10.3 Priority Projects for Feasibility Study

Priority projects for feasibility study are selected based on the following factors:

(1) The project which needs the immediate action:

The project which needs the immediate action has effective countermeasures to the current traffic problems such as connection of missing link, bridge construction and flyover.

New bridge construction across the Ravi River, connection of missing link in Krishan Nagar and Shad Bagh and flyovers along major transport corridors have been discussed and studied by the related agencies as the immediate effect of traffic problems in LMA.

Table 10.3.1 and Figure 10.3.2 summarize the traffic problems versus countermeasures with related agencies through the analysis of current traffic problems and data collections.

Considering these Tables and Figures, the improvement of 3 problematic intersections along Ferozepur Road is selected as the project which needs the immediate action.

New road construction such as Ring Road Project and bridge construction across the Ravi River are going to start the studies by World Bank.

(2) The project which has the large scale of investment cost and needs preparatory studies, and highly affect to the urban transport policies:

Introduction of LRT which is selected as one of the long-term projects, has the largest scale of investment cost among the various projects in this master plan. This project also highly affects to the other modes of transport because this is the new type of public transport system in LMA.

(3) Consistency between selected projects as the feasibility study:

These two projects are located along Ferozepur Road which is the heaviest public transport corridor in LMA. Intersection improvement and introduction of LRT are selected from road and public transport sub-transport sector, respectively.

These are illustrated in Figure 10.3.1.

Figure 10.3.1 Priority Projects for Feasibility Study

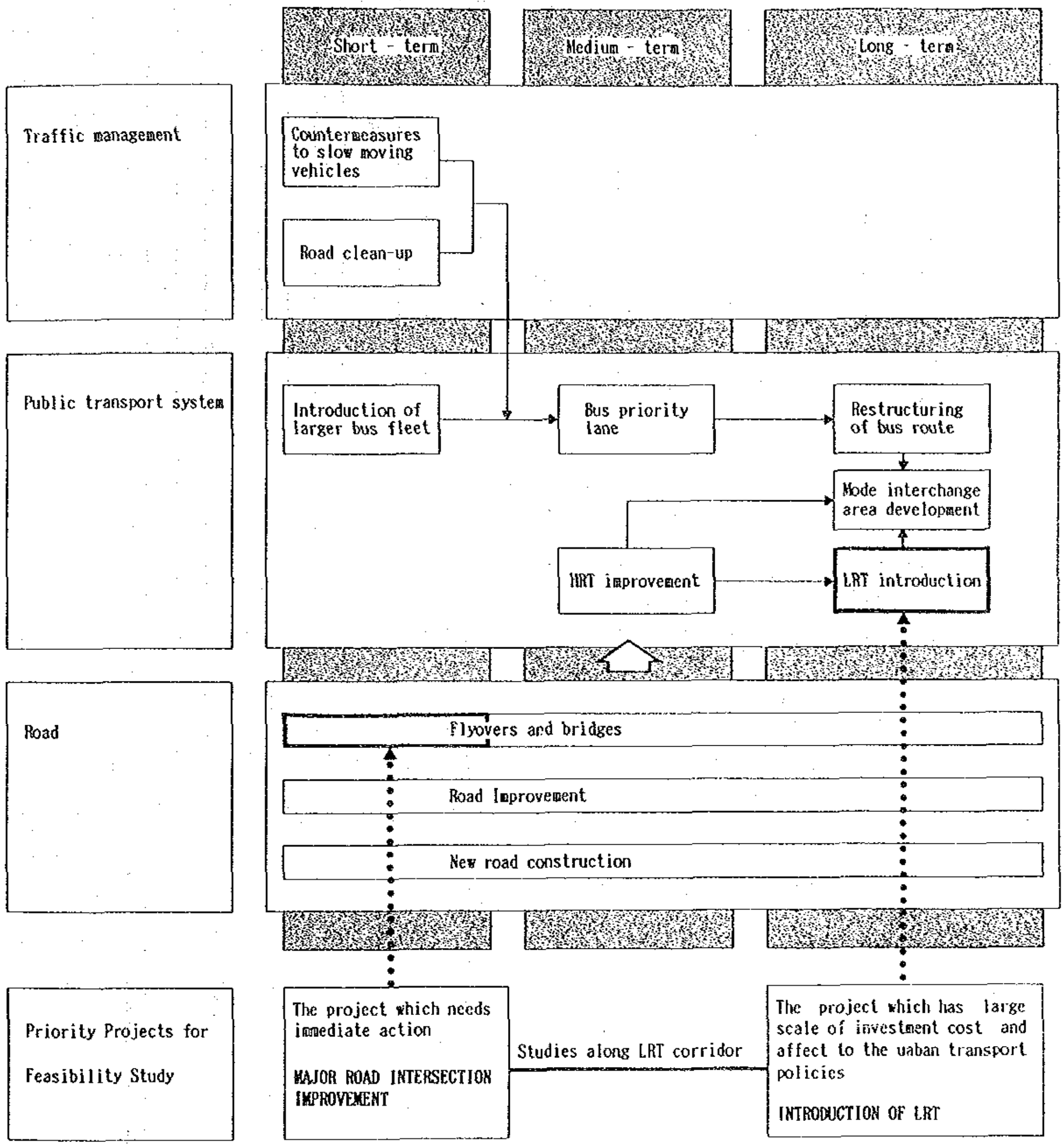


Table 10.3.1(1) Current Traffic Problems Versus Countermeasures with Related Agencies (1)

Identified Problems	Countermeasures		Project		Plan / Idea			CSTS	Remarks
			PUDP	SDP/ADP	World Bank	TEPA	Others		
1. Road Network									
a. Lacks of circumferential Road in the Urbanized Area	. Create Circumferential Road in the Urbanized Area	1.a.1: Widening of Khawaja Farid Road - Bahawalpur Road - Queen's Road - Egerton Road - Durand Road - Shalimar Road- New Link <C1>				○		○	
		1.a.2: Ring Road - New Ravi Bridge - Bund Road - Allama Iqbal Road - Canal Bank Road - Shalimar Link Road - New Link <C2>						○	
		1.a.3: Ring Road (From Ferozepur Road to G.T. Road) <C4>			○			○	
b. Lack of Distributor in Krishan Nagar and Shad Bagh Area	. Create Distributor	1.b.1: Krhishan Nagar Area New Link + Widening of Existing Road from the Mall to Bund Road)				○			
		1.b.2: Krishan Nagar Area Widening of Khawaja Farid Road							
		1.b.3: Shad Bagh Area Shalimar Road to Bund Road <Part of C1>						○	
		1.b.4: Shad Bagh Area Shalimar Link Road to Bund Road <Part of C2>						○	
c. Lack of Trunk Road in the Southern Development Area	. Creat Trunk Road Network	1.c.1: Ring Road <C4>			○			○	
		1.c.2: Link Road to Ring Road						○	
2. Road Link									
a. Traffic Volume on the Ravi Bridge exceed its capacity	. New Bridge Construction	2.a.1: Part of Ring Road			○			○	
b. Missing Link	. Connect the Missing Link	2.b.1: New Flyover - G.T. Road		○				○	
c. Narrow Trunk Road	. Widening	2.c.1: Sheikhupura Road				○			
		2.c.2: Bund Road		○					
		2.c.3: Shalimar Link Road				○			
		2.c.4: Walton Road				○			
		2.c.5: Queen's Road				○			
		2.c.6: Shalimar Road <Flyover>						○	
		2.c.7: Jail Road <Flyover>						○	
		2.c.8: G.T. Road				○			
d. Deteriorated Link	. Improvement of Road	2.d.1: Bund Road		○					
		2.d.2: G.T. Road				○			
		2.d.3: Shalimar Link Road				○			
e. Difficulty of Land Acquisition for the Proposed Road	. Land Acquisition of Proposed Roads	2.e.1 Mass Transit Corridor and Other Proposed Roads						○	

Table 10.3.1(2) Current Traffic Problems Versus Countermeasures with Related Agencies (2)

Identified Problems	Countermeasures		Project: PUDP	Project: SDP/ADP	Plan / Idea: World Bank	Plan / Idea: TEPA	Plan / Idea: Others	CSTS	Remarks
3. Intersection									
a. Problematic Intersection (Irregular Int., Multi-leg Int. Heavy Traffic Int.)	. Intersection Improvement/ Flyover	3.a. 1: G.T. Road/Bund Road	○			○ Flyover			
		3.a. 2: Ravi Road/Circular Road				○ F/O			
		3.a. 3: Eikmoria	○			○ F/O			
		3.a. 4: Mall/Mcleod Road				○ F/O			
		3.a. 5: Shimla Hill	○						
		3.a. 6: Chauberji				○			
		3.a. 7: Muzang Chungi	○			○ F/O		◎	→ Immediate Action
		3.a. 8: Canal Bank/Allama Iqbal Road	○						
		3.a. 9: Canal Bank/Mall	○						
		3.a.10: Canal Bank/Jail Road				○ F/O			
		3.a.11: Canal Bank/Ferozepur Road				○ F/O		○	
		3.a.12: Ferozepur Rd./Main Gulberg				○ F/O		○	
		3.a.13: Canal Bank/Campus Road				○ F/O			
		3.a.14: Wahdat Road/Allama Iqbal Road							
		3.a.15: G.T. Road/Shalimar Link Road							
		3.a.16: Old Ravi Bridge/Bund Road	○						
		3.a.17: Yatim Khana							
		3.a.18: G.T. Road/Shalimar Road							
b. Level Crossing (Rail / Road)	. Flyover	3.b.1: Rail/Shalimar Link Road, Canal Bank				○ F/O(PC-1)			
		3.b.2: Rail/Park Road				○ F/O			
4. Road Traffic									
a. Non-motorized Vehicle (1)									
. Motorized Traffic between Motorized and Animal Drawn Vehicle cause Traffice Jams in the Urbanized Area	. Segregated Traffic System	4.a.1: Circular Road (Segregated Lane)	○						
	. Ban of Animal Drawn Vehilce from Trunk Road	4.a.2: Permitted Area of Animal Drawn Traffic (Walled City + Krishan Nagar + Shad Bagh exclude Trunk Road)						○	→ For the Introduction of Bus Priority Measures
		4.a.3: Exclusive Lane for Animal Drawan Vehicle on the Trunk Road.						○	
b. Non-Motorized Vehicle (2)									
. Heavy Cycle Traffic on the Trunk Road during commuting hours cause traffic congestion	. Cycle Exclusive Lane	4.b.1: Cycle Lane (Ferozepur Road)				○		○	→ Along Bus Corridors
		4.b.2: Cycle Lane (Canal Bank Road)				○		○	
	. Improvement of Public Transport System	4.b.3: Introduction of Urban Bus Route along Ferozepur Road						○	
c. Heavy Vehicle Traffic cause Traffic Jams in the Urbanized Area	. Ban/Divertion of Heavy Traffic from the Urbanized Area	4.c.1: Ring Road			○				
	. Transfer the Freight Terminal/Market to the Outskirt of the Urbanized Area	4.c.2: New Freight Terminal				○		◌	
	. Creation of Access to the Freight Terminal/ Market	4.c.3: New Access to the Vegitable Market						○	

Remarks brackets: "Along Mass Transit Corridor" links 3.a.7, 3.a.11 and 3.a.12; "For the Introduction of Bus Priority Measures" links 4.a.2 and 4.a.3; "Along Bus Corridors" links 4.b.1 and 4.b.2.

Table 10.3.1(3) Current Traffic Problems Versus Countermeasures with Related Agencies (3)

Identified Problems	Countermeasures		Project		Plan / Idea			CSTS	Remarks
			PUDP	SDP/ADP	World Bank	TEPA	Others		
5. Traffic Management									
a. Road Encroachment along the Trunk Roads	. Road Clean-Up	5.a.1: G.T. Road (Truck Stand)						○	
		5.a.2: G.T. Road (On Street Market and Bus Terminal)						○	
		5.a.3: Shalimar Link Road (Truck Stand from/to Dryport)						○	
		5.a.4: Allama Iqbal Road (On Street Market)						○	
		5.a.5: Mcleod Road (Bike Shop)						○	→ For the Introduction of Bus Priority Measures
		5.a.6: Lytton Road (Bike Shop and On Street Market)						○	
		5.a.7: Ferozepur Road (Bus Terminal, On Street Shop and Animal Feeding)						○	
		5.a.8: Multan Road (On Road Shop and Bus Terminal)						○	
		5.a.9: Bund Road (Bus/Rickshaw/Tonga Stand and Animal Feeding)						○	
6. Car Parking									
a. Traffic Congestion along the Mall Service Road	. Parking Measures (Toll System)	6.a.1: Service Road of the Mall						○	
	. Construction of Parking Buildings	6.a.2: The Mall Area				○			
b. On Street Parking along the congested Anarkali Area	. Parking Measures	6.b.1: Anarkali Area						○	
c. Illegal On-street Parking in front of Private School during going/coming back to/from School	. Ban of On-street Parking	6.c.1: Jail Road						○	
		6.c.2: Durand Road						○	
7. Bus Route									
a. Mixture of different types of Bus especially large number of minibus causes traffic congestion along the Trunk Roads	. Introduction of larger size of bus fleet	7.a.1:						○	
	. Rerouting (Large/Medium-size Bus ⟶ Trunk Road Small-size Bus ⟶ Feeder Service)	7.a.2:						○	
	. Bus Lane (Heavy Bus Corridor + Wide Road, More than 4 -Lane)	7.a.3:						○	
b. Poor Bus Service in the Urbanized Area and Southern Development Area	. Introduction of Feeder Service	7.b.1:						○	
	. Introduction of New Bus Route	7.b.2:						○	

Table 10.3.1(4) Current Traffic Problems Versus Countermeasures with Related Agencies (4)

Identified Problems	Countermeasures	Project: PUDP	Project: SDP/ADP	Plan / Idea: World Bank	Plan / Idea: TEPA	Plan / Idea: Others	CSTS	Remarks
8. Bus Stop / Terminal and Other Facilities								
a. Most of Bus Terminals are on-road	. Creation of off Road Bus Terminal and Mode Interchange Area 8.a.1:	○					○	
b. Poor Bus Facilities such as Shelter, Sign and Bus Bay	. Improvement of Bus Facilities 8.b.1:	○					○	
9. Bus Operation/Management/ Finance								
a. Problem of PRTC	. Strengthening of PRTC Organization 9.a.1:	○						
10. Railway								
a. Insufficient Use of PR	. Use of PR for Urban Transport 10.a.1:						○	
	. Improvement of Station Plaza (Mode Interchange Area) 10.a.2:						○	
11. Traffic Safety/Institutional Aspects of TEPA		○			○		○	

