4.2 Estimation of Future Traffic Demand

4.2.1 Methodology

The process applied for the estimation of the future traffic demand followed the 4 steps described hereinafter.

(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 the observed traffic volume between 1966 and 1991 on Howrah Bridge is 1.5, smaller than the same ratio in other city areas. For example even in the congested city center at Chowringhee Road and Park street the ratio reached 2.0. It shows that the cross-river traffic was restrained due to the lack of capacity on the existing Howrah Bridge. Once the 2nd Hoogly Bridge is opened, the restraint will be released and cross-river traffic will increase at a rate higher than the values in Table 4.2.1.

With the limited data available and uncertainties regarding the effect of the toll to be imposed for crossing the second Hooghly Bridge, it was not possible to carry out a detailed investigation into the likely increase in traffic volume. On the basis of approximate calculations it was estimated that a figure of 20,000 additional vehicles per day should be assumed in 1998.

The approximate calculations were based on a comparison between the growth in the number of registered vehicles and the growth in cross-river traffic, between 1951 and 1964 after the opening of the Howrah Bridge. In all cases the growth in cross-river traffic exceeded the growth in registered vehicles.

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

(3) Cross-River Traffic Volume Assignment for 1998

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.

Figure 4.2.1 shows the desire lines for cross-river traffic for the adopted 1998 volume (Case C in Table 4.2.2 above). The desire lines are based on the roadside O-D survey as described in Section 4.1.2 (2). The additional 20,000 cross-river vehicles per day adopted as described in (2) above to take into account the effects of the opening of the 2nd Hooghly Bridge was assigned equally between Zone 36 (Shalimar Station) and Zone 51 (South Howrah), ie. 10,000 to each zone.

Using the desire lines the cross-river traffic from Table 4.2.2 above has been assigned to the road network according to travel times and distances. Traffic has been assigned to either the Howrah Bridge or the 2nd Hooghly Bridge and the results are summarized in Table 4.2.3. For Case B, assignments have been carried out both with and without the 2nd Hooghly Bridge. The results of the traffic assignment for Case C on the whole road network are shown graphically in Figure 4.2.2.

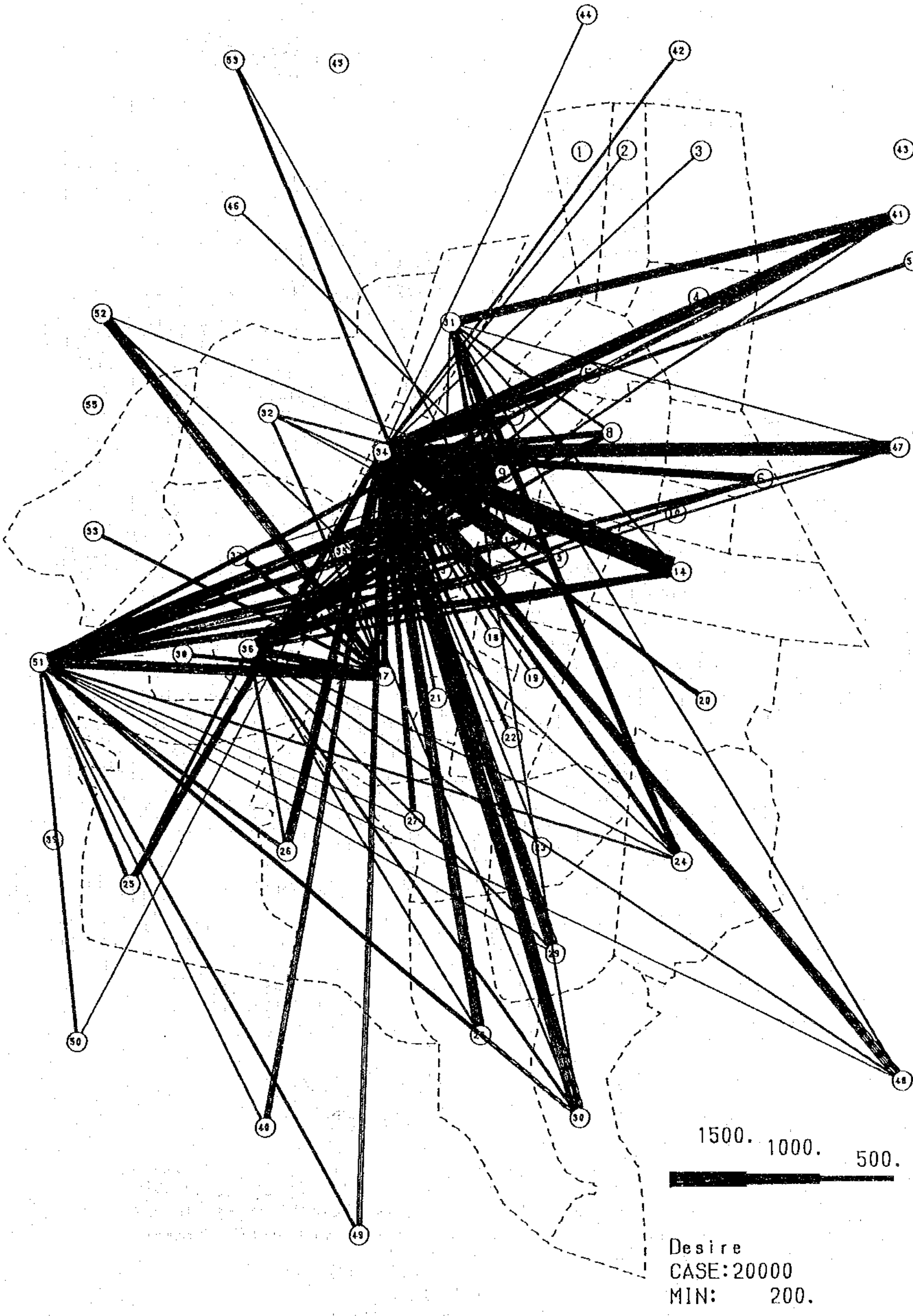


Figure 4.2.1 Desire Lines for Cross-River Traffic in 1998 (Including additional 20,000 vehicles/day river crossings)

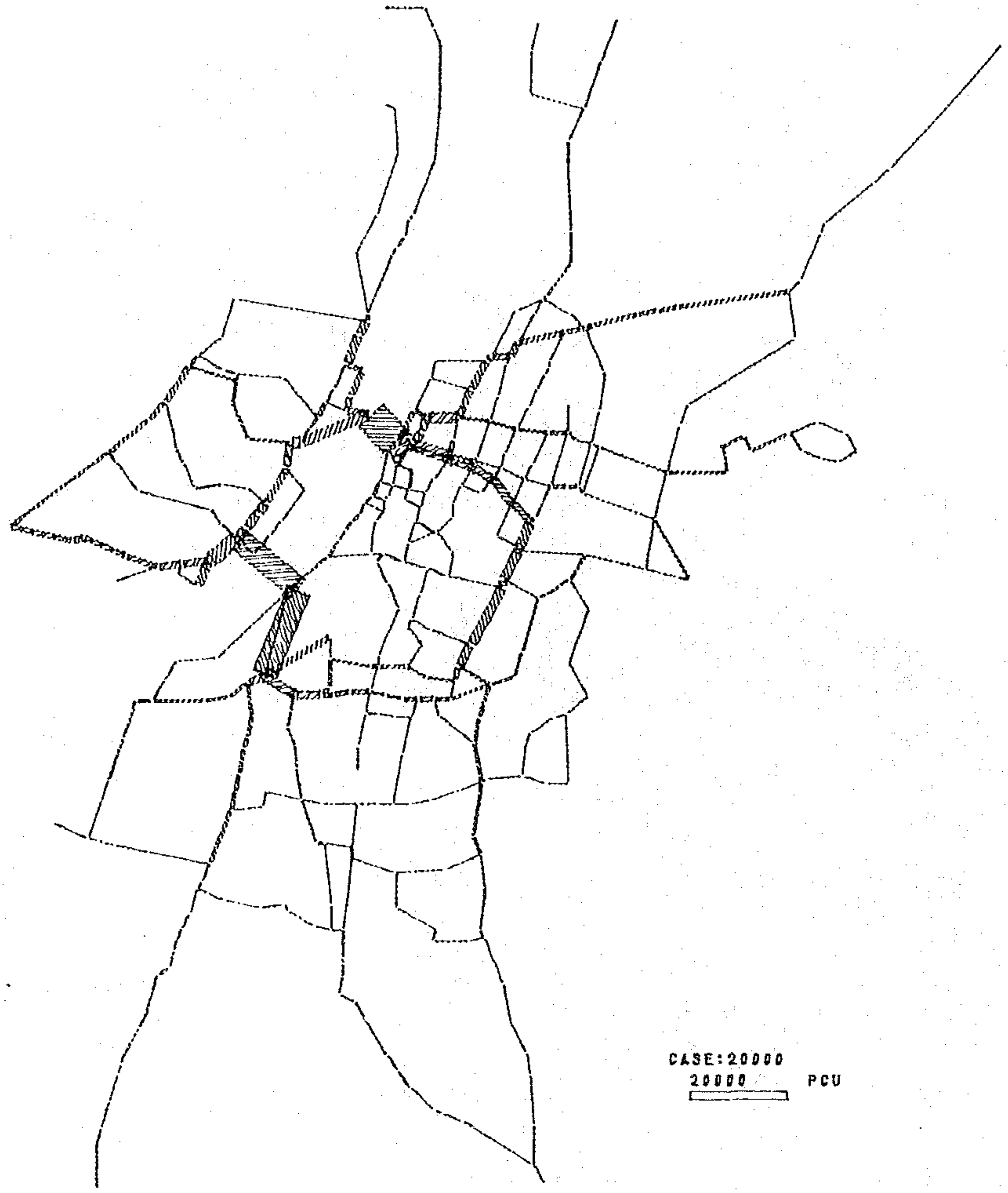


Figure 4.2.2 Assignment of Hooghly River Crossing Traffic in 1998 (2nd Hooghly Bridge construction completed ; Including additional 20,000 vehicles/day ; Case C)

Table 4.2.3 Cross-River Traffic Volume Assignment for 1998

(Unit : PCU/day)

YEAR	Case	Total Cross-River Traffic (Table 4.1.3)	Traffic Volume Assignment	
			Howrah Bridge	2nd Hooghly
1991	A. Existing	86,824	86,284	
1998	B. Growth at 3.6%/year -B1. Without 2nd Hooghly Bridge -B2. With 2nd Hooghly Bridge	 111,410 111,410	 111,410 77,613	 33,797
1998	C. Adopted 1998 volume (Case B2 plus 20,000 veh/day)	143,724	84,115	59,609

(4) Mathematical Formula for Traffic Assignment to Surveyed Intersections

Future traffic volumes at the surveyed intersections were calculated by the following formula. The first part of the equation (Q1991 x E) represents the traffic volume growth rate from Section (1) above. The second part of the equation allows for the effects of the opening of the 2nd Hooghly Bridge and for traffic generated by future development as described in Sections (2) and (3) above.

$$Q1998 = (Q1991 \times E) + (Qf - Qn)$$

where

Q1998 : Forecast Intersection Traffic Volume in 1998

Q1991 : Surveyed Traffic Volume in 1991

E : Growth Ratio between 1991 and 1998

Ints. No 1 & 2 E = 1.252

Other Ints. E = 1.283

Qf : Predicted Cross-River Traffic Assignment for 1998 assuming 20,000 additional vehicles per day (Case C).

Qn : Cross-River Traffic Assignment for 1998 without the 2nd Hooghly Bridge and assuming 3.6% annual growth rate (Case B1)

Qn = 1991(1 Bridge) x 1.283

4.2.2 Intersection Traffic Volumes

Figure 4.2.3 shows the future forecast traffic volume at each intersection.

At Intersections No. 2 and 18 detouring of the north-south traffic between J.L.Nehru Road and Chittaranjan Road due to the traffic jam caused by the construction work at the intersection was observed. The future traffic volumes in the above mentioned approach were therefore estimated by adding the detouring traffic, which was calculated from the difference of the observed traffic volume of J.L.Nehru Road at Intersections No.8 and 18.

