7 BUS FACILITIES IMPROVEMENT PLAN

7.1 Introduction of Bus Lanes

7.1.1 Transportation Demand and Number of Bus Lanes

(1) Types and capacity of bus fleet

The present bus type in the Study Area as discussed in Chapter 3.3 of this report is classified as follows: (a) articulated buses, (b) double-decker buses, (c) ordinary buses, (d) medium-sized buses, and (e) small-sized buses. The transportation capacity of the buses during peak hours (assuming the maximum capacity) is given in Table 7.1.1.

Table 7.1.1 Transportation Capacity of Various Bus Types

Bus Type	Number of Seating	Number of standing passengers	Traffic Capacity (maximum number of passengers per bus)
Articulated bus	38+38	62+62	200
Double-decker bus	80	80	160
Ordinary bus	36	64	100
Medium-sized bus	26	44	70
Small-sized bus	19	31	50

The transportation capacity of bus per direction per hour is related to its operation frequency. The Study Team estimated the frequency at 500-600 buses per direction per hour under ideal conditions, with a headway at 6 seconds. However, taking into consideration the factors such as the time needed for loading and unloading passengers, it will be more realistic to assume a headway at 20-30 seconds. Based on these considerations, the estimated maximum transportation capacity of bus lane was estimated as shown in Table 7.1.2.

Table 7.1.2 Maximum Transportation Capacity of Buses by Departing Intervals

Bus Type	Passenger capacity	Traffic capacity per hour on 20-sec departing interval per direction	Traffic capacity per hour on 30-sec departing interval per direction	Traffic capacity per hour on 1-min departing interval per direction
Articulated bus	200	36,000	24,000	12,000
Double-decker bus	160	28,800	19,200	9,600
Ordinary bus	100	18,000	12,000	6,000
Medium-sized bus	70	12,500	8,400	4,200
Small-sized bus	50	9,000	6,000	3,000

(2) Number of necessary bus lanes

In order to plan the trunk bus lanes, it is necessary to determine several variables such as the number of necessary trunk bus lanes, the network of bus routes, bus frequencies and bus types. Therefore, this section intends to compare the future bus demand in 2010 with the bus lane capacity assuming that buses depart every minute or every thirty seconds. This result will apply only to bus separated from other vehicles. The number of required bus lanes was estimated as shown in Table 7.1.3.

Table 7.1.3 Number of Necessary Bus Lanes

Names of Roads	Traffic capacity per hour on 1-min departing interval (ordinary buses) (A)	Traffic capacity per hour on 30-sec departing interval (ordinary buses) (B)	Passenger demand for year 2010 (number of passengers per hour per direction) (C)	(C)/(A)	No. of necessary bus lanes (number of bus lanes per direction)
Renmin Bei-Lu	6,000	12,000	13,000	2.1	1~2
Renmin Nan-Lu	6,000	12,000	7,200	1.2	1
Jiefang Lu	6,000	12,000	3,300	0.6	1
Fuqing Lu	6,000	12,000	5,400	0.9	1
Shudu Road East	6,000	12,000	8,100	1.4	1~2
Shudu Road West	6,000	12,000	13,400	2.2	1~2
Xin Renmin Nan-Lu	6,000	12,000	6,200	1.0	1
Hongxing Lu	6,000	12,000	6,200	1.0	1
Shuanglin Lu	6,000	12,000	8,100	1.4	1
Inner Ring Road	6,000	12,000	5,600	0.9	1
1st Ring Road	6,000	12,000	11,000	1.8	1~2
2nd Ring Road	6,000	12,000	6,900	1.2	1
Wuhouci Da-Jie	6,000	12,000	5,400	0.9	1
Chadianzi Lu	6,000	12,000	10,300	1.7	1~2

The following conclusions can be drawn from Table 7.1.3.

(a) The major bus demand is in the east-to-west and south-to-north main lines. Ordinary buses are required to depart every thirty seconds.

(b) There is relatively less bus demand in other radial roads. Ordinary buses are required to depart every minute.

(c) There is relatively more bus demand in the 1st and 2nd Ring Roads. Ordinary buses are required to depart every thirty seconds.

(d) In conclusion, major traffic axes with large bus demand are east-to-west axis, south-to-north axis and ring road axes.

7.1.2 Structure Type of Trunk Bus Lanes

As discussed in the previous section, a dedicated trunk bus lane per direction will be enough to meet the demand of bus passengers. The traffic demand shown in Table 7.1.3 is the result of traffic assignment conducted to know the demand distribution on the

existing road network. The ratio of the number of passengers over bus capacity is 1.0 or 0.7 (with ordinary buses departing every one minute). Thus, it is inferred that future transport demand can easily be met if buses depart every minute during peak hours. Given this demand level, it is unnecessary therefore to build a large-scale bus and road or elevated busway by 2010.

In the existing 4-lane roads, the inner two lanes are for vehicular traffic mixed with buses while the outer two lanes are for bicycle traffic. Consideration must be given to the present situation of road utilization wherein it must be ensured that before setting bus lanes on the same road section, bus lanes should be separated from other vehicular traffic lanes. The following must also be taken into consideration for the car, bus and bicycle traffic:

(a) The balance between road capacity and traffic demand.

(b) The balance between demand for buses and road capacity.

(c) The arrangement for bicycle traffic (improving network of bicycle roads).

(d) The balance between roadside land use and road usage.

(e) Optimum utilization of present road space (in different time periods).

7.1.3 The Location of Bus Lanes on Present Roads

As explained above, the present roads will be used for accommodating the proposed bus lanes. This section discusses where the bus lanes should be placed. The present road facilities are used by all kinds of motorized and bicycle traffic as well as by pedestrians. The proposed bus lane should be situated within this given space in consistency with the present road use.

(1) Preparation of Alternative plans

The bus lanes are proposed for major existing roads having more than four lanes. The standard road sections with more than four lanes in Chengdu City are generally classified into two types depending on whether segregated bicycle lanes are set. The roads without segregated bicycle lanes are designed in a way that the two outer lanes are generally used for bicycle traffic and the inner two lanes are for motorized vehicular traffic. On the other hand, roads with segregated bicycle lanes are with clear separation for the bicycle lanes and motorized vehicular lanes; four lanes are completely used for motorized vehicles. Based on the characteristics of such traffic and road facilities, five alternatives have been considered and the explanation on the proper placing of the bus lanes on the present road space is given below and illustrated Figure 7.1.1

a) Plan A

In Plan A, the two outer lanes, which are at present bicycle lanes, will be used as bus lanes where bicycle traffic shall be prohibited. The setting of the lanes as *secondary busway (bus priority lane)* shall prohibit bicycle traffic only during peak hours. The setting of the lanes as *primary busway (bus exclusive lane)* shall prohibit bicycle traffic throughout the day. Bus stops shall be set up at designated points on the present sidewalk. Decreasing the width of sidewalk and carriageway will make it possible to accommodate parking bays for buses at bus stops. This plan assumes no additional right of way acquisition.

b) Plan B

In Plan B, the two inner lanes are used as bus lanes and the two outer lanes, which are presently for bicycle traffic, shall be used for all other vehicular traffic. In this case, bus stops will be newly placed between the bus lanes and the vehicle lanes. Then the vehicles pass the other side of bus stops. The lanes for buses to park at bus stops (with width of 3.0 meters) and bus platform (with width of 2.0 meters) occupying a total width of 5.0 meters, are possible by way of lessening the width of carriageway and sidewalk. Acquisition of additional land for bus stops is not considered.

c) Plan C

This plan is for the roads with existing segregated bicycle lanes. In Plan C the present two outer vehicle lanes are changed into bus lanes like in Plan A where the two outer lanes shall be for bus lanes and the two inner lanes shall be for all other vehicular traffic. Bus stops shall be set up in the outer median by lessening to some extent the width of both inner and outer lanes, thus not requiring additional land.