Figure 10.3.2(1) Current Traffic Problems Versus Countermeasures

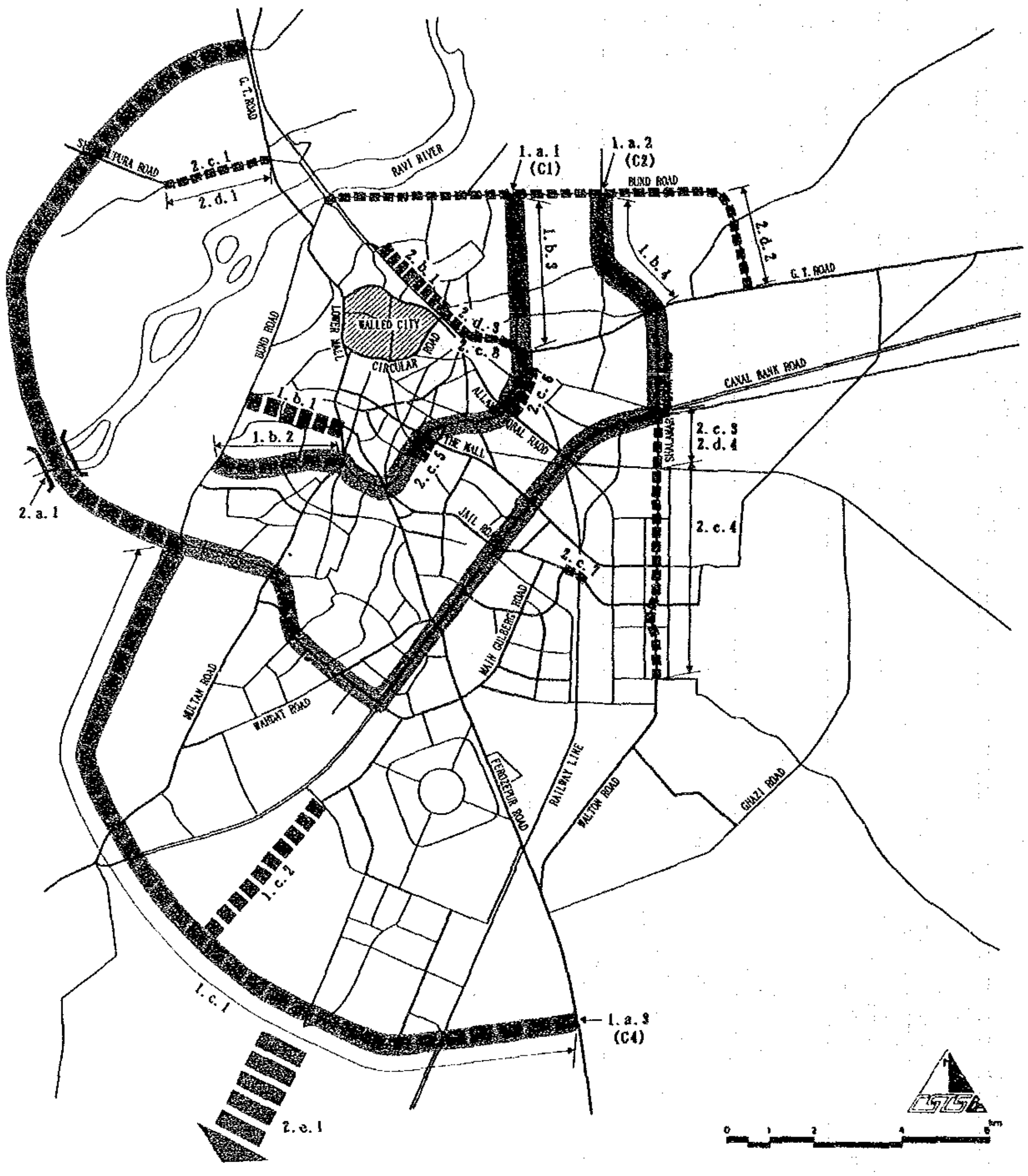


Figure 10.3.2(2) Current Traffic Problems Versus Countermeasures

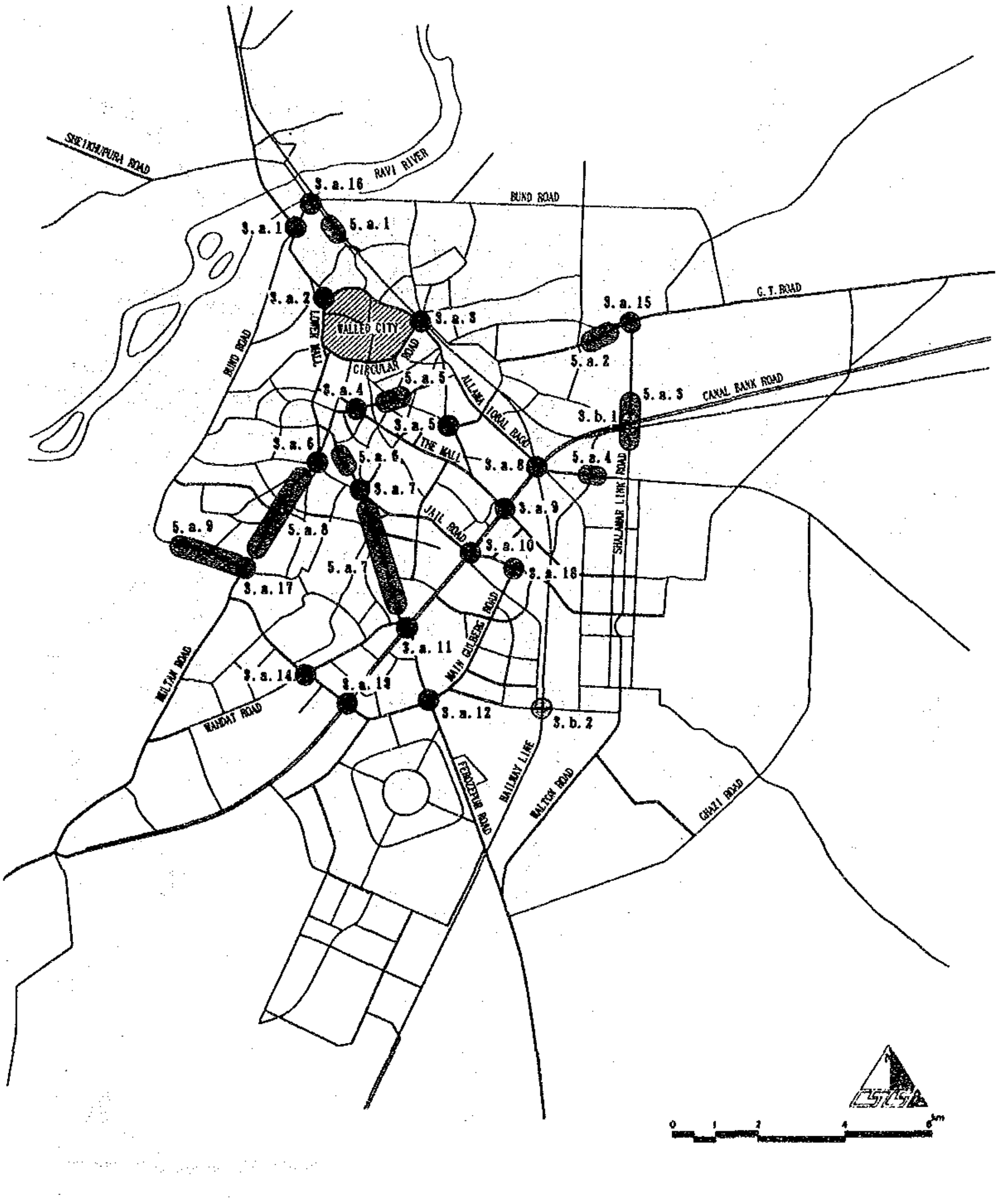


Figure 10.3.2(3) Current Traffic Problems Versus Countermeasures

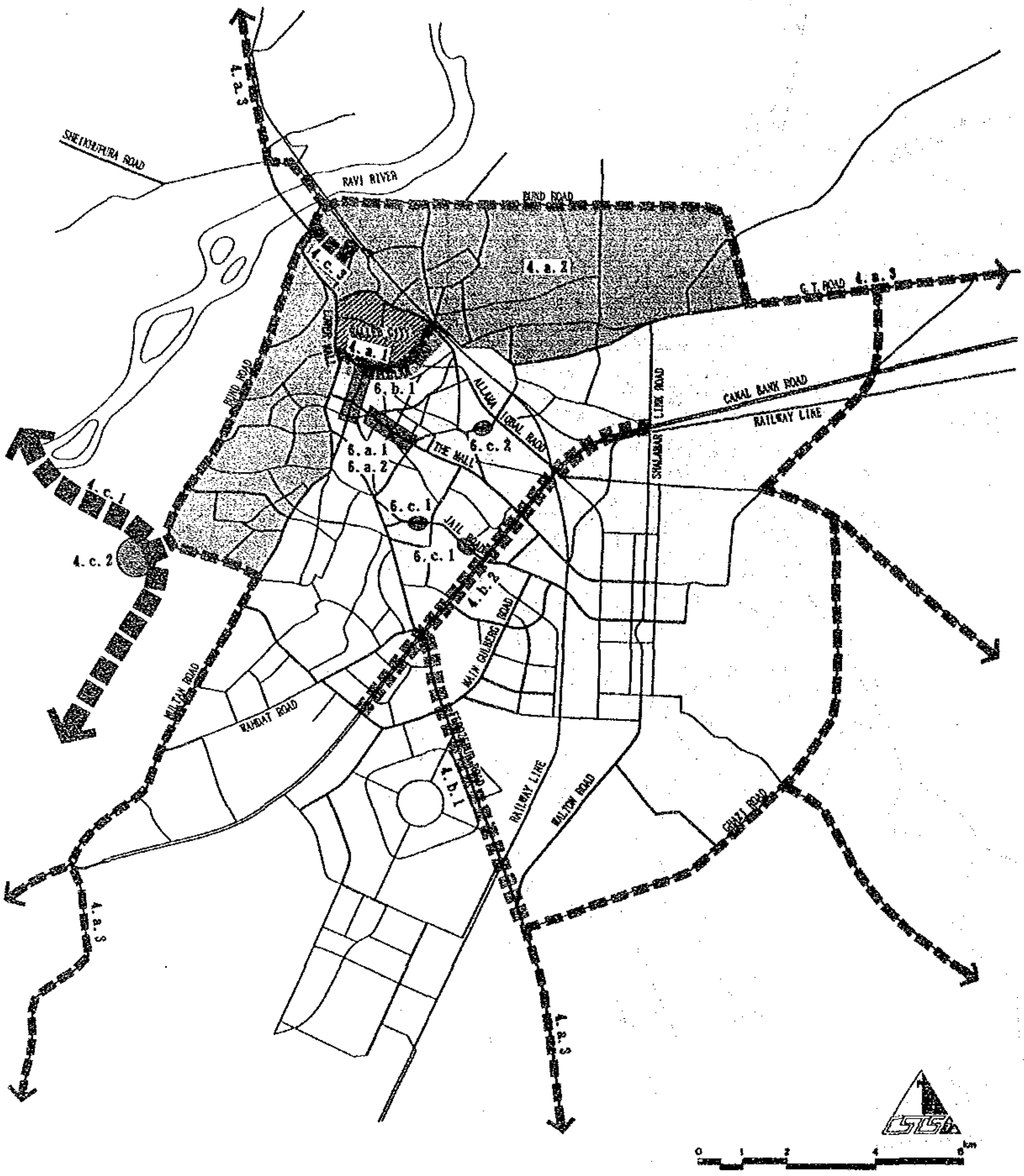
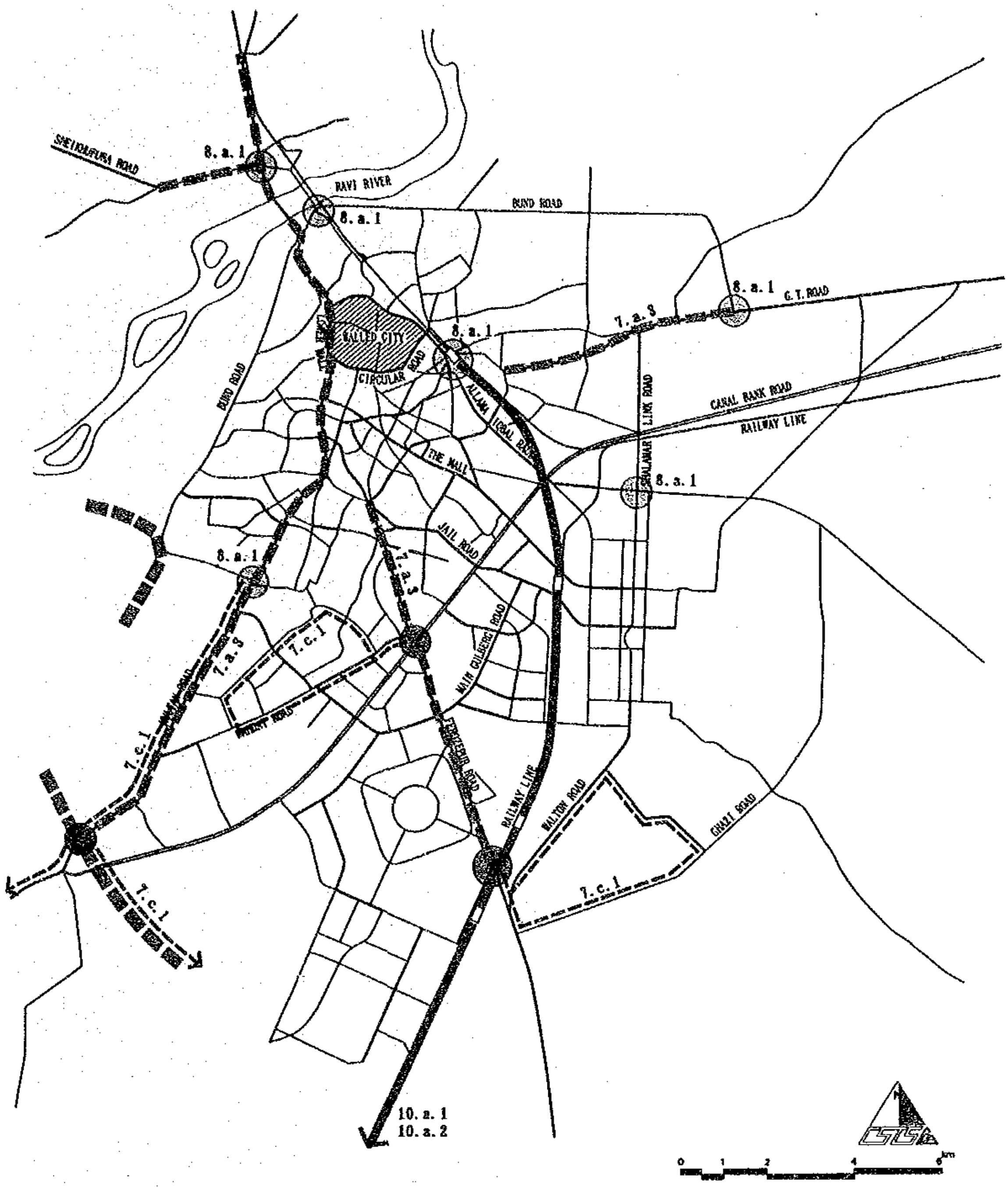


Figure 10.3.2(4) Current Traffic Problems Versus Countermeasures



CHAPTER 11. MAJOR ROAD INTERSECTION IMPROVEMENT

CHAPTER 11 MAJOR ROAD INTERSECTION IMPROVEMENT

11.1 Existing Conditions

There are a number of roundabout intersections in the Study Area, some were constructed in years before World War II. Generally, the roundabout is located at main intersections, occupying relatively large area. It provides a greenery spot, monument, water pond/fountain and other types of facilities which contribute to the scenery of the city.

However, continued development of traffic has exceeded the traffic capacity of the roundabout intersections. Improvement of the intersection has been seen at some points.
Existing main intersections are classified by pattern as shown in Figure 11.1.1. Some of which have traffic jam because of poor geometric design, while the traffic jam has been accelerated by the increased traffic volume.

At present, LDA has been implementing the intersection improvement project within Punjab Urban Development Project (PUDP) partly using the resources of World Bank. The improvement is signal installation, traffic signs and marking, reshaping of the geometric feature, and others on the selected intersections and railway crossings in built-up areas of Lahore. Major intersections are illustrated in Figure 11.1.1.

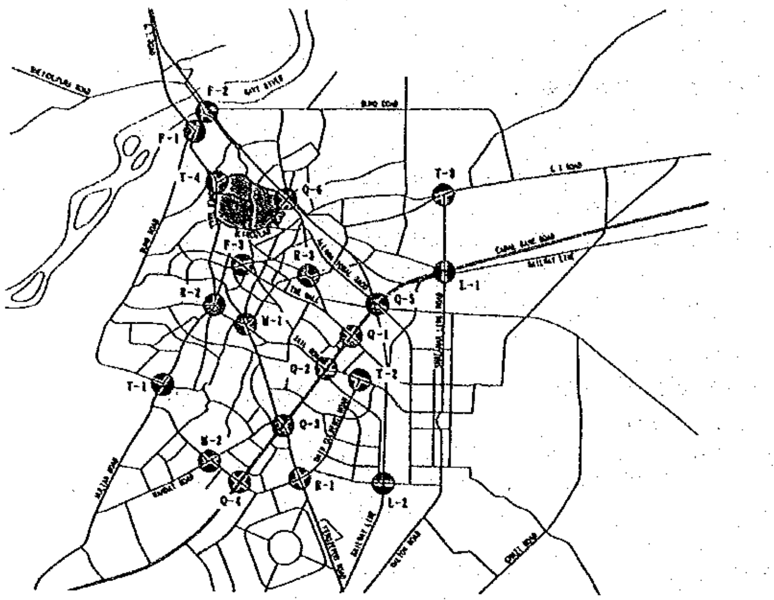
Considering the above project, this study in CSTS JICA selected 12 main intersections for the subject of screening study through which a few intersections are taken for a feasibility study. Table 11.1.1 and Figure 11.1.2 present the morning peak hour traffic inflows into each intersection. The inflows are in the range of 5,000-13,000 pcu/hr.

Intersections of Qartaba Chowk, Jail Road/Canal Bridge, Chouburji, Ferozepur Road/Canal Bridge, Kalma Chowk and The Mall/Canal Bridge have larger traffic inflows than the remaining intersections. They are located on main public transport corridors. The traffic volume in peak hour is found between 7.00-9.00 a.m.

One aspect of traffic on roads is the large volume of motor cycles and bicycles. They account for more than 50 % of the total vehicles. The largest percentage is found at 73 % on GT Road/Shalimar Link Road junction.

The congestion is shown by a saturation degree which is enumerated by a ratio of the inflow traffic over the capacity of inflow lanes in terms of pcu. Assuming the capacity per lane on the approach section at 2,000 pcu/hr and the green hour of traffic signal is approximately 35-40 % for one direction, because of the crossing traffic, the inflow capacity per lane per section is approximated at 700-800 pcu/hr. Detailed examination will be required since the above method is only rough calculation of saturation degree.

Figure 11.1.1 Major Intersections in Lahore



Type of Intersection

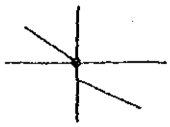
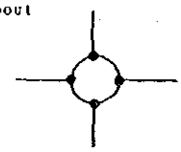
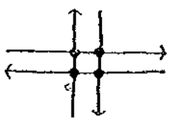
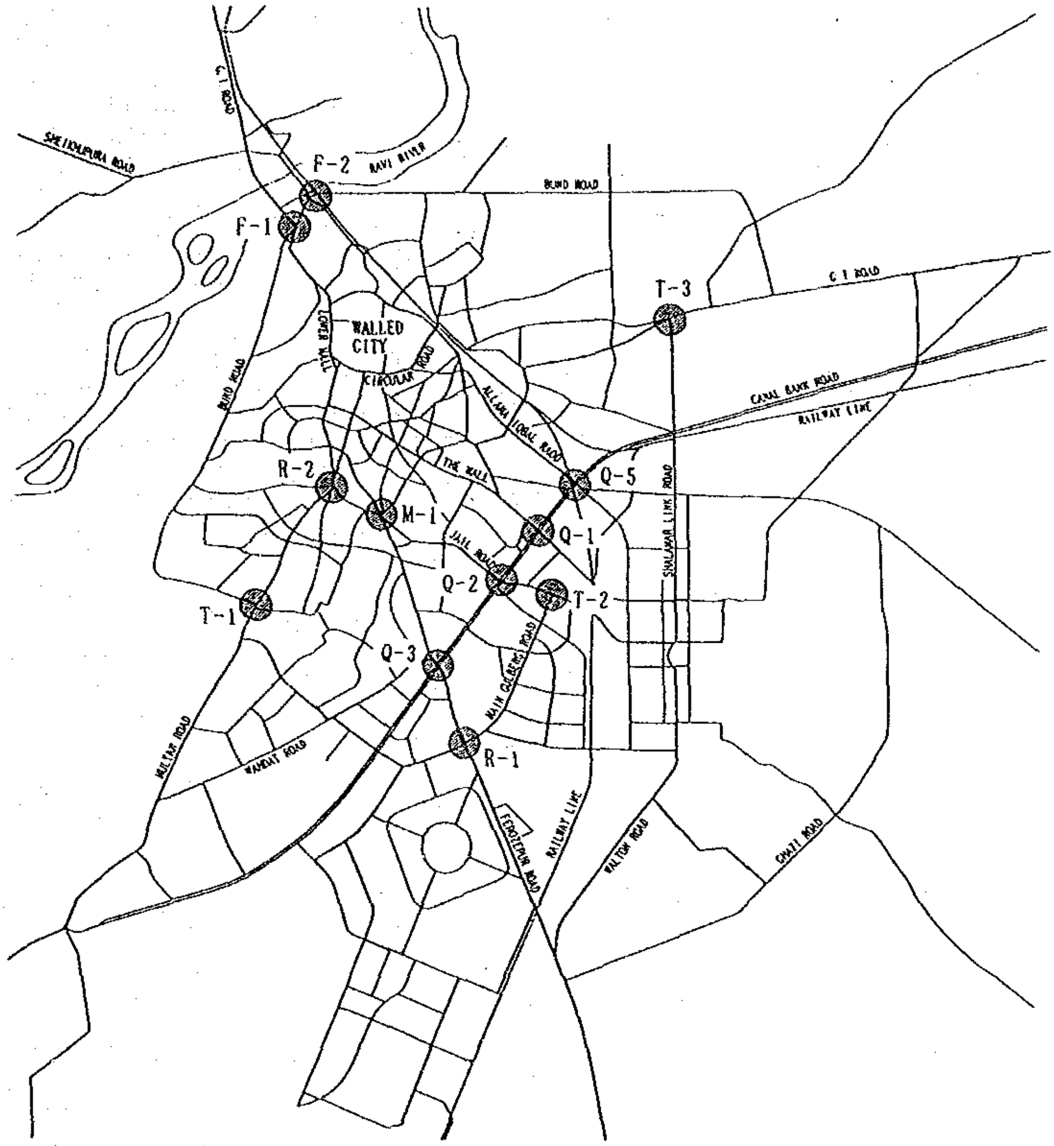
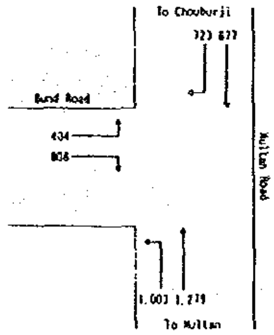
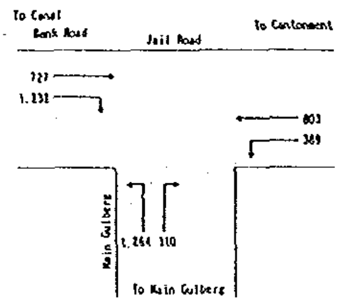
Type		Name of Intersection	Location
T-Leg		·Yatim Khana ·Fawala Chowk ·GT Road/Shalimar Link Rd ·Ravi Road/Circular Rd	T-1 T-2 T-3 T-4
4-Leg		·GT Road/Bund Road ·Old Ravi Bridge ·The Mall/Mcleod Road	F-1 F-2 F-3
Multi- Leg		·Muzang Chungi ·Wahdat Rd/Allama Iqbal Rd	M-1 M-2
Roundabout		·Kalma Chowk ·Chouburji ·Shimla Hill	R-1 R-2 R-3
Quasi-roundabout		·The Mall/Canal Bank Rd ·Jail Rd/Canal Bank Rd ·Ferozepur Rd/Canal Bank Rd ·Campus Rd/Canal Bank Rd ·Allama Iqbal Rd/Canal Bank Rd ·Eikmoria	Q-1 Q-2 Q-3 Q-4 Q-5 Q-6
Level Crossing		·Shalimar Link Rd/Railway ·Park Road/Railway	L-1 L-2

Figure 11.1.2 Traffic Flows at Major Intersections, Peak hour (1)

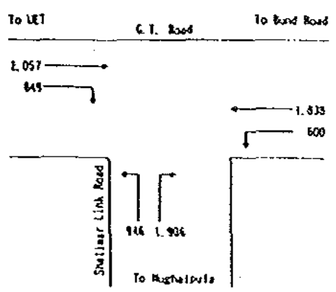




No. : T-1
Name of
Intersection : Yatim Khana chowk
Time : 8:00-9:00
Unit : pcu/hour, All vehicles

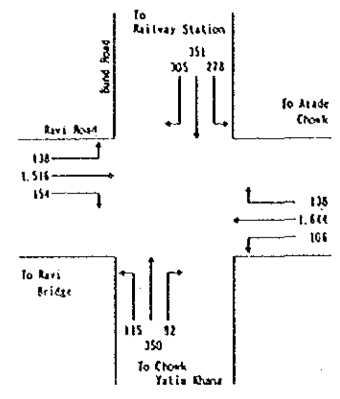


No. : T-2
Name of
Intersection : Fawala Chowk
Time : 7:00-8:00
Unit : pcu/hour, All vehicles

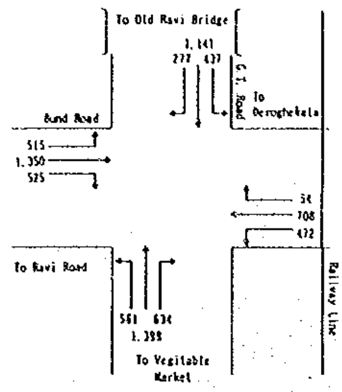


No. : T-3
Name of
Intersection : G.T. Road/Shalimar Link Road
Time : 7:00-8:00
Unit : pcu/hour, All vehicles

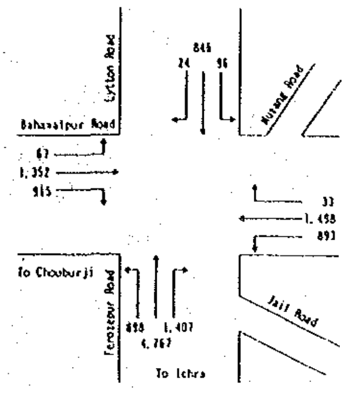
Figure 11.1.2 Traffic Flows at Major Intersections, Peak hour (2)



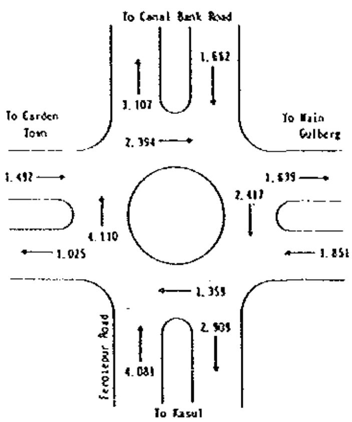
No. : F-1
Name of Intersection : Bativara Chowk
Time : 8:00-9:00
Unit : pcu/hour, All vehicles



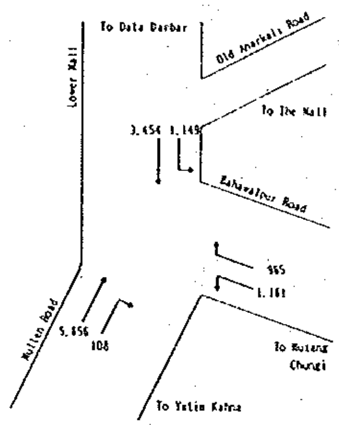
No. : F-2
Name of Intersection : Old Ravi Bridge
Time : 8:00-9:00
Unit : pcu/hour, All vehicles



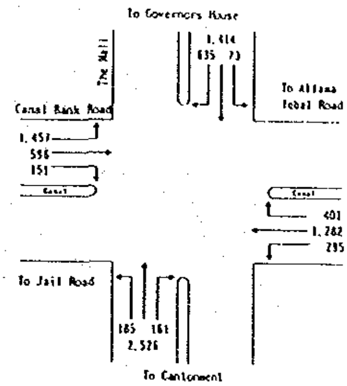
No. : N-1
Name of Intersection : Karlaba Chowk (Muzang Chungi)
Time : 7:00-8:00
Unit : pcu/hour, All vehicles



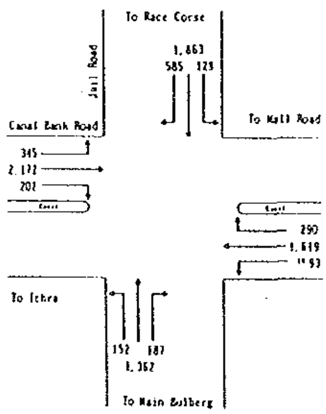
No. : R-1
Name of Intersection : Kalma Chowk
Time : 7:30-8:30
Unit : pcu/hour, All vehicles



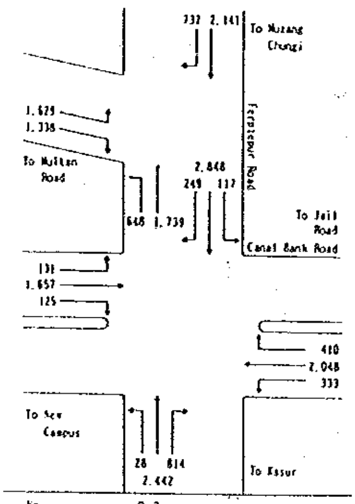
No. : R-2
Name of Intersection : Chouburgi Chowk
Time : 8:00-9:00
Unit : pcu/hour, All vehicles



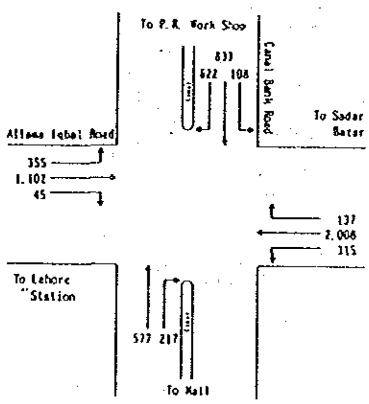
No. : Q-1
Name of Intersection : Mall Road/Canal Bridge
Time : 8:00-9:00
Unit : pcu/hour, All vehicles



No. : Q-2
Name of Intersection : Jail Road/Canal Bridge
Time : 7:00-8:00
Unit : pcu/hour, All vehicles



No. : Q-3
Name of Intersection : Ferozepur Road/Canal Bridge
Time : 8:00-9:00
Unit : pcu/hour, All vehicles



No. : Q-5
Name of Intersection : Dharampura Chowk -North-
Time : 8:00-9:00
Unit : pcu/hour, All vehicles

If the traffic volume per lane at the approach section is larger than 700 to 800 PCU/hr, its section may have certain traffic jam or queuing. It is found the following intersections have larger ratios in traffic/capacity by using the above standard:

a. Qartaba Chowk
b. Jail Road/Canal Bridge
c. Chouburji
d. Ferozepur Road/Canal Bridge
e. Ferozepur Road/Wahdat Road
f. Kalma Chowk
g. The Mall/Canal Bridge

Taking into account the following factors the intersections on the Ferozepur Road (c, d+e, and f) are determined to have urgency in designing a grade-separated intersection. They are discussed in 11.2 of this chapter.

(1) LDA will improve the intersections at Chouburji and The Mall/Canal Bridge in the on-going World Bank assistance project.

(2) Ferozepur road is on the main corridor from the center to the south where new urbanization is taking place. Public transport service also concentrate along this road.

(3) A light rail transit (LRT) line is proposed along this corridor in the long term plan. While keeping aside the space for LRT, a flyover construction is better included in the short term project in order to mitigate vehicle traffic congestion.

Table 11.1.1 Hourly Traffic Flows at Major Intersections

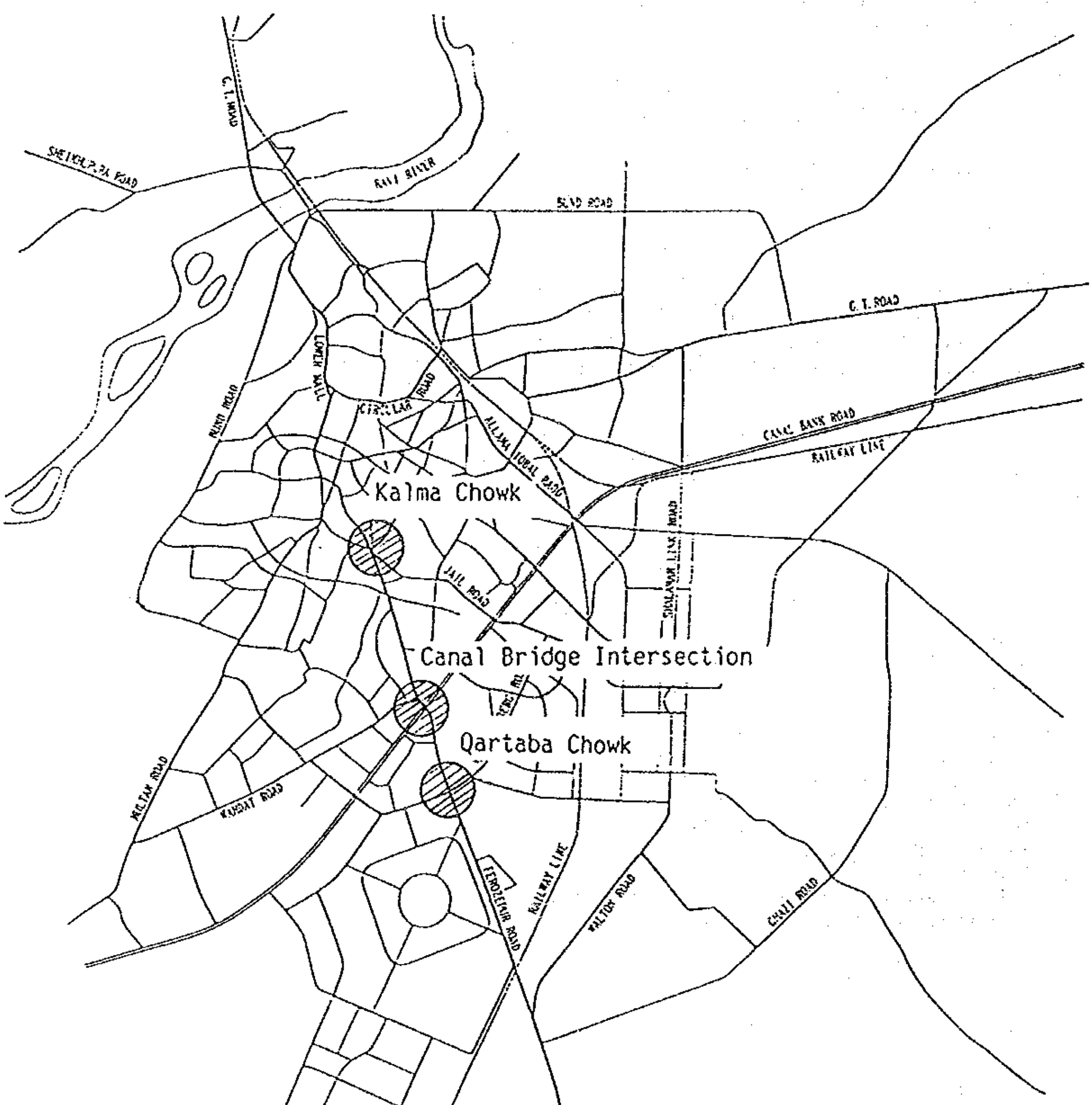
No.	Name of intersection	Period	Total hourly inflow traffic		Excluding animal drawn vehicles				
			(veh)	(pcu)	(veh)	(pcu)	% of 2-wheel vehicles	% of heavy vehicles	pcu per lane
M-1	Kartaba Chowk I	7:00-8:00	15427	12796	15300	12288	56.0	3.6	1120
F-2	Old Ravi Bridge	8:00-9:00	3983	8073	2764	3197	56.0	24.2	400
Q-5	Dharampura Chowk	8:00-9:00	8584	6319	8440	5743	68.0	3.0	570
T-1	Yatim Khana Chowk	8:00-9:00	4560	5174	4282	4062	53.8	11.0	410
F-1	Batiwara Chowk	8:00-9:00	4510	5187	4394	4723	51.9	17.6	470
T-2	Fawala Chowk	7:00-8:00	5651	4725	5646	4705	35.4	0.8	670
Q-2	Jail Rd./Canal Bridge	7:00-8:00	11671	8998	11666	8978	46.2	1.1	900
R-2	Chouburji Chowk	8:00-9:00	15870	12493	15649	11609	60.2	3.0	1160
Q-3	Ferozepur Rd./Canal Bridge	8:00-9:00	14836	11202	14802	11066	55.6	2.3	1110
Q-3	Ferozepur Rd./Wahdat Rd.	8:00-9:00	10264	8232	10175	7876	55.9	2.3	980
R-1	Kalma Chowk	7:30-8:30	12551	9958	12457	9582	51.7	3.4	870
T-3	G.T. Rd./Shalimar Link Rd.	7:00-8:00	7438	8196	6458	4276	73.1	3.2	610
Q-1	Mall Road/Canal Bridge	8:00-9:00	12478	9176	12478	9176	50.4	0.7	920

11.2 Improvement Plan of Three Major Intersections

The following three major intersections along Ferozepur Road were identified as the most important intersections to be improved urgently, from the viewpoint of smooth traffic flow based on the analysis of the existing traffic demands.

- Qartaba Chowk,
- Canal Bridge Intersection and
- Kalma Chowk

Figure 11.2.1 Location of three Major Intersections



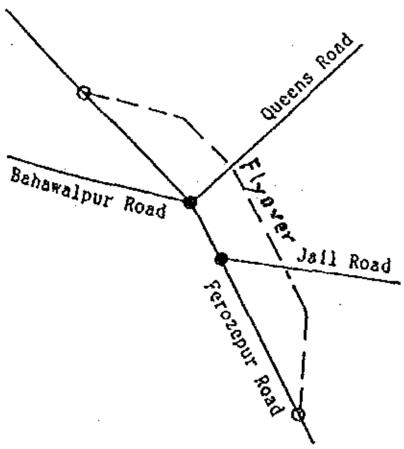
The improvement plans for these intersections are carefully considered not only from the viewpoints of efficient traffic flow and reasonable type of structure, but also of the consistency with future LRT introduction along this Ferozepur corridor.

11.2.1 Traffic Flow and Road Alignment Plan

(1) Qartaba Chowk

This intersection consists of five legs, Lytton Road, Ferozepur Road, Bahawalpur Road, Jail Road and Queens Road. Judging from the traffic flow volume, the two directions between Lytton Rd. and Ferozepur Rd., and between Jail Rd. and Ferozepur Rd. have heavy traffic demand. In this respect, introduction of the grade-separated structure directly connecting these three roads is effective. However, the grade-separated structure with three legs requires traffic signal installment on the structure and may cause some traffic congestion there.
A simple grade-separated structure, therefore, is planned for the direction with heaviest traffic demand, between Lytton Road and Ferozepur Road.

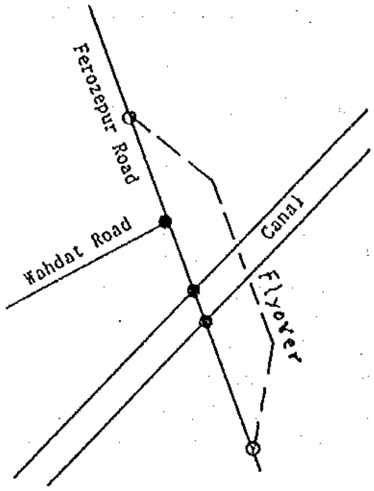
Figure 11.2.2 Qartaba Chowk



(2) Canal Bridge Intersection

At this intersection, it is required to separate the main flow along Ferozepur Road from Canal Road. In addition, since there is the beginning of Wahdat Road at 200m north from this intersection, the grade separation of Ferozepur Road should be extended over both Wahdat Road and Canal Road.
There are big alignment curve at this intersection. Thus, in case of improvement of this intersection, grade-separated structure can be planned to straighten its alignment for smooth traffic flow. However, straight alignment of new structure will occupy a lot of private residential areas and it requires more lond acquisition cost. Therefore, new structure will be placed over the existing Ferozepur Road.

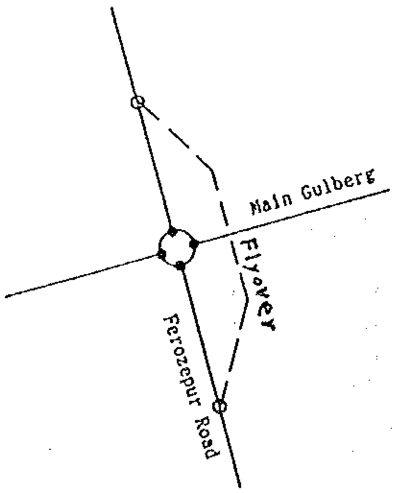
Figure 11.2.3 Canal Bridge Intersection



(3) Kalma Chowk

A monument is built at the center of this intersection. JICA Study Team examined the construction of grade-separated structure without removal of this monument.
After a lot of studies such as economical construction cost, smooth traffic flow, introduction of LRT system, etc., the new structure is proposed to be split into up flow and down flow with the monument as the center.
Furthermore, foundations of structure will be placed inside the monument circle so that traffic flow will not be obstructed.

Figure 11.2.4 Kalma Chowk



11.2.2 Type of Structures

(1) Planning of intersection profile

There are two types of grade-separated structures at the intersection. One is the elevated structure and the other is the under-pass structure. The advantages and disadvantages of each type are as shown below.

Table 11.2.1 Comparison of Structure Types

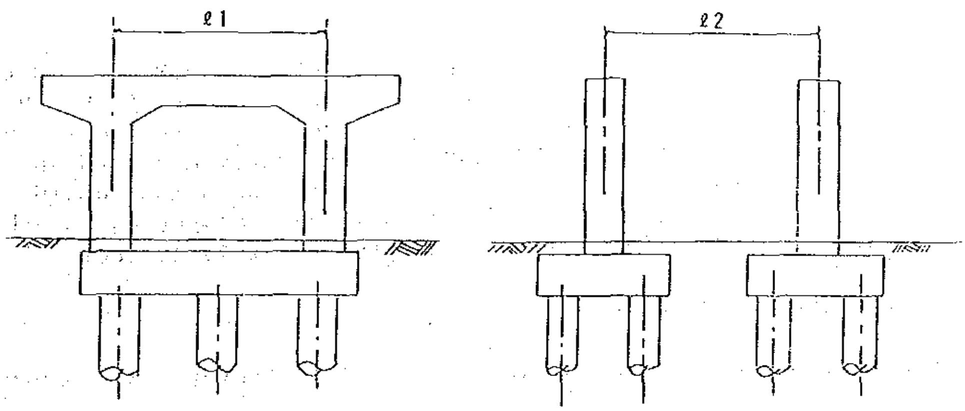
	Elevated structure	Under-pass structure
Type of structure	super-structure: hollow box girder sub-structure: pile foundation	box culvert
Construction cost	approx. 10 million Rs. at Qartaba Chowk	approx. 20.3 million Rs. at Qartaba Chowk
Maintenance cost	none	approx. annual 1.0 mill. Rs. for water discharge pumps
During construction	no necessary for traffic detour except for peak construction period.	Traffic detour should be conducted for all construction period.
Environment & scenic beauty	Noise will be producted and scenic beauty may be spoiled.	Noise will not be producted and scenic beauty may not be spoiled.

From the above comparisons, elevated structure is much more suitable for this project.

(2) Sub-structure

The sub-structure has the following two types:

(type 1) (type 2)



Type 2 requires less materials than Type 1, but there are the following problems for Type 2.

- Distance between columns are bigger ($l_2 > l_1$), thus the existing road will be narrowed.

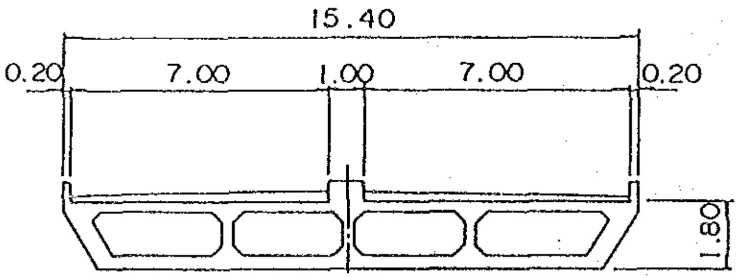
- Due to negative friction for piles, foundation may be subsided after long period. It may cause the cracks on super-structure since each column is independent support.

On the basis of the above discussions, Type 1 will be adopted for the project since width of roads are narrow and geologic stratum is composed of deep soft sand soil in Lahore City.

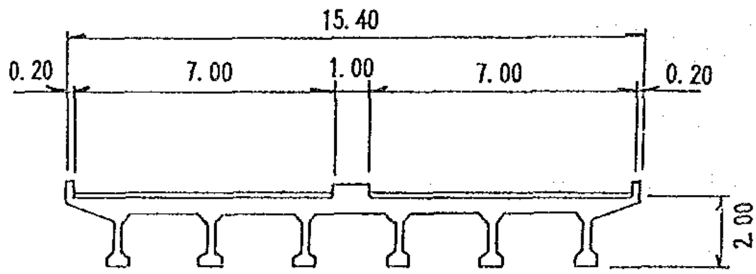
(3) Super-structure

There are two types of super-structures.
One is the hollow-box girder (Type 1) and the other is precast beams and deck slab (Type 2).

Type 1 (hollow-box girder)



Type 2 (precast beams and deck slab)



Type 1 is lighter than Type 2, thus Type 1 is more economical cost. Type 1 is built monolithically as a one piece by cast-in-place concrete. Timber support is used under the girders on the existing road during construction. Type 2 requires more materials and also broad yard for preparation of precast beams. Yard for beams should be located in the suburbs of Lahore and they will be transported to the site at night. Consequently, Type 1 is adopted for this project.

(4) Standard Structure of Flyover

After examination of sub-structure and super-structure as above, standard structure of flyover is planned to be a 35 meters span bridge. Side view of flyover and its sections are shown on Figure 11.2.5 to 11.2.7.

Figure 11.2.5 Side View of Flyover

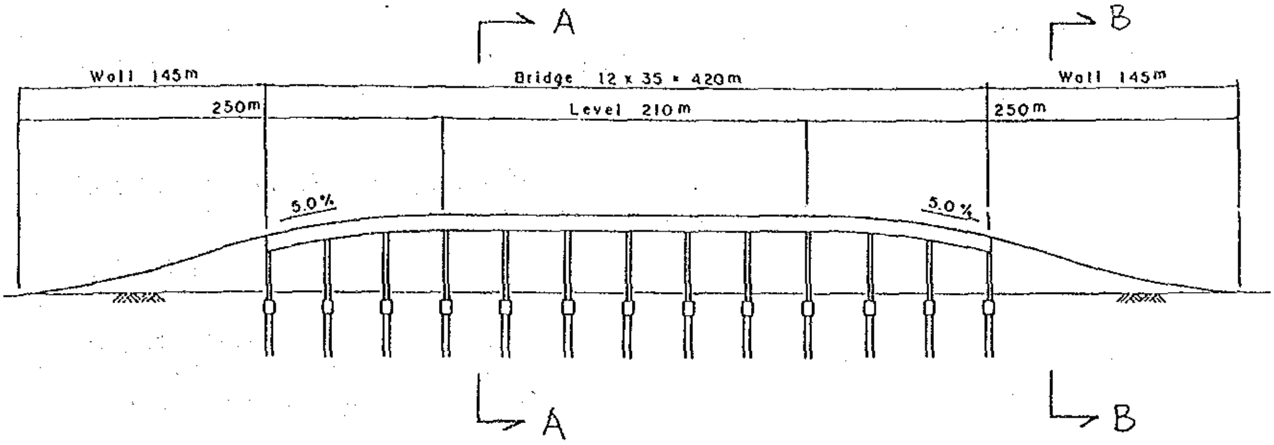


Figure 11.2.6 Section A-A

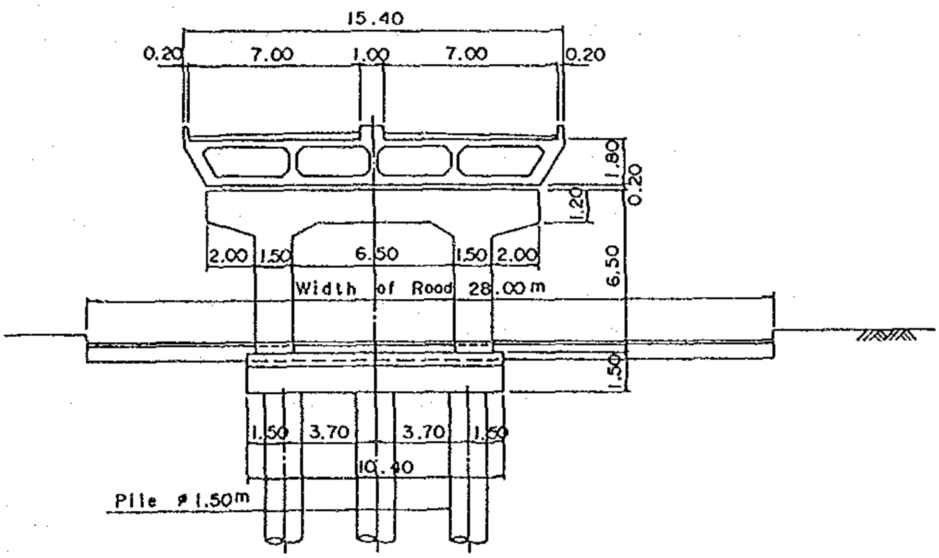
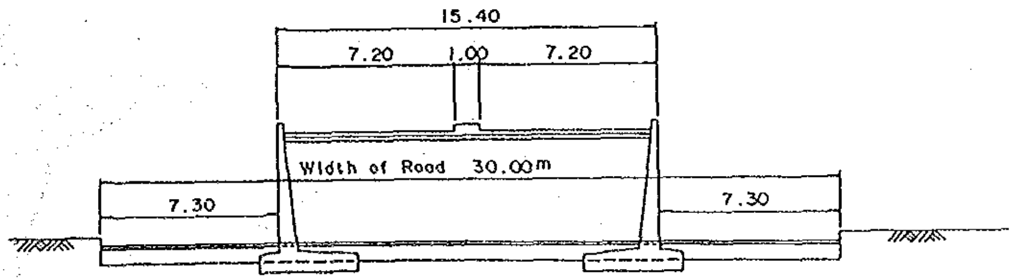


Figure 11.2.7 Section B-B



11.2.3. Geometrical Design and Markings

Geometrical structure and markings at objective intersections are designed based on the Lahore Traffic Manual and taking into account the following factors:

(1) Design speed and vehicles
(2) Inflow traffic volume at each intersection
(3) Configuration of cross section
(4) Elevated structure of flyover

Considering above factors, planning directions for the geometrical design and markings of each intersection are as follows:

(1) Qartaba Chowk

At-grade portion of this intersection is one of the problematic multi-leg intersections in LMA. Therefore, the provision of right-turn lane from Gulberg along Jail Road is one of the key factors for channelization in this intersection.

(2) Canal Bridge Intersection

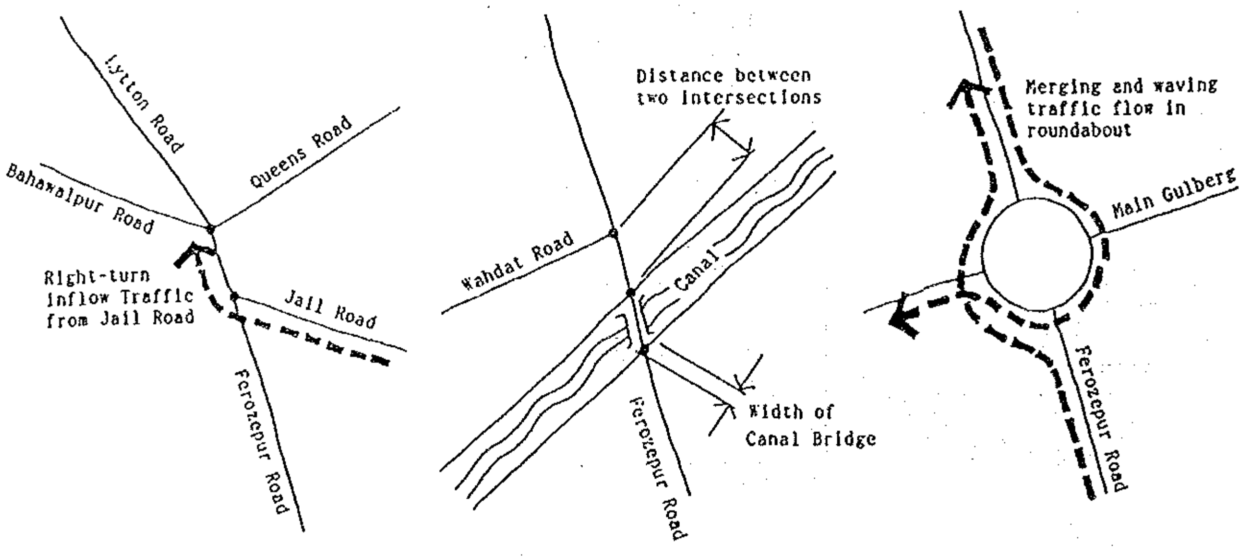
The width of Canal Bridge and the distance from Wahdat Road intersection are the critical factors for the planning of this intersection.

(3) Kalma Chowk

This is one of the large scale roundabout in Lahore. Traffic flow in the roundabout is oneway with slow travel speed and complicated. Therefore, markings in the roundabout is the key factor for the planning.

Figure 11.2.1 Key Factors for Geometrical Design and Markings in Each Intersection

Qartaba Chowk | Canal Bridge Intersection | Kalma Chowk



11.3 Construction Cost

11.3.1 Premises

(1) Construction cost estimation is to be carried out based on the prices at the end of 1990.

(2) Construction cost is to be presented in the local currency (Pakistan Rupees). The exchange rate is 1US Dollar=21.70Rupees=132 Japanese Yen.

(3) Cost estimation is to be split into foreign currency and local currency.

(Foreign currency)
- Wages of foreign personnel
- Imported materials and machineries (CIF price)
- Overhead and profit of foreign firms

(Local currency)
- Wages of local personnel
- Local materials
- Overhead and profit of local firms
- Managing and maintenance costs of equipment

(4) Tax and duties

Tax and duties comprises of custom duty, sales tax, import surcharge, Iqra surcharge, income tax and Octroi. The rate of those charges differ from equipment to equipment.

(5) Economic and financial costs

The project costs are estimated both terms of economic and financial costs. The economic cost is estimated by subtracting all transfer costs such as custom duty, sale taxes, import surcharge, etc. from the financial cost.

11.3.2 Construction Cost

The construction cost based on the above premises is shown in Table 11.3.2 to Table 11.3.7, and the cost estimation for three flyovers are summarized in Table 11.3.1.

Table 11.3.1 Construction Cost for Flyovers

(million Rupees)

Location	Structure Length (m)	Economic Cost	Financial Cost
Qartaba Chowk	710	80.278	103.413
Canal Bridge Intersection	745	86.513	111.445
Kalma Chowk	605	64.800	87.474

Table 11.3.2 Cost Summary of Qartaba Chowk

(thousand Rupees)

Item	without taxes & duties	with taxes & duties
[local cost]		
labor	15,593.32	
material	29,772.20	
other	15,351.83	
land	0.00	
subtotal:	60,717.35	60,717.35
import taxes & duties		21,050.98
taxes on local materials		2,084.05
Total local costs		83,852.39
[foreign cost]		
foreign cost	18,629.19	
freight on import	931.46	
Total foreign costs	19,560.65	19,560.65
T O T A L	80,278.00	103,413.03

Table 11.3.3 Cost Breakdown of Qartaba Chowk

unit : thousand Rs.

item	unit cost Rs	unit	quantity	costs without taxes & duties	foreign costs %	foreign costs	local costs %	local costs	labor Rs %	labor Rs	material Rs %	material Rs	other Rs %	other Rs	land Rs	import taxes & duties %	import taxes & duties	taxes 12.5% on lcl mtl %	taxes 12.5% on lcl mtl	freight on import %	freight on import
earthwork	39	m3	5500	214.500	27	57.915	73	156.585	20	31.317	55	86.122	25	39.146		113	65.444	56	6.029	5	2.896
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
sub base course 30cm	244	m3	1300	317.200	27	85.644	73	231.556	20	46.311	55	127.356	25	57.889		113	96.778	56	8.915	5	4.282
agg. base course 30cm	287	m3	1300	373.100	27	100.737	73	272.363	20	54.473	55	149.800	25	68.091		113	113.833	56	10.486	5	5.037
prime coat	13.5	m2	4350	58.725	27	15.856	73	42.869	20	8.574	55	23.578	25	10.717		113	17.917	56	1.650	5	0.793
base course 10cm	1185	m3	435	515.475	27	139.178	73	376.297	20	75.259	55	206.963	25	94.074		113	157.271	56	14.487	5	6.959
wearing course 5cm	1427	m3	497	709.219	27	191.489	73	517.730	20	103.546	55	284.751	25	129.432		113	216.383	56	19.933	5	9.574
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
piles d=1.5m	15000	m	940	14100.000	27	3807.000	73	10293.000	20	2058.600	55	5661.150	25	2573.250		113	4301.910	56	396.281	5	190.350
piers	2000	m3	2200	4400.000	27	1188.000	73	3212.000	20	642.400	55	1766.600	25	803.000		113	1342.440	56	123.662	5	59.400
hollow box girder	2500	m3	5000	12500.000	27	3375.000	73	9125.000	20	1825.000	55	5018.750	25	2281.250		113	3813.750	56	351.313	5	168.750
parapets	2200	m3	290	638.000	27	172.260	73	465.740	20	93.148	55	256.157	25	116.435		113	194.654	56	17.931	5	8.613
R.C steel	16500	t	1370	22605.000	27	6103.350	73	16501.650	20	3300.330	55	9075.908	25	4125.413		113	6896.786	56	635.314	5	305.168
P.C steel	25000	t	17	425.000	27	114.750	73	310.250	20	62.050	55	170.638	25	77.563		113	129.668	56	11.945	5	5.738
bearings	65000	t	24	1560.000	27	421.200	73	1138.800	20	227.760	55	626.340	25	284.700		113	475.956	56	43.844	5	21.060
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
retaining wall	2000	m3	1500	3000.000	27	810.000	73	2190.000	20	438.000	55	1204.500	25	547.500		113	915.300	56	84.315	5	40.500
R.C steel	16500	t	150	2475.000	27	668.250	73	1806.750	20	361.350	55	993.713	25	451.688		113	755.123	56	69.560	5	33.413
new jersey barrier	1400	m	580	812.000	27	219.240	73	592.760	20	118.552	55	326.018	25	148.190		113	247.741	56	22.821	5	10.962
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
miscellaneous				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
lightings	580000	km	0.71	411.800	27	111.186	73	300.614	20	60.123	55	165.338	25	75.154		113	125.640	56	11.574	5	5.559
sighns & markings	340000	km	0.71	241.400	27	65.178	73	176.222	20	35.244	55	96.922	25	44.056		113	73.651	56	6.785	5	3.259
util. relocation	500000	km	0.71	355.000	27	95.850	73	259.150	20	51.830	55	142.533	25	64.788		113	108.311	56	9.977	5	4.793
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
total facilities & systems				65711.419		17742.083		47969.336		9593.867		26383.135		11992.334			20048.554		1846.819		887.104
												0.000		0.000			0.000		0.000		0.000
land	0	m2	0	0.000	0	0.000	100	0.000	0	0.000	0	0.000	0	0.000	0.000	0	0.000	0	0.000	0	0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
engineering	10	%	65711	6571.142	0	0.000	100	6571.142	40	2628.457	20	1314.228	40	2628.457		0	0.000	56	91.996	0	0.000
project admin.	5	%	65711	3285.571	0	0.000	100	3285.571	80	2628.457	20	657.114	0	0.000		0	0.000	56	45.998	0	0.000
subtotal				75568.132		17742.083		57826.049		14850.781		28354.477		14620.791	0.000		20048.554		1984.813		887.104
contingencies	5	%		3778.407		887.104		2891.302		742.539		1417.724		731.040	0.000		1002.428		99.241		44.355
TOTAL				79346.538		18629.187		60717.351		15593.320		29772.201		15351.830	0.000		21050.982		2084.054		931.459

Table 11.3.4 Cost Summary of Canal Bridge Intersection

(thousand Rupees)

Item	without taxes & duties	with taxes & duties
[local cost]		
labor	16,804.47	
material	32,084.64	
other	16,544.22	
land	0.00	
subtotal:	65,433.33	65,433.33
import taxes & duties		22,686.03
taxes on local materials		2,245.92
total local costs		90,365.29
[foreign cost]		
foreign cost	20,076.14	
freight on import	1,003.81	
total foreign costs	21,079.94	21,079.94
TOTAL	86,513.27	111,445.23

Table 11.3.5 Cost Breakdown of Bridge Intersection

unit : thousand Rs.

item	unit cost Rs	unit	quantity	costs without taxes & duties	foreign costs %	foreign costs	local costs %	local costs	labor Rs %	labor Rs	material Rs %	material Rs	other Rs %	other Rs	land Rs	import taxes & duties %	import taxes & duties	taxes 12.5% on lcl mtl %	taxes 12.5% on lcl mtl	freight on import %	freight on import
earthwork	39	m3	5000	195.000	27	52.650	73	142.350	20	28.470	55	78.293	25	35.588		113	59.495	56	5.480	5	2.633
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
sub base course 30cm	244	m3	1300	317.200	27	85.644	73	231.556	20	46.311	55	127.356	25	57.889		113	96.778	56	8.915	5	4.282
agg. base course 30cm	287	m3	1300	373.100	27	100.737	73	272.363	20	54.473	55	149.800	25	68.091		113	113.833	56	10.486	5	5.037
prime coat	13.5	m2	4350	58.725	27	15.856	73	42.869	20	8.574	55	23.578	25	10.717		113	17.917	56	1.650	5	0.793
base course 10cm	1185	m3	435	515.475	27	139.178	73	376.297	20	75.259	55	206.963	25	94.074		113	157.271	56	14.487	5	6.959
wearing course 5cm	1427	m3	424	605.048	27	163.363	73	441.685	20	88.337	55	242.927	25	110.421		113	184.600	56	17.005	5	8.168
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
piles d=1.5m	15000	m	770	11550.000	27	3118.500	73	8431.500	20	1686.300	55	4637.325	25	2107.875		113	3523.905	56	324.613	5	155.925
piers	2000	m3	1840	3680.000	27	993.600	73	2686.400	20	537.280	55	1477.520	25	671.600		113	1122.768	56	103.426	5	49.680
hollow box girder	2500	m3	3650	9125.000	27	2463.750	73	6661.250	20	1332.250	55	3663.688	25	1665.313		113	2784.038	56	256.458	5	123.188
parapets	2200	m3	220	484.000	27	130.680	73	353.320	20	70.664	55	194.326	25	88.330		113	147.668	56	13.603	5	6.534
R.C steel	16500	t	1060	17490.000	27	4722.300	73	12767.700	20	2553.540	55	7022.235	25	3191.925		113	5336.199	56	491.556	5	236.115
P.C steel	25000	t	13	325.000	27	87.750	73	237.250	20	47.450	55	130.488	25	59.313		113	99.158	56	9.134	5	4.388
bearings	65000	t	18	1170.000	27	315.900	73	854.100	20	170.820	55	469.755	25	213.525		113	356.967	56	32.883	5	15.795
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
retaining wall	2000	m3	1500	3000.000	27	810.000	73	2190.000	20	438.000	55	1204.500	25	547.500		113	915.300	56	84.315	5	40.500
R.C steel	16500	t	150	2475.000	27	668.250	73	1806.750	20	361.350	55	993.713	25	451.688		113	755.123	56	69.560	5	33.413
new jersey barrier	1400	m	580	812.000	27	219.240	73	592.760	20	118.552	55	326.018	25	148.190		113	247.741	56	22.821	5	10.962
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
miscellaneous				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
lightings	580000	km	0.61	353.800	27	95.526	73	258.274	20	51.655	55	142.051	25	64.569		113	107.944	56	9.944	5	4.776
sighns & markings	340000	km	0.61	207.400	27	55.998	73	151.402	20	30.280	55	83.271	25	37.851		113	63.278	56	5.829	5	2.800
util. relocation	500000	km	0.61	305.000	27	82.350	73	222.650	20	44.530	55	122.458	25	55.663		113	93.056	56	8.572	5	4.118
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
total facilities & systems				53041.748		14321.272		38720.476		7744.095		21296.262		9680.119			16183.037		1490.738		716.064
												0.000		0.000			0.000		0.000		0.000
land	0	m2	0	0.000	0	0.000	100	0.000	0	0.000	0	0.000	0	0.000	0.000	0	0.000	0	0.000	0	0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
engineering	10	%	53042	5304.175	0	0.000	100	5304.175	40	2121.670	20	1060.835	40	2121.670		0	0.000	56	74.258	0	0.000
project admin.	5	%	53042	2652.087	0	0.000	100	2652.087	80	2121.670	20	530.417	0	0.000		0	0.000	56	37.129	0	0.000
subtotal				60998.010		14321.272		46676.733		11987.435		22887.514		11801.789	0.000		16183.037		1602.126		716.064
contingencies	5	%		3049.901		716.064		2333.837		599.372		1144.376		590.089	0.000		809.152		80.106		35.803
TOTAL				64047.911		15037.336		49010.575		12586.807		24031.890		12391.878	0.000		16992.189		1682.232		751.867

Table 11.3.6 Cost Summary of Kalma Chowk

(thousand Rupees)

Item	without taxes & duties	with taxes & duties
[local cost]		
labor	12,586.81	
material	24,031.89	
other	12,391.88	
land	0.00	
subtotal:	49,010.58	49,010.58
import taxes & duties		16,992.19
taxes on local materials		1,682.23
total local costs		67,685.00
[foreign cost]		
foreign cost	15,037.34	
freight on import	751.87	
total foreign costs	15,789.20	15,789.20
T O T A L	64,799.78	83,474.20

Table 11.3.7 Cost Breakdown of Kalma Chowk

unit : thousand Rs.

item	unit cost Rs	unit	quantity	costs without taxes & duties	%	foreign costs	%	local costs	%	labor Rs	%	material Rs	%	other Rs	land Rs	%	import taxes & duties	%	taxes 12.5% on lcl mtl	%	freight on import
earthwork	39	m3	5000	195.000	27	52.650	73	142.350	20	28.470	55	78.293	25	35.588		113	59.495	56	5.480	5	2.633
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
sub base course 30cm	244	m3	1300	317.200	27	85.644	73	231.556	20	46.311	55	127.356	25	57.889		113	96.778	56	8.915	5	4.282
agg. base course 30cm	287	m3	1300	373.100	27	100.737	73	272.363	20	54.473	55	149.800	25	68.091		113	113.833	56	10.486	5	5.037
prime coat	13.5	m2	4350	58.725	27	15.856	73	42.869	20	8.574	55	23.578	25	10.717		113	17.917	56	1.650	5	0.793
base course 10cm	1185	m3	435	515.475	27	139.178	73	376.297	20	75.259	55	206.963	25	94.074		113	157.271	56	14.487	5	6.959
wearing course 5cm	1427	m3	424	605.048	27	163.363	73	441.685	20	88.337	55	242.927	25	110.421		113	184.600	56	17.005	5	8.168
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
piles d=1.5m	15000	m	770	11550.000	27	3118.500	73	8431.500	20	1686.300	55	4637.325	25	2107.875		113	3523.905	56	324.613	5	155.925
piers	2000	m3	1840	3680.000	27	993.600	73	2686.400	20	537.280	55	1477.520	25	671.600		113	1122.768	56	103.426	5	49.680
hollow box girder	2500	m3	3650	9125.000	27	2463.750	73	6661.250	20	1332.250	55	3663.688	25	1665.313		113	2784.038	56	256.458	5	123.188
parapets	2200	m3	220	484.000	27	130.680	73	353.320	20	70.664	55	194.326	25	88.330		113	147.668	56	13.603	5	6.534
R.C steel	16500	t	1060	17490.000	27	4722.300	73	12767.700	20	2553.540	55	7022.235	25	3191.925		113	5336.199	56	491.556	5	236.115
P.C steel	25000	t	13	325.000	27	87.750	73	237.250	20	47.450	55	130.488	25	59.313		113	99.158	56	9.134	5	4.388
bearings	65000	t	18	1170.000	27	315.900	73	854.100	20	170.820	55	469.755	25	213.525		113	356.967	56	32.883	5	15.795
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
retaining wall	2000	m3	1500	3000.000	27	810.000	73	2190.000	20	438.000	55	1204.500	25	547.500		113	915.300	56	84.315	5	40.500
R.C steel	16500	t	150	2475.000	27	668.250	73	1806.750	20	361.350	55	993.713	25	451.688		113	755.123	56	69.560	5	33.413
new jersey barrier	1400	m	580	812.000	27	219.240	73	592.760	20	118.552	55	326.018	25	148.190		113	247.741	56	22.821	5	10.962
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
miscellaneous				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
lightings	580000	km	0.61	353.800	27	95.526	73	258.274	20	51.655	55	142.051	25	64.569		113	107.944	56	9.944	5	4.776
sighns & markings	340000	km	0.61	207.400	27	55.998	73	151.402	20	30.280	55	83.271	25	37.851		113	63.278	56	5.829	5	2.800
util. relocation	500000	km	0.61	305.000	27	82.350	73	222.650	20	44.530	55	122.458	25	55.663		113	93.056	56	8.572	5	4.118
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
				0.000		0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
total facilities & systems				53041.748		14321.272		38720.476		7744.095		21296.262		9680.119			16183.037		1490.738	·	716.064
												0.000		0.000			0.000		0.000		0.000
land	0	m2	0	0.000	0	0.000	100	0.000	0	0.000	0	0.000	0	0.000	0.000	0	0.000	0	0.000	0	0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
engineering	10	%	53042	5304.175	0	0.000	100	5304.175	40	2121.670	20	1060.835	40	2121.670		0	0.000	56	74.258	0	0.000
project admin.	5	%	53042	2652.087	0	0.000	100	2652.087	80	2121.670	20	530.417	0	0.000		0	0.000	56	37.129	0	0.000
subtotal				60998.010		14321.272		46676.738		11987.435		22887.514		11801.789	0.000		16183.037		1602.126		716.064
contingencies	5	%		3049.901		716.064		2333.837		599.372		1144.376		590.089	0.000		809.152		80.106		35.803
TOTAL				64047.911		15037.336		49010.575		12586.807		24031.890		12391.878	0.000		16992.189		1682.232		751.867

11.4 Economic Evaluation

11.4.1 Method/Premises

To estimate economic feasibility of each flyover proposed here, an economic evaluation is carried out with assumption that:

1. Costs of construction of each flyover are economic costs.
2. Benefits of each flyover are derived from VOC savings. VOC Savings is the difference between VOCs at concerned roads around the area where each flyover is planned to be constructed. Before the construction of each flyover, traffic volume is derived from the Traffic Survey carried out by this Study. After the construction new Traffic volume is appropriated including the concerned flyover.
3. Economic evaluation is carried out by each flyover. It means that the effect of the construction of a flyover is confined to its effect and not calculated by a simultaneous implementation of 3 flyovers.
4. Each flyover will be constructed during the years from 1991 to 1992. Construction costs (Initial Investments) will be distributed 25% in 1991 and 75% in 1992.
5. Evaluation term is 30 years from the commencement of each flyover's operation.

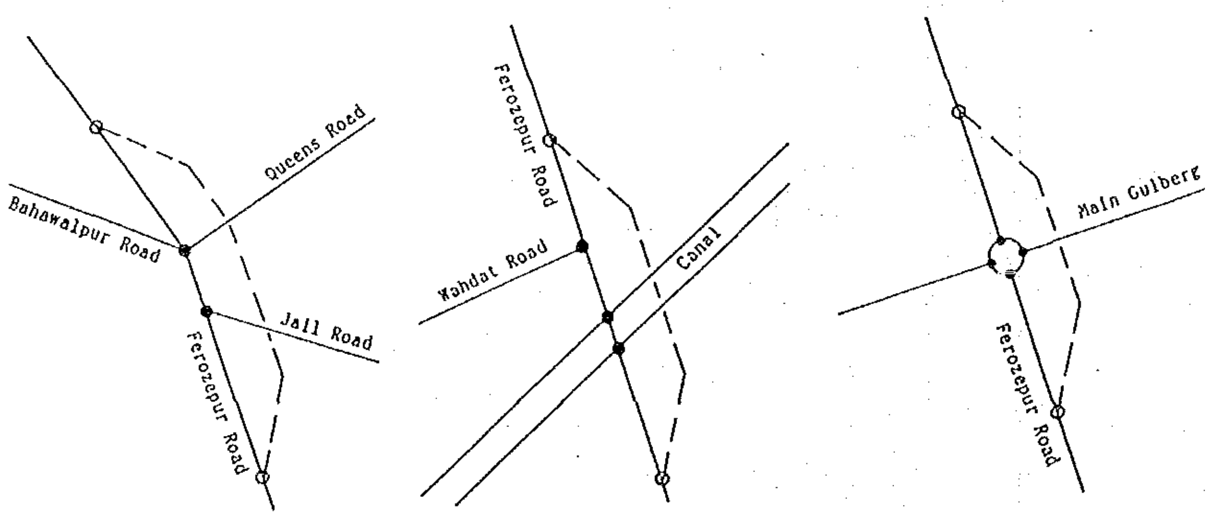
Three indicators such as the Net Present Value (NPV), the benefit-cost ratio (B/C Ratio) and the Economic Internal Rate of Return (EIRR) are chosen as comparable for economic evaluation.

11.4.2 Conditions for Evaluation

Outline of each planned flyover is shown in Figures 11.4.1.

Figure 11.4.1 Outline of Three Intersections

Qartaba Chowk   Canal Bridge Intersection   Kalma Chowk



Distance, average speed and traffic volume (in terms of PCU) of each concerned links with and without the flyover is tabulated as shown in Appendix Tables.

VOCs of each case are calculated applying Economic VOC shown in Chapter 9 and details in Appendix Tables. In this calculation, only the links directly related to the flyover and the flyover itself are applied "Improved Road Condition" VOCs.
VOCs of other links are calculated based on "Unimproved Road Condition" VOCs, because this evaluation is under the existing condition.

Results of VOCs before and after the construction of each flyover are as follows.

Table 11.4.1 Comparison of VOCs with/without Flyovers

(1990 constant price)

	Qartaba Chowk	Ferozepur/Canal	Kalma Chowk
Without Flyover ('000 Rs.)	340,623.2	850,059.7	1,039,322.2
With Flyover ('000 Rs.)	283,067.3	726.702.1	1,001,589.2
Difference ('000 Rs./day)	57,555.9	123,357.6	37,733.0
VOC Savings (Rs. mil. /year)	21,008	45,026	13,773

As the VOC Savings calculated above are the Economic Benefits of the first year of each flyover's operation, the cost/benefit flows for project life are developed and shown in the Appendix together with the costs of construction and annual operation/maintenance.

11.4.3 Evaluation Results

As shown in Table 11.4.2, every flyover seems to be quite economically feasible with more than 20% of EIRR.

Table 11.4.2 Economic Evaluation Results

	(1) Qartaba Chowk	(2) Ferozepur/Canal	(3) Kalma Chowk
B/C Ratio	2.53	5.03	2.05
Net Present Value (NPV)	101 million Rs.	287 million Rs.	56 million Rs.
EIRR	27.4%	49.3%	22.9%

These results are derived independently by each flyover and exclude other quantifiable Benefits such as savings of Travel Time Costs (TTC). As it is so, the results should be regarded very much conservative. And, if any 2 flyovers or all of flyovers are constructed simultaneously, favourable effects will be multiculated drastically.

In addition to the above evaluation, some aspects are considered and the conclusion is summarized in Table 11.4.3.

Table 11.4.3 Summary of Flyovers' Evaluation

Alt.	Name of intersection	Inflow traffic volume, exiting (PCU/hour)	Traffic change at flyover	Economic evaluation	Construction cost (Mil. Rs.)
1	Qartaba Chowk	Total =12,300 Per lane= 1,120	Under F/O Before =64,300 After =48,800 On F/O After =32,300	B/C ratio =2,527 NPV =101,035 (Mil. Rs.) EIRR =27.358%	103.4
2	Ferozepur Road/Canal bridge & Wahdat Road	Ferozepur Rd/ Canal Bridge Total =11,100 Per lane= 1,110 Ferozepur Rd/ Wahdat Rd Total = 7,900 Per lane= 990	Under F/O Before =93,700 After =58,500 On F/O After =37,100	B/C ratio =5,027 NPV =287,047 (Mil. Rs.) EIRR =49.290%	111.4
3	Kalma Chowk	Total = 9,600 Per lane= 870	Under F/O Before =106,600 After =61,400 On F/O After =48,500	B/C ratio =2,053 NPV=56,208 (Mil. Rs.) EIRR =22.876%	83.5

CHAPTER 12. LRT INTRODUCTION

CHAPTER 12 LRT INTRODUCTION

The necessity of LRT (Light Rail Transit) introduction in the future, as one of the alternative higher capacity public transport system, has been proved in the previous chapters, and further feasibility is studied to a certain extent in this chapter.

12.1 Planning Direction

At the beginning of feasibility study, the following conditions are considered as the basic directions/premises for planning.

(1) Target year

The year 2010 is set as the year to start normal commercial operation.

(2) Route

The first priority section, in consideration with future extension of network explained in the master plan, is selected for feasibility study; the corridor along Ferozepur Road from the existing urban activity center to Model Town.

(3) Segregation from other existing modes

Grade-separated system is applied, in order to keep punctual and convenient service, avoiding the traffic congestion on roads.

(4) Harmony with other existing modes

Public transport users can chose any alternative modes; bus, railway and other public transport, by their preference and convenient transfer to/from LRT can be available at stations.

(5) Landscape

Careful consideration is necessary, in route planning and structure design, from the aspect of preservation of historical landscape, greenery and scenic beauty in Lahore.

(6) Terminal Development

LRT stations provide various opportunities to renew/redevelop the built-up area surrounding the station. This potential of the urban development should be considered from the beginning stage of the plan.

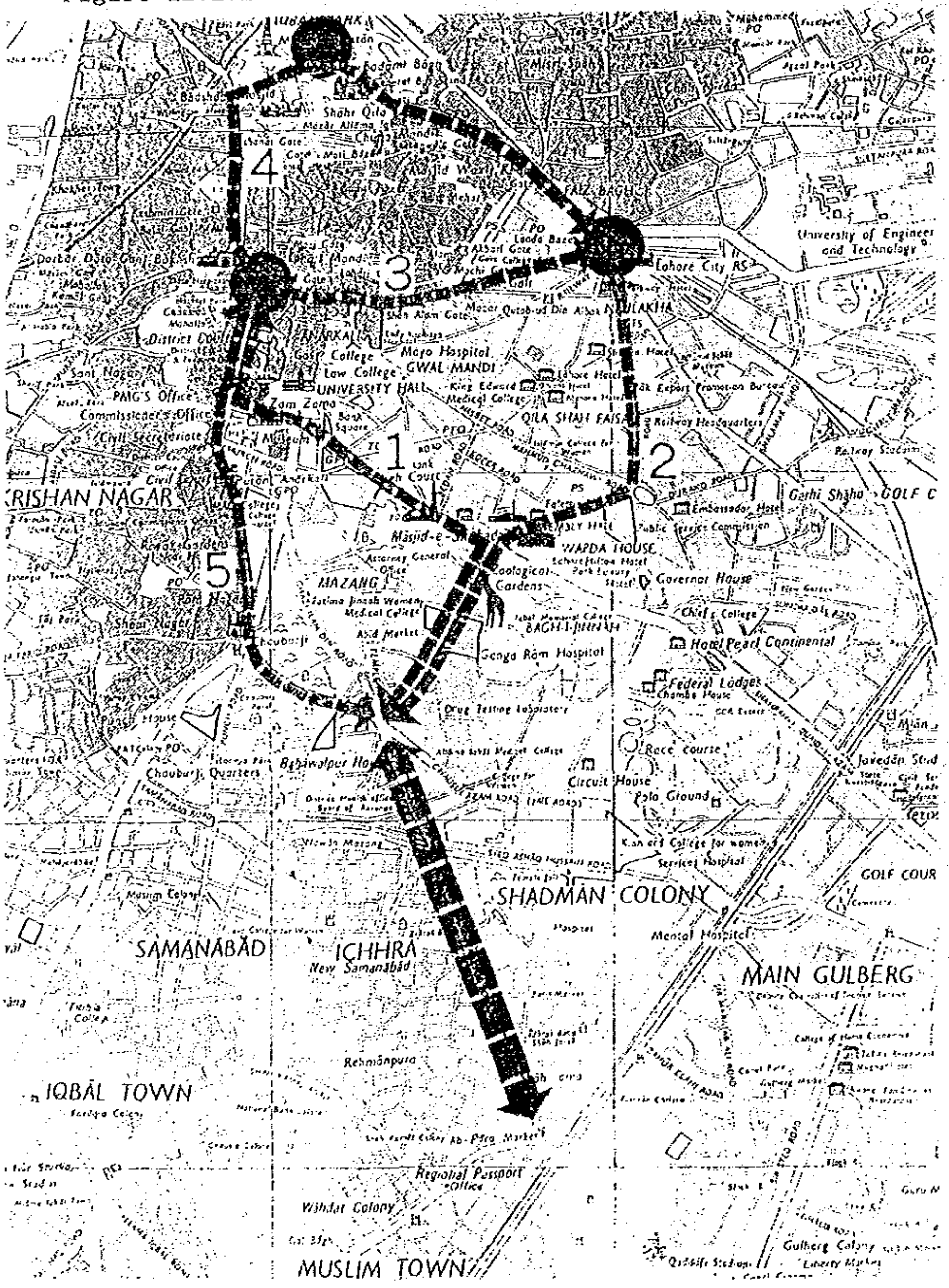
12.2 Route Alternatives

The basic route of the preliminary line is determined in the master plan study, and a proposed route to examine its feasibility is studied and selected from the following some points-of-view.

12.2.1 Starting Point and North Section

The alternative routes in the north section are selected as shown in Figure 12.2.1.

Figure 12.2.1 Alternative Routes in the North Section



Three candidates were listed as the starting point of the LRT line in the north.

a) Lahore city railway station
b) Badami Bagh
c) Data Darbar

Each area was compared from the following points:

- Availability of terminal space
- Transfer to/from other modes
- Route possibility towards south
- Demand generation/attraction
- Land use
- Location suitable for future extension

Regarding route alternatives, there are five alternative alignments and they are compared with each other.

The most well urbanized areas, including government offices, business center, commercial areas, etc., are located along the route of No. 1, No. 2 and No. 5.
While, the construction difficulties by existing buildings, road narrowness and land use along the alternative routes are found in the case of No. 2, No. 3 and No. 4.

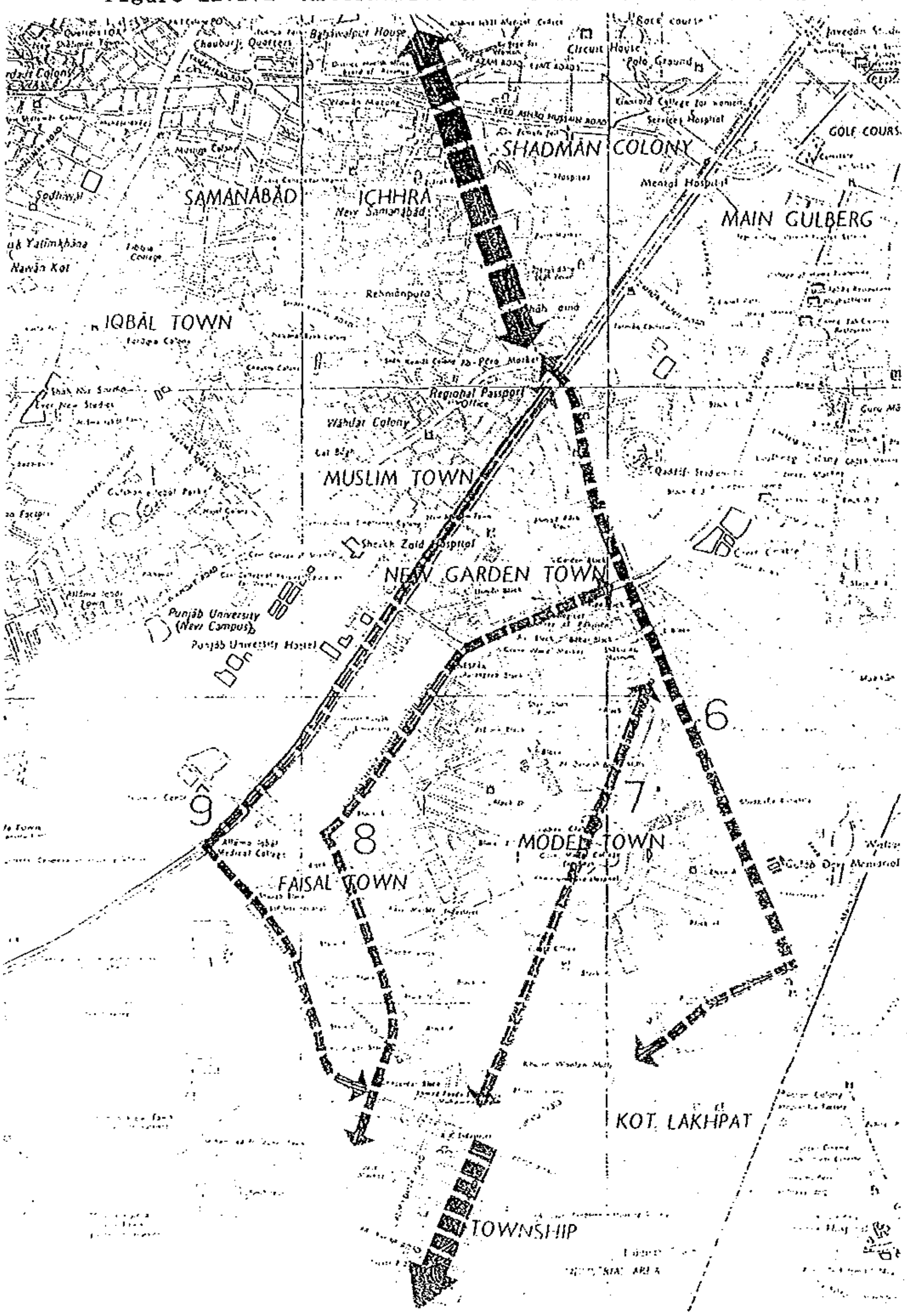
The route alignment for the initial stage, therefore, was selected so as to connect Data Darbar, Lower Mall, the Mall, Queens Rd. and Ferozepur Rd. in the north section.

12.2.2 South Section and South Terminal

In the southern part of the LRT route, four alternative routes are planned, taking urbanization condition, existing road conditions and topographic condition into considerations.

These alternatives are shown in Figure 12.2.2.

Figure 12.2.2 Alternative Routes in southern Section



The alternative route No. 6 is selected in this feasibility study, because of easiness of construction and larger demand.

At the same time, route No. 6 has certain advantages for the connection with Pakistan Railway towards south and for available land of car depot site in Kot Lakhpat area.

The detailed route alignment is illustrated in Figure 12.2.3, and more details are in the attached "Drawings".

This route also covers the heaviest public transport corridor along Ferozepur Road, as shown in Figure 12.2.4.

Figure 12.2.3 Proposed LRT Route

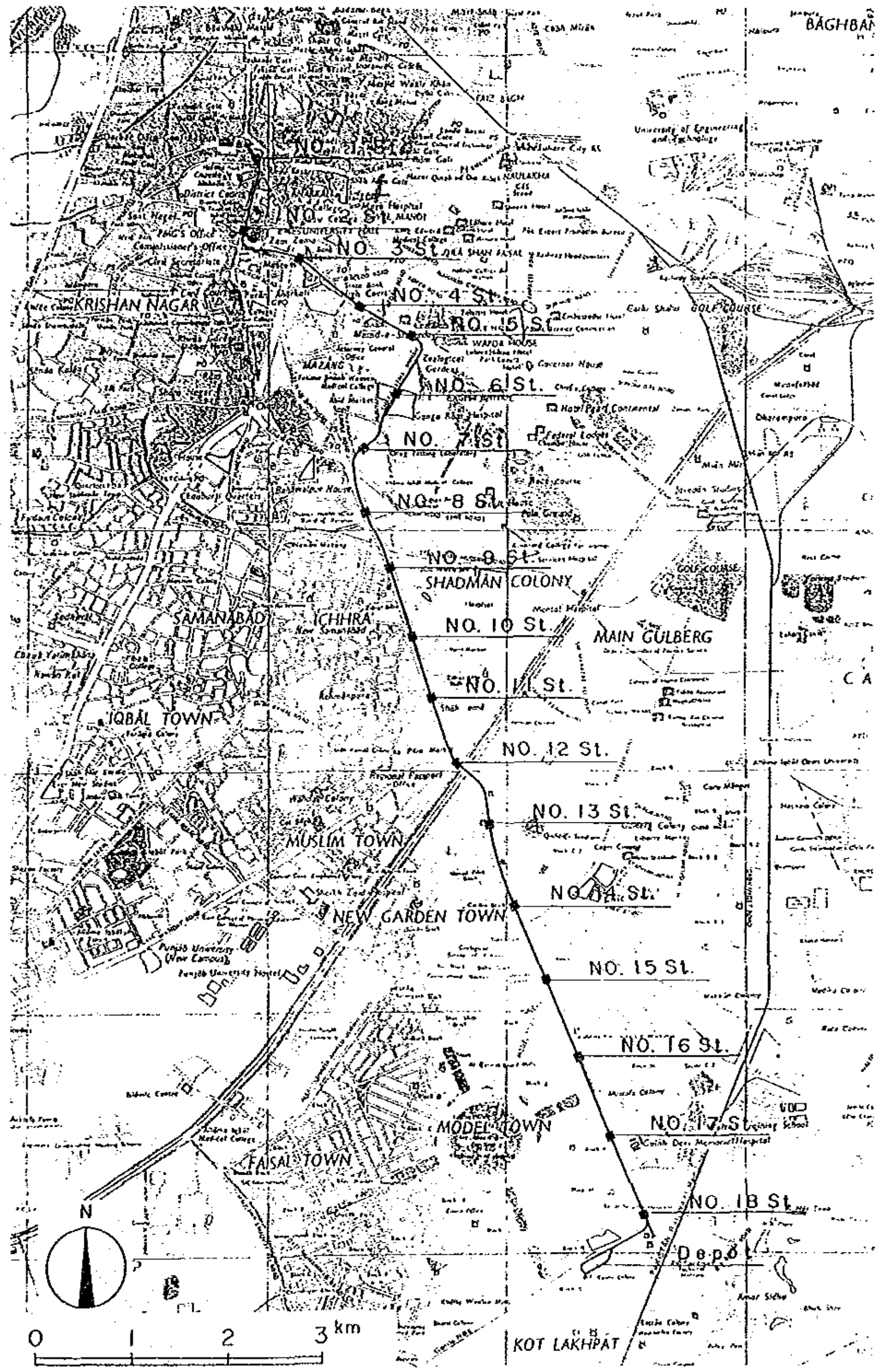
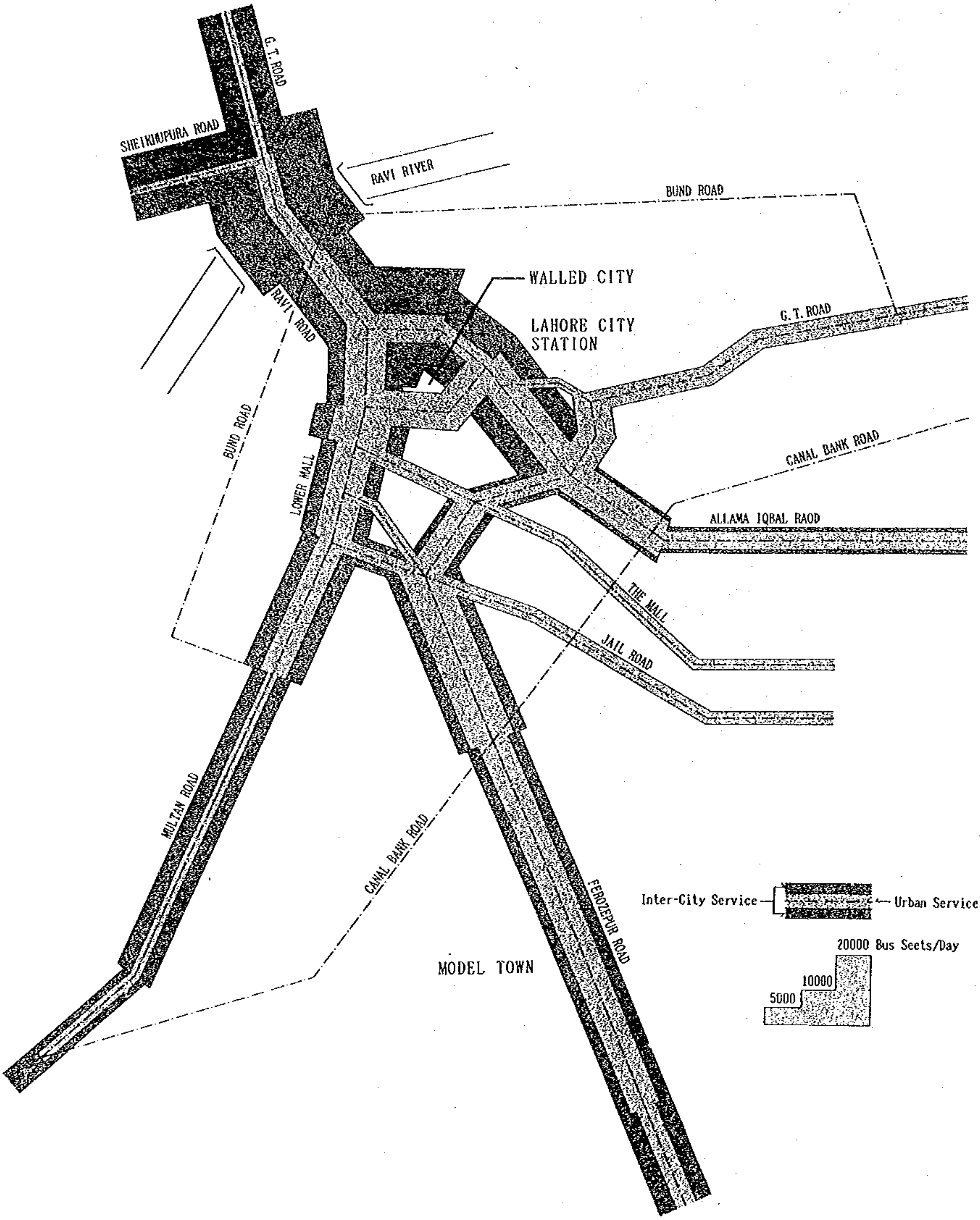


Figure 12.2.4 Present Public Transport Corridor



12.3 Demand Estimate

12.3.1 General

The demand forecast of proposed LRT is one of the most important factors to examine the feasibility of the project.

Since there are many uncertain factors at this stage, the following premises are considered.

- LRT, HRT and Buses are three competitive modes of public transport.
- Public transport users can choose any mode by their preference; travel time, fare, comfort, etc.
- Transfer between each mode will be improved.
- In this forecast, diversion from private transport to public is negligible.

12.3.2 Traffic Assignment for Public Transport Network

Based on the proposed transport network in 2010 and the estimated 2010 public OD table, the traffic assignment was done for each mode; LRT, HRT and Bus.

(1) Modal split of public transport in future

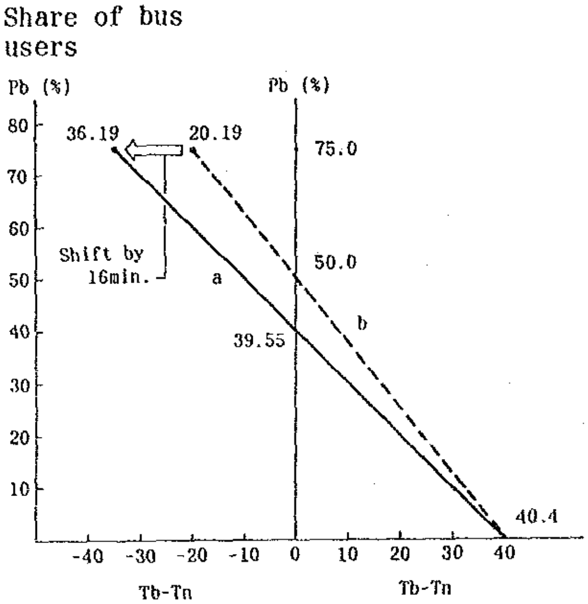
A model formula showing the modal choice relationship was discussed in Chapter 4, which showed very small shares in the use of existing trains compared to buses (including minibuses). The model is revised here to forecast volumes of passengers on the proposed LRT lines and PR commuter trains (HRT).

Buses passenger interview survey in Chapter 4 showed the following information: approximately 75% of the interviewed persons showed preference of faster new service even in the face of higher fares.

	Additional Average payment	Average Time Reduction	Rs./min.
75%	Rs.1.31	8 min.	0.16
75%	Rs.1.88	16 min.	0.11
75%	Rs.2.32	24 min.	0.10
75%	Rs.1.88	16 min.	0.12

In Figure 12.3.1, the line "b" shows a hypothetical tendency of modal shares of buses (including minibuses) and LRT in a sense that if frequency and fare are quite similar and the travel time is equal between the two modes, the share must be 50% respectively. As discussed in Chapter 4, the passengers at 75% are in favor of faster service with a higher fare. The line "a" can be drawn by shifting the line "b" toward left by 16 minutes, where "16 minutes" is accompanied by a higher fare by Rs.1.88 in average on one ride.

Figure 12.3.1 Diversion Model : Buses vs. LRT



b : Pb = 50.00-1.238*(Tb-Tn)

a : Pb = 39.55-0.979*(Tb-Tn)

Pb: The percent share of bus

Tb: Travel time by buses

Tn: Travel time by the new mode including LRT

Line b: To be used for the estimate of diversion in future

Pb = 39.55 - 0.967 * (Tb-Tn), Pn = 100-Pb

where, Tn : the travel time from O to D by new mode

Tb : the travel time from O to D by buses

Pb : the percent share of bus users (%)

Pn : the percent share of new mode users (%)

The new line "b" in the figure may include the following factors and can be used for the approximate of passengers on the LRT in 10-15 years from now.

- A relatively higher fare for the better service reduces the diversion ratios for the new service. Higher speed and better service will shift the line "b" toward the left, while a higher fare toward the right in the figure.

- The new service by LRT will have frequent train service of 2-6 minute interval at an average travel speed of 30 km.

- The waiting time at the stop is assumed as follows:

LRT	:	4 minutes in the average through a day
Bus on roads	:	5 minutes in the average through a day
Bus on priority lane	:	5 minutes in the average through a day
Heavy rail urban service	:	10 minutes in the average through a day
Walk	:	5 minutes for both origin side and destination respectively

(2) Applied model

Based on the above analysis, the following model of modal choice is practically applied for the demand estimate by computer simulation, between LRT, HRT and Bus. The line a in Figure 12.3.1 is reshaped into a logit curve as under:

$$P = \frac{1}{1 + e^{a+b\Delta T+c\Delta C}}$$

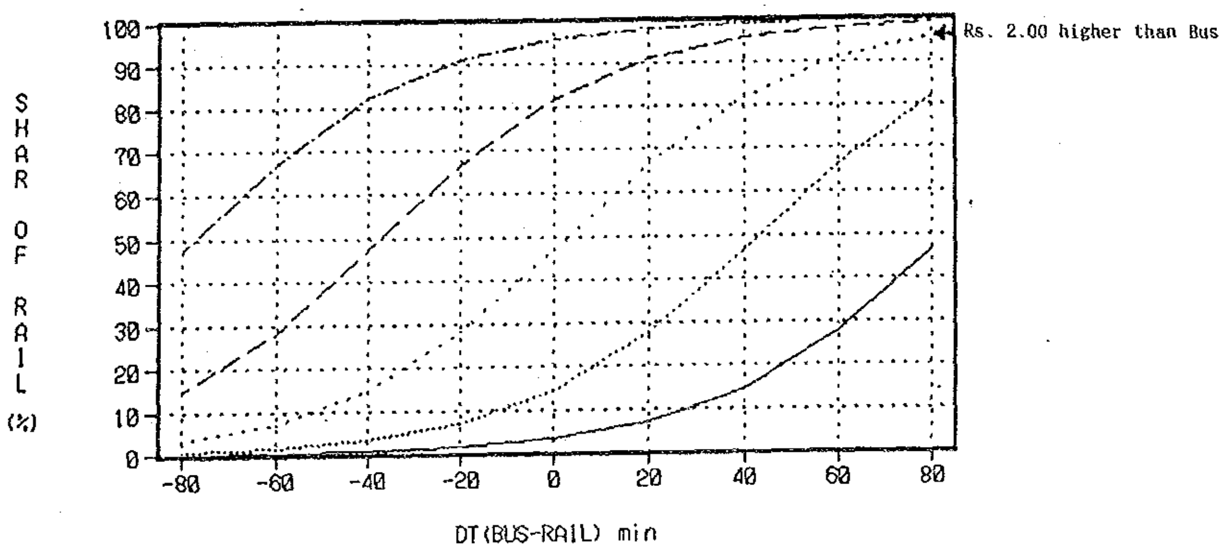
where, P: Share of Rail in %

ΔT: Time difference, Bus-Rail

ΔC: Cost difference, Bus-Rail

a,b,c: parameter a = 0.127
b = -0.041
c = -16.500

Figure 12.3.2 Applied Model of Modal Choice



12.3.3 Assignment Result for 2010

1) LRT and HRT

Using the OD matrix of public service person trips in 2010, the network of LRT, HRT and Bus routes on roads in 2010, and the modal split model, the users on LRT are estimated. Figure 12.3.3 shows the estimated passengers on LRT+HRT in 2010.

The total of passengers per day in 2010 is 231,000 on LRT and 71,300 on HRT. The maximum number of passengers is found at the mid-section between the 10-12 (Ichhra-Canal) stations, 163,000 persons in the total of both directions per day. Passengers changing the line between HRT and LRT on the crossing point of Model Town south are estimated at 25,900 persons in both directions.

2) LRT and Buses

Figure 12.3.4 shows the passengers on the new transit services and those on the buses on the parallel roads.

* On the sections south of Canal Rd crossing to Model Town South, 53% of passengers (108,700 persons) are on LRT.

* Between Kalma Chowk and Canal, 46% (131,000 persons) are on LRT.

* Between Wahdat Rd and Ichhra, 65% (163,000 persons) are on LRT.

* Between Qartaba Chowk and Ichhra, 74% (156,000 persons) are on LRT.

Figure 12.3.3 Passengers on LRT & HRT, 2010

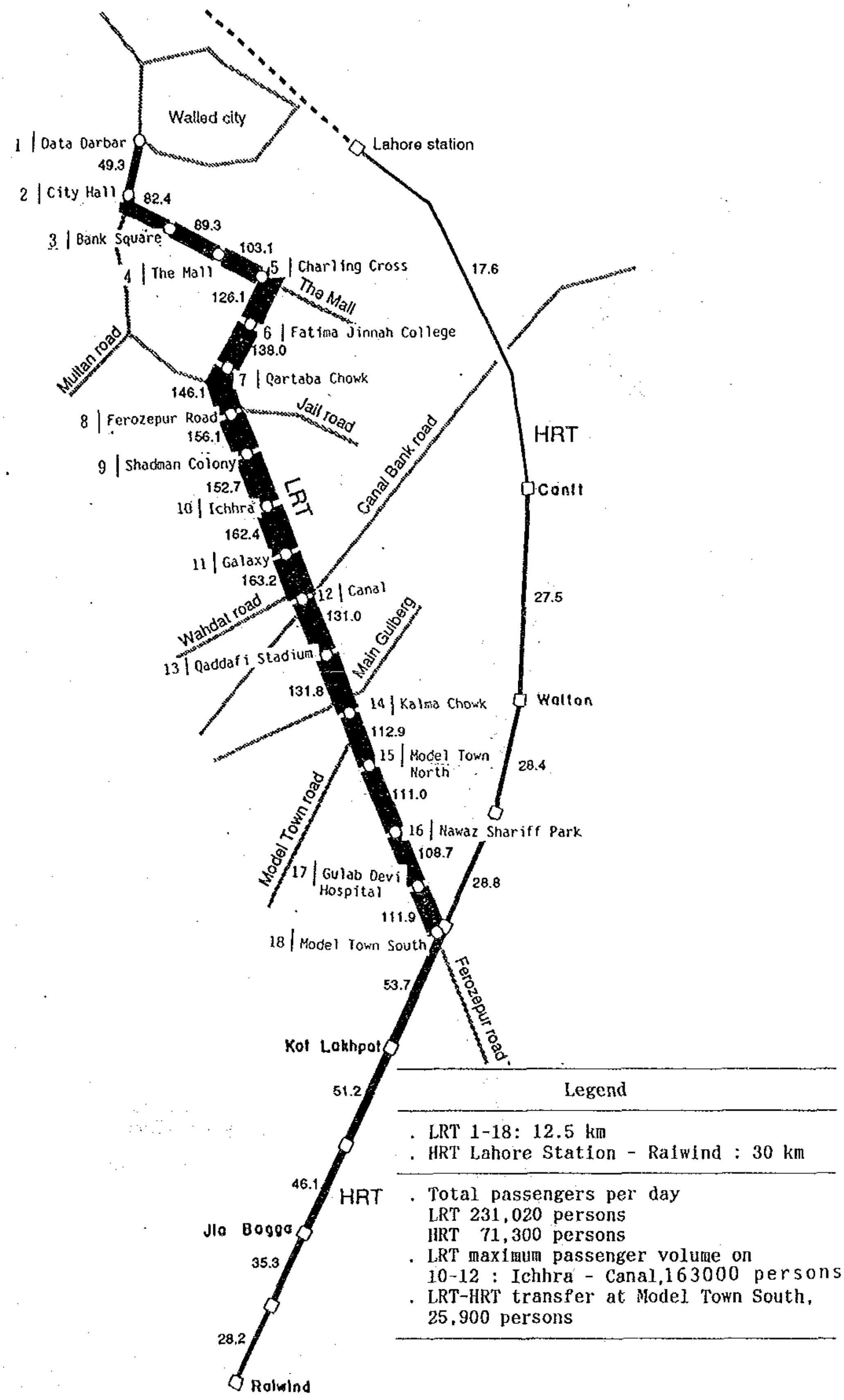
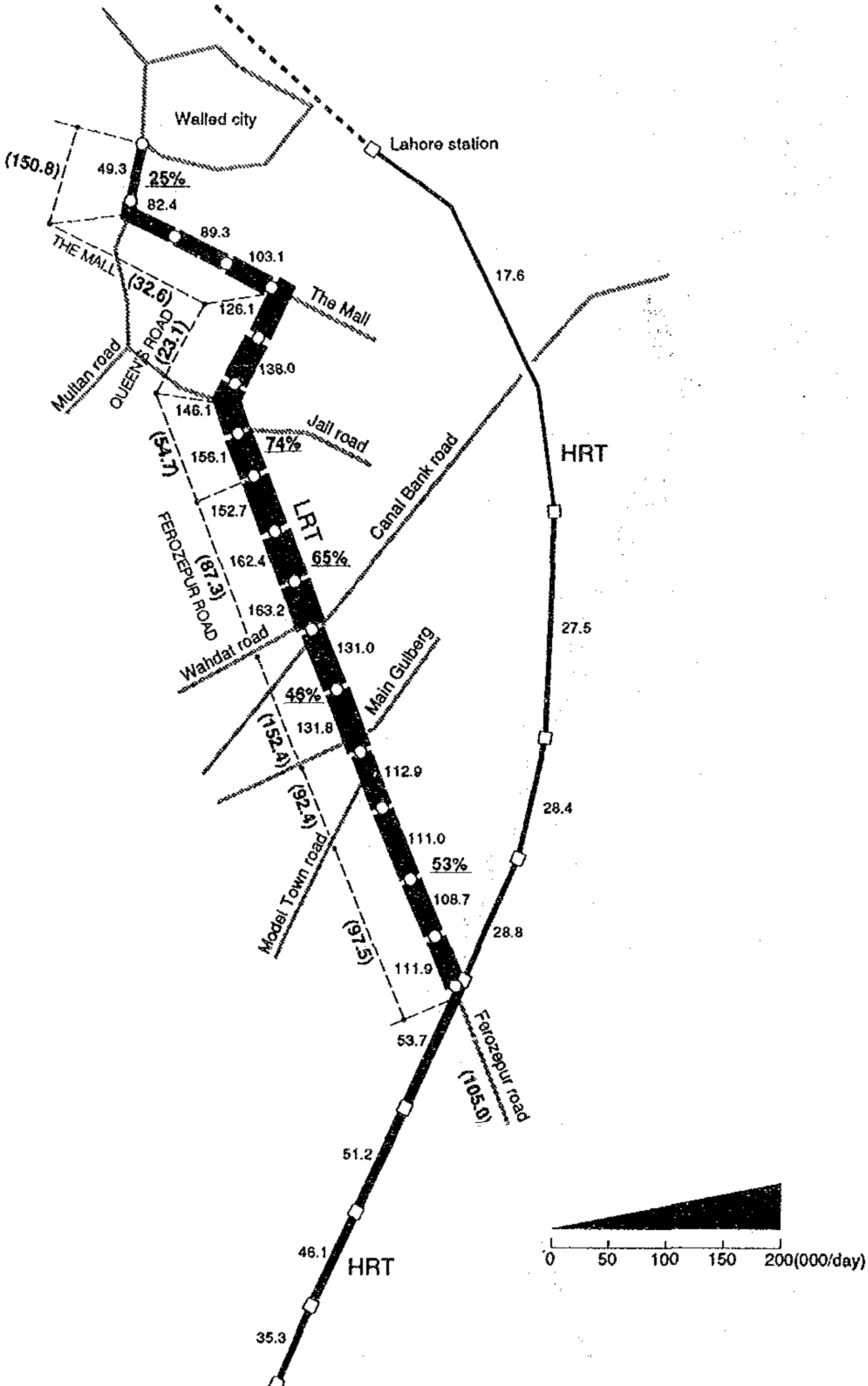


Figure 12.3.4 Passengers on Buses and LRt, 2010



The following figures are the summary of traffic assignment for the selected plan (LRT & HRT). They indicate substantial reduction in the total travel distances and hours through LRT & HRT when compared with "without in 2010".

Plan	Do Nothing With clean up 1990	Do Nothing With clean up 2010	LRT & HRT, 2010 LRT = 12.5 km HRT = 40.0 km
Daily passengers	—	—	LRT = 231,000 HRT = 71,300
Max. passenger sections	—	—	LRT = Ichhra - Canal 163,000 HRT = Model Town South - Kot Lakhpat 53,700
Total pass.-km in PCU'000*	10,905.9 (100)	23,528.9 (215)	22,565.0 (207)
Total pass.-hour in PCU'000*	744.8 (100)	3,401.5 (457)	2,217.0 (298)

*Including private and public motorized vehicles.

3) Medium sized bus

Currently, 75-80% of public buses are minibuses of 14-18 seats on Ferozepur Road. If the percent composition of minibus 77% and regular bus 23% are maintained in 1990 and 2010 without LRT & HRT, the total buses on mid-Ferozepur Section will be 6,500 for 1990 and 12,500 for 2010. If LRT & HRT are constructed, buses can be 4,400 in 2010. They are shown in Table 12.3.1.

If medium buses will replace minibuses to operate with a larger capacity per bus, the total bus traffic on that section can be reduced by nearly half (by 47%). The example case on mid-Ferozepur section is also shown in Table 12.3.1. Use of a larger bus size is discussed in Chapter 13 and actions for gradual size change are recommended.

Table 12.3.1 Bus Size and Traffic Volume

Mid-Ferozepur Section [Ichahra - Canal (Muslim town Chowk)]
No. of buses/passengers on roads.

		1990 Present	2000 without LRT&HRT	2010 without LRT&HRT	2010 with LRT&HRT
i Bus passengers		130,000	180,200	249,700	87,300
ii Bus volume converted by 20 occupants/bus[1] for all types of buses					
	Total	6,500	9,020	12,500	5,300
	Reg.	1,500	2,070	2,880	500
	Mini	6,500	6,950	9,620	4,800
iii 1/3 of Minibuses are replaced by medium buses with 30 occupants in 2001 and 2/3 in 2010.[3] The total buses will be: [2]					
	Total	-	7,785	9,080	3,595
	Reg.	-	2,070	2,880	500
	Med.	-	1,085	2,990	1,495
	Mini	-	4,630	3,210	1,600

Notes : 1) Average occupants 14.0 for a minibus and 40.0 for a regular bus (Table 9.3.8) in 1990. (14.0x77%)+(40.0x23%) = 20.0/average bus.
2) if 30 occupants per medium bus would be used instead of the 14 occupant minibus, the average occupants are 37.6. Using this unit, the passengers are converted to the large sized buses.
3) Of minibuses, 1/3 will be replaced by medium buses in 1996-2000 and 2/3 will be replaced in 2001-2010.

12.4 Train Operation

(1) Train operation route

Every train will be operated through the whole route between Data Darbar station (North Terminal) and Model Town South station (South Terminal). No trains will turn back at any en-route station.

(2) Scheduled speed

The scheduled speed is estimated at 30 km/hr, based on the characteristic performance of the proposed railcar (see paragraph 12.5) and the proposed route alignment (see Paragraph 12.3). The maximum speed is proposed to be 80 km/hr.

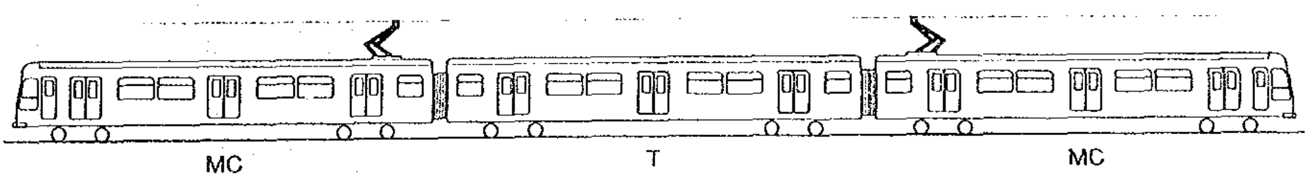
(3) Train headway

The minimum train headway is proposed to be two minutes. Shorter headway is desirable to attract passengers, however, the headway shorter than around two minutes is not practical.

The headway in off peak hours will be longer depending on traffic demand.

(4) Train formation

The number of railcar composing a train is decided based on the forecast traffic volume and the proposed train headway.
The maximum traffic flow has been estimated at 163,240 at the section between Galaxy station and Canal station (see paragraph 12.2). On the other hand, the minimum train headway has been estimated at two minutes. Therefore, the number of railcar composing a train is computed to be three consisting of two driving cars and a trailing car. The train formation will not be changed even if the traffic volume is changed. In such case, only train headway will be changed instead of train formation. The train composition will be two driving cars with each driver's cab and a trailing car as shown in the following figure:



Note
MC : driving car with driving cabin
T : trailing car

Trailing cars or driving cars without driver's cabin can be added at the middle of the train set, if passenger volume increases in future.

(5) Number of train sets to be operated

The number of train sets required to operate the LRT system will be computed based on the scheduled speed and the minimum train headway.

scheduled speed:	30 km/hr
minimum train headway:	2 minutes
time required to turn back at each end station:	4 minutes

Therefore, the number of train sets to be operated is:

29 train sets

(6) Number of railcar required

The number of railcar required is computed as follows:

Number of train sets to be operated:	29 sets
Train formation:	Mc + T + Mc
Ratio of contingency for inspection and repair:	assumed to be 20 %

Therefore,
Number of railcar required:

Mc	70
T	35

12.5 Railcar and Car Depot

12.5.1 Railcar

(1) Track conditions

The track conditions on which the railcar will be operated are as follows:

Track gauge	1,435 mm
Maximum gradient	
on main line	2.5 %
on connecting line with car depot	4.0 %
Minimum radius curve	100 m

(2) Type of railcar

There are two types of railcar. One is articulated type and another is non-articulated type. The former is suitable to be operated on tracks having curves with small radius. Accordingly, this type is usually applied to tram cars operated on streets on which sharp curves may be located at road crossing. The latter is not available to run through such sharp curves. However, unit costs of manufacturing and maintenance for railcar of this type are usually less than that of the former type.

The minimum radius of the curves on the proposed track will be 100 meters. Therefore, non-articulated railcar will be introduced since they are available to be operated easily on the proposed tracks.

(3) Dimensions

Small size railcars are desirable to reduce construction cost of tracks, viaduct and other civil structures. However, railcar size is the smaller, railcar cost per passenger will be the higher.

Considering the forecast traffic volume, the dimensions of the railcar are proposed as follows:

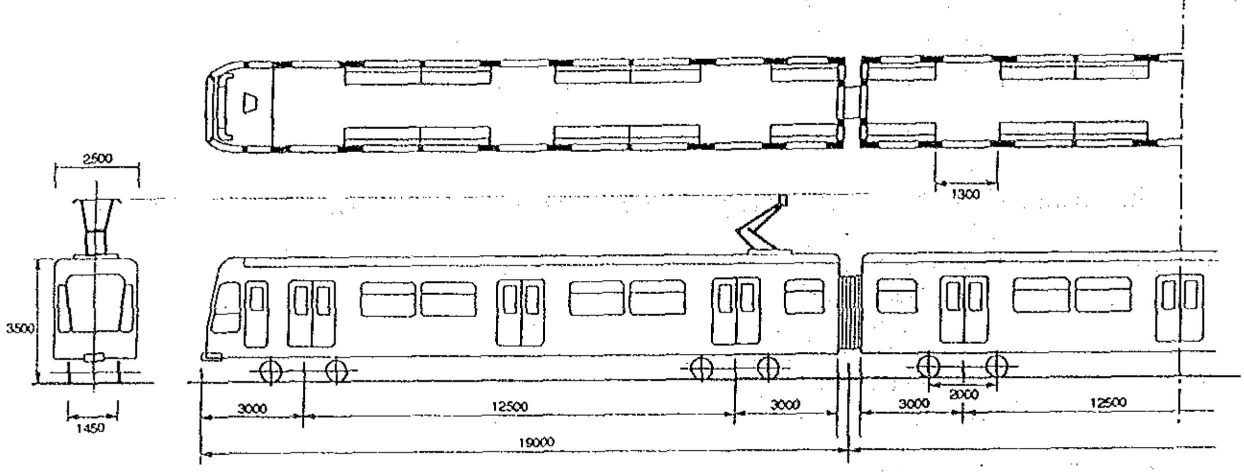
Track gauge	1,435 mm
Body length	18.5 m
Total width	2.5 m
Height (rail to roof)	3.5 m
Floor height	0.95 m
Wheel diameter	0.66 m
Tare weight	
driving car	31 t
trailing car	26 t

Passenger capacity

	seating	standing
driving car	48	148
trailing car	56	154

The general views of the proposed railcar are shown in Figure 12.5.1.

Figure 12.5.1 General View of Proposed LRT Railcar



(4) Characteristic performance

High acceleration and deceleration of railcar are essential to reduce travelling time in case that distances between stations are short. On the other hand, the maximum speed is not necessary to be high in such case.

The characteristic performances of the railcar are proposed as follows:

Line voltage	DC 1,500 V
Maximum speed	80 km/hr
Maximum acceleration	1.0 m/s/s
Deceleration at service braking	1.3 m/s/s
Deceleration at emergency braking	2.1 m/s/s

12.5.2 Railcar Depot

A railcar depot will be constructed for the purpose to park, clean, inspect and repair the railcar. The location of the depot is shown in the attached Drawings No. 23.

(1) Number of railcar to be accommodated

The number of train sets to be owned is 35 sets as mentioned in paragraph 12.4 (6). In midnight, 3 sets will be parked at the north terminal station and the remains will be accommodated in the railcar depot, because no trains will be operated in midnight.

(2) Maintenance of railcar

The maintenances of the railcar are divided into two categories. One is heavy maintenances executed in the workshop, and another is light maintenances executed in the light maintenance shed. The kinds of maintenances are as follows:

Light maintenance

daily maintenance
weekly maintenance

monthly maintenance

Heavy maintenance

yearly maintenance
two-yearly maintenance

The extra repair will be executed in addition to the above maintenance, if necessary.

(3) Railcar washing

The railcar will be washed daily. The washing will be done when train sets are passing through the washing plant.

(4) Facilities of railcar depot

The following facilities are necessary to execute the works mentioned above.

- Tracks (outdoor)
  . stabling track
    effective length   19 m x 3 car x 27 set = 1,539 m
  . washing track
  . test track
  . receiving and dispatching tack
  . pull up track

- Light maintenance shed
  . building
  . daily maintenance track   2 tracks
  . weekly maintenance track   2 tracks
  . monthly maintenance track   1 track
  . machine shop

- Workshop
  . building
  . mantle and dismantle track   2 tracks
  . body repair shop
  . truck repair shop
  . traction motor shop
  . other electrical parts shop
  . machine shop
  . painting shop

- Washing plant
- Warehouse
- Signal cabin
- Welfare building

(5) Layout

The layout of the proposed railcar depot is shown in the Drawing No. 23.

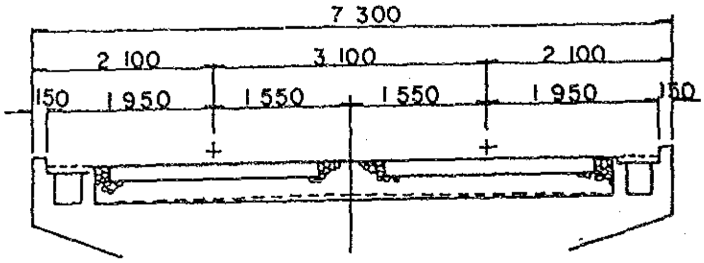
12.6 Civil Works

A complete construction of LRT system consists of railcar, track, structure, stations, power supply, signalling and telecommunications, car depot, etc. Civil works, in this chapter, deal with track, structures and stations.

Civil works occupy the most construction cost among the above work items. Therefore, they must be planned economically, easy-constructed and maintenanced, and well-coordinated with other facilities.

12.6.1. Track

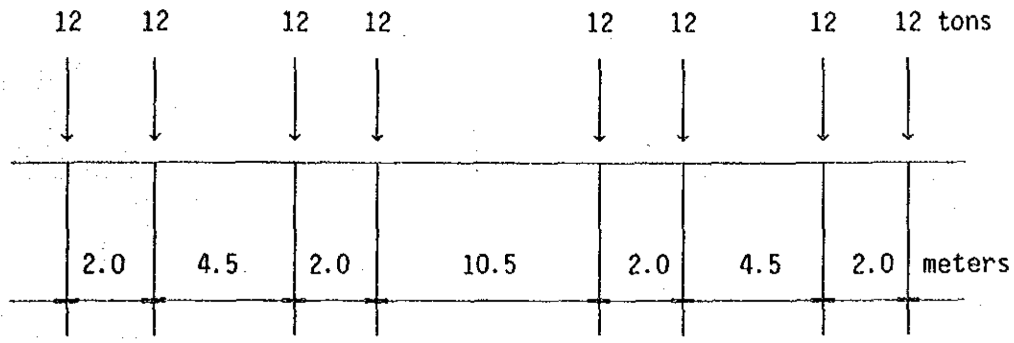
(1) Track dimension:



(2) Track design standards:

Item	Standard	Remarks
Gauge	1,435 mm	
Maximum design speed	80 km/hr	
Maximum curve radius	100 m	for main track
	80 m	for depot
	300 m	for station section
Maximum grade	2.5 %	for main track
	1.0 %	for station
Vertical curve	2,000 m	in horizontal curve R<800m
	3,000 m	in horizontal curve R>800m
Track-center distance	3.1 m	for main track
	4.0 m	for depot
Rail	50 kg/m	
Sleeper	concrete	
Ballast thickness of track	200 m	under the sleeper
Turnout	No.8 (1:8)	for main track
	No.6 (1:6)	for depot
Live load	12 ton/1 axle	train moving load
Over head clearance	4.7 m	clearance between the bottom of structures and the road surface

(3) Train live load



12.6.2 Structures

The type of elevated structures will be selected on the basis of the following ideas.

(1) The main structures will be made from reinforced and prestressed concrete for the convenience of local procurement and on-site construction. The use of steel structures will be avoided, if possible, except in special parts.

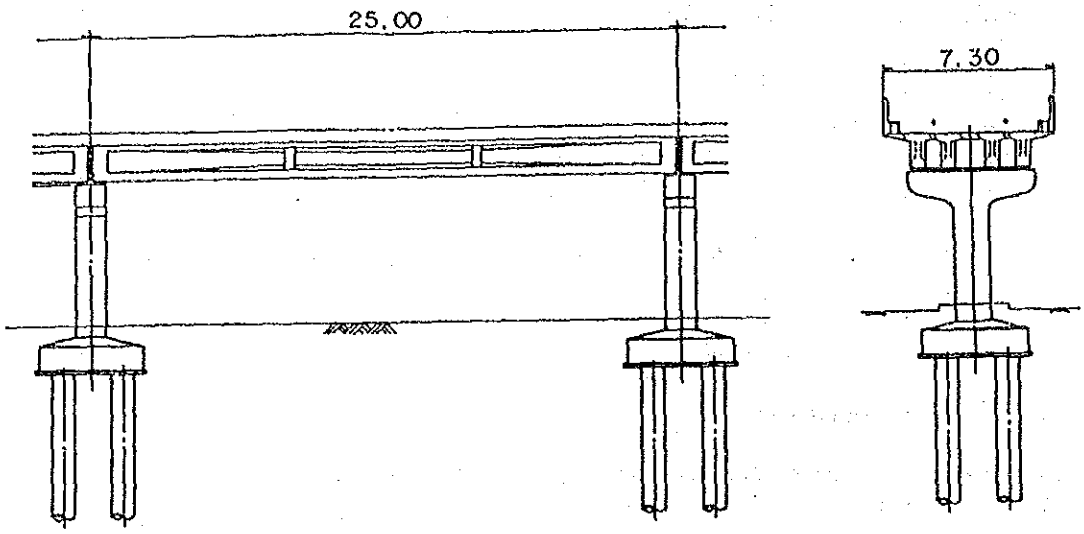
(2) Elevated structures will be carefully designed for noise and vibration issues as well as scenic beauty.

(3) Elevated structures will be planned to overpass roads with one or two spans. Their piers will also be placed not to obstruct road traffic and buried objects.

(4) The length of each span should be uniform so that all structures will be designed as a standard type for both sub-structures and super-structures.

From the above viewpoints, the prestressed concrete (PC) girder with 25 meters long per span is adopted for the super-structure along the existing road. In the same manner, reinforced concrete (RC) pier with cast-in-place concrete piles is adopted for the sub-structures. Structures are supported by the pile foundations penetrated through deep sand stratum. General view of structures are illustrated on Figure 12.6.1.

Figure 12.6.1 General View of Structures



12.6.3 Stations

There are two types of station. One is the station with separate platform and other is the station with island platform. The advantages and disadvantages of each type are shown below.

width of platform	Separate platform	Island platform
Track alignment	o	x
Future extension	o	x
Construction cost	x	o
Width of platform	x	o

Generally an island platform is preferable where the length of train formation is greater than 200 m. If train formation length is shorter than 100 m, separate platforms are preferable in most cases. Based on the above comparisons, separate platforms will be adopted in this project.

Location of station will be determined by the following ideas.

(1) Each station distance must be suitable for LRT system (ex. 700 to 1,200 meters interval is the standard distance for urban railways.)

(2) Coordination with urban planning and with other related public facilities must be considered.

(3) Transferring to and from other transportation systems must be easy as well as accessibility for passengers should be achieved.

Based on the above reason, JICA Study team selected the location for each station as follows:

No.	Station name (temporary)	Station mileage (Km)(m)	Distance between (m)	Remarks
1	Data Darbar	0 000	-	Darbar Data Ganj Bakhsha
2	City Hall	0 600	600	City Hall, District Courts
3	Bank Square	1 240	640	Bank Square, Museum
4	The Mall	1 850	610	Masjid-e-Shohada
5	Charling Cross	2 450	600	Assembly Hal, WAPDA House
6	Fatima Jinnah College	3 190	740	Fatima Jinnah Medical College
7	Qartaba Chowk	3 940	750	Junction with Lytton Road, Jail Road Bahawalpur Road ad Queens Road
8	Ferozepur Road	4 600	660	
9	Shadman Colony	5 250	650	
10	Ichhra	5 880	630	Bus terminal
11	Galaxy	6 650	770	Markets and theaters
12	Canal	7 420	770	Junction with Wahdat Road and Canal Road
13	Qaddafi Stadium	8 120	700	Qaddafi Stadium
14	Kalma Chowk	8 890	770	Junction with Main Gulberg Road
15	Model Town North	9 910	910	Junction with Model Town Road
16	Nawaz Shariff Park	10 700	900	Park
17	Gulab Devi Hospital	11 600	900	Gulab Devi Memorial Hospital
18	Model Town South	12 500	900	Bus terminal
		Average Distance between stations	735.3	

(1) Main facilities in station

The main facilities of a station are as follows:

. Guiding facilities : Concourse, passage, etc.
. Passenger facilities : Ticket sales, ticket barrier, etc.
. Station office facilities : Room for stationmaster and staff, etc.

(2) Platform

. The length of platform is 70 meters by adding 13 meters of allowance to 57 meters of the train length.
. The width of separate platform is 4 meters each.

(3) Platform shed

For each station, a platform shed is provided in the portion near the stage and concourse.

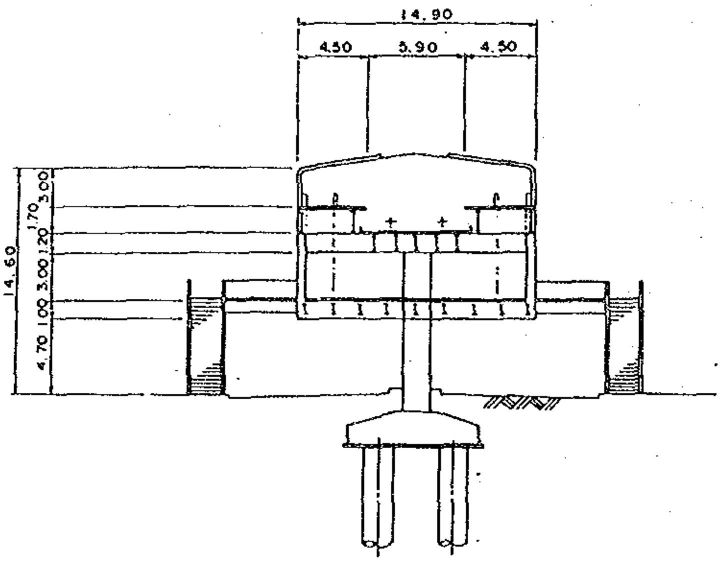
(4) Other related facility plan

As the related facilities to be provided as station facilities, there are many for offering services to getting on and off passengers

(public facilities, commercial facilities, etc.), facilities incidental to station services (parkings, connecting bus terminals, etc.) and so on, which display their terminal functions in combination with the station squares as one body.
It is recommendable for these related facilities, therefore, to plan and provide such a station square as matching the circumstances surrounding each station.
Station layout is shown in Figure 12.6.2.

Figure 12.6.2 Station Layout

Sectional view



12.7 Power Supply, Signaling and Telecommunications

12.7.1 Power Supply

(1) Supply network

The power supply system for the LRT will receive electric power for traction, lighting and auxiliary purpose from the power distribution network of WAPDA Lahore at the voltage of AC 132 kV or 66 kV.

(2) Substation

The electric power for traction is transformed and rectified into DC 1,500V at the substations of the LRT and distributed to the feeder line. The low voltage power, which is fed to the stations and facilities, is transformed at the substations into AC 220V and distributed to the sites. The substations will be located as to minimize the line losses and to keep permissible voltage drops.

Major items applied to substations are as follows:

- Number of substations	
along line	5
in depot	1
- Average spacing	2.5
- Type of substation	in door
- Rectifier unit	
numbers per st.	5
nominal rating	2,000kW, 1,500V

(3) Overhead contact line

The electric power is supplied to railcars of trains through overhead contact lines. The overhead contact line system will consists of contact wires, catenary wires, messenger wires and supporting structures, the composition of which will be determined due to train operation conditions such as the maximum speed, the minimum train headway and the motor power of the operated trains.

For the LRT, a simple catenary system with single contact wire is proposed. Rigid cantilever arms to support the catenary system will be installed as shown in the Drawing No. 22.

12.7.2 Signaling system

The signaling system will be equipped to ensure the safety of the train operation. The proposed signaling system consists mainly of automatic block system, relay interlocking device and automatic train stop equipment.

(1) Automatic block system

The automatic block system will be provided to get smooth operation along the line by spacing the trains. Only one train can enter each block section following the aspects of the automatic signals. The type of the proposed automatic signals is a wayside signal, and the kind of aspects of the automatic block signals are as follows:

Color	
Green	Proceed
Yellow	Proceed with expectation to stop at next signal
Red	Stop

The block signal indicates red when the next section is occupied by another train. The block signal becomes yellow when the next block section is clear, and becomes green when the next two block sections are clear.

Both terminal stations (North and South) will be equipped with centralized signaling with route control. A mimic diagram and a control desk are located in the signal-man room.

The length of each block section is decided so as to stop a train arriving at the section at the maximum speed within the section.

(2) Relay interlocking

A relay interlocking system is equipped for the signaling system. The interlocking system equipped at the terminal stations will be added with automatic route control device to control the route to the stabling track automatically.

The control device of the automatic block system on route are equipped in instrument cases located at the side of tracks.

(3) Automatic train stop

Automatic train stop device will be provided to stop trains which overrun red signals. The system is completed by installation of speed control device where speed restriction is necessary. The ground parts of the system are provided at each signal, while on-board units are equipped on both ends of trains.

12.7.3 Telecommunications

The main telecommunication devices include a telephone network, a UHF radio network and a public address system.

(1) Telephone network

The ordinary telephone network will be equipped to allow operational and administrative communication for the operation of the proposed LRT service and interval communication between the offices. The network consists of a private automatic branch exchange and the telephone sets.

The exchange will be installed at the equipment room of the administration building in the depot, and the connecting lines with the public telephone network will be provided to allow communications with its subscribers. The internal communications will be done automatically, while the external communications will be done automatically and/or through the operator. Incoming calls from the external subscribers will be received through the operator.

The telephone sets will be located at each station, at midpoints between stations, at the end of stabling area and in the administration building.

(2) UHF Radio system

The train radio system will be equipped to allow voice communication between the dispatching center and mobile radio sets, and also portable radio sets for maintenance crew.

The base station will be located at the car depot. The base station will have channels to allow selective, group or general call to mobile radio sets through the dispatcher control desk.

The mobile radio sets will be accommodated into all vehicles to allow communications with the dispatcher and with other mobile radio sets through the base station.

The portable radio sets will be of a handiest to allow the same communications as mobile radio sets for maintenance of the LRT facilities and for shunting operation of the trains.

(3) Public address system

The public address system will be equipped to allow information announcement for passengers in the LRT stations and direct speech communications with the employee of LRT such as shunting workers and maintenance crew, and to make emergency calls as necessary for the passengers in the stations. The system will comprise the master equipment with an operational panel installed at the administration building and the loudspeakers installed at platforms of stations, station yards and the depot.

12.8 Construction and Operation Cost

12.8.1 Premises

(1) Construction Cost estimation is to be carried out based on the prices at the end of 1990.

(2) Construction cost is to be presented in the local currency (Pakistan Rupees). The exchange rate is 1US$ = 21.70 Rs.= 132 Japanese Yen.

(3) Cost estimation is to be split into foreign currency and local currency.

(Foreign currency)
- Wages of foreign personnel
- Imported materials and machineries (CIF price)
- Overhead and profit of foreign firms

(Local currency)
- Wages of local personnel
- Local materials
- Overhead and profit of local firms
- Managing and maintenance costs of equipment

(4) Tax and duties

Tax and duties comprises of custom duty, sales tax, import surcharge, Iqra surcharge, income tax and Octroi.

(5) Economic and financial costs

The project costs are estimated both terms of economic and financial costs. The economic cost is estimated by subtracting all transfer costs such as custom duty, sale taxes, import surcharge, etc. from the financial cost.

12.8.2 Construction Cost

The Construction cost for LRT with 12.5 km long based on the above premises are shown in Table 12.8.1 and 12.8.2. Construction cost for LRT is 4,539 million Rs. and 5,965 million Rs. in economic and financial cost respectively. As described on tabulations, the costs include civil works, traction powers, signalling, communication, can depot, rolling stocks, land acquisition, etc.

12.8.3 Operation and Maintenance Costs

Operation and maintenance costs of LRT consist of staffing needs, physical facility electrical energy usage, rail vehicle component repair and replacement costs, and the fleet and service statistics resulting from rail passenger service. LRT annual O and M costs were estimated by referring to karachi Mass Transport Study (1987 prices). The estimates are:

Table 12.8.1 Estimated Operation & Maintenance Cost for LRT

	(Rs.)	(%)
Energy	144,344,218	31.63
Demand	36,974,514	8.10
Veh. mtc. svcs & matl.	116,880,991	25,61
Way & struc svcs & matl.	30,780,000	6.74
Sta & bldg svcs & matl.	6,400,000	1.40
Electr. svcs & matl.	61,560,000	13.49
Sgnl / cmmnca svcs & matl.	6,156,000	1.35
Motor pool mtc & fuel	1,392,257	0.31
Claims & Liabil	610,222	0.13
Advertis / info	610,222	0.13
Personnel & hous. allow	37,281,600	8.17
Personnel fringes	13,421,376	2.94
Total O & M cost	456,411,400	100.00
Cost per veh. km	16.596	

LRT vehicle operation are calculated as follows:

Peak hour : 2 min.headway, 30 trains/hr x 5 hr x 2 dir.=300 trains/day
Off peak hour: 5 min.headway, 12 trains/hr x 8 hr x 2 dir.=192 trains/day
Off peak hour: 10 min.headway, 6 trains/hr x 8 hr x 2 dir.= 96 trains/day

Total 588 trains/day

Annual train km = 588 x 12.5 km x 365 day = 2,683,000
Annual vehicle km = 2,683,000 x 3 units = 8,049,000

$$\text{End of 1990 Price equivalence} = \frac{\$21.70 \text{ (1990 preice)}}{\$18.00 \text{ (1987 preice)}} = 1.20$$

Annual O and M costs for economic price are
8,049,000 x 16.596 x 1.20 = 160.3 mil.Rs.

Annual O and M costs for financial price are estimated on the basis of the ratio of economic and financial construction costs in the followings:

$$160.3 \times \frac{5{,}965 \text{ (financial)}}{4{,}539 \text{ (economic)}} = 210.7 \text{ mil.Rs.}$$

Table 12.8.1 Cost Summary of LRT System

(1) Construction Cost

(unit : million Rupees)

Item	without taxes & duties	with taxes & duties
[local cost]		
labor	706.64	
material	1,394.56	
other	670.31	
land	143.00	
subtotal:	2,914.51	2,914.51
import taxes & duties		1,328.64
taxes on local materials		97.62
total local costs		4,340.77
[foreign cost]		
foreign cost	1,556.67	
freight on import	67.40	
total foreign costs	1,624.07	1,624.07
T O T A L	4,538.58	5,964.84
total length in km	12.50	12.50
cost per km	363.09	477.19

(2) Operation and Maintenance Cost

(unit : million Rupees)

LRT SYSTEM	Without taxes & duties per year	With taxes & duties per year
	160.3	210.7

COST TABULATION (LRT SYSTEM)

Table 12.8.2 Cost Breakdown of LRT System

unit : million Rs.

item	unit cost Rs	unit	quantity	costs without taxes & duties	foreign costs %	foreign costs	local costs %	local costs	labor Rs %	labor Rs	material Rs %	material Rs	other Rs %	other Rs	land Rs	import taxes & duties %	import taxes & duties	taxes 12.5% on lcl mtl %	taxes 12.5% on lcl mtl	freight on import %	freight on import
elevated station	15,300,000	each	18	275.400	27	74.358	73	201.042	20	40.208	55	110.573	25	50.281		113	84.025	56	7.740	5	3.718
elevated line sec.	58,000	m	12,035	698.030	27	188.468	73	509.562	20	101.912	55	280.259	25	127.390		113	212.969	56	19.618	5	9.423
track & ballast	6,065,000	km	13.39	81.210	27	21.927	73	59.284	20	11.857	55	32.606	25	14.821		113	24.777	56	2.282	5	1.096
traction power	21,700,000	km	13.39	290.563	27	78.452	73	212.111	20	42.422	55	116.661	25	53.028		113	88.651	56	8.166	5	3.923
lighting	314,000	km	13.39	4.204	27	1.135	73	3.069	20	0.614	55	1.688	25	0.767		113	1.283	56	0.118	5	0.057
signalling	10,850,000	km	13.39	145.282	27	39.226	73	106.055	20	21.211	55	58.331	25	26.514		113	44.325	56	4.083	5	1.961
communication	250,000	km	13.39	3.348	27	0.904	73	2.444	20	0.489	55	1.344	25	0.611		113	1.021	56	0.094	5	0.045
signs & markings	120,000	km	13.39	1.607	27	0.434	73	1.173	20	0.235	55	0.645	25	0.293		113	0.490	56	0.045	5	0.022
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
yards & shops	13,360,000	LS	13.39	178.890	27	48.300	73	130.590	20	26.118	55	71.824	25	32.647		113	54.579	56	5.028	5	2.415
O & M buildings	100,000	LS	13.39	1.339	27	0.362	73	0.977	20	0.195	55	0.538	25	0.244		113	0.409	56	0.038	5	0.018
util. relocation	4,600,000	LS	13.39	61.594	27	16.630	73	44.964	20	8.993	55	24.730	25	11.241		113	18.792	56	1.731	5	0.832
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
rolling stocks (HC)	13,685,000	each	70	957.950	60	574.770	40	383.180	20	76.636	55	210.749	25	95.795		52	298.880	56	14.752	5	28.739
rolling stocks (T)	3,174,000	each	35	111.090	60	66.654	40	44.436	20	8.887	55	24.440	25	11.109		52	34.660	56	1.711	5	3.333
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
total facilities & systems				2810.507		1111.620		1698.887		339.777		934.388		424.722			864.862		65.407		55.581
land	7000	m2	10,000	70.000	0	0.000	100	70.000	0	0.000	0	0.000	0	0.000	70.000	0	0.000	56	0.000	0	0.000
land	1500	m2	40,000	60.000	0	0.000	100	60.000	0	0.000	0	0.000	0	0.000	60.000	0	0.000	56	0.000	0	0.000
training & startup	5	%	2810.507	140.525	27	37.942	73	102.584	80	82.067	20	20.517	0	0.000		113	42.874	56	1.436	0	0.000
spare parts	15	%	2810.507	421.576	27	113.826	73	307.751	5	15.388	75	230.813	20	61.550		113	128.623	56	16.157	5	5.691
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
engineering	15	%	2810.507	421.576	27	113.826	73	307.751	40	123.100	20	61.550	40	123.100		113	128.623	56	4.309	0	0.000
project admin.	5	%	2810.507	140.525	27	37.942	73	102.584	80	82.067	20	20.517	0	0.000		113	42.874	56	1.436	0	0.000
						0.000		0.000		0.000		0.000		0.000			0.000		0.000		0.000
subtotal				4064.710		1415.155		2649.555		642.399		1267.784		609.372	130.000		1207.856		88.745		61.272
contingencies	10	%		406.471		141.515		264.955		64.240		126.778		60.937	13.000		120.786		8.874		6.127
TOTAL				4471.181		1556.670		2914.510		706.639		1394.563		670.309	143.000		1328.642		97.619		67.400

12.9 Economic and Financial Assessment

12.9.1 General

In this section economic and financial analyses on the Light Rail Transit (LRT) project are carried out. In the economic analysis of LRT, benefits are measured by savings in VOC of public buses, excluding those of private vehicles. Reduction in time cost of passengers are enumerated at 30% of the saved time of those on the new transit and those remain on buses, where the 30% accounts for the composition of trip home to work, work to home, and those work to work. In the financial analysis, a sensitivity test is conducted to find out the extent of subsidy for the initial cost and the extent of higher revenue which would be realized by a higher fare and less passengers.

12.9.2 Economic Analysis

Economic costs for construction (initial investment), additional investment (renewal of rolling stocks) and annual operation/maintenance of LRT were estimated in the preceding section. Economic benefits consist of two factors, namely VOC savings and TTC savings. For calculation of VOCs both "WITHOUT" and "WITH" of LRT, only "Public Buses" are taken into consideration. In estimating travel time cost, (TTC) savings, also only TTC of public mode users are studied and 30% of it is quantified as it is assumed that in the total amount of passengers in "Public" transport around one third of them are production-oriented.

These figures are tabulated in Appendix Tables 12.9.1, 12.9.2 and 12.9.3. Benefit cost enumeration is conducted on the following assumption;

1. Construction cost (initial investment) divided equally for 5 year construction stage from 2005 to 2009.

2. Additional investment (renewal of rolling stocks) occurs every 15 years.

3. Evaluation term of 30 years starts from introduction of LRT (2010).

4. Traffic volume, VOC savings and TTC savings increase with an annual rate of 3.00%.

Detailed cost and benefit flows from 2005 to 2039 are shown in Appendix Table 12.9.4.

As is shown on Appendix Table 12.9.4, an economic internal rate of return (EIRR) of 19.23% was estimated.

Considering the fact that measures are taken to make "Benefit" more conservative, this figure is favourable and it could be concluded that the project is economically feasible.

12.9.3 Financial Analysis

In evaluating financial conditions of LRT project, base-case is set as;

1. Fare of LRT to be Rs.5.00/trip. (Rs.2.00 higher than average bus fare)

2. Daily number of passengers appropriated to be 231,000 at the fare on the first year of operation.

3. Annual number of operation to be 300 days.

4. Rate of annual passenger increase to be 3.00%.

5. Construction, additional investment (renewal of rolling stocks: every 15 years) and annual operation/maintenance cost are given at the preceding section as "Financial Cost".

With above assumptions, a financial cash flow is tabulated in Appendix Table 12.9.5. As shown in the table, a financial internal rate of return (FIRR) is calculated to be 2.50%.

The result of Sensitivity Analyses is shown in Table 12.9.1.

Table 12.9.1 Sensitivity Analyses

		FIRR (%)
Base Case		2.50
Revenue Increase	+10%	3.37
	+20%	4.17
	+33%	5.12
	+50%	6.24
	+100%	9.05
Subsidized by the Federal Government	+25%*	4.12
	+50%*	6.61
	+75%*	11.71
	+80%*	13.63

* subsidized portion (investment cost)

There are two options which would increase the return (FIRR): one by a higher fare and revenue and the other by subsidizing the initial cost of LRT construction. Higher revenue would have a risk of a higher fare and less passengers. On the other hand substantial subsidy at a low interest charge seems necessary to realize a profitable operation.

Those analyses indicate difficult aspects of financial management of LRT project, while it would result in a reasonable economic return. The assumption is that LRT will be opened for public in 2010, 20 years ahead from now. It is too long to determine in detail the factors necessary to estimate economic and financial viabilities. The factors would change beyond the limitation of this kind of analysis. Continued studies on LRT feasibility in technical, economic, financial and managerial aspects are necessary for years to come.

12.10 Organization and Management

12.10.1 Organization

LRT plays very important public and social roles.
An appropriate service level must be therefore maintained such as safe, accurate, efficient operation, and railcar, track maintenance, etc.
From this viewpoint, establishment of the management body of the LRT as an enterprise organization is considered to be appropriate. As to keep constantly its operation in a good condition, Figure 12.10.1 operating organization will be planned.

12.10.2 Personnel Plan

In fixing the scale of the personnel required for efficiently operating the organization, taken into account were scale of estimated transport demand, train operating plan and various kinds of transport facilities as well as the present situation of Pakistan and Japan's transportation enterprises. Table 12.10.1 shows examples of the number of personnel for the LRT.

12.10.3 Education and Training

(1) Education Necessary prior to Opening for Business

a) Training of the education instructors

Education and training for the staff, prior to putting into service, is indispensable for carrying out a smooth business operation. The education of the instructors who will be in charge of the training and education of the staff must be done even earlier. The following stages are desirable for the training of the instructors.

1st stage : Special technical and practical education concerning the operation and maintenance of electric railcar trains.

2nd stage : Actual practice of operation and maintenance techniques, in another country which has the same type of transportation system.

3rd stage : Special technical training and practical education concerning equipment, such as the rolling stock, the electrical power system, signal system, etc., which will be introduced in the nations where the equipment is obtained.

4th stage : Preparation of the laws, regulations and manuals by the training instructors.

b) Content of instruction and number of training instructors

It will be necessary to train 12 persons as instructors. The 12 training instructors will learn the content shown in Table 12.10.2.

Table 12.10.1 Personnel Plan

Herdquarters	General affairs	Directors		2
		Division manager		1
		General affairs	Department manager	1
			General affairs	10
			Secretaries	6
		Accounting	Department manager	1
			Financial	2
			Accounting	6
			Material	5
		Total		34
	Transpotation	Division manager		1
		Sale	Department manager	1
			Sale	3
			Station affairs	3
		Operation	Department manager	1
			Operation	6
			Dispatching	9
		Total		24
	Engineering	Division manager		1
		Rolling stock	Department manager	1
			Rolling stock	7
		Ground facilities	Department manager	1
			Civil facilities	3
			Electric facilities	9
		Total		22
	Herdquarters sections' total			80
Operation	Transpotation	Passenger handling	Station	315
		Operation	Planning	10
			Drivers	39
			Conductor	39
		Total		403
	Engineering	Rolling stock	Inspection and repair	45
		Civil facilities	Maintenance	42
		Electric facilities	Maintenance	22
		Total		109
	Operation sections' total			512
Grand total				592

Table 12.10.2 Content of Instruction and Numbers of Instructors

Expertise	Subjects	Details	Number of Instructors
Train operation	Train operation procedures and laws	Operating regulations, methods of train operation	3
Rolling stock	Structure of rolling stock, maintenance technology	Electricity, machinery, controls and radios for rolling stock	3
Civil engineering	Track, earthworks, maintenance technology	Tracks, turnouts, structures, station, etc.	3
Electricity	Electrical equipment, maintenance technology	Electrical power, communications, signals, etc.	3
	TOTAL		12

(2) Dispatching of Well-experienced Instructors

It will be necessary to obtain the assistance of foreign instructors at the time of first putting into service for the following reasons. For instance, because the time available for the training local instructors in other countries is limited and unexpected situations may occur during operation. They are beyond the capabilities of the instructors, because of their limited experience with actual operation. It is also possible to imagine a case in which the instructor cannot completely convey his knowledge of techniques to other members of technical staff.

The duty of the foreign instructors is, basically, to act at an adviser to the local training instructors. Therefore, all daily business operations will be carried out by the regular staff members, and all preliminary education and instruction will be done by the training instructors. There will be a total of 4 foreign instructors : 1 for train operation, 1 for rolling stock, 1 for civil engineering, and 1 instructor for signals and electricity.

(3) Plan for Education and Training

Table 12.10.3 shows the necessary schedule for education and training, up to the time of the putting into service of the LRT.

(4) On-the-Job Training

The achieving of a constant increase in the accumulation of technological expertise, is an essential element in order to control and maintain a safe, efficient, and highly reliable transportation system. Once service begins, the technical staff will be asked to become more familiar with the techniques necessary for the operation and maintenance of the LRT. It is therefore important that the technical staff receives periodic on-the-job training to achieve an increase in their levels of techniques.

Figure 12.10.1 Operating Organization of LRT

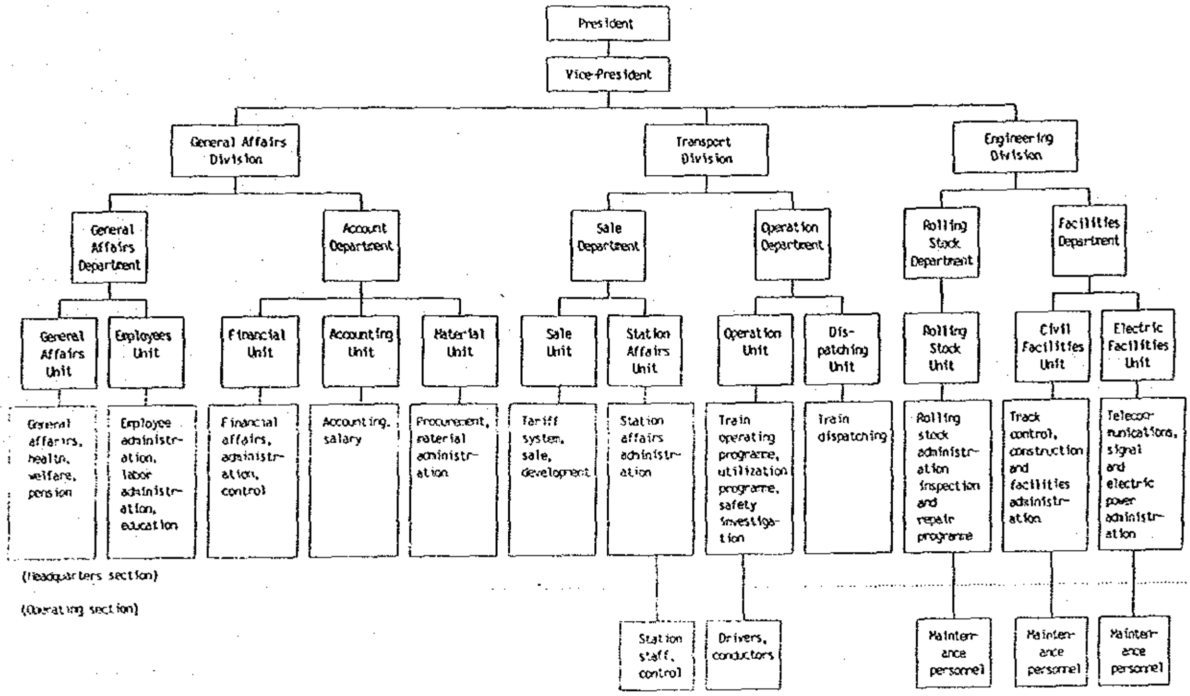


Figure 12.1.2 Instruction and Training Program

Item \ Year	1	2	3	4	5	Total
Instruction and training program		————	————	————	————	12 +580 (Person)
① Instructor		12 ———	————			12
② Dispatching personnel				12 ———	————	12
③ Station personnel				60 →	374 ——	374
④ Operating line section				7 ———	————	7
⑤ Crew				42 →	84 ——	84
⑥ Rolling stock maintenance personnel				15 →	45 ——	45
⑦ Civil facilities maintenance personnel				15 →	39 ——	39
⑧ Electric facilities maintenance personnel				8 → (↑ Supervisors)	19 ——	19
Foreign engineer (Technical instructor)	4 ———	————	————	————	————	(Person) 4

CHAPTER 13. OTHER DETAILED STUDIES

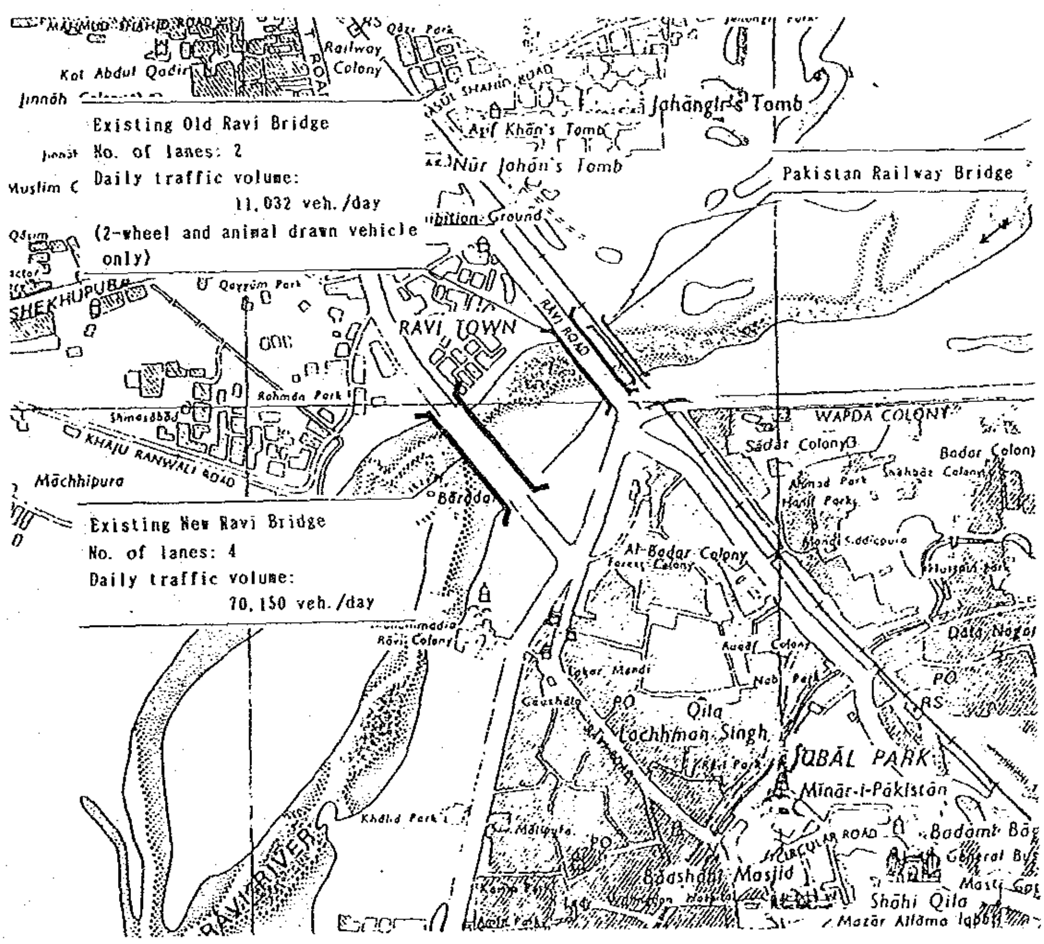
CHAPTER 13 OTHER DETAILED STUDIES

13.1 Alignment/Structure Outline of Additional Bridges across Ravi River

13.1.1 Existing Situation

There are two road bridges crossing the Ravi River. The old bridge has two lane wide roadway, but motorized vehicles are banned to run because of danger in structural collapse. Only non-motorized vehicles including animal carts move on this bridge. So called "New Ravi Bridge", a four lane roadway bridge, serves for all motorized vehicles. Traffic on the existing new Ravi Bridge counted 70,150 vehicles/day, while the capacity was supposed at 48,000 vehicles/day in 1990. A large traffic volume like this shows traffic congestion on the bridge and the sections around it.
Plans of an additional new bridge have been studied in the past several years, although not a full scale technical and economic feasibility study has been conducted yet, while traffic volume will continue to increase in the course of urban and economic development of the LMA.

Figure 13.1.1 Existing Bridges over Ravi River



13.1.2 Location Plan of Additional Bridges

Alternative location plans will be proposed on the down-stream (towards west) of the existing bridge, since the up-stream side has wider width, needs a substantial longer approach road sections and less urbanization potential. The down-stream side is rather close to the urban area which is planned to develop further to the southwest. There are three alternative locations appropriate to the comparison taking into consideration the following factors.

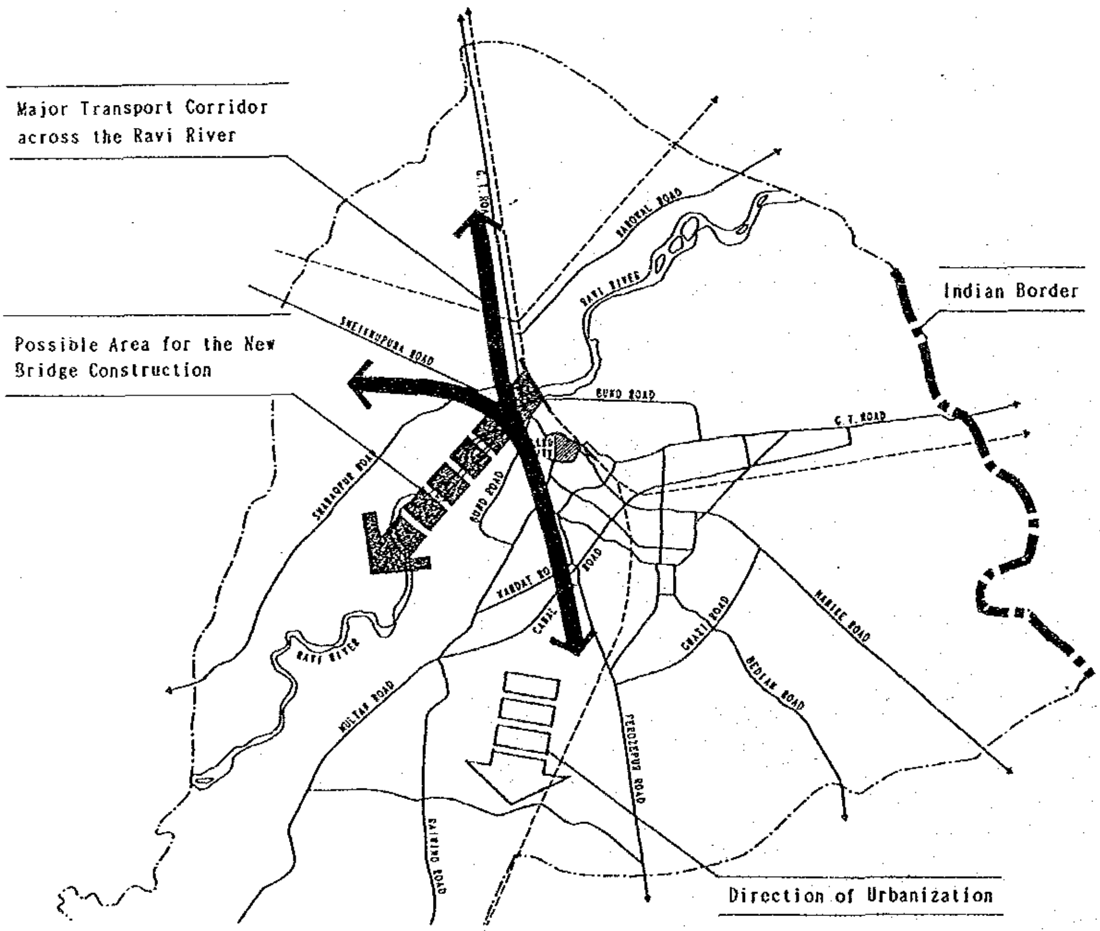
(1) Road Network and Traffic Flows

Roads in LMA have a basic pattern that primary roads emanate from the central part including Walled City. Toward east is located the boarder with India, at the end of Narawal and Wagha roads. This side has a constraint of development. Larger urban growth will be in directions to the north along GT Road (N-5 road to Islamabad), to the northwest to Sheikhupura, and to the south along Multan, Raiwind and Ferozepur roads. Traffic flow will increase along the corridors linking those three directions.

(2) Urban Development

Urbanization has been seen strongly in the direction to the south, and housing areas have developed to the south. LDA intends to guide LMA's further development in this direction, so the traffic demand will be.

Figure 13.1.2 Area around the Existing Ravi Bridges



13.1.3 Comparison of the Alternatives

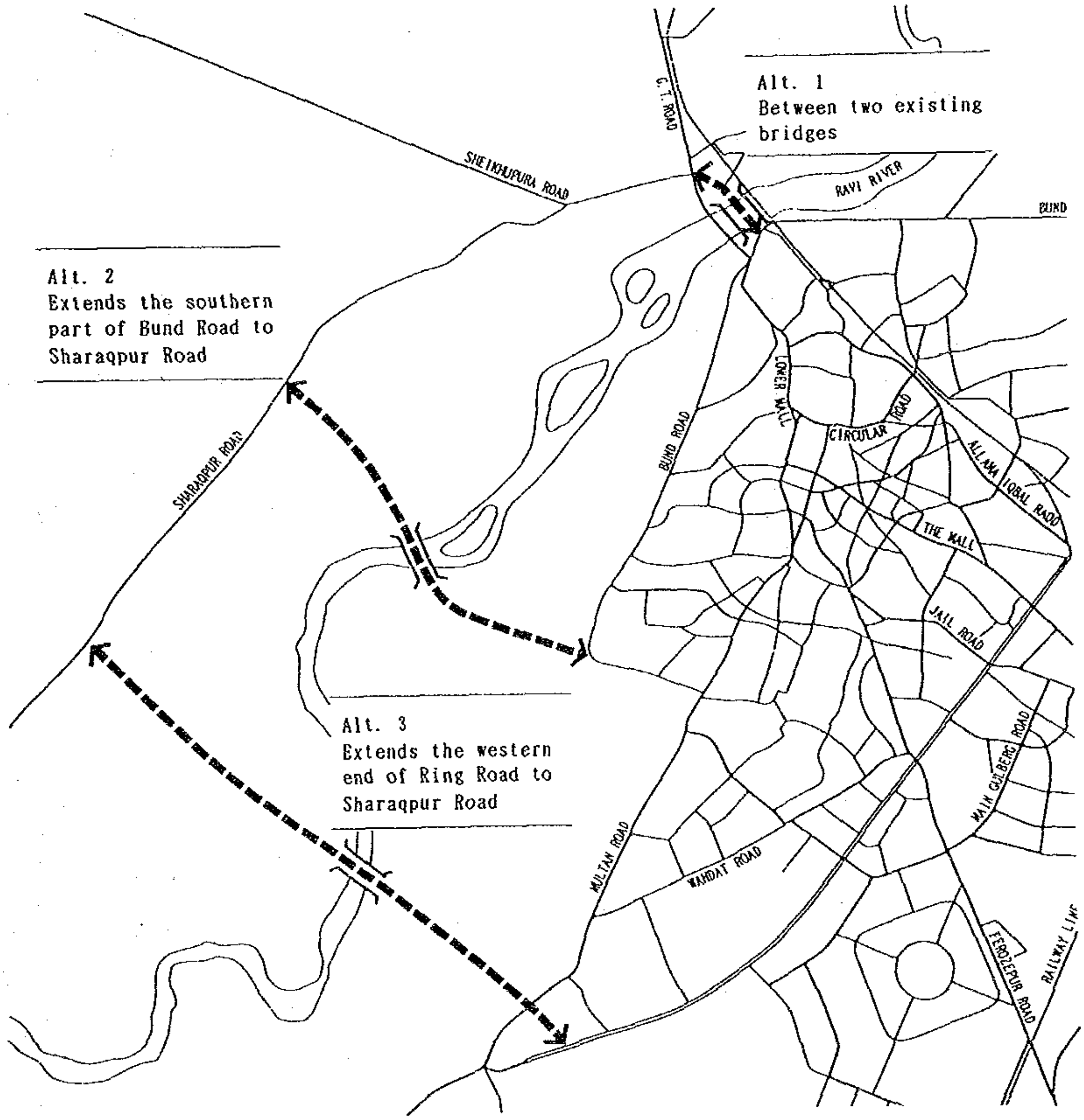
The three location plans are proposed as shown in Figure 13.1.3 and in the following:

Alt.-1 Reconstruction of the old bridge

Alt.-2 A new linkage from the Sharaqpur road and the south-west corner of Bund Road West

Alt.-3 A new linkage of both sides of the river at 10 km southwest of the above Alt.-2

Figure 13.1.3 Alternative Location Plans of the Additional Bridge



Compared elements are summarized in Table 13.1.1, where discussed elements are:

(1) Length of the bridge and approaches

(2) Approximated cost of construction

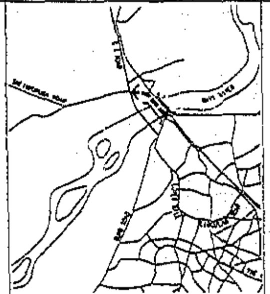
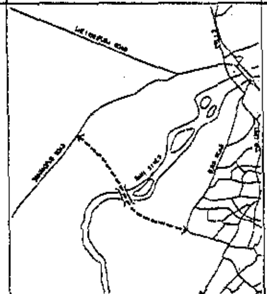
(3) Estimated traffic on each of the alternatives in 1990

(4) Changes in congestion on the sections of Ravi Road and Lower Mall

(5) Reduction in PCU-hour over the whole LMA road network

(6) Other impacts on the urban development and urban traffic

Table 13.1.1 Comparison of the Alternatives

Alt.	Alignment	Length of bridge and approaches (m)	Preliminary cost (Mill.Rs.)	Traffic volume on the existing and new bridges	Reduction of pcu*hour	Impact to the urbanization and urban transport	Overall evaluation
1	 Between two existing bridges	Bridge = 500 Appoaches=4,400	500	Existing=42,400 *(1.10) New =35,200 (0.92) Unit:pcu/day * Figures in parentheses are volume-capacity ratio	26,500 *Result of traffic as-signment of Year1990 OD on the exi-sting net-work vs. existing network + new bridge	The location of the additional bridge is close to the existing new bridges. Traffic can be split over these bridges and a substantial reduction of traffic on the existing bridge will be realized. (77,500 pcu/day --> 42,400). The reduction is modest on Ravi road and Lower Mall. The additional bridge will contribute to the urban and traffic growth following the existing pattern. Diversion traffic will be largest among the alternatives.	Length is the shortest. no specific problems in the construction and the least cost plan among the alternatives. Diversion traffic from the existing bridge is the largest. The location is suitable to the existing traditional urban activities and transport cores. •The lowest construction cost with largest diversion traffic from the existing bridge.
2	 Extends the southern part of Bund Road to Sharaqpur Road	Bridge = 550 Appoaches=6,300	540	Existing=66,300 (1.73) New =11,500 (0.30)	20,200	Reduction of traffic on the existing bridge will be less than the above 1. but reduction of traffic on Ravi Rd and Lower Mall will be more than the above 1. Multan Rds in the central area will benefit from the reduction of large vehicles. The location is close to the designated new urban development area and will support the development.	Diversion traffic is less than the above case 1. Construction cost is higher than the above case 1. •Can be integrated in the long run development plan of LMA because it is closer to the new urban development area in the southern LDA.
3	 Extends the western end of Ring Road to Sharaqpur Road	Bridge = 600 Appoaches=9,400	610	Existing=68,200 (1.78) New = 9,500 (0.25)	38,000	Reduction of traffic on the existing bridge will be smaller than the above 2, but reduction on Ravi Rd - Lower Mall will be larger than the above 1. Through-traffic of heavy vehicles will benefit mostly with this location. Diverted traffic will be smallest among the alternatives.	Diversion will be the smallest of the 3 alternatives. Construction cost is the largest because of the longest bridge and approaches. Long trips of through-traffic will divert to this newly located bridge. •If through traffic increases much more than the urban activity development of Lahore, this will be the most effective among the alternatives.