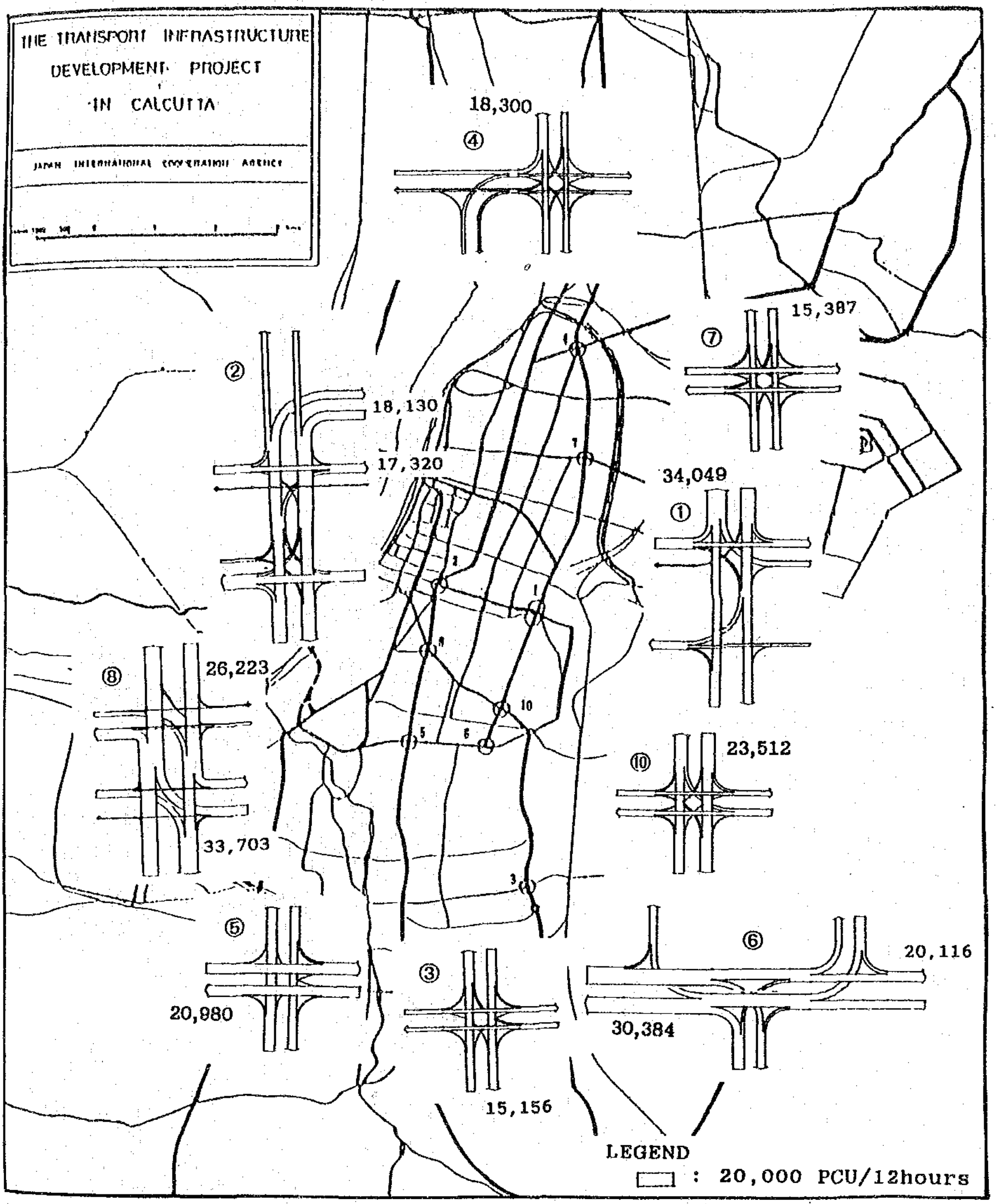


Figure 4.2.3 Future Traffic at Each Intersection

CHAPTER 5

TRANSPORT INFRASTRUCTURE IMPROVEMENT ALTERNATIVES

CHAPTER 5 TRANSPORT INFRASTRUCTURE IMPROVEMENT ALTERNATIVES

5.1 Summary of Existing Problems

It can be said that traffic conditions in Calcutta are chaotic. These conditions include traffic jams at intersections, mixing of fast and slow vehicles and pedestrians walking on the roadways. Some of the problems relating to the traffic conditions are discussed below.

5.1.1 Traffic Volume and Vehicle Type

Surveyed traffic volumes are indicated in Figure 4.1.8. The highest volume was measured at Howrah Bridge and was 61,000 vehicles/day. There are 6 lanes on this bridge meaning that it is operating at near full capacity.

Other high volumes were measured along J.L.Nehru Road, the city's widest main road, at the intersection of Park Street, ie 42,000v/12hr. At the Esplanade however, while potential demands were considered to be very high, the actual counted volume was not so high due to the present constricted roadway caused by the metro construction.

Along A.J.C.Bose Road, with a roadway width of 15 to 20 meters, medium traffic volumes of 20,000v to 30,000v were measured. However, at the Shyambazar five leg intersection actual counted volumes were not so high, since poor geometry and obstacles on the roadway are resulting in inefficient usage of the available road space.

The majority of vehicles counted were Indian made "Ambassador" passenger cars used as government cars, private cars and taxis.

Buses are the major public transport mode of the City. At Shyambazar 28% of the counted traffic volume were buses. A rate of more than 10% was commonly observed at surveyed intersections.

Another distinguishing feature of traffic in Calcutta is the mix of slow moving, usually human-powered, vehicles and motor vehicles. Rickshaws, pushcarts, bicycles and tricycles all share the roadway with motor vehicles. However, at the intersections near the CBD the mix is reduced with slow moving vehicles being prohibited from the main street. Mix rates of more than 10% slow vehicles were observed along the northern part of A.J.C.Bose Road and Howrah Bridge.

5.1.2 Traffic Control at Intersections

Twenty-nine critical intersections in the area encompassed by A.J.C. Bose Road, A.P.C. Road, the Canal River and Hooghly River were found to have traffic signals, mostly installed along the major arterials. Of these, however, signals at only 2 intersections were found to be functioning.

Instead of signal control, manual traffic control by policemen was observed at approximately 120 intersections, 93 on arterial roads and 27 on minor streets. This kind of traffic control has the following inherent problems:

(1) Excessively Long Cycle Time

Cycle times used by the policemen tend to be excessively long, a characteristic commonly observed in other cities. Normal cycle time by signal control is usually around 2 minutes and rarely exceeds 3 minutes whereas the cycle time at some manually controlled intersections was observed to be longer than 6 minutes.

Excessively long cycle times have the following undesirable effects.

(a) Ineffective Right of Way Time

Traffic demand at an approach usually does not arrive at saturation flow over the entire duration of a long right-of-way time. If, sometime after the start of right-of-way time, the approach flow is no longer saturated, this right-of-way time should be assigned to another approach where vehicles are waiting to cross the intersection.

(b) Long Queues at Intersection Approaches

Due to the long right-of-way time given to a single approach, the number of queuing vehicles at the other approaches becomes very large. When these queues become very long they block off exit lanes of upstream intersections and generally reduce their efficiency.

(c) Induces Infringement

When queues become too long, drivers become impatient and start to overtake and jam up the lane beyond center line resulting in impairment to the smooth start up of traffic going in the opposite direction.

(2) Unnecessary Turning Prohibitions

Turning prohibitions or one-way regulations are often enforced even though they may not be warranted at certain manually controlled intersections. When this happens, unnecessary detours are produced, resulting in longer travel times and unnecessary increases in traffic volumes in terms of vehicle.kilometers.

(3) Localized Control

The policemen can only control traffic by observing the traffic situation within their range of vision, but are unable to take into account the upstream and downstream traffic situation. Such localized control does not ensure smooth traffic flow along major arterial roads and reduces the overall capacity.

(4) Health and Accident Hazards

Policemen are exposed to high levels of air pollution while working long hours on duty at the intersections, causing a serious health hazard . They also face accident hazards particularly at night time when visibility is very poor.

5.1.3 Intersection Geometry

Complex intersection configurations with 5 approaches, staggered T intersections, inconsistent lane numbers and poor channelisation are found to be causing bottleneck effects.

5.1.4 Parking Facilities

Off street parking facilities are inadequate in the CBD areas in Calcutta. Limited on-street parking is allowed but the number of parking spaces is grossly insufficient to meet the demand. Parallel parking is often allowed on both sides of the streets and at times, perpendicular parking is practiced. As a result, road capacity in the CBD is greatly reduced.

The major off street parking in the CBD is limited to open or covered car parks at B.B.D. Bag. The CBD area has a large number of old buildings with limited numbers of parking facilities. These old buildings are being preserved by the city council and therefore no substantial increase in off street parking can be expected in the near future.

Parking near intersections is another problem. At intersections No.4, 7 and 10, many vehicles were observed to either park or wait at the curb very close to the exit lanes of these intersections. These parked vehicles often block off the traffic flow, creating chronic traffic congestion.

5.1.5 Conflict of Trams and Buses with Vehicular Movements

The surface tram is one of the oldest and important modes of transport in Calcutta. However, crossings of tramcars at intersections invariably reduce the handling capacity of the intersections. Routing and tracking of trams needs improvements to minimize conflicts with vehicular traffic.

Buses stopping or slowing down near or in the midst of intersections to pickup or let down passengers greatly impede the smooth flow of traffic. Buses sometimes do not stop at the designated bus stops and this in turn encourages passengers to wait at the intersections. This problem is seen at almost all of the study intersections and the intersection corners are often seriously congested with waiting bus passengers.

5.1.6 Pedestrians and Hawkers at Intersections

There are considerable commercial activities concentrated at and near intersections in Calcutta. Intersections have in fact become focal points where vendors, hawkers, on-lookers and shoppers converge. People are observed to hawk their merchandise at all four corners of some study intersections, particularly intersections No.1, No.2, No.3, No.4 and No.7; and sometimes even on the carriageway.

Most of the wide streets have sidewalks but in most cases these facilities are largely occupied by hawkers and other informal merchants. Crosswalks are provided at most of intersections and along shopping streets, but usually pedestrians do not make use of these provisions.

The state of these pedestrian conditions has led to the intrusion of pedestrian traffic onto carriageways and intersection areas. The frequent presence of pedestrians on the roadway is slowing traffic and reducing the road capacity.

5.1.7 Pavement Conditions

Pavement conditions are described in Chapter 2.6.2 and Chapter 10.2. The main problem affecting traffic operation is the very rough pavement in the vicinity of tram lines, with the result that vehicles can only cross these areas when traveling very slowly.

5.1.8 Traffic Control Devices

Center and lane markings are poor and do not exist on many roads. Stop lines at some intersections are faded. The absence of lane and center markings encourages indiscriminate lane changing and overtaking. The marking material is cold paint manually applied. The use of more durable reflecting materials is recommended.

Regulatory and guidance traffic signs are rarely installed, undoubtedly causing some difficulty for outsiders driving in Calcutta. There are several roads in the city where the direction of one-way flow varies according to the time of day but despite the complicated traffic system there are inadequate signs to warn drivers. Other regulatory signs such as 'no waiting', 'no parking', and 'no turning' are not adequately installed.

5.2 Conditions at Study Intersections

5.2.1 Location and Conditions

Figure 1.3.1 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.

5.2.2 Problems at Each Study Intersection

The problems observed at each of the study intersections are described below and are summarised on Table 5.2.1, a matrix showing the observed transport problems at each of the study intersections.

(1) Moulali, Intersection No.1

This is the intersection of A.P.C.Roy Road with Lenin Sarani but it should be considered as an intersection complex with the southern intersection of S.N.Banerjee Road as they are important east-west connectors and operate as a pair of one way streets for traffic. The north-south and east-west traffic volumes are heavy and one of the problems of the intersection complex is the abutting religious property between the two intersections which has narrowed the roadway.

Another major problem is that tramcars are operated in the opposite direction to the one way vehicular traffic on Lenin Sarani. This causes complex traffic control and reduces handling capacity and traffic safety.

(2) Esplanade, Intersection No.2

This intersection is located at the city's most busy downtown area which attracts traffic and pedestrians and appears to be very congested even though the existing traffic volume measured here is not so high. The congestion is due to the gross reduction of intersection handling capacity because of the following factors:

(a) narrow roadway (due to metro construction work),

(b) tramcars run counter to the one way traffic on Lenin Sarani,

(c) tramcars 'change lane' at the middle of the intersection,

(d) the huge volume of pedestrians crossing the intersection since it is located next to the tram terminal and near to the bus terminal. Sidewalks are largely occupied by hawkers,

Table 5.2.1 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.

(e) the junction of Bentick St. and Chittaranjan Ave. is located very close to the main intersection,

(f) the intersection approach from the south on Chowringhee Rd is wider than the exits on Chittaranjan Ave. and Lenin Sarani. The results of the travel time survey confirmed that northbound traffic is slower than southbound.

(3) Gariahat, Intersection No.3

The present traffic volume is not so high but, in view of the development trends of Calcutta towards the southern areas, traffic volume at this intersection may increase rapidly in the future.

The Gariahat area is one of the newly developed commercial districts in Calcutta, and this intersection faces a problematic intrusion of vendors and hawkers. The median of the southern approach is being illegally occupied and used as shops and living space. Traffic signals exist on both high and low poles and pedestrian signals are also present but they are not functioning.

(4) Shyambazar, Intersection No.4

This intersection has a number of critical problems. Physically it is a major intersection with 4 main and 1 minor road. The Barakpur Trunk Road towards the north is an important linkage with the Barrackpur-Barasat Development Complex to the north of the CMD with heavy bus traffic. In addition there is a memorial statue in the center of this intersection. Trams turning into the minor road (Bidhan Sarani) also contribute to the complexity of traffic control here.

A large number of buses coming from the east NH No.34 are observed to stop within the intersections when letting down the passengers. The metro construction on B. Bose Avenue has narrowed down the width of the western approach. As Shyambazar is one of the new shopping areas in Calcutta, the intersection is crowded with pedestrians and hawkers. Lastly, traffic control signals installed at this intersection are not functioning.

The actual traffic volume handled here is not high, though congestion occurs throughout the day. Since there are considerable delays it suggests that the capacity is insufficient and improvements are necessary.

(5) Rabindra Sadan, Intersection No.5

This intersection does not have the congestion problems of the other intersections. Except for some buses that occasionally jam the exit lanes of the intersection, traffic flow here is fairly smooth and orderly at present.

This intersection however will experience the most impacts from the opening of the Second Hooghly Bridge. Traffic volume in the near future may exceed the capacity of an at-grade intersection.

The north and west approaches of this intersection are narrow and do not have enough width to accommodate a 4 lane flyover if this is deemed necessary. Moreover, the existence of the metro structure underneath this intersection will become a limitation to the construction of a flyover.

(6) Beck Bagan, Intersection No.6

This is the turning point of A.J.C.Bose Road from the north-south corridor to the east-west corridor. Improper channeling consisting of islands and a median have resulted in a reduction of traffic capacity of this intersection.

There is no serious problem for the 3 leg intersection itself but there is a problem on the east-west section of A.J.C. Bose road created by heavy turning movement on A.J.C. Bose Road between Intersection No 5 and No 6. The zigzag movement of traffic using Sarat Bose Road and Ballygange Circular Road and filtering through Camac Street and Laudon Street is a major cause of the heavy turning movements.

(7) Maniktala, Intersection No.7

Traffic volume of this intersection is in fact not very high, being affected by the northern intersection of Shyambazar. Although the present east-west traffic volume is not so significant, the fact that some of the administrative activity of the present CBD will be relocated to Salt Lake City in the future should be considered, and this intersection will need improvements.

(8) Park Street, Intersection No.8

The key problem of this intersection is its complicated geometric configuration. The simple four leg intersection of J. Nehru Road, Park Street and Outram Road is located very close to the intersection at Guru Nanak Sarani and Kyd Street. Thus this intersection effectively becomes a 6-legged intersection. Considerable lost time to clear conflicting movements through the intersection was observed. Delays were observed to be excessively long, particularly in the evening.

Another critical problem observed here is bus operation. Many buses turn right to J. Nehru Rd. from Outram Road, and stop in the midst of the intersection to get passengers. These buses often obstruct the entire south bound traffic. As a consequence, the right-of-way time given for this turning movement is excessively long in order to clear all buses.

(9) Lock Gate, Intersection No.9

This intersection is different from the other intersections in that the conflicting movement is a railway rather than a road and traffic flow across the railway is not yet possible. Lock Gate ends at junctions on either side of the railway line. A pedestrian overhead bridge is constructed over the railway lines. The railway lines are not the main lines but service lines to the railway yard and factories and thus the frequency of rail services is low.

A survey was carried out to estimate the gate closure time if a gate was installed at the intersection. The surveyed total closing time of the gate between 8 am and 8 pm would be 69.5 minutes or 9% of the total survey hours. More than 65% of the gate closures would be were less than 2 minutes duration.

Lock Gate Road could function as a bypass route of Barrackpur Trunk Road if a flyover was constructed over the railway lines. Provision of a connection between the southern end of Lock Gate Road and Kashipur Road would be necessary if the

Lock Gate flyover is constructed. Improvements to the intersection between Lock Gate Road north and Barakpur Trunk Road would also be necessary in order to fully feed the capacity of this flyover.

(10) Mullikbazar Intersection No.10

The traffic volume at this intersection is not so heavy considering the width of A. J. C. Bose road and part of the road space is used as parking and even as garages for large vehicles. Those vehicles should be removed from the road side, as the intersection will experience a great increase in traffic with the opening of the Second Hooghly Bridge.

The right turning traffic from Park St east to A.J.C. Bose Road is high in addition to the right turning trams. Park Street is operated as a one-way street with reversible direction according to the time of day.

In the morning when Park Street is operated from east to west, no traffic congestion is observed at the Park Street approach but in the evening, when the traffic is reversed, slight congestion is observed at the approach.

5.3 Improvement Options for each Study Intersection

5.3.1 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.

5.3.2 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 5.3.1 below.

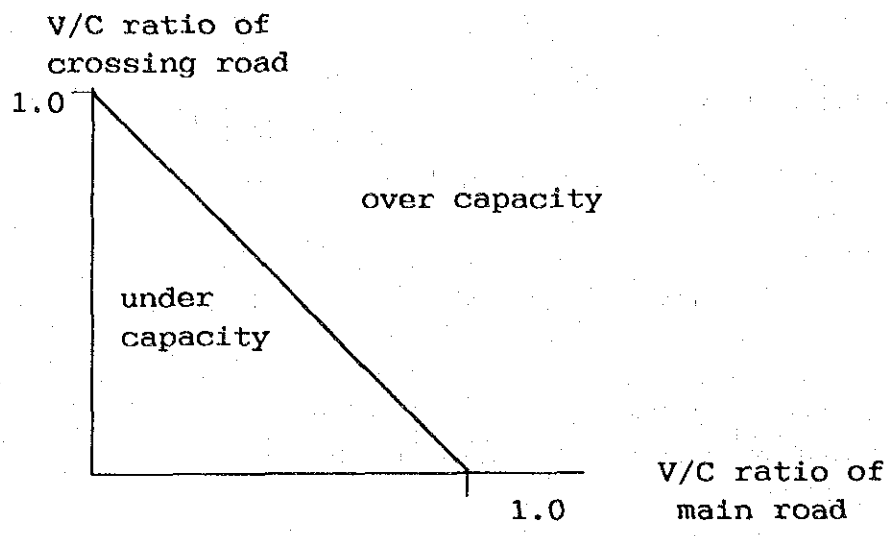


Figure 5.3.1 Volume/Capacity Relationship at Intersections

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 5.3.2(a) shows the v/c ratios for the present traffic volume of all the study intersections. According to the Figure, at Park Street (No.8) the ratio exceeds 1.0. and at Moulali (No.1) it was approaching 1.0.

Figure 5.3.2(b) shows the v/c ratios for the estimated future traffic volume of all the study intersections. According to the Figure, the ratios of Rabindra Sadan (No.5) and Beck Bagan (No.6) show significant increases, indicating increases of traffic volume relating to the Second Hooghly Bridge.

At Park Street (No.8), Moulali (No.1) and Esplanade (No.2) the ratios indicate considerable increase. Whereas Shyambazar (No.4) has a ratio slightly over 1.0 and Maniktala (No.7) and Mullik Bazar (No.10) both have ratios of around 1.0. Gariahat (No.3), however, has a ratio of less than 1.0.

(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.

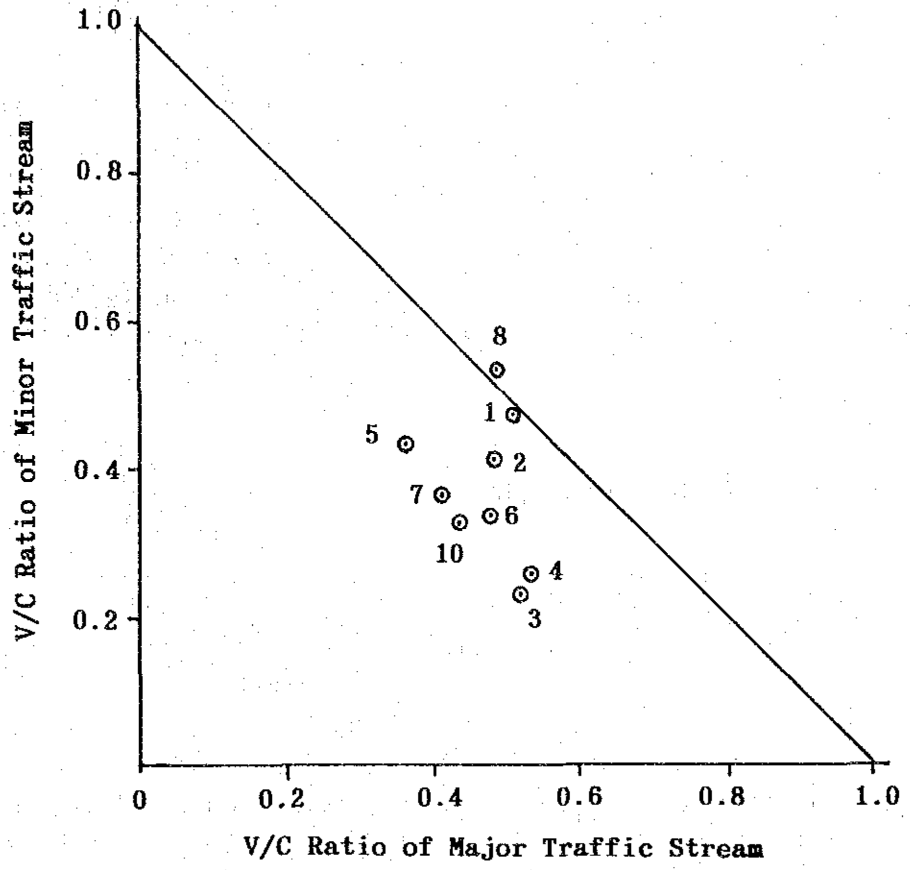


Figure 5.3.2 (a) V/C Ratio of Study Intersection Under Existing Traffic Demand Conditions

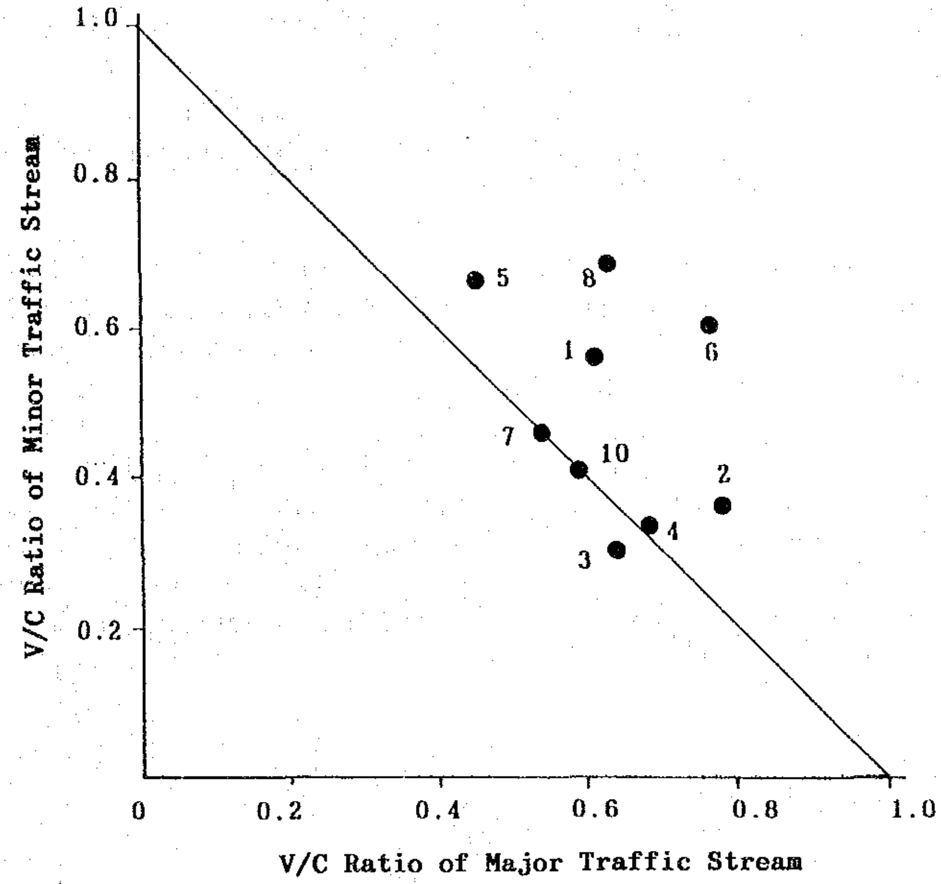


Figure 5.3.2 (b) V/C Ratio of Study Intersection Under Future Traffic Demand Conditions

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.

5.3.3 Improvement Option Plans

(1) Flyover Option Plans

The objective of formulating the options was to identify as large a number as possible of the most suitable options for improvement of intersections. In addition to the obvious option of having the flyover in the direction of the major traffic flow, various alternative plans were also put forward. Criteria were established for the evaluation of options but in this phase of the Study the evaluation was made in general terms only.

Figures 5.3.3 (a) and (b) show the existing constraints at the Study Intersections. The width of the right of way is described for each approach road of the intersection. Table 5.3.1 shows the possible direction of the flyover and problems connected with each option.

Flyovers proposed along the major traffic flow and having 4 lanes were considered to be highly efficient in alleviating the traffic congestion in terms of increased capacity and shortened delay time. (No.1 N-S, No.2 N-S, No.3 N-S, No.7 N-S and No.8 N-S)

At intersections where the construction of a 4 lane flyover would be difficult due to inadequate right of way or any other reasons, 3 or 2 lane flyovers with one way or reversible lane operations have been considered (No.2, No.4, No.5, No.6 and No.10).