d) Plan D

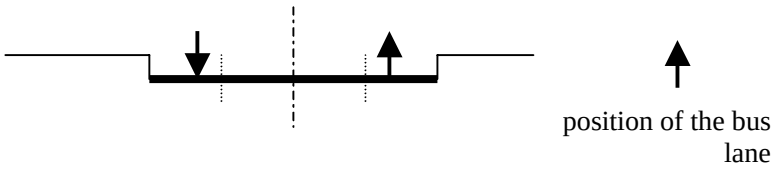
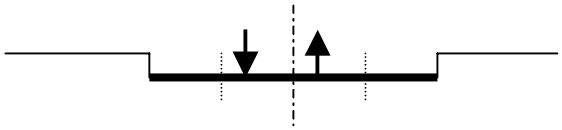
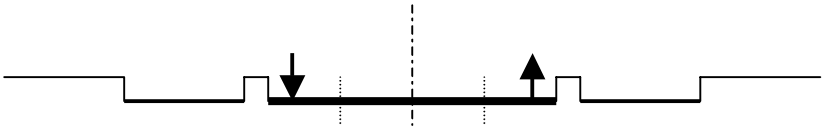
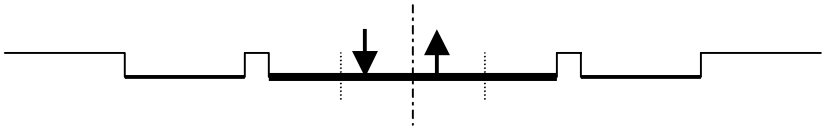
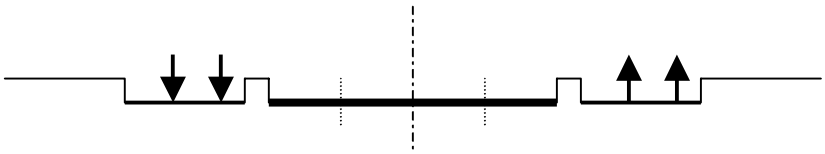
This plan is also for the roads with existing segregated bicycle lanes. In Plan D, the two inner lanes with special bicycle lanes are changed into bus lanes, traffic arrangement of which is the same as in Plan B. There shall be no need for additional land to build bus stops.

e) Plan E

This plan is also for the roads with existing segregated bicycle lanes. In Plan E, the present bicycle lanes are converted into bus lanes, the width of which is 6.00-7.00 meters, enough for buses to pass through when demand for bus is large. Thus, two one-way bus lanes can be made possible. If only one bus lane can meet the bus demand, then only one of the two bicycle lanes will be converted into a

bus lane (with width of 3.50 meters). In this case, the best way is to separate the bicycle lane and the bus lane with a bicycle lane width of 2.0 meters to 2.5 meters. In addition, it shall be necessary to improve the pavement structure for bus lanes because of the weak structure of the present bicycle lanes.

Figure 7.1.1 Positions of Bus Lanes

Comparative plans	Position of the bus lanes
Plan A (There are no segregated bicycle lanes.) Change the outer lanes into bus lanes.	
Plan B (There are no segregated bicycle lanes.) Change the inside lanes into bus lanes.	
Plan C (There are segregated bicycle lanes.) Change the outer lanes into bus lanes.	
Plan D (There are segregated bicycle lanes.) Change the inside lanes into bus lanes.	
Plan E (There are segregated bicycle lanes.) Convert bicycle lanes into bus lanes.	

(2) Characteristics and Evaluation of Alternative Plans

1) Characteristics of the Alternative Plans

The advantages and disadvantages of the alternative plans are comparatively shown in Table 7.1.4.

2) Evaluation of Alternative Plans

Whether there are existing segregated bicycle lanes or not, it is either the outer lanes (as in Plan A and Plan C) or the inner lanes (as in Plan B and Plan D) converted to bus lanes. Comparing these two options in terms of traffic safety, ease of traffic arrangement, relative cost and convenience of bus lanes, the Study Team arrived at the conclusion that the plan in setting the trunk bus lanes at the

outer lanes is better (as in Plan A and Plan C). The comparative advantages are as follows:

a) Plans A and C make it easier to change the lane use from bus to bicycle or vice versa.
b) The construction of bus stops in Plans A and C brings fairly small influence to other traffic facilities.
c) Passenger safety in Plans A and C is much higher since passengers need not cross the vehicle lanes to get on or get off the buses.
d) The new facilities for buses in Plans A and C shall be least costly. Furthermore, better use of present facilities on sidewalk or outer median can be made.

In cases when demand for buses is greater than the bus lane transport capacity, Plan E can be adopted instead of Plan C. In Plan E, there is complete separation of lanes for different traffic modes, which in turn translates into a larger transport capacity aside from higher level of safety for passengers. However, designated bicycle lanes in Plan E have already been paved for bicycle use, and need some improvements such as strengthening of pavement.

Another thing that should be considered is the proposed Subway Line 1, which is anticipated to be operational by 2010. The plan for bus lanes should therefore consider the proposed subway system. If the alignment set for the bus lanes is the same as that of the subway, the bus lanes in Renmin Bei-Lu and Renmin Nan-Lu should look into the subway plan. Construction of subway should commence by 2005 if it is intended to be operational by 2010.

Table 7.1.4 Characteristics of Alternative Plans

Alternative	Advantages	Disadvantages
Plan A	a. It's easy to change arrangement for bicycles, buses and cars. b. The change scale of facilities for buses is fairly small, so it's very economical. c. It's of great safety for passengers to get on or get off.	a. It does not provide good service to residents and shops along the road. b. It's difficult to manage the use of bus lanes. (Care must be taken for traffic safety because it is easy to violate the use of bus lanes.) c. Vehicles on the inner lanes cross bus lanes to turn left. d. Capacity of bus lanes is reduced. e. Capacity of vehicle lanes is reduced.
Plan B	a. It's safe for other vehicles to travel. b. It brings little impact on residents along the road. c. It can increase the capacity of bus lanes.	a. The present of traffic management is greatly changed. b. Passengers should take care of safety when they cross vehicle lane before getting on or after getting off. c. The change of arrangement of bicycles, buses and automobiles is difficult. d. Buses are difficult to turn left or right at the crossings. e. It costs much to set bus lanes. f. Capacity of vehicle lanes is reduced. g. Width of sidewalk is decreased (two meters) to build bus stops.
Plan C	a. It's easy to change arrangement of traffic. b. Bus stop can be built on the outer median. c. It's of great safety for passengers to get on or get off. d. It brings almost no impact on traffic of bicycles.	a. Buses are difficult to turn left. b. Capacity of vehicle lanes is reduced. c. Width of bicycle lanes should be decreased to build bus stops (about 1.0m).
Plan D	a. It's easy to change arrangement of traffic. b. It's convenient for buses to turn left on bus lane. c. Capacity of bus lanes increases. d. It brings almost no impact on traffic of bicycles.	a. It costs much to build new bus stops. b. Width of bicycle lanes should be decreased to build bus stops (about 3.0m).
Plan E	a. It's unnecessary to build new facilities for there are bicycle lanes available, which can be changed into bus lanes. b. Capacity of vehicle lanes increases. c. All of the four lanes can be changed into vehicle lanes. d. Capacity of bus lanes increases.	a. The present pavement structure of bicycle lanes should be improved. The project scale is fairly large. b. It's difficult for buses to turn left. c. It's necessary to build new bicycle lanes since the present bicycle lanes are changed into bus lanes. d. It takes fairly long to complete the project.

7.1.4 Plan for the Introduction of Trunk Bus Lanes

Planning for setting bus lanes are made based on the aforementioned options. The following are the main items that should be considered:

(1) To separate the bus and private vehicle lanes in the same road section

To ensure traffic safety and increase bus speed by means of alleviating traffic jam, bus and private vehicles lanes should be separated.

(2) To introduce bus lanes in trunk roads

At present, buses are operated on Primary Roads and Secondary Roads. For existing major roads with segregated bicycle lanes, generally two inner lanes are used for cars and two outer lanes for buses. As for the four-lane roads without segregated bicycle lanes, cars and buses share the two inner lanes and two outer lanes are only for bicycles. Peak traffic of bicycles is usually in the morning and in the evening (with a ratio of 15%-18%). The traffic of bicycles in daytime is very small. Moreover, vehicular traffic including buses in the daytime is 15,000-25,000 vehicles per day. While the total capacity of four lanes is 40,000-50,000 vehicles per day, the normal traffic is about 50% of this volume. The rate of peak traffic varies with different roads, ranging from 9%-10%. There is however a fairly steady traffic in the daytime. The main cause of traffic jams is the presence of both buses and bicycles during peak hours. The normal traffic does not usually reach the total capacity of the four lanes. Generally there are no severe traffic jams during the daytime.

Given the above characteristics of traffic in Chengdu City, two options can be proposed on how to plan the setting of bus lanes to match demand for buses. The first option is to introduce bus priority lanes (secondary busway). It aims at improving bus traffic at peak hours. The second option is to introduce bus exclusive lanes (primary busway). It aims at improving bus traffic throughout the day. Specifically, the proposed programs are as follows:

(a) **Secondary Busway:** Only at the morning or evening traffic peaks, change two outer lanes of roads with more than four lanes into bus lanes (where buses have priority). Cars, bicycles and others are restricted to pass through these lanes during peak hours. Bus priority lanes are separated from car lane by a safety structure except in the daytime.

(b) **Primary Busway:** Bus lanes are exclusively for buses for the whole the day. In these lanes, cars, taxis, bicycles, and pedestrians are restricted throughout the day. Private vehicle lanes are separated from bus lanes.

(3) Traffic capacity of bus lanes

The secondary Busway uses the outer lanes of the existing roads. However, its traffic capacity would be small by the interference of cars and bicycles. As for Primary Busway (exclusive bus lanes), only buses can pass through these lanes. As a result, the capacity of such lanes are fairly large. Thus, it was judged based on the following considerations that Primary Busway be introduced where the demand for bus exceeds 6,000 passengers per hour per direction and Secondary Busway be considered for lower demand levels.

(a) Primary Busway is exclusive for buses. Heavy investment only in favor of bus users should be avoided.

(b) The Primary Busway of Curitiba City, Brazil has a minimum headway of one minute. The following data can be taken as a reference. The maximum volume of passengers in Curitiba City is 14,000 persons per hour in one direction using three-car buses with a capacity of 270 persons.

(c) The Key Route Bus in Nagoya City, Japan has a minimum headway of about 2-3 minutes.

(d) The time spent at the bus stops will vary according to the numbers of passengers and platforms, which is about 30-60 seconds.

(e) Given the above-mentioned situation, Primary Busway in the Study Area with ordinary buses having a seating capacity of 36 seats and a capacity of 100 passengers at peak hours with one minute headway would carry a volume of 6,000 persons per hour per direction.

(4) Present roads to be converted into bus lanes

As already mentioned, acquisition of road right-of-way for possible construction of bus roads is very difficult for an urban area, especially one that is densely developed like Chengdu. There are so many high office structures and commercial establishments along the main roads, which makes the widening project of present roads more difficult. Hence, the drawn-main and subsidiary-main lanes can be operated within the present road-construction land. Considering the structure of the bus routes, it is assumed that bus lanes can be set on the following roads based on the abovementioned points.

(a) Secondary Busways are to be established on the roads, which have more than 4 lanes of 25-30 meters wide.

(b) Primary Busways are introduced on the main roads with four or more than six lanes.

(c) Bus lanes can be set on the present segregated bicycle lanes. If this would be pursued a pavement improvement project suitable for segregated bicycle lanes should be undertaken.

7.1.5 Identification of Trunk Bus Lanes

(1) General

Traffic axles in planned target area that needs improvement have been discussed in detail in Chapters 5 and 6. In these chapters, considerations were placed on the seven systems (seven aspects) of traffic axles, the concerned utilization of land, movements to city, present and future network of roads, situation of traffic, traffic demand, and so forth. The plan must be based on the assumed traffic axles and the fundamental policies of setting bus routes. In particular, traffic demand and facilities for present roads should be considered.

(2) Reinforcement of traffic axles and traffic demand

Forecast demand for private vehicles and buses in 2010 on traffic axles, and main routes where traffic axles are involved and the inside area of traffic axles is shown in Table 7.1.5.

From Table 7.1.5 the following can be concluded:

(a) As discussed earlier, it was estimated for a Primary busway that 6,000 bus passengers are being transported every hour per direction if buses depart per minute. Thus, every traffic axis with a bus traffic demand over this volume needs improvement of bus system.

(b) It is necessary to introduce Primary Busway on North Traffic Axis, South Traffic Axis, East Traffic Axis and West Traffic Axis.

(c) It is estimated that there will be 2,000-3,000 bus passengers per hour per direction in other traffic axes like North-to-East, South-to-East and North-to-West Traffic Axes. This could be easily met if 20 ordinary buses with 36-seating capacity and a maximum capacity of 100 passengers will depart every hour. Primary Busway may be an over-investment for such traffic axes with a relatively low bus demand. To ensure the reliability and safety of buses, Secondary Busway will be suitable for such roads.

Table 7.1.5 Transportation Demand in 2010

No.	Traffic Axis	Names of Present Main Routes	Traffic Demand in 2010	Average Traffic Demand in 2010
1	North Traffic Axis	1. Renmin Bei-Lu 2. Jiefang Lu 3. Fuqing Lu 4. Beizhan Xi-Lu	Buses 26,000 persons per hour cars 8,500 persons per hour	Buses 6,500 persons per hour cars 2,200 persons per hour
2	East-North Traffic Axis	1. Jianshe Lu 2. Xinhong Lu 3. Shuanglin Lu	Buses 9,200 persons per hour cars 1,700 persons per hour	Buses 3,100 persons per hour cars 570 persons per hour
3	East Traffic Axis	1. Shudu Road 2. Old Cheng-Yu Highway 3. Cheng-Long Highway	Buses 18,900 persons per hour cars 5,900 persons per hour	Buses 6,300 persons per hour cars 2,000 persons per hour
4	South Traffic Axis	1. Renmin Nan-Lu 2. Xin Renmin Nan-Lu 3. Ximianqiao Jie	Buses 16,000 persons per hour cars 9,800 persons per hour	Buses 5,400 persons per hour cars 3,300 persons per hour
5	South-West Traffic Axis	1. Chuan-Zang Highway 2. Wuhou Da-Dao 3. Caojin Lu	Buses 6,700 persons per hour cars 4,800 persons per hour	Buses 2,300 persons per hour cars 1,600 persons per hour
6	West Traffic Axis	1. Shudu Road 2. Qinghua Lu	Buses 15,800 persons per hour cars 3,600 persons per hour	Buses 7,900 persons per hour cars 1,800 persons per hour
7	North-West Traffic Axis	1. Fuqin Lu 2. Chadianzi Lu 3. Shawan Lu 4. Jiulidi Lu	Buses 18,200 persons per hour cars 5,900 persons per hour	Buses 4,500 persons per hour cars 90 persons per hour

Notes: 1) Traffic demand was calculated in terms number of passengers per direction.
2) Traffic demand refers to the total demand of 3-4 roads included in every traffic axis.

(3) Selection of Traffic Axes for the Introduction of Trunk Bus Lanes

In this section, future traffic demand is assigned onto the network of main roads, which constitute every traffic axis, based on the small traffic zones. Meanwhile, a comparative study is done between traffic demand and road capacity. Then, the proper roads to introduce the trunk bus lanes are determined.

Table 7.1.6 shows traffic demand, transport capacity and condition of road facilities in every traffic axis. It is assumed that traffic axes where Primary Busway should be introduced are North Traffic Axis, South Traffic Axis and East Traffic Axis. Based on this assumption, the following considerations were made for both traffic and road facilities in formulating the plans:

(a) Among the four main roads, which constitute North Traffic Axles, the road system of Renmin Bei-Lu (Renmin Bei-Lu and Renmin Zhong-Lu) are most

likely to be set with Primary Busway. In terms of the proper number of lanes, the favorable situation of road facilities should have road widths of 40 meters.

(b) Among the three routes, which constitute the South Traffic Axle, Shudu Road is most likely to be with Primary Busway since the width of roads here can best ensure the implementation of the bus lanes.

(c) Among the three routes which constitute South Traffic Axle, Renmin Nan-Lu is most likely to be with Primary Busway since its six lanes dual carriageway and width of roads at 40-50 meters can best ensure the implementation of the bus lanes.

(d) West Traffic Axle consists of the west section of Shudu Road and Qinghua Lu. The volume of traffic here is very large at 13,000. Concerning function and network, the west section of Shudu Road is similar to the east section of the road since Primary Busway have been set on this section.

(e) Concerning punctuality of buses and traffic safety, Secondary Busways are set on other major roads. If volume of bus traffic and automobile traffic is less than the capacity of two lanes roads then trunk and Secondary Busways will not be set on major roads.

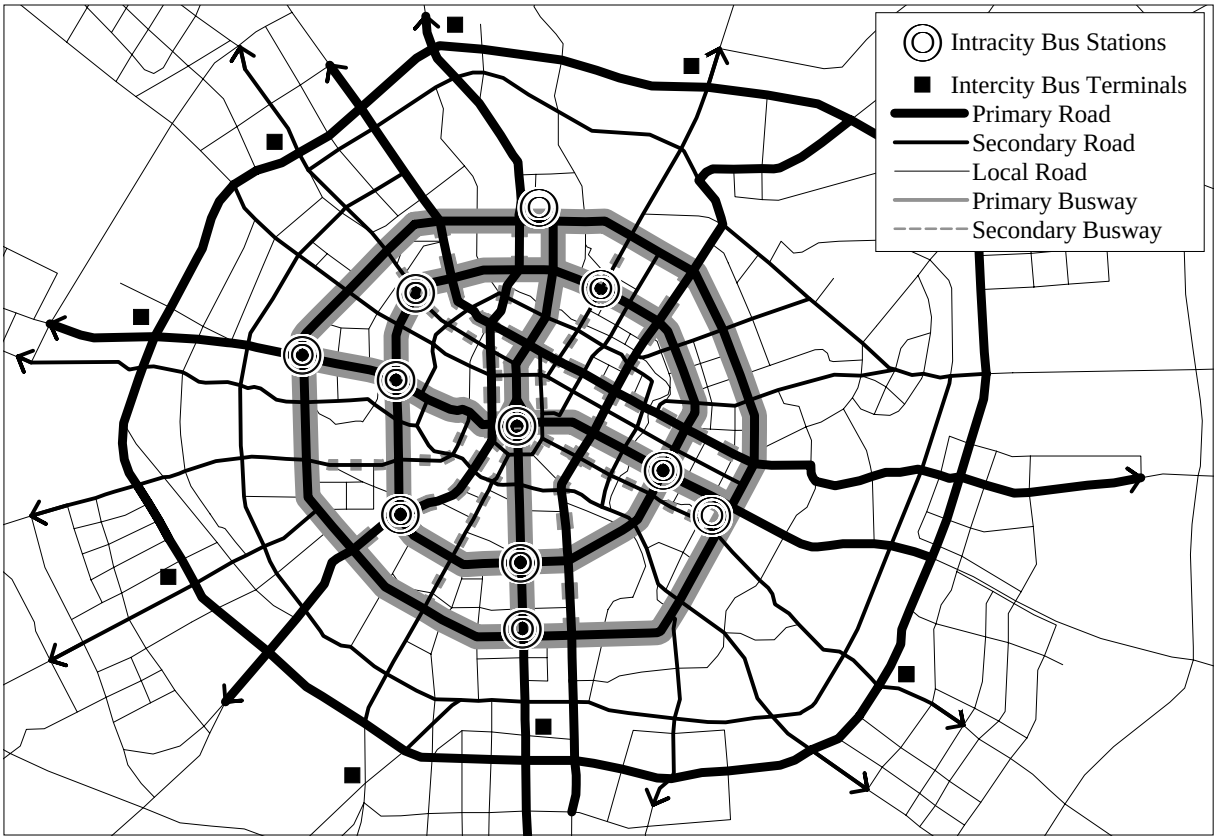
The plan of the trunk bus lane network with the introduction of Primary and Secondary Busways are shown in Figure 7.1.2.

Table 7.1.6 Future Transportation Capacity and Volume of Main Routes of Major Traffic Axle

Traffic Axis	Names of Existing Trunk Roads	No of Lanes	Right of Way width (m)	Traffic Volume in 2010		Traffic Capacity per lane on the road with two lanes (PCU/h)	Traffic Capacity per lane on the 4-lane road (PCU/h)
				buses (PCU/h)	cars (PCU/h)		
North Traffic Axis	1)Renmin Bei-Lu (system)	4	40-50 with bicycle lane 5m	750(13,000)	1,200	600	3,200
	2)Jiefang Lu (system)	4	20-30	180(3,300)	700	600	2,250
	3)Fuqing Lu (system)	4	20-30	300(5,400)	1,100	600	2,250
	4)Beizhan Xi-Lu (system)	4	30 with bicycle lanes 5m	230(4,200)	1,100	600	2,250
East-North Traffic Axis	1)Jianshe Lu (system)	4	15-30	60(1,100)	220	600	2,200
	2)Xinhong Lu (system)	4	20-30	----------	--------	600	2,250
	3)Shuanglin Lu (system)	4	30-40 There are bicycle lane 5m	450(8,100)	1,400	600	2,250
East Traffic Axis	1) East part of Shudu Rd.	4	40-50 with bicycle lanes 7m	450(8,100)	1,400	600	3,200
	2)Old Cheng-Yu Highway (system)	4	20-30	400(7,200)	580	600	2,200
	3)Cheng-Long Highway (system)	4	20-30	200(3,600)	870	600	2,200
South Traffic Axis	1)Renmin Nan-Lu (system)	6	40-50 with bicycle lanes 7m	400(7,200)	1,400	600	2,800
	2)Xin Renmin Nan-Lu (system)	4	40	340(6,200)	1,500	600	3,200
	3)Ximianqiao Jie (system)	4	35-40 with bicycle lanes 5m	140(2,600)	1,800	600	2,250
South-West Traffic Axis	1)Chuan-Zang Highway (system)	4	25-30	300(5,400)	1,200	600	2,250
	2)Wuhou Da-Dao (system)	4	30	----------	--------	600	2,250
	3)Caojin Lu (system)	4	30	70((1,300)	1,100	600	2,250
West Traffic Axis	1)Shudu Road (system)	4	40-50 with bicycle lanes 7m	740(13,400)	1,400	600	3,200
	2)Qinghua Lu(system)	4	30	130(2,400)	320	600	2,250
North-West Traffic Axis	1)Fuqin Lu(system)	4	25	100(1,800)	1,200	600	2,250
	2)Chadianzi Lu (system)	4	20	570(10,300)	710	600	2,250
	3)Shawan Lu(system)	4	20-30	190(3,500)	810	600	2,250
	4)Jiulidi Lu(system)	4	20	140(2,600)	110	600	2,250

Notes: 1) The name of every road stands for one route. (The same route may have several names.)
2) Volume of traffic in 2010 refers to that of typical sections of relative road systems.
3) The PCU(the conversion factor of vehicles to cars) of buses is 2.5. The ave. no. of passengers= 45.

Figure 7.1.2 Network of Primary and Secondary Busways (2010)



7.1.6 Functions and Structure on Primary and Secondary Busways

(1) Functions of Primary and Secondary Busways

1) Functions and traffic operation of Primary Busway

Primary Busways have the following functions and design:

a) These bus lanes are dedicated lanes especially for buses to use the whole day. Hence, bicycles, cars and other private vehicles are restricted to pass.

b) To ensure reliability of buses and travel speed, special bus signal on bus lanes are installed.

2) Functions and traffic operation of Secondary Busway

The Secondary Busways have the following functions and traffic operation:

a) These bus lanes are used as lanes where buses have priority only at morning peak hours (for 2-3 hours) and at evening peak hours (for 2-3 hours).

b) Bicycles are restricted to pass.

c) Private vehicles (including taxis) can pass when there are no buses, but they must at all times give way to buses.

d) Traffic operation remains the same as at present except for restricted hours.

e) To ensure reliability of buses and travel speed, bus priority signal on bus lanes are installed.

(2) Structure of bus lanes

1) Cross-section of Primary Busway

Bus lanes are set on the following main roads: (1) Renmin Bei-Lu and Renmin Zhong-Lu (2) Renmin Nan-Lu (3) the east section of Shudu Road (4) the west section of Shudu Road. Bus lanes are, likewise planned for the present east-to-west and south-to-north main routes and 1st Ring Road and 2nd Ring Road. Considering the above mentioned traffic arrangement, the following are assumed:

a) There is basically one lane for every direction.

b) Outer lanes are converted into bus lanes.

c) Private vehicle lanes and bus lanes are separated by different pavement constructions with different colors.

d) When there is not enough space for private vehicles traffic because of the bus lanes, initially four bus lanes will be converted into six lanes within the present space of roads. (The width of automobile lanes, bicycle lanes and pavements shall be reduced.)

The cross-section of Shudu Road with six lanes is shown in Figure 7.1.3.

2) Cross-section of Secondary Busway

Bus lanes are set on main roads, which are not east-to-west and south-to-north main routes. Concerning traffic arrangement on these lanes, the assumed implementation of bus lanes is as follows:

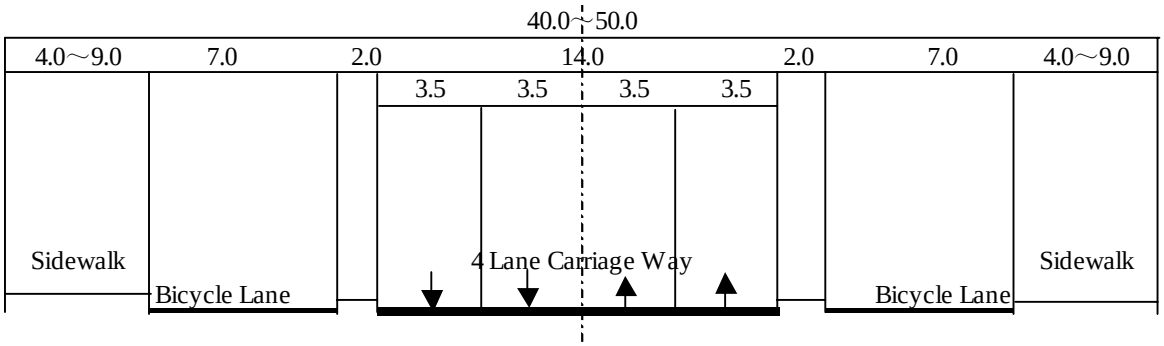
a) There is basically one lane per direction.

b) Bus lanes have priority on roads with four lanes.

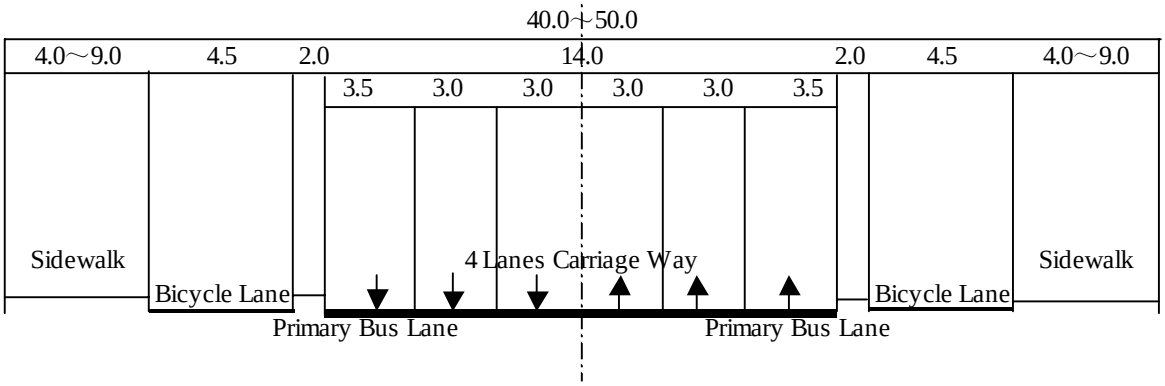
c) Bus lanes where buses have priority are put into use during morning and evening peak hours (for 2-3 hours of every period), buses and private vehicles can be separated by simple movable tools or facilities.

Figure 7.1.3 Cross-Section of Primary Busway

1.Cross-Section of Existing Four-Lane Road



2.Cross-Section of Proposed Primary Busway



7.1.7 Description of Project Location

As mentioned above, Primary Busways are introduced on the existing primary road and the Secondary Busways are introduced on the existing secondary road, considering traffic axes to be reinforced, and future transport demand on the existing roads.

The existing roads for the Primary Busway are as follows:

a) East-West Primary Road (Shudu Road L=9.0km)
b) North-South Primary Road (L=8.0km)
c) 1st Ring Road (L=19.0km)
d) 2nd Ring Road (L=27.0km)

The existing roads for the Secondary Busway are as follows.

a) Xin Nan-Lu — Hongxing Lu (L=8.0km)
b) Shuanglin Lu — Shawan Lu (L=8.0km)
c) Wuhouci Da-Jie — Dongchenggen Jie (L=8.0km)
d) Ximianqiao Jie (L=4.0km)
e) Dashi Xi-Lu (L=4.0km)
f) Jiefang Lu (L=4.0km)
g) Chadianzi Lu Extension (L=4.0km)
h) Dong Da-Jie (L=4.0km)

As for Primary Busway, a total of 4 projects have been identified, while Secondary Busway projects have been packaged into 7 projects by combining d) and e) above which belong to the same traffic axis. The cost of each project identified is estimated in a later section of this report.

7.2 Improvement of Bus Transfer / Terminal Facilities

7.2.1 Bus Route Networks from a Supply-and-Demand Perspective

The following analysis is based mainly on the bus service condition from supply-demand perspective.

As discussed in Chapter 5, travel between residences is hindered by a generally below-average bus service. One needs to transfer buses more than once to get to a destination, and this problem mainly occurs in the outskirts of the 3rd Ring Road as well as the west and southeast area between the 2nd Ring Road and 3rd Ring Road. Conditions within the 2nd Ring Road become better, with the average bus transfer frequency down to one.

In terms of bus frequency between the roads, the current bus service within the 2nd Ring Road is effective. This goes the same for some main roads outside 2nd Ring Road, though the average bus service level is much lower than inside 2nd Ring Road.

The supply and demand situation near the city is characterized by the low population and mall demand outside the city. This results in limited profits for bus operators and deteriorates bus service. However, with the development of the inner city, large residential areas will be built outside 2nd Ring Road and will surely bring more demand in the future.

Tables 7.2.1 and 7.2.2 show the possible changes in traffic demand of buses from areas outside 3rd Ring Road and between 2nd Ring Road and 3rd Ring Road to city center. It is projected that there will be a surge of traffic demand between 2nd and 3rd Ring Road areas and the nearby areas except the western part of the city. Demand for buses to the city center will fairly increase, especially at the south and north portion of the city.

Meanwhile, the north and west parts outside 3rd Ring Road needs to develop more bus services to meet its future demand. Though demand in the east part is still modest, some demand surge is expected in the future. The south will have great demand, especially services to the city center. It should be noted that demand for long-distance bus will substantially increase in the future so it is necessary to discuss how to provide bus service to meet the growing bus demand.

From the viewpoint of the growing transport demand, a review on how to enhance the present bus service and how to provide long-distance and high-speed bus service is required.

Table 7.2.1 Projected Changes in Bus Demand in Areas between Second Ring Road Outskirts and City Center

Corridor	Bus Demand (thousand people per day)					
	Between 1st Ring Road and 2nd Ring Roads			City Center (inside 1st Ring Road)		
	Year 2000	Year 2010	2010 – 2000	Year 2000	Year 2010	2010 – 2000
North	8	24	16	14	29	15
Northeast	3	24	21	7	16	9
East	6	26	20	11	28	17
South	4	20	16	8	17	9
Southwest	2	12	10	6	13	7
West	4	8	4	6	10	4
Northwest	1	15	14	5	15	10

Table 7.2.2 Projected Changes in Bus Demand in Areas between Third Ring Road Outskirts and City Center

Corridor	Bus Demand (thousand people per day)								
	Between 3rd Ring Road and 2nd Ring Road			Between 1st Ring Road and 2nd Ring Road			City Center (Inside 1st Ring Road)		
	Year 2000	Year 2010	2010-2000	Year 2000	Year 2010	2010-2000	Year 2000	Year 2010	2010-2000
North	11	21	10	22	31	9	10	12	2
Northeast	0.3	4	3.6	0.0	0.0	0	0.1	1	0.9
East	1	17	16	3	20	17	4	24	20
South	2	8	6	1	6	5	1	16	15
Southwest	3	8	5	3	6	3	12	19	7
West	6	35	29	5	6	1	9	9	0
Northwest	2	9	7	2	8	6	4	11	7

Analysis of the results shows that, as well as the radial road directions, there are still some origin-destination (OD) pairs with large transport demand such as from the north train station to areas near 1st Ring Road. With metropolitan development, traffic demand in the neighborhood will increase substantially. It is needed to design road network taking into account characteristics of transport demand.

7.2.2 Change in Boarding, Alighting and Transferring of Passengers

Figures 7.2.1 and 7.2.2 illustrate the number of passengers boarding, alighting and transferring at present and in the future based on transit assignment analysis in Chapter 5. These are based on the present bus route networks. The following are the problems and issues concerning bus terminal based on demand forecast analysis.

(1) Current Problems

- Majority of the bus demand takes place especially in places like the Tianfu Square, Remin Zhong-Lu Er-Duan, and near Hongxing Lu. At present, there are no special facilities to separate buses from other vehicles so passengers can only get on or off a bus at the bus stop by the road, which could bring traffic accident. Also, bus riders are inconvenienced when transferring buses due to long distance between bus stops.
- A number of bus demand is also seen along main roads and at intersections of 1st Ring Road, especially in areas near the Jiuyanqiao, Qingjiang Lu, Hongpailou, Jiefang Lu and Yingmenkou Lu. Some places have long-distance bus terminals but all intra-city buses don't stop there. It could also create some safety and convenience problems.
- In areas inside and outside 2nd Ring Road, passengers are concentrated near the North Railway Station, Qinglongchang and Wuguiqiao where the short- and long-distance bus terminals are located.

(2) Future Issues

- The bus demand inside the city center and in 1st Ring Road and 2nd Ring Road will continue to increase in the near future with the same distribution. The number of passengers is projected to reach 500,000 in the future with over 300,000 passengers at present are in the neighborhood of Tianfu Square. In many places, the number of passengers will be above 100,000. Thus, the lack of bus facilities will be one of the key issues in the future.
- Comparing the two subway scenarios, i.e. with and without the subway line, distinct differences are found especially along the subway line particularly on the following areas: nearby the zoo, the Railway Station, the Tianfu Square, Renmin Nan-Lu, and crossings between 1st Ring Road and 2nd Ring Road where a lot of people change buses.
- Future bus demand will increase nearby 3rd Ring Road which has a small bus demand at present. It will be thus difficult to serve intra-city buses using inter-city bus terminals located near 2nd Ring Road in terms of physical aspect.

Figure 7.2.1 Bus Demand Distribution at Present

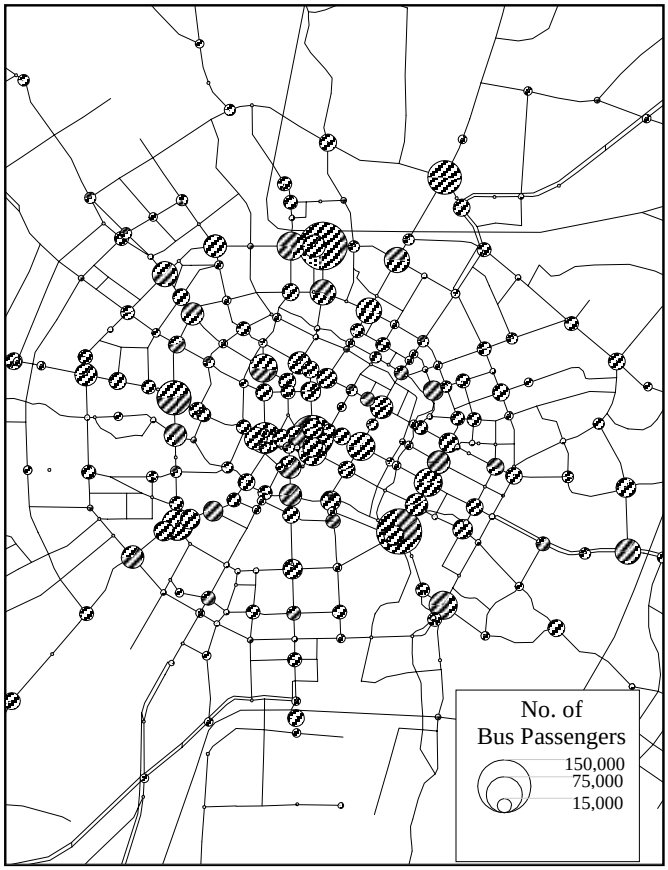
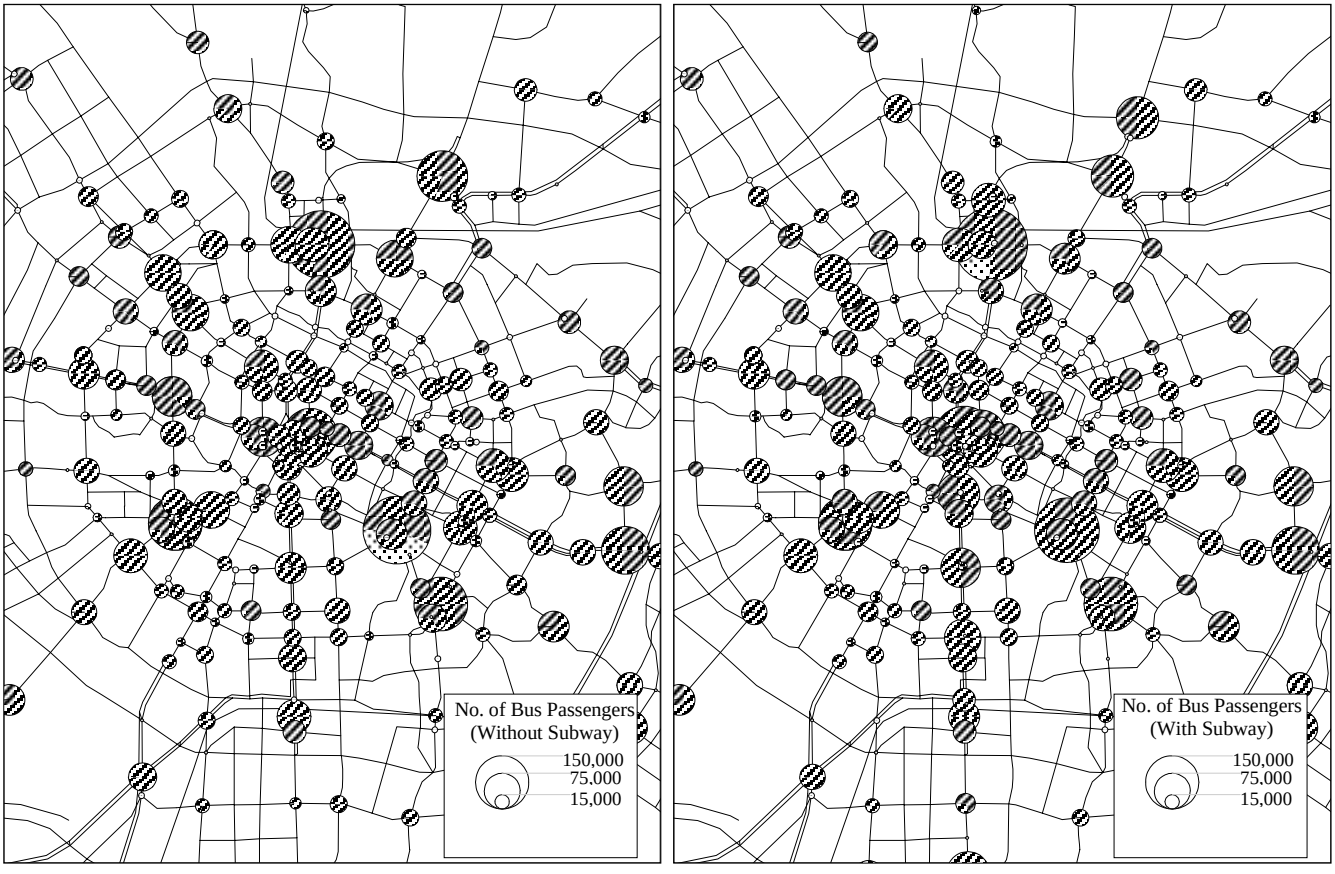


Figure 7.2.2 Bus Demand Distribution in the Future



7.2.3 Guidelines for Bus Route Network Improvement

A basic principle in transport planning indicates that transport networks should be responsive to changes in transport demand. With transport services provided by the public transport, considering the public transport demand makes formulation of new public transport network easier. For this study, the following factors that will be considered in formulating the public transport network are 1) road space requirement and location, 2) reduction of inter-modal transfers and 3) provision of necessary transport services such as nonstop and emergence, etc. It is therefore necessary that city government stress on the provision of public transport services based on transport demand. An efficient public transport network is key to the strategic development of an emerging city center and developing center, with the provision of minimum public service to an area with small transport demand.

Taking into consideration the transport demand, guidelines are formulated for an immediate and short-term public transport network as follows:

- Provide more bus service to suburban areas where public transport service is poor (poor accessibility due to transfers)
- Provide more bus service to new industrial areas or residential areas where bus demand will increase.
- Provide new bus service or introduce new trunk bus service between areas that are of substantial bus demand
- Introduce new express bus service in routes with large-scale development and substantial bus demand.
- Readjust the existing bus routes accordingly with the introduction of exclusive or priority bus lanes.

Given that satisfactory bus service such as operation frequency is provided to meet demand, guidelines for formulation of bus route network in 2010 can be proposed as follows:

- Strengthen bus service in emerging city center and large-scale development area.
- Re-arrange bus routes to secure minimum public service.
- Rearrange bus routes according to operation of subway line 1.

Guidelines for rearranging bus routes according to introduction of exclusive and priority bus lanes and subway operation can be summarized as follows:

1) Rearrangement of bus routes according to introduction of exclusive and priority bus lanes. It is recommended to rearrange bus routes by combining the following types (refer to Figure 7.2.3).

Type 1: High-speed secured route with exclusive or priority bus lane, which is composed of various operation services according to the demand such as local, trunk and express buses

Type 2: High-speed secured route with exclusive on priority bus lane especially in order to serve the role of access to urban area which is composed of various operation services according to the demand such as local, trunk and express buses.

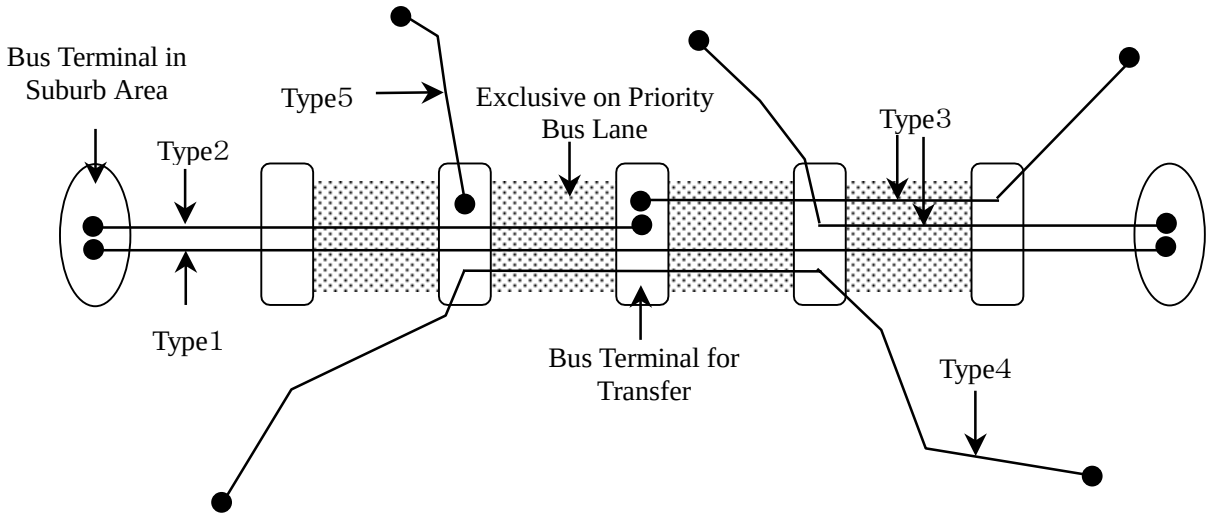
Type 3: Bus route for connecting urban area and neighboring area nearby exclusive or priority bus lane where exclusive or priority bus lane is partly available. Entry or exit to/from exclusive or priority lane is done at one terminal.

Type 4: Bus route for connecting urban area and neighboring area where exclusive or priority bus line is partly available. Entry or exit to/from exclusive or priority lane is done at bus terminal.

Type 5: Bus route to connect bus terminal with neighboring area.

Type 3-5 serve as feeder service.

Figure 7.2.3 Types of Public Transport Routes



2) Rearrangement of bus routes according to subway operation. It needs to abolish some bus route along the subway line after subway operation. Bus will mainly play a role of feeder service to subway station by combining Type 3-5.

7.2.4 Assessment of the Bus Terminals and Transfer Points Development

(1) Development Policies

1) **Guidelines to improve transfer point and inter-city bus terminals are as follows:**

- Improvement of transfer facilities
- Responding to the demand
- Coordinating effectively the network of exclusive and priority bus lanes
- Reducing through traffic
- Establishing long-term plan for transfer points of public transport
- Ensuring safety for public transport users
- Utilizing existing bus terminals
- Improving intersections
- Operating with profitability in line with urban development

2) **Improvement of inter-city bus terminal**

- Formulating transfer points for public transport according to main corridor
- Connecting intra-city and inter-city buses effectively
- Connecting bus terminal with starting and ending stations of railway
- Providing bus garages, bus inspection facility and CNG transport facilities
- Operating with profitability in line with urban development

(2) Bus Transfer Points Development Plan in the Urban Area

An alternative areas for introducing transfer facilities, points intersecting radial and ring roads inside the Second Ring Road were adopted because they are expected to bring substantial increase in demand, to improve with exclusive or priority bus lanes and subway operation. Table 7.2.3 shows change in bus demand at transfer points at present and in the future.

As many as 300,000 passengers already exist around the Tianfu Square at present but the demand will be accelerated to reach about 530,000 passengers in the future. Particularly the demand is expected to be beyond 100,000 passengers in the following areas: 1) Jiuyanqiao along the 1st Ring Road, 2) Gaoshengqiao, 3) North Railway Station along the Second Ring Road, and 4) Niushikou. The demand will especially increase at alarming pace around Tianfu Square and North Railway Station due mainly to introduction of subway line.

Table 7.2.3 Change in Bus Demand at Major Transfer Points

(Unit: thousand passengers/day)

Transfer Point	Road	Year 2000			Year 2010		
		Boarding and Deb-arkation	Transfer	Total	Boarding and Deb-arkation	Transfer	Total
Tianfu Square	Renmin Nan-Lu	167	140	307	346	182	528
Jiuyanqiao	the 1st Ring Road	73	66	139	184	94	278
Gaoshengqiao	the 1st Ring Road and Wuhouci Da-Jie	48	58	106	134	111	245
1st Ring Road South	the 1st Ring Road and Renmin Nan-Lu	9	18	27	45	45	90
Qingyang Xiao-Qu	The 1st Ring Road and Qingjiang Dong-Lu	30	35	65	53	32	85
Ximen	The 1st Ring Road and Yingmankou Lu	16	14	30	41	32	73
Beimen	The 1st Ring Road and Jiefang Lu	21	17	38	36	18	54
Shuinianhe	The 1st Ring Road and Dongfeng Lu	25	24	49	27	15	42
North Railway Station	The 2nd Ring Road and Renmin Bei-Lu	145	68	213	280	99	379
Niushikou	The 2nd Ring Road and Shuanggui Lu	33	18	51	100	44	144
2nd Ring Road South	The 2nd Ring Road and Renmin Nan-Lu	1	1	2	41	41	82
Entrance of Cheng-Wen Expressway	The 2nd Ring Road and Qingjiang Zhong-Lu	11	22	33	28	28	56

Note: Figures are based on transit assignment results.
No. of transfers was assumed at 2 times per one passenger.

Though assuming that the bus services can meet the transport demand, substantial demand increase could cause traffic congestion and accident at the transfer points.

It is therefore necessary to solve these problems by providing for the improvement of transfer facilities. It should however be noted that, as land acquisition is very difficult especially in the urban area, emphasis should be given on the provision of transfer facilities in line with urban renewal and the effective use of existing terminal facilities.

Even though Jiuyangiao brings about a large potential demand in the future, it seems to be not appropriate to directly provide transfer facilities there due to limitation of transfer facility space and poor access to urban area. Instead, it may be recommended to establish transfer facilities around the east-west axis. As a result, it can, with the provision of exclusive or priority bus lane, serve as a pivotal transfer facility in the future, making it possible to transfer smoothly.

Table 7.2.4 shows a list of transfer facilities of intra-city bus facilities.

Table 7.2.4 Bus Transfer Facilities

Location	Type of intersection	Existing Bus Terminals	Link with other transport mode	Remarks
Tianfu Square	Plane		Line 1 Subway	
Gaoshengqiao	Plane	Gaoshengqiao Bus Terminal	Subway (long term)	
1st Ring Road South	Plane		Subway (long term)	
Qingyang Sub-district	Plane		Subway (long term)	
Ximen	Plane	Ximen Bus Terminal	Subway (long term)	
Beimen	Plane	Beimen Bus Terminal		
Shuinianhe	Plane			Relieving the pressure of transfer at Jiuyanqiao
North Railway Station	Plane	North Center Station	Railway, Line 1 Subway	
Niushikou	Overpass	Shuangqiao Passenger Transport Center	Subway (long term)	Relieving the pressure of transfer at Jiuyanqiao
2nd Ring Road South	Overpass			
Entrance of Cheng-Wen Expressway	Plane		Subway (long term)	

(3) Inter-city Bus Terminal Development Plan

As shown in Table 7.2.5, inter-city bus development is under the planning stage. One project has been completed, and another one is under construction. The objective of these projects is to move inter-city bus terminal the along the 1st Ring Road to other areas. As the city expands, the bus route network tends to expand as well. Moving the present inter-city bus terminal to the suburban area is in accordance with the city expansion and effective operation of bus transport system based on Chengdu City's development plan until the year 2010.

In Chengdu City's plan, inter-city bus terminals are planned to be set up towards different directions accordingly. Existing facilities can be utilized in some areas where future demand is not so significant, as follows: Longtansi Bus Terminal, Cheng-Nan Expressway Bus Terminal and Baliqiao Bus Terminal.

As a result, 7 terminals are proposed to be improved up to 2010 and they are summarized in Table 7.2.6.

Table 7.2.5 Inter-city Bus Terminal Development Plan in Chengdu City

Number	Terminal	Location	Area (ha)	Remarks
Long-distance bus stations				
1	Longtansi Small Bus Terminal	Between outer 3rd Ring Road and the west of Niu-Long Expressway	1.3-2.7	Qinglongchang Station (municipal), Zhaojuesi Station (suburban)
2	Cheng-Nan Expressway Bus Terminal	the northeast of the intersection of 3rd Ring Road and Cheng-Nan Expressway	4.0	Cheng-Nan Expressway is still under construction
3	South Railway Station Passenger Transport Terminal	The east of the southern part of South Railway Station	6.7	
4	Shiyang Bus Terminal on Cheng-Ya Expressway	Near the intersection of Cheng-Ya Expressway and Cheng-Le Expressway	4.0	In use (Shiyang Central Station)
5	Shunjiang Lu Bus Terminal on Chuan-Zang Expressway	Near the intersection of 3rd Ring Road and Chuan-Zang Expressway	3.3	
6	Jinniu Bus Terminal on Cheng-Guan Expressway		5.3	Under construction
7	Dongzikou Bus Terminal on Cheng-Peng Expressway	The northeast of the intersection of 3rd Ring Road and Cheng-Peng Expressway	4.0	
8	Jiangjunbei Bus Terminal on Chuan-Shan Expressway	Between the north of Third Ring Road and the west of Chuan-Shan Expressway	4.7	
9	Honghe Central Terminal	The north of the intersection of 3rd Ring Road and Cheng-Yu Expressway	2.0	
10	Qingjiang Lu Central Station at West Railway Station	Between outer 3rd Ring Road and the north of Qingjiang Lu	2.0	
11	Baliqiao Bus Terminal	Between the north of 3rd Ring Road and the west of Baliqiao section of Old Cheng-Peng Expressway	2.7	
Long-distance Bus Terminals in long-term scheme				
12	Cheng-Yu Expressway Bus Terminal	Between outer 3rd Ring Road and the north of Cheng-Yu Expressway	5.3	Wuguiqiao Station (municipal), Chen-Yu Expressway Station (suburban)
13	Haibin Bus Terminal on Cheng-Mian Expressway	Between 3rd Ring Road and the southeast of Cheng-Mian Expressway	5.3	
14	Cheng-Ren Expressway Bus Terminal			

Table 7.2.6 Planned Inter-city Bus Terminal

Number	Station	Location	Area (ha)	Long-distance bus stations already in use
3	South Railway Station Passenger Transport Terminal	The east of the southern part of South Railway Station	6.7	
5	Shunjiang Lu Bus Terminal on Chuan-Zang Expressway	Near the intersection of 3rd Ring Road and Chuan-Zang Expressway	3.3	Hongpailou Bus Terminal
7	Dongzikou Bus Terminal on Cheng-Peng Expressway	The northeast of the intersection of 3rd Ring Road and Cheng-Peng Expressway	4.0	Wukuaishi Bus Terminal
8	Jiangjunbei Bus Terminal on Chuan-Shan Expressway	Between the north of 3rd Ring Road and the west of Chuan-Shan Expressway	4.7	North Bus Terminal, Hehuachi Passenger Transport Station, Gaosuntang Bus Terminal
9	Honghe Central Terminal	The north of the intersection of 3rd Ring Road and Cheng-Yu Expressway	2.0	
10	Qingjiang Lu Central Terminal at North Railway Station	Between outer 3rd Ring Road and the north of Qingjiang Lu	2.0	Jinsha Passenger Transport Bus Terminal
11	Baliqiao Bus Terminal	Between the north of 3rd Ring Road and the west of Baliqiao section of Old Cheng-Peng Expressway	2.7	

The present inter-city bus terminals can be utilized as follows:

