McLeod St, the west side ramp will have a gradient of 5%. The bridge length will be 277m.

A steel girder bridge will be used to minimize on-site work and avoid obstruction to current traffic in the vicinity of the intersection. Prestressed concrete composite girders will be adopted for the approach sections.

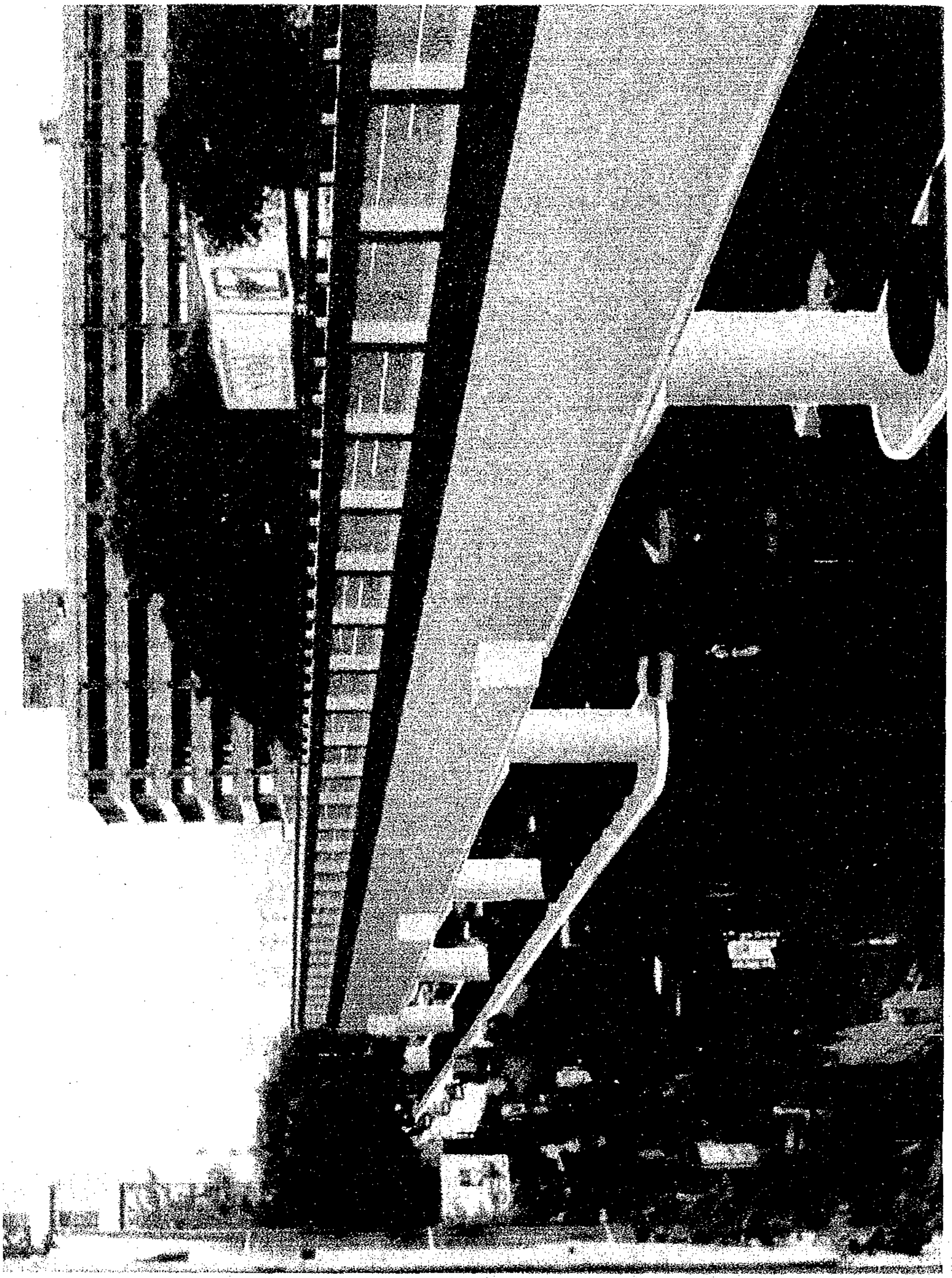


Figure 7.2.1 Future Image Photograph at No.5 and NO.6 Continuous Flyover

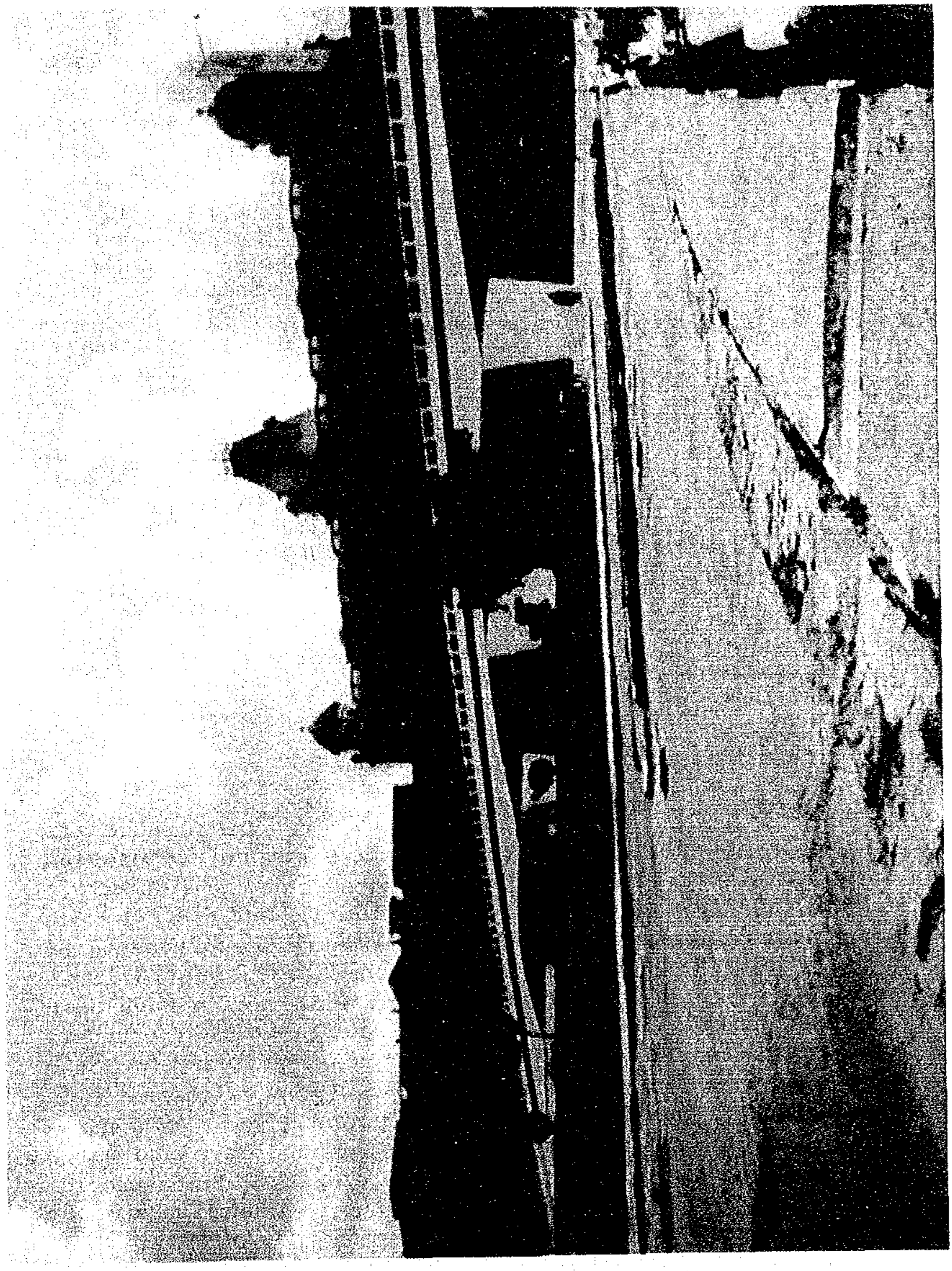


Figure 7.2.2 Future Image Photograph at No.8 Flyover