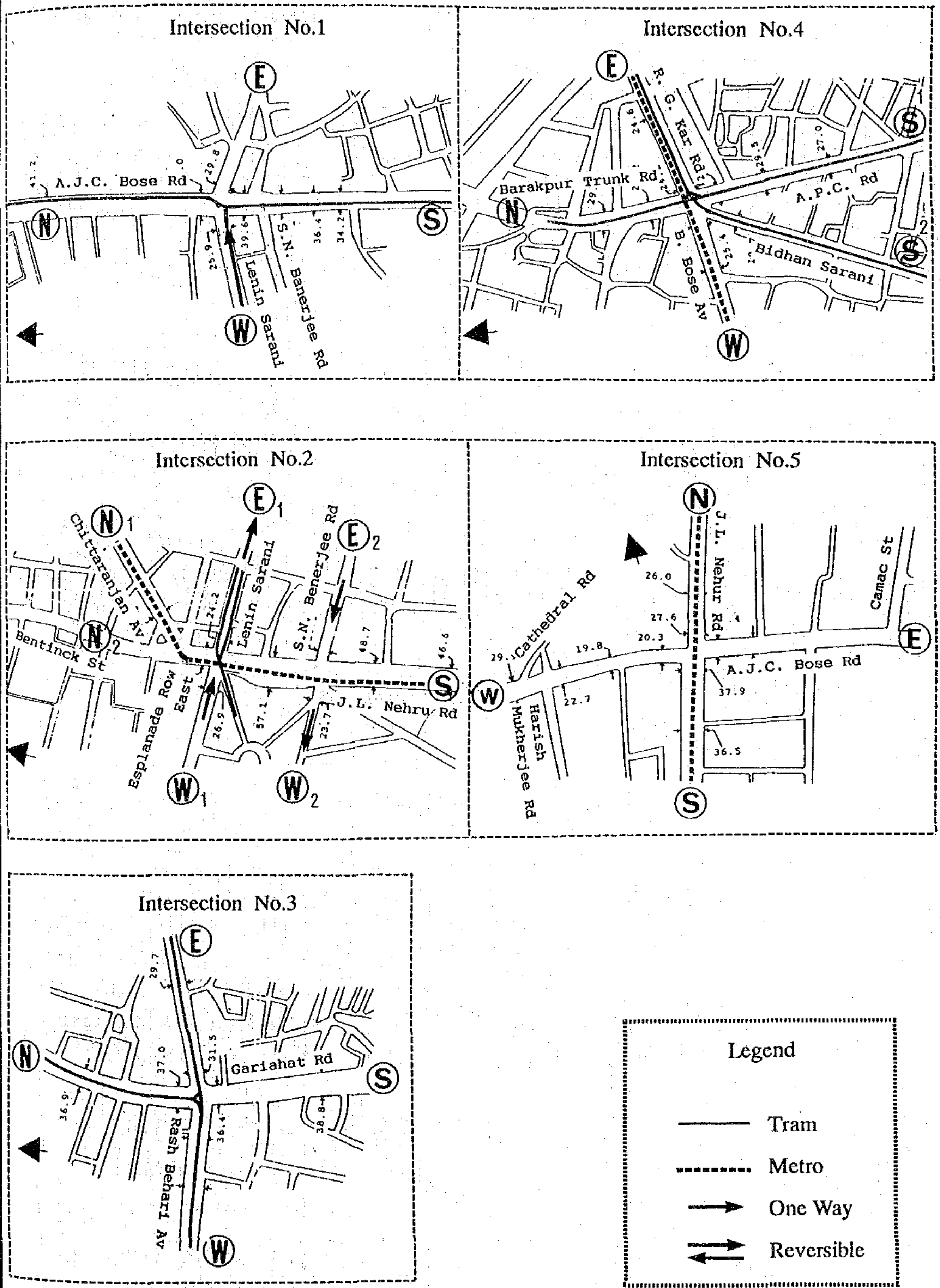


Figure 5.3.3(a) Plans of Existing Intersections

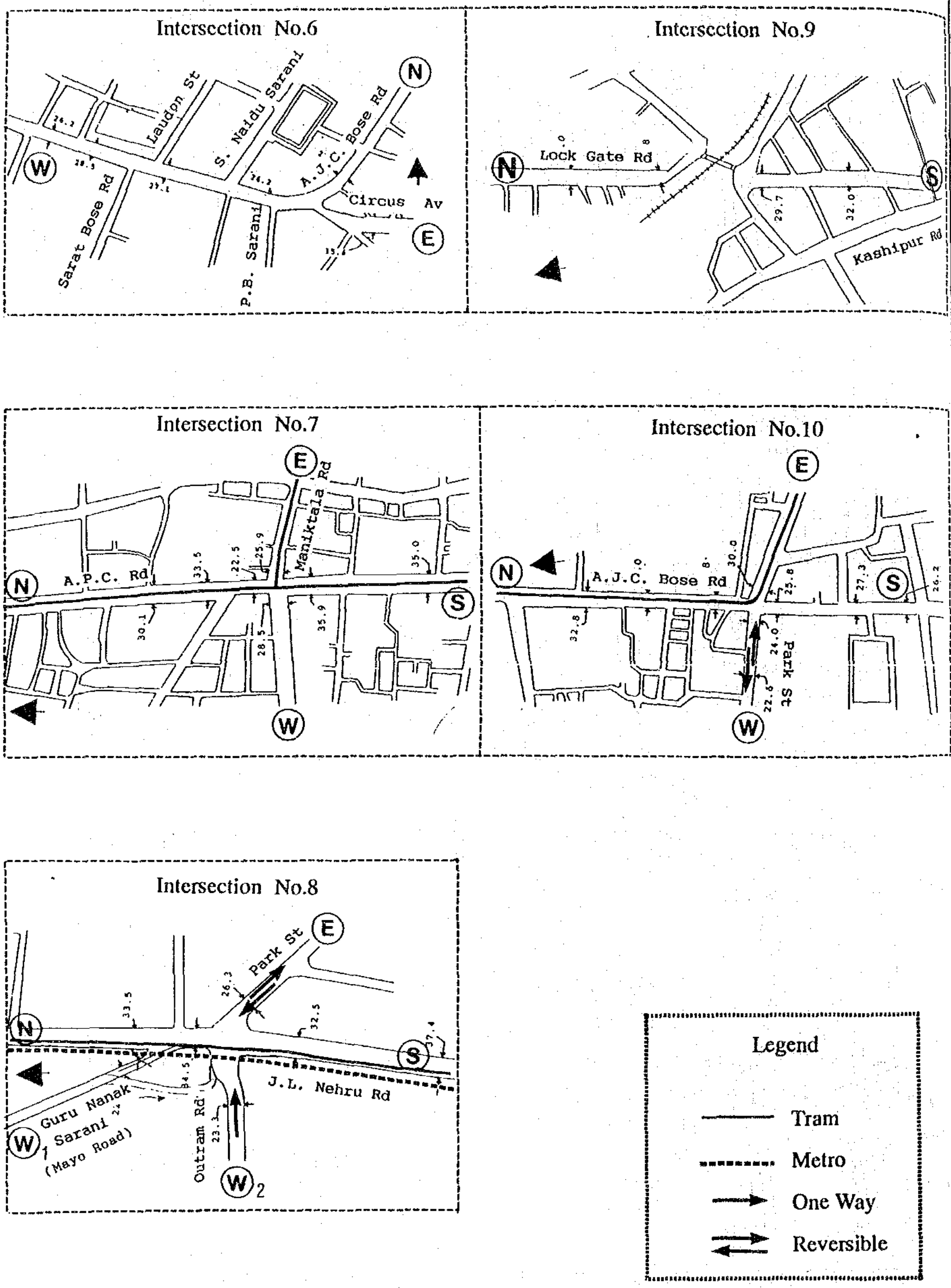


Figure 5.3.3(b) Plans of Existing Intersections

No.	Direction	Traffic Flow	R.O.W. Lane	Operation	Length	Metro	Tram	Water Sewer Gas
1	N-S E-W	O	4 O 2 O	<u>One Way(f)</u>	△		△ X	W.S.G. W.S.G.
2	N1-S N2-S E1-W1 E2-W2	O △ △	4 O 2 O 2 O	<u>One Way(f)</u>	△ △ △	△	X	s.G.
3	N-S E-W	O X	4 O 4 O				△ △	s.G. S.
4	N-S E-W	O X	3 O 4 X 3 O 4 X	Two Way(r)		X	△ △	W.s.
5	N-S E-W	△ O	3 O 4 X 2 O 3 X	One Way(r)		X		s. s.
6	W-E W-N	O △	2 O 2 O	One Way(f) One Way(f)				S.w. S.w.
5—6	W-N W-E		3 O	Two Way(r) One Way(f)				
7	N-S E-W	△ △	4 O 3 O 4 X		△		△ △	W.S. W.S.
8	N-S E-W1 N-E E-W1 E-W2	O △ X	4 O 3 O	One Way(r) One Way(r)				s.G. s.G. s.G.
9	N-S	O	4 O					S.
10	N-S E-W	△ △	4 X 3 O 3 X 2 O	<u>One Way(r)</u>			△ △	S. S.

(Refer also to Figure 5.3.3)

<u>Legend</u>

Traffic Flow
- O — Major traffic flow
- △ — Moderate traffic flow
- X — Minor traffic flow

R.O.W.
- 4 O — R.O.W. adequate for 4 lane flyover
- 4 X — R.O.W. not adequate for 4 lane flyover

Length
- O — Standard
- △ — Longer than standard

Metro
- X — Metro station under the road
- △ — Metro tunnel under the road

Tram
- X — Tram in one way road or narrow road
- △ — Tram in approach road

W Water Pipe } Large diameter
S Sewer Pipe } Large diameter
G Gas Pipe - Large number

w, s, g } Not large

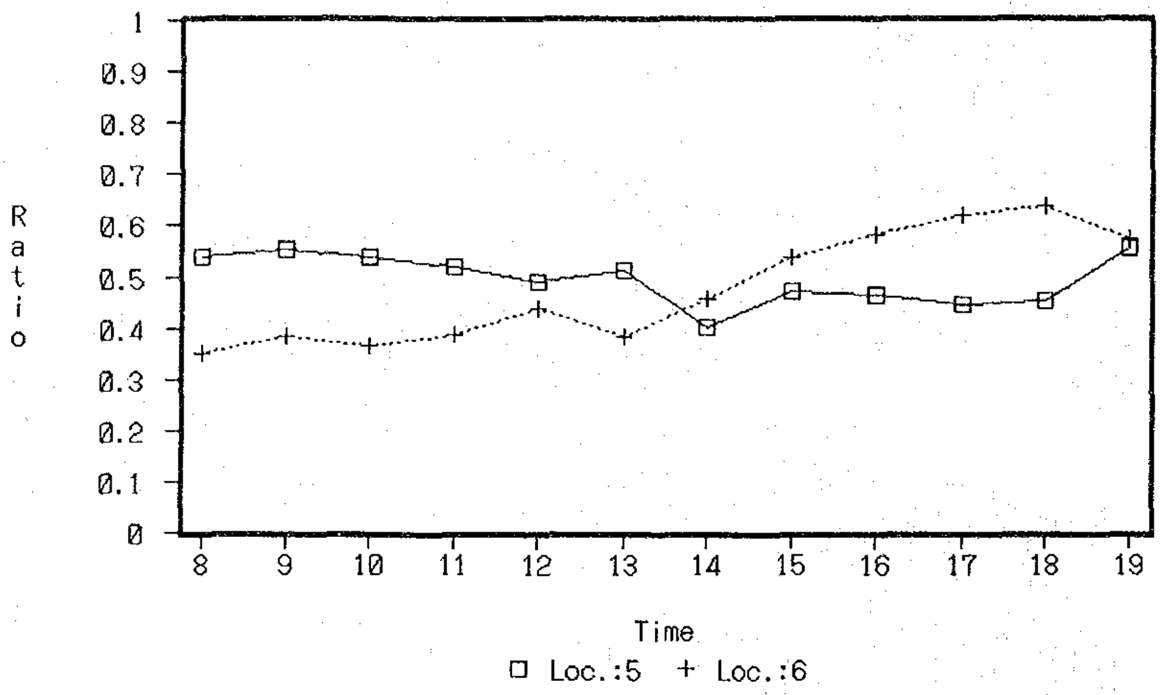
One Way
- f : fixed
- r : reversible
- with underline : the approach road is operated as one way
- without underline : the approach road is not operated as one way or reversible lane

Table 5.3.1 Summary of Existing Conditions

In cases where the approach road is not now operated as a one way or reversible lane system, those options must be carefully investigated. (No.4 and No.5)

As shown in Figure 5.3.4 below the direction of the predominant traffic flow changes from a.m. to p.m. at Intersections No.5 and No.6, indicating that one way reversible operation could be adopted for those intersections.

Figure 5.3.4 Traffic Volume Ratio in 1991
West-East/Total



Options having flyovers along the metro corridor are expected to have long construction periods and high construction costs. In cases where the metro station is located near the intersection, those tendencies become stronger (No.4 E-W and No.5 N-S). Construction periods for flyover options where the relocation of tram tracks is necessary are expected to create disruption to the tram services as well as to traffic. (No.1, No.2, No.3, No.4, No.7 and No.10)

Considering the above-mentioned criteria, N-S flyover options for No.1, No.2, No.3, No.4, No.7 and No.8 and E-W flyover options for No.5, No.6 and No.10 were selected for further study. Along A.J.C. Bose road between intersections No.5 and No.6, the traffic flow of A.J.C. Bose road is hindered by the crossing of vehicles in the N-S direction, especially since there are no straight crossroads, only staggered T junctions. Therefore a 3-lane continuous flyover between No.5 and No.6 is considered as an alternative.

(2) At-grade Improvement Option Plans

Principally at the intersections where the V/C ratio estimated under future traffic demand conditions is comparatively low, at-grade improvement options were studied. (No.3, No.4, No.7 and No.10)

Even though the V/C ratio was relatively high at Intersection No.2, the at-grade improvement option was considered for the following reasons;

1) Construction cost of a flyover is high due to the existing metro tunnel
2) Turning traffic volumes are comparatively high
3) Capacity of the intersection is expected to increase with marginal land acquisition

The V/C ratio at Intersection No.8 is even higher but the option of at-grade improvements has still been considered because of the sensitive nature of the location immediately adjacent to the Medan and also because it may be possible to realign Guru Nanak Sarani and to widen J.L. Nehru Road on the Maidan side.

5.3.4 Alternative Intersection Improvement Proposals for Feasibility Assessment

Table 5.3.2 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 5.3.2 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 5.3.3.

Table 5.3.3 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	-

As mentioned in Section 5.3.3 (2), an additional sub-option will be included in Alt.I and Alt.II in which the at-grade improvement option is assumed at Intersection No.2. Sub-options will also be considered in Alt.I and Alt.II in which at-grade improvements replace the flyover at Intersection No.8, provided that at-grade improvements can be shown to have sufficient capacity. In addition, for Intersection 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 Intersection No.9 will replace the flyovers at Intersection No.4 and No.7.

5.4 Parking Facilities Improvements

5.4.1 Parking Characteristics

Table 5.4.1 shows average parking duration and turnover between 8 a.m. and 8 p.m. by sector surveyed in 1991 and 1964. Parking characteristics have not changed much over these 30 years.

Table 5.4.1 Parking Characteristics

Sector No.	Av.Duration (min.)	Av.T/O in 1991	T/O in 1964
8	98.9	6.08	6.60
9	121.5	4.48	4.40
10	118.9	5.30	5.80
12	88.3	5.40	4.40

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 anticipated 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. The locations are shown in Figure 5.4.1 and the proposed facilities are described in more detail below.

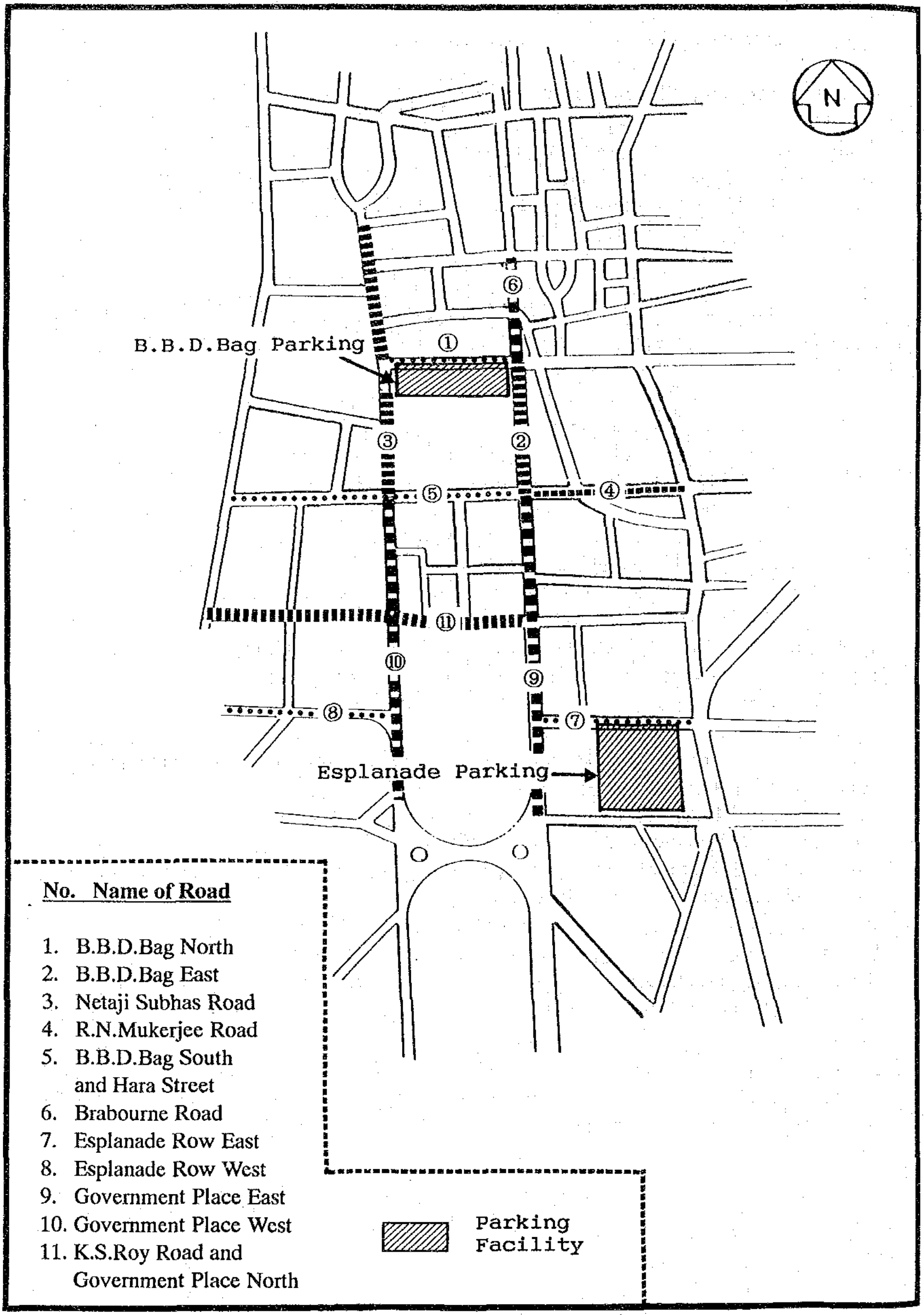


Figure 5.4.1 Location of Parking Facilities and Streets

5.4.2 B.B.D.Bag Parking

Based on the assumptions described above, the parking facility at B.B.D. Bag should be designed to cater for vehicles now parking on the streets listed in Table 5.4.2. The corresponding minimum number of parking spaces which should be provided is also shown in the Table.

Table 5.4.2 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. 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.

5.4.3 Esplanade Parking

The proposed parking facility at the Esplanade should be designed to cater for vehicles now parking on the streets listed in Table 5.4.3. The corresponding minimum number of parking spaces which should be provided is also shown in the Table.

Table 5.4.3 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 99 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. 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.

CHAPTER 6

ASSESSMENT OF INTERSECTION IMPROVEMENT PLANS USING TRAFFIC FLOW SIMULATION

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

The procedure of simulating traffic flow under different conditions is summarized in Figure 6.2.1. The four major tasks in this procedure are further elaborated below. Simulation results for the 'Do-Nothing Case' and other proposed infrastructure improvement plans are described in sections 6.3 and 6.4.

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. When simulating traffic flow in a road network, intersections are treated as bottlenecks. Traffic flow conditions are recorded with an interval scanning function which can be set at every 1-15 minutes. At each scanning, excess demand at an intersection is restrained and this is computed as delay or queue length at the intersection. 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.

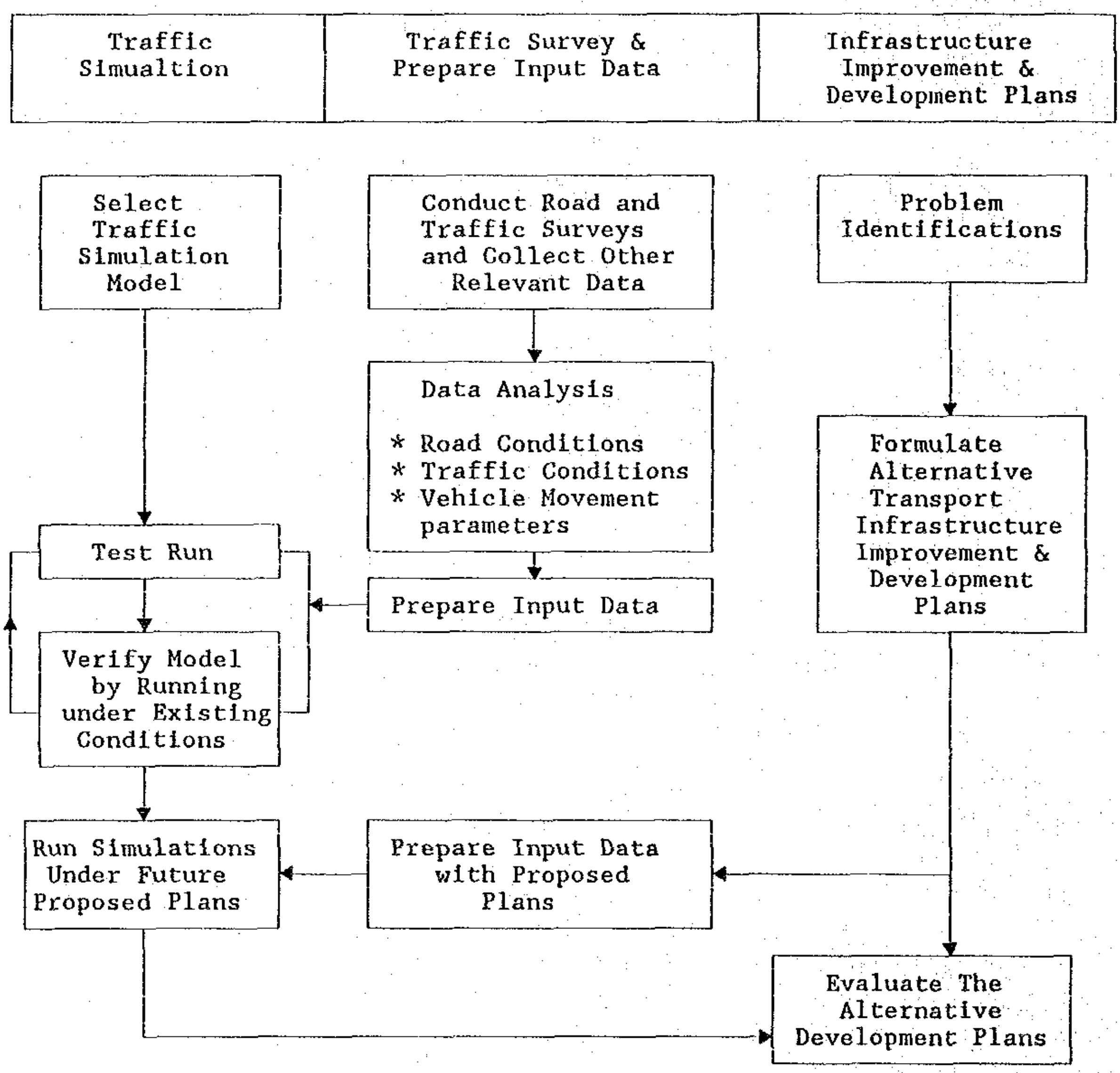


Figure 6.2.1 Procedure for Traffic Flow Simulation

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 (see Figure 6.2.2). 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.

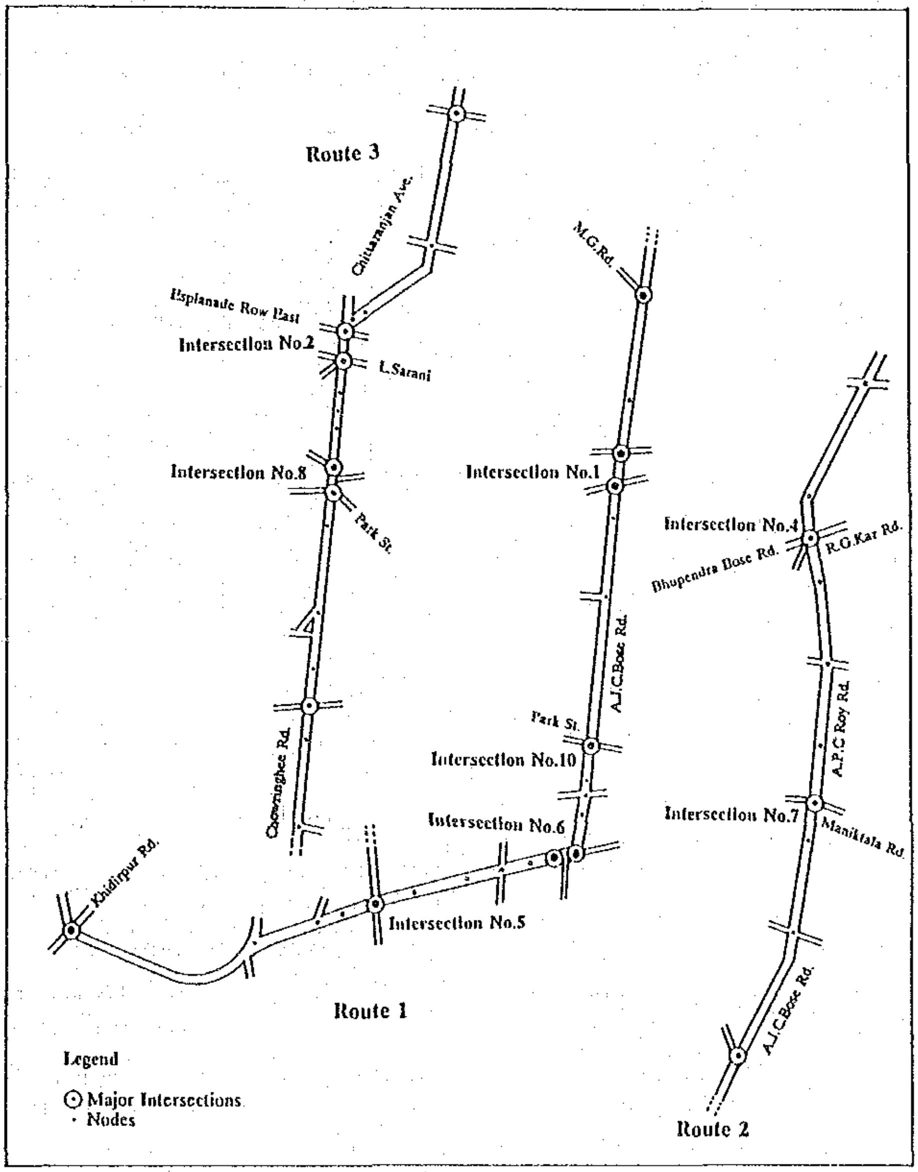


Figure 6.2.2 Division of Study Corridors into Three Routes

Different combinations of the locations for constructing flyovers along the study routes have been set up in accordance with the alternative transport infrastructure improvement plans established in Chapter 5.3. Simulation of these alternatives will allow the alternatives to be compared and evaluated.

A total of 5 alternative cases for Route 1, 4 alternatives for Route 2, 4 alternatives for Route 3 and 2 alternative for the isolated Intersection No.3 are set up for simulating the future traffic flow conditions along the study corridors, each with different numbers of flyovers and at different locations. (Table 6.2.1)

Table 6.2.1 List of Simulation Alternative Cases by Route

Route	Alternative Cases	Proposed Flyovers
Route 1	1-1	(Do-Nothing Case)
	1-2	No.1, 5, 6
	1-3	No.1, 5&6
	1-4	No.1, 5, 6, 10
	1-5	No.1, 5&6, 10
Route 2	2-1	(Do-Nothing Case)
	2-2	No.4, 7
	2-3	No.9
	2-4	No.4, 7, 9
Route 3	3-1	(Do-Nothing Case)
	3-2	No.2, 8
	3-3	No.8,*
	3-4	No.8,(No.2,4Lane)
Isolated	4-1	(Do-Nothing Case)
	4-2	No.3

* Intersection No.2 will be improved to 3-lane when the Metro construction is completed

For each of the routes, a 'Do-Nothing' case where no improvement to the existing transport infrastructure is simulated. The results of simulating this scenario will form the basis for comparing and assessing the results of other alternative improvement plans.

Besides analysing the effects on traffic flow of constructing flyovers at different intersections, the alternatives are devised so as to deliberate the following issues:

a. One issue is to gauge the benefits of constructing a continuous flyover at Intersection No.5 through 6 as compared to individual flyovers since these two intersections are located very close to each other on Route 1.

b. The second issue is to test the possibility of avoiding the need for a flyover at Intersection No. 2 on Route 3 in view of the presence of multiple and difficult physical constraints.

c. Lastly, the need to measure effects or changes on traffic flows by constructing a flyover at Intersection No.9 as compared to having flyovers at Intersections No.4 and 7 on Route 2.

Results of simulation of the alternatives by each route are compared and analyzed in this Chapter. The final alternative improvement plans covering all the routes are generated by combining different alternatives from each of the routes. These are discussed in Chapter 9.

6.2.3 Data Input

Data input requirements of any simulation model often become the major constraint that dictate its application. Input data for the I/O model are not as large and detailed as other models. The study team was able to collect and assemble all the necessary input data for the I/O model within their short stay in Calcutta.

The input data required for I/O model can be categorized into the following:

Road Condition Data

a. Road network (represented by link connections)
b. Length of links in meters
c. Number of lanes servicing the moving traffic

Traffic Condition Data

a. Intersection turning movements
b. Entry link traffic volumes

Traffic Characteristics Data

a. Mean value of start-up lost time
b. Mean value of saturation flow
c. Free flow speed
d. Mean value of headway distance during stopping caused by congestion (or jam density).

Traffic Operation Data

a. One way traffic operation
b. Signal (or policemen) control timing.

All the necessary input data listed above were obtained directly through various site surveys at the study intersections such as traffic volumes while others are computed using the survey results. Examples of the latter form of input data are the free flow travel speed which was computed and found to be 36.7 km/hr, while the saturation flow rate at intersection approaches was estimated to be about 1400 veh/lane/hour.

6.2.4 Verification of Model

Before the I/O model can be applied to simulate future traffic conditions, verification of its applicability is necessary. This was carried out by means of simulating the existing traffic conditions and comparing the simulation results with actual site observation data.

A number of runs were executed and the model was further fine tuned to optimally re-create the actual existing traffic conditions. When the results of the simulation are comparable to the actual observed data, the model is deemed ready for simulating future traffic conditions. The results of the simulation as compared to the observed existing traffic conditions at eight of the study intersections along the three routes are shown in Table 6.2.2.

The ratios of simulated traffic volume to observed values for all approaches vary from 0.86 - 1.02 among the intersections. The I/O model adopted shows a high degree of accuracy in simulating traffic flow at the study intersections.

In Figure 6.2.3, the observed traffic flow at intersections along Route 1 are compared to the simulation results. The simulated traffic volume at some approaches was found to be exactly equal to the observed values. (similar results for other routes can be found in the Technical Paper on Traffic Simulation in the Technical Report.)

In Figure 6.2.4, the observed average hourly delay in veh.hour during peak hours at the study intersections along Route 1 are compared with those derived from the simulation. The results show that the model is able to predict such delays with acceptable degree of accuracy, that is within the order of the observed values. Simulation of delay is in fact more difficult and less precise compared to simulating traffic flow volume as the former depends on more complex real time drivers behavior. (Similar results for other routes can be found in the Technical Paper on Traffic Simulation in the Technical Report.)

The simulated queue lengths under existing conditions along Route 1 by hour from 9:00 to 20:00 hrs are plotted and shown in Figure 6.2.5.

Referring to Figure 6.2.5, delays are particularly conspicuous at Intersection No.1 (S.N. Banerjee/Lenin Sarani) on AJC.Bose Road. This delay gradually builds up during the morning and peaks at around 14:00 hours, extending to about 1,300 meters upstream to Alimuddinst intersection and beyond for the north bound traffic stream.

Table 6.2.2 Comparison of Simulated Results to Observed Values of Traffic Flow Conditions at Study Intersections

Unit: Vehicle

Intersection	Approach 1		Approach 2		Approach 3		Approach 4		All Approaches	
Number	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated
#1	17266	17213	4790	4789	13428	13642	0	0	35484	35644
*		1.00		1.00		1.02		-		1.00
#2	9171	9256	0	0	17656	15932	10623	10622	37450	35810
*		1.01		-		0.90		1.00		0.96
#4	8854	8859	3313	3295	10021	10732	9779	9779	31967	32665
*		1.00		0.99		1.07		1.00		1.02
#5	13423	13423	14669	14216	14828	14827	12922	13014	55842	55480
*		1.00		0.97		1.00		1.01		0.99
#6	15138	13488	22241	21046	14876	14876	22608	23320	74863	72730
*		0.89		0.95		1.00		1.03		0.97
#7	11694	11735	7500	7413	10328	10397	11440	11440	40962	40985
*		1.00		0.99		1.01		1.00		1.00
#8	26894	27476	15769	13583	22278	20346	12184	12179	77125	73584
*		1.02		0.86		0.91		1.00		0.95
#10	17050	17025	10860	10860	12703	12975	8766	8765	49379	49625
*		1.00		1.00		1.02		1.00		1.00

* : Ratio of Simulated Values to Observed Values
Approach 1: N–S, Approach 2: E–W, Approach 3:S–N, Approach 4: W–E

ROUTE1

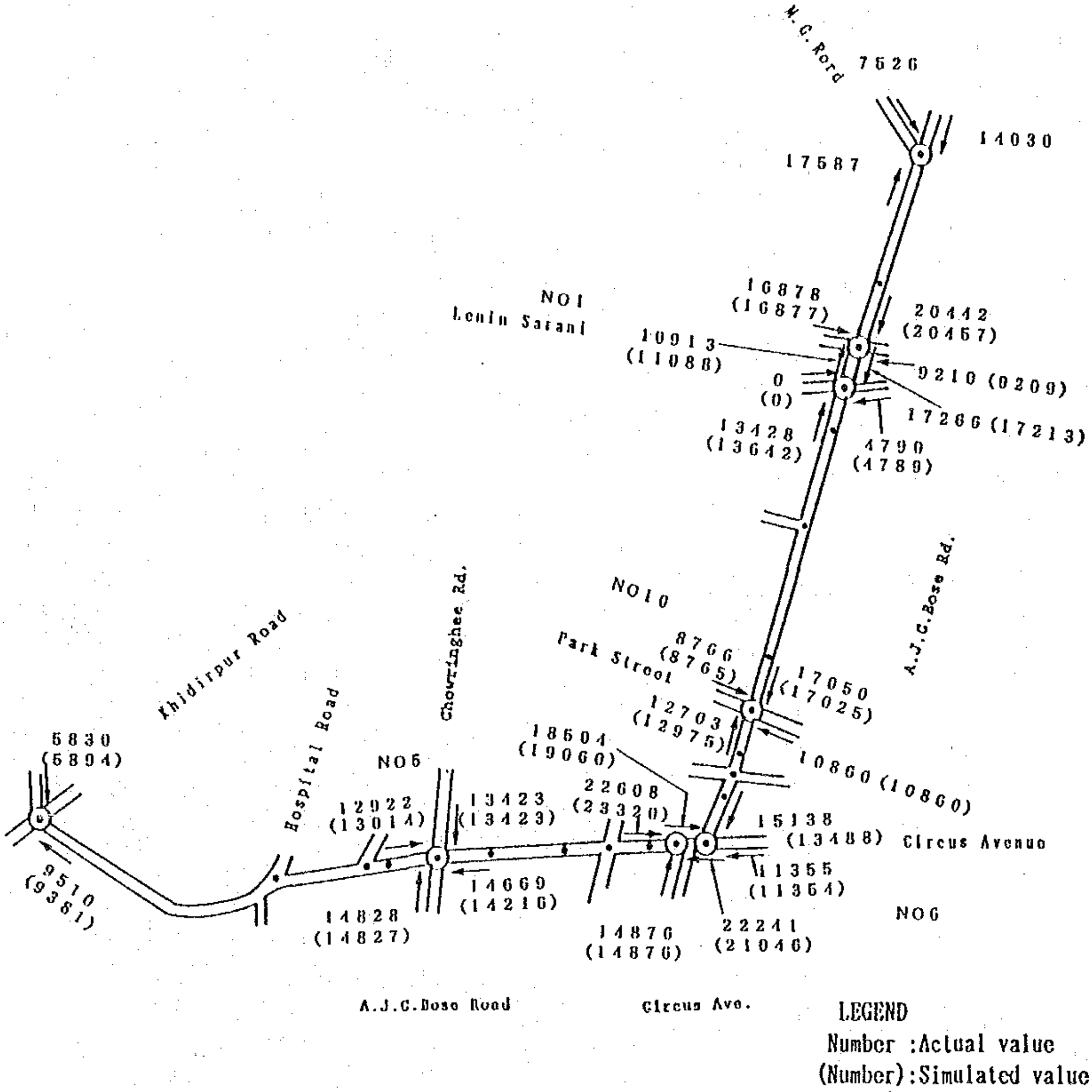


Figure 6.2.3: Results of Simulation of Traffic Flow at Intersections on Route 1 for 12 hours

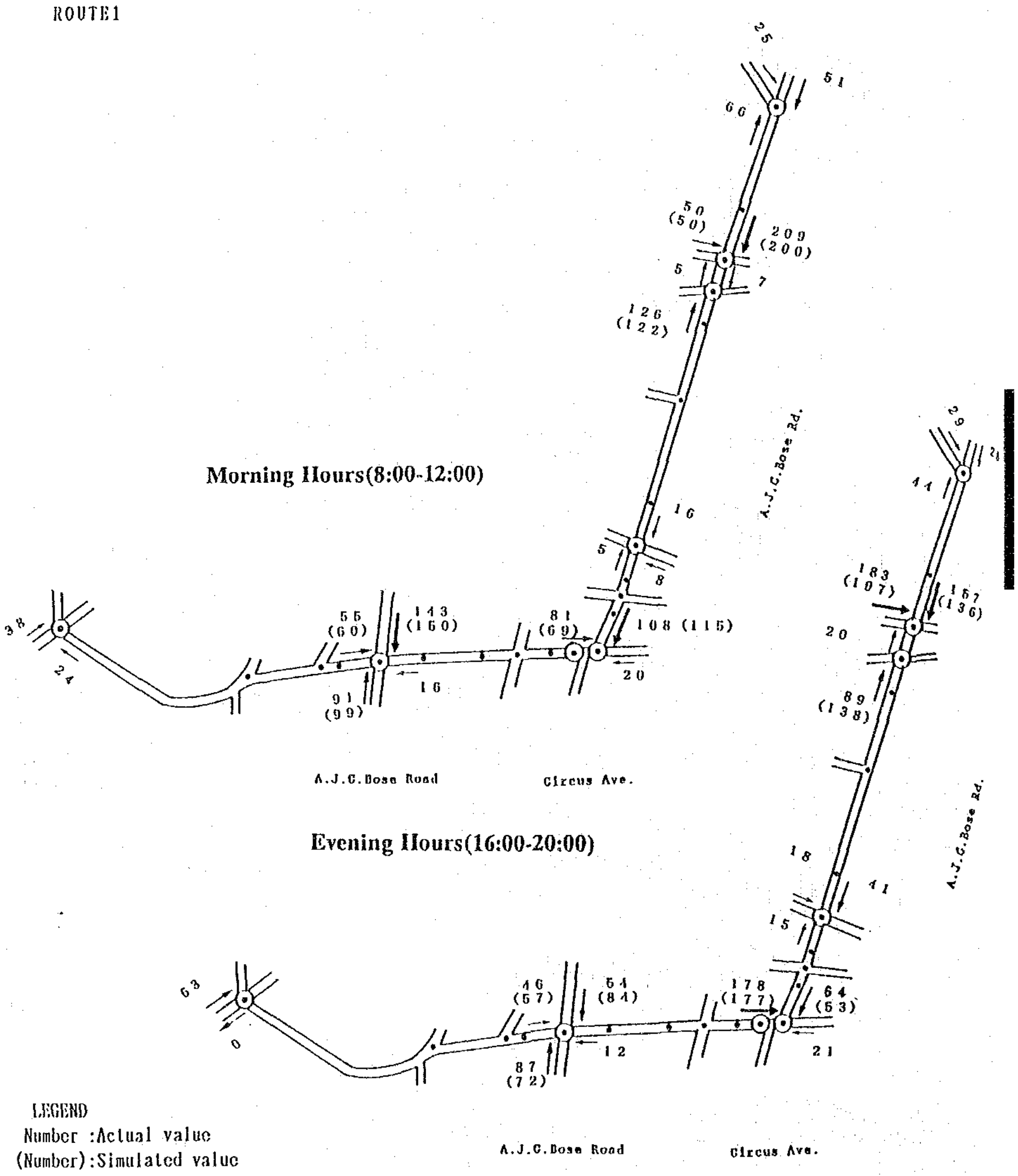


Figure 6.2.4 Results of Simulation of Vehicle Delay at Study Intersections along Route 1 During Peak Hours

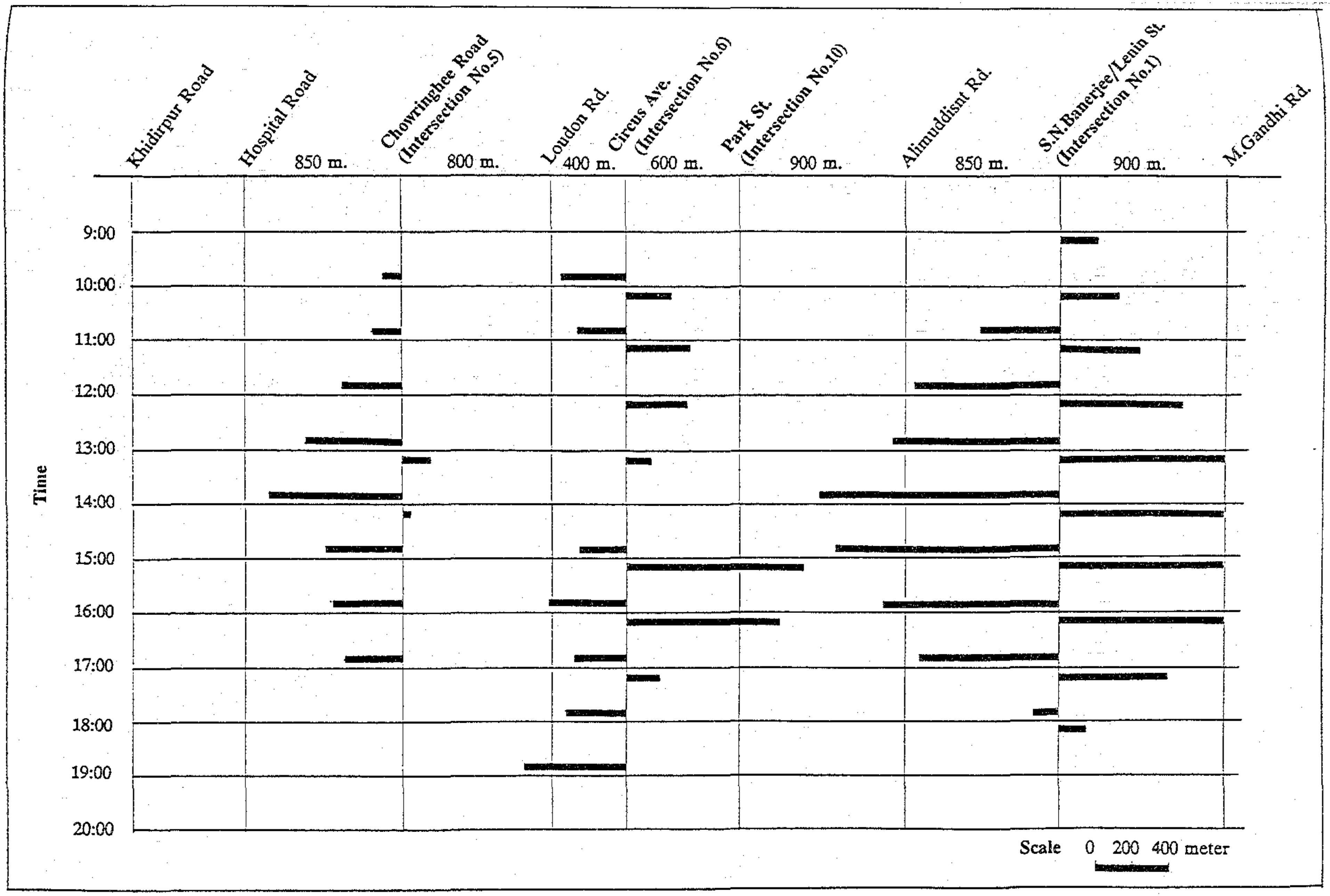


Figure 6.2.5 Simulated Queue Length on AJC Bose Road (Route 1) Under Existing Traffic Conditions

Queue length for the south bound traffic stream at Intersection No.6 during peak hour is also excessive, and it would extend up to Park Street intersection and beyond for a distance of about 900 meters. Queue lengths during off peak hours at this intersection are however manageable.

Queue length at Intersection No.5 (Chowringhee Rd.) is fair under existing conditions, having a queue length of only 400 meter or less for most hours. Queue length at Intersection No.10 is comparatively small under the present conditions.

6.3 Simulating Future Traffic Conditions Under the 'Do-Nothing' Case

Future traffic conditions with no improvement done to the study intersections was simulated using the verified I/O model and the forecast future traffic demand. The simulated future traffic conditions along the three routes expressed in such indicators as total delay time, and average speed are compared with the existing conditions (see Table 6.3.1).

Table 6.3.1 Comparing Simulated Future Traffic Conditions Under Do-Nothing Case with Existing Conditions

Route	Case	Entering Volume (veh)	Total Delay (veh.hrs)	Total Delay Ratio	Average Speed (km/hr)
1	Existing	154,518	23,609	1.0	9.1
	Future Do-Nothing	245,769	164,229	7.0	3.2
2	Existing	54,907	9,663	1.0	10.6
	Future Do-Nothing	87,726	32,491	3.4	7.8
3	Existing	143,587	37,171	1.0	5.9
	Future Do-Nothing	187,976	128,458	3.5	3.7
All	Existing	353,012	70,443	1.0	7.8
	Future Do-Nothing	521,471	325,178	4.6	3.9

Without infrastructure improvements, future traffic conditions along the three study routes would worsen as traffic demand increases by 1998. The study intersections on Route 1 for instance, are expected to handle a traffic increase of 60% by 1998. With such an increase, the total delay in terms of total vehicle.hours, would increase by 7 times from the existing 23,609 veh.hours to 164,229 veh.hrs in 1998. The average travel speed would be expected to fall to only one third of the existing level.

Along Route 2, the study intersections face an increase in traffic demand of 87,730 compared to 54,900 at present. This increase in traffic would cause a total delay of 32,491 veh.hours, a 3.4 times increase from the existing level. The average speed would fall to 7.8 km/hr.

For Route 3, the total delay would increase by 3.5 times to 128,458 veh.hours under the Do-Nothing Case. Among these three Routes, Route 1 is expected to experience the worst deterioration of traffic conditions in the future under the Do-Nothing Case, followed by Route 3 and Route 2.

As shown in the table above, the total delay for the three routes in the future under the Do-Nothing scenario would increase by 4.6 times. This confirms the observation that the level of service of the major arterials of AJC Bose Road and Chowringhee-JL Nehru Road would deteriorate very quickly in the near future. Delays would be excessive and queues at the major intersections would extend to upstream intersections. This outcome is shown in Figure 6.3.1 which compares simulated queue length at the study intersection along Route 1 under the future Do-Nothing scenario with those under existing traffic conditions.

Queues are excessively long at all the study intersections. The queue at Intersection No.5 for south bound traffic is as along as 3.2 km, extending up to beyond Alimuddinst Street. Travel speed is simulated to be only about 3.2 km/hr. Comparing the two diagrams, queues also persist beyond 20:00 hours in the Do-Nothing Case. Under the existing traffic conditions, queues would disappear along this Route after 19:00 hours.

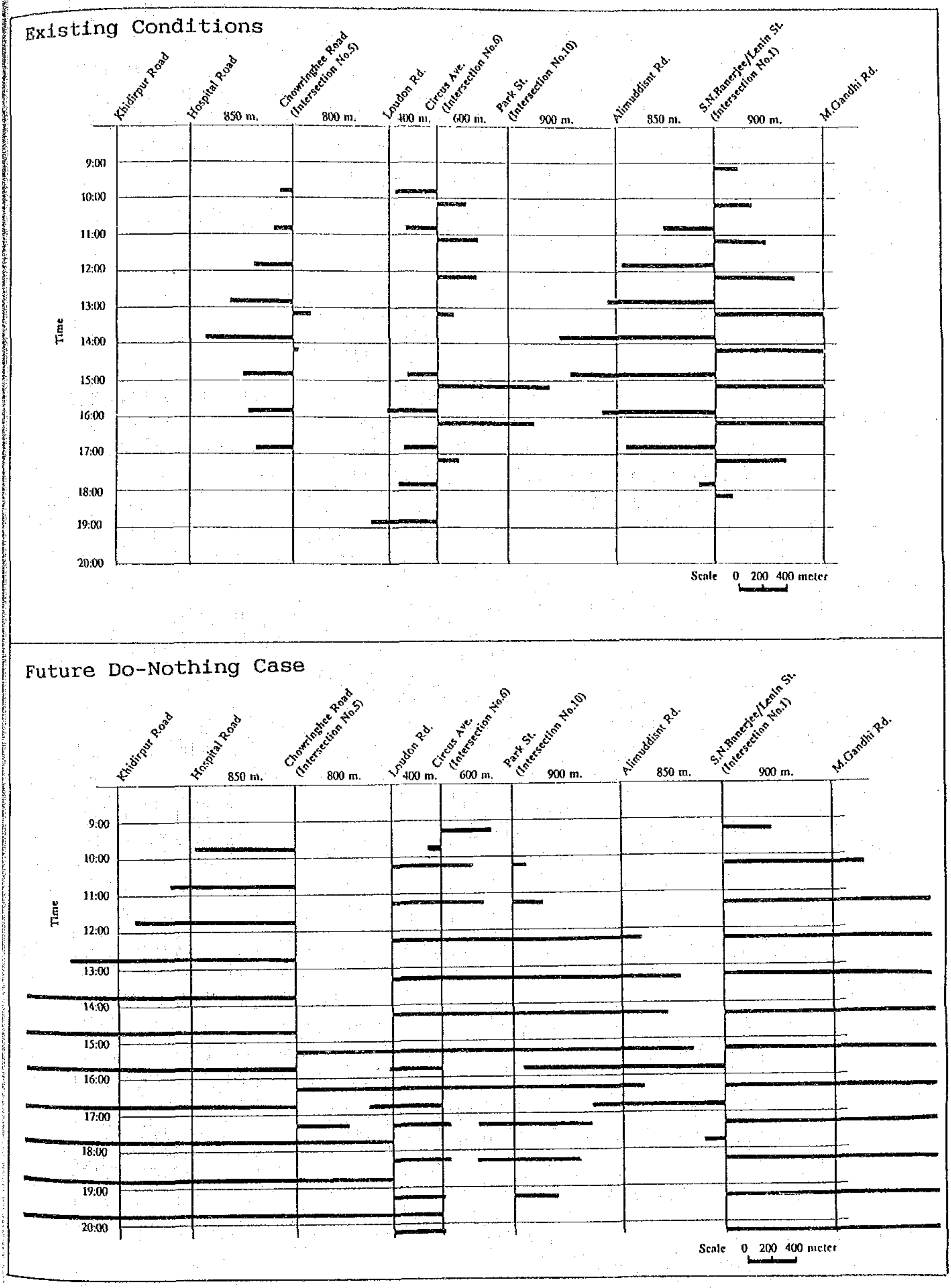


Figure 6.3.1 Simulated Queue Length on AJC Bose Road under Existing Traffic Conditions and under the Future Do-Nothing Scenario

6.4 Simulation Results For The Alternative Plans

Simulations were run for the various alternative plans set up in Figure 6.2.1. 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.

For assessing traffic impact, indicators such as average speed, total delay and total entering volume are the most appropriate. 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 6.4.1.

Table 6.4.1 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

An index of total delay of the alternative plans to that of the existing conditions is given in the Table to present the extent of the delay in comparison to the delay as experienced in Calcutta along the three study routes today.

The delay reduction ratio is a measure of the capability of other alternative plans in improving total delay in the Do-Nothing Case.

Assessing the effectiveness in reducing total vehicle delays for Route 1, Plan 1-5 would be the best among the alternative plans, capable of improving the future traffic conditions to a level better than the existing conditions. This plan would reduce some 89% of the total delay in the Do-Nothing Case.

A comparison of Plans 1-2 and 1-3 reveals that construction of a continuous flyover bridge from Intersection No.5 to 6 is far superior than having two individual flyovers at No.5 and 6. The continuous bridge is able to achieve a reduction in the total vehicle delay of about 26,700 veh.hrs. on the fact that most through traffic will be able to pass through Intersections No. 5 and 6 unhindered. For this reason, a continuous flyover from Intersection No.5 to 6 is recommendable from the traffic impact viewpoint.

Reduction of total delays from the 'Do-Nothing Case' on Route 2 for Plans 2-2 and 2-3 are very close, 31,020 against 31,260 veh.hrs, indicating that effects of having two flyovers at Intersection No.4 and 7 are about the same as having a flyover at Intersection No.9. Having all the three flyovers, however, would further reduce delay but only by a negligible margin.

The construction of a flyover at Intersection No.2 is effective in reducing the total vehicle delay by as much as 29,000 veh.hrs. over a 12 hours period (comparing Plans 3-2 and 3-3). However, a 4 lane at-grade improvement (Plan 3-4) is found to be equally effective in reducing delay of up to 26,500 veh.hrs. or 90% of the delay reduction of a flyover. It can be deduced from this analysis that either a flyover at Intersection No.2 or a 4-lane at-grade improvement is equally desirable.

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.

Traffic simulation has been carried out for the various transport infrastructure improvement alternative plans set up in accordance with Chapter 5.3 and the results will be used for a technical and economic comparison and evaluation. The above simulation results merely provide an assessment of these alternatives by route from the traffic impact point of view. Cost-effectiveness of constructing a continuous flyover bridge from Intersection No.5 to 6, for instance, is to be further examined in Chapter 9 where construction costs of the proposed flyovers and benefits from savings in total delay and fuel consumption are estimated for a cost-benefit evaluation. Likewise, the cost-effectiveness of constructing a flyover at Intersection No.2 or at-grade improvement of the intersection to 4-lanes is to be further deliberated in Chapter 9.

CHAPTER 7

PRELIMINARY DESIGNS

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;

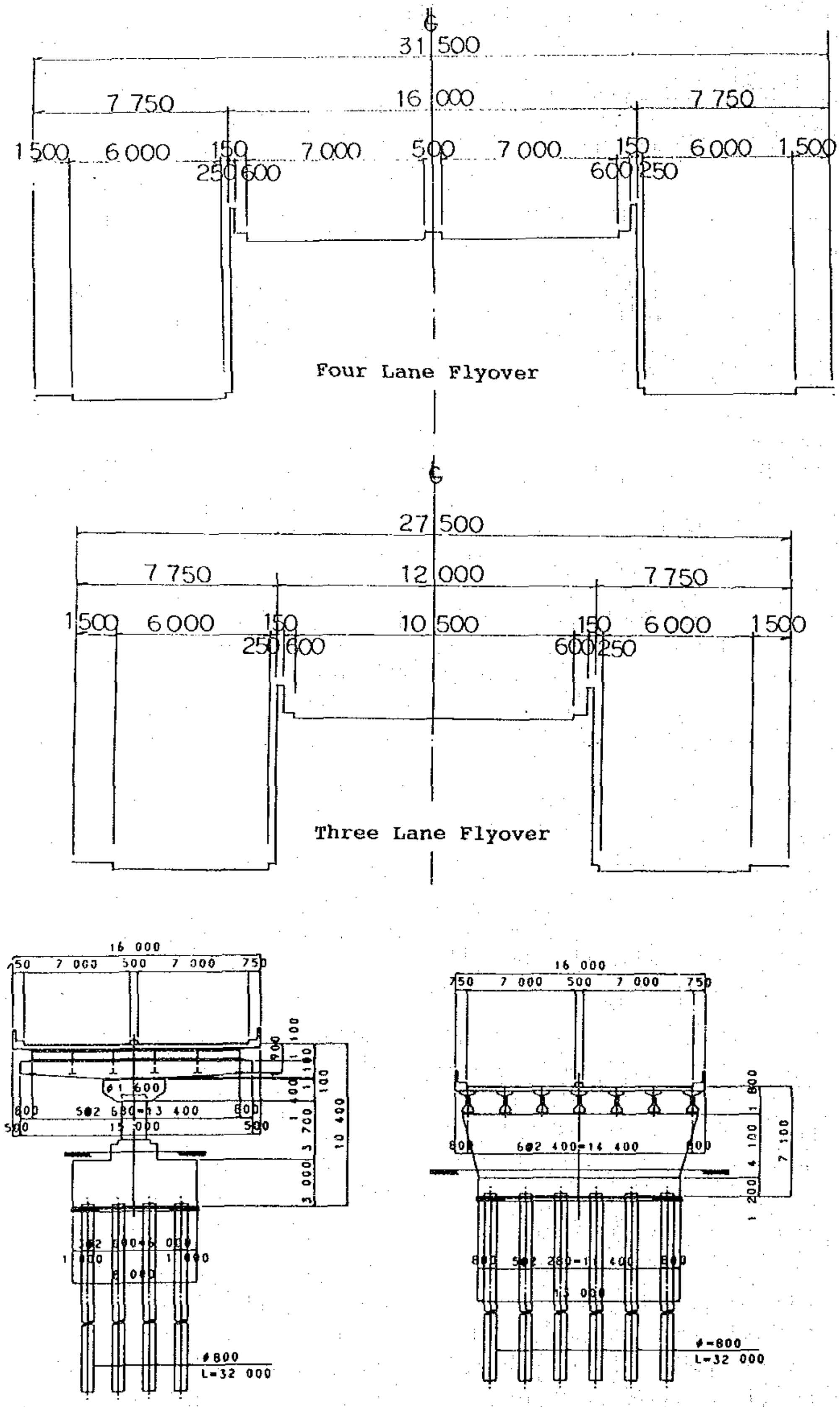
design speed	: 50 km/h
minimum lane width	: 3.5m
curb width	: 0.5m
maximum superelevation	: 7 %
minimum radius	: 100m
steepest grade standard	: 1:25 (4.0 %)
special case	: 1:20 (5.0 %)
minimum vertical curve	: 1,000m radius
vertical clearance	: 5.0m ordinary case
	: 5.4m for tram, 6.7m for train
length 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, ie. approximately 5.75m minimum. Thus the minimum total right of way width required to accommodate a 4-lane flyover is 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.



(Steel Plate Girder) (PC Composite Girder)

Figure 7.1.1 Typical Flyover Cross Section

(2) At-grade Intersection Improvement

Some fundamental road geometric design elements such as those discussed below must be considered when preparing at-grade intersection improvement plans.

(a) Number of Legs at intersection

The number of intersecting legs in principle should not exceed four. The number of conflicting, merging and diverging points increases very rapidly as intersecting legs increase. More conflict points means higher potential for traffic accident occurrence. Intersection capacity is also affected since the limited cycle time must be shared by each leg.

(b) Alignment

The angle at which the legs intersect should be at or near a right angle (ideally more than 75 degrees). Right angle intersections have advantages over skew angled intersection in terms of the shorter crossing istance and smaller conflicting area, contributing to higher safety levels and an increase in capacity.

(c) Lane Number

The number of lanes should be determined based on the present and future traffic demands.

(d) Provision of Turning Lanes

Provision of turning lane is recommended where the volume of turning traffic is significantly large. However, regardless of the amount of traffic volume, provision of right turning lanes can be very useful for reducing delays to through traffic.

(e) Provision of Islands and Medians

The provision of traffic islands is recommended if, upon tracing the path of all possible vehicle movements at the intersection, there are some pavement areas clear of any wheel paths. The provision of a refuge island should be considered where there is significant pedestrian flow.

Medians should be provided at all multi-lane streets and intersection approaches to prevent serious accidents.

(f) Installation of Traffic Control Devices

Proper installation of traffic control devices such as signal lights, road markings and traffic signs should be taken into consideration in order to ensure that channelization is effective.

7.1.2 Structural Design Standards

Bridges in India are constructed according to the Indian Roads Congress standards and this Study will, in principle, adhere to these standards. The main design conditions are as follows.

(1) Loading

(a) Live Loading

The IRC has multiple categories for each bridge classification. The bridges in this Study will be designed for main trunk inner-city roads and will be used by Class AA and Class A loaded vehicles.

(b) Earthquake effects

IRC uses the following formula for horizontal seismic force

$F_{eq} = \alpha \beta \lambda G$

where

α = Location coefficient

β = Soil foundation coefficient

λ = Importance coefficient of Bridge

For the location coefficient, Calcutta is classed as zone III and given a coefficient of $\alpha = 0.04$. The N-value obtained by the soil survey at the sites of the flyovers was 10 - 30 and the soil type has been designated as type 2, where β = 1.0. The coefficient for the level of importance is classified into important bridges and others with important bridges given the coefficient λ = 1.5. Accordingly, the earthquake coefficient is S.C = 0.06.

(2) Vertical Clearance

The IRC has vertical clearance regulations for roads while there are none for railways and trams. Accordingly, for this Study the following values will be used as limits for height.

* Roads 5.0 m
* Tram way 5.4 m
* Railway 6.7 m

Moreover the road width will be that of the lanes plus 0.25m.

(3) Major materials strength

The strength of concrete and steel materials used are set with consideration given to the conditions in the West Bengal state. The strength of the various materials is shown in Table 7.1.1.

Table 7.1.1 Strength of Various materials

Material	Grade	Strength
Concrete for Superstructure	M30	fck=30 Mpa
Substructure	M25	fck=25 Mpa
pile	M25	fck=25 Mpa
Prestressed Concrete	M40	fck=40 Mpa
Reinforcing Bar	S415	fy=415 Mpa
Prestressing Steel		fp=160 kg/mm^2
Structural Steel(Mild Steel)		fy=23.6kg/mm^2
Structural Steel(High Tensile Steel)		fy=29.9kg/mm^2

Note : fck;Characteristic compressive strength at 28 days
fy;Yield strength
fp;Ultimate tensile Strength of prestressing steel

7.1.3 Bridge Type

The bridges to be designed in this Study are above grade flyovers for the purpose of alleviating traffic congestion at intersections along the main trunk roads in the core area of Calcutta. 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. The bridges, which will be constructed within the city, will harmonize with the environment. With consideration given to these points, the superstructure, substructure and foundation type will be selected taking into account practices and conditions in the West Bengal state.

(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. Concrete structure bridges (reinforced concrete and prestressed concrete) are common in Calcutta and the vicinity however the bridge with the longest span crossing the Hooghly river is a steel structure bridge.

The sites for the bridges designed by this Study are at intersections of main trunk roads where traffic volumes are heavy and bridge construction must be carried out either with minimal road closure or without road closure at all. It is therefore necessary to select a bridge type requiring the least site work in terms of time and area. Bridge type selection will be made taking into consideration the above points.

(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 re quiring 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

(1) Intersection Improvement Plan

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.

(2) Structure

The north-south flyover will cross over the two intersections of Lenin Sarani Rd. and S. N. Banerjee Rd. with A. J. C. Bose Rd. 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.

The bridge type will be steel near the intersection and prestressed concrete composite at the approach to minimize on-site work and the disruption of the traffic flow. For sectors where the median is narrow, steel piers will be used.

7.2.2 Intersection No. 2 - Esplanade

(1) Intersection Improvement Plan

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 meet traffic requirements, a 4-lane flyover has been proposed even though the right-of-way along Chittaranjan Avenue is slightly narrow. However, even with the construction of the flyover, a 3-lane at-grade intersection has been proposed underneath to handle remaining traffic. 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 number of pedestrians using the Esplanade in the vicinity of the Lenin Sarani intersection is large and, since a pedestrian overpass is planned for the future, the flyover profile has been planned to accommodate it.

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.

(2) Structure

The flyover substructure design must be adapted to the site conditions which include the underground metro tunnel running along Jawaharlal Nehru Rd. In addition, the traffic congestion is very high at this intersection and the construction period must therefore be as short as possible. Taking these points into consideration, the bridge type and substructure design were selected.

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

(1) Intersection Improvement Plan

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.

(2) Structure

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

(1) Intersection Improvement Plan

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. Proposals for operating the traffic along this flyover include operation as; a) 3 lane one-way traffic with direction changes according to the time of day, or b) bidirectional with 2 lanes being assigned to the direction with the heavier traffic. During late night hours and other light traffic periods the center lane should be used as a median with only the outer 2 lanes available to traffic.

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 tram lines will be relocated in order to make room for 3 lanes of approach traffic for each of the approach sections with insufficient width. The tram lines will be relocated to the lanes closest to the footpath to provide 3 lanes, inclusive of the tram lane.

(2) Structure

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

(1) Intersection Improvement Plan

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 2-lane flyover would be operated either one-way only or bidirectional depending on the time of day.

(2) Structure

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

(1) Intersection Improvement Plan

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 this flyover overpasses Ballygangi Circular Rd and Rawdon St, the north-south traffic using these roads will be separated from the through traffic.

(2) Structure

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)

(1) Combined Intersection Improvement Plan

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. Either of two cases can be adopted for traffic operation; a) one-way with the direction changing depending on the time of day, or b) bidirectional with 2 lanes being assigned to the direction with the heavier traffic.

(2) Continuous Structure

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

(1) Intersection Improvement Plan

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 the intersection approaches should be shared by trams and vehicles, to provide 3 lanes in the approach sectors.

(2) Structure

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.

(1) Intersection Improvement Plan

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 (Guru Nanak Sarani). This flyover will separate the traffic from Park St and Mayo Rd from the north-south through traffic and the traffic flow will be greatly improved. Moreover, the tram lines located on the west side of J. L. Nehru Rd are to be relocated to the side of the paved road so as not to cause obstruction to the north-south traffic.

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 would be simplified and the capacity increased. At-grade improvements with both 3 and 4 through lanes in each direction on J.L. Nehru Road have been costed in Chapter 8 and are included in Volume IV - Drawings. However, further feasibility analysis of the at-grade improvements has not been carried out for the following reasons;

(a) Traffic volumes are very high. The capacity of a signalised intersection with 3 or 4 lanes in each direction on J.L. Nehru Road was found to be insufficient for the predicted traffic volumes in 1998. Even with 5 lanes on J.L. Nehru Road the capacity would still not be adequate.

(b) Substantial land acquisition from the Maidan is required for any at-grade improvement option. While this land is government owned, the land acquisition process is not simple and could cause delays to construction.

(c) Any at-grade option with more than 3 lanes on J.L. Nehru Road would require modifications to the Metro entrances.

(2) Structure

At this intersection location it is possible to consider the diversion of tram services and traffic during the construction period to a position west of the J. L. Nehru/Chowringhee Rd. in the park area. Moreover, because this region is a scenic part of Calcutta, preliminary design plans were carried out with strong consideration given to the appearance of the structure. 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

(1) Intersection Improvement Plan

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.

It should be noted that provision of a connection between the southern end of Lock Gate Road and Kashipur Road would be necessary if the Lock Gate flyover is constructed. Improvements to the intersection between Lock Gate Road north and Barackpur Trunk Road would also be necessary in order to fully feed the capacity of this flyover.

(2) Structure

This bridge crosses the 6 tracks of the railway line. The gaps between the 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 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

(1) Intersection

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. In this case, the 2 lanes will operate as one-way only with the direction changing depending on the time of day, in accordance with the rest of Park St.

(2) Structure

This flyover runs along Park St passing over A.J.C. Bose Rd. 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.

7.3 Off-Street Parking Facilities

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

DESIGN STANDARDS FOR PARKING FACILITIES

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

7.3.1 B.B.D. Bag North Parking Facility

In Chapter 5.4.2, three alternatives were put forward for this parking facility. Alternative A was found to provide less than the number of parking spaces required (732 min.) unless the facility was extended slightly under B.B.D. Bag North (Alternative C). Alternative B was rejected because of the adverse effects it would have on the adjacent Writers Building. Hence preliminary designs and costing have been prepared for an underground parking facility with two underground levels and which extends approximately 5m into the area beneath the B.B.D. Bag North road. The total capacity is 794 cars. The ground level area is currently used as a parking facility and will be extended at ground level to match the underground facility. Two entrance/exits will be provided on B.B.D. Bag North Rd, an entrance on Council House St and an exit on Old Court House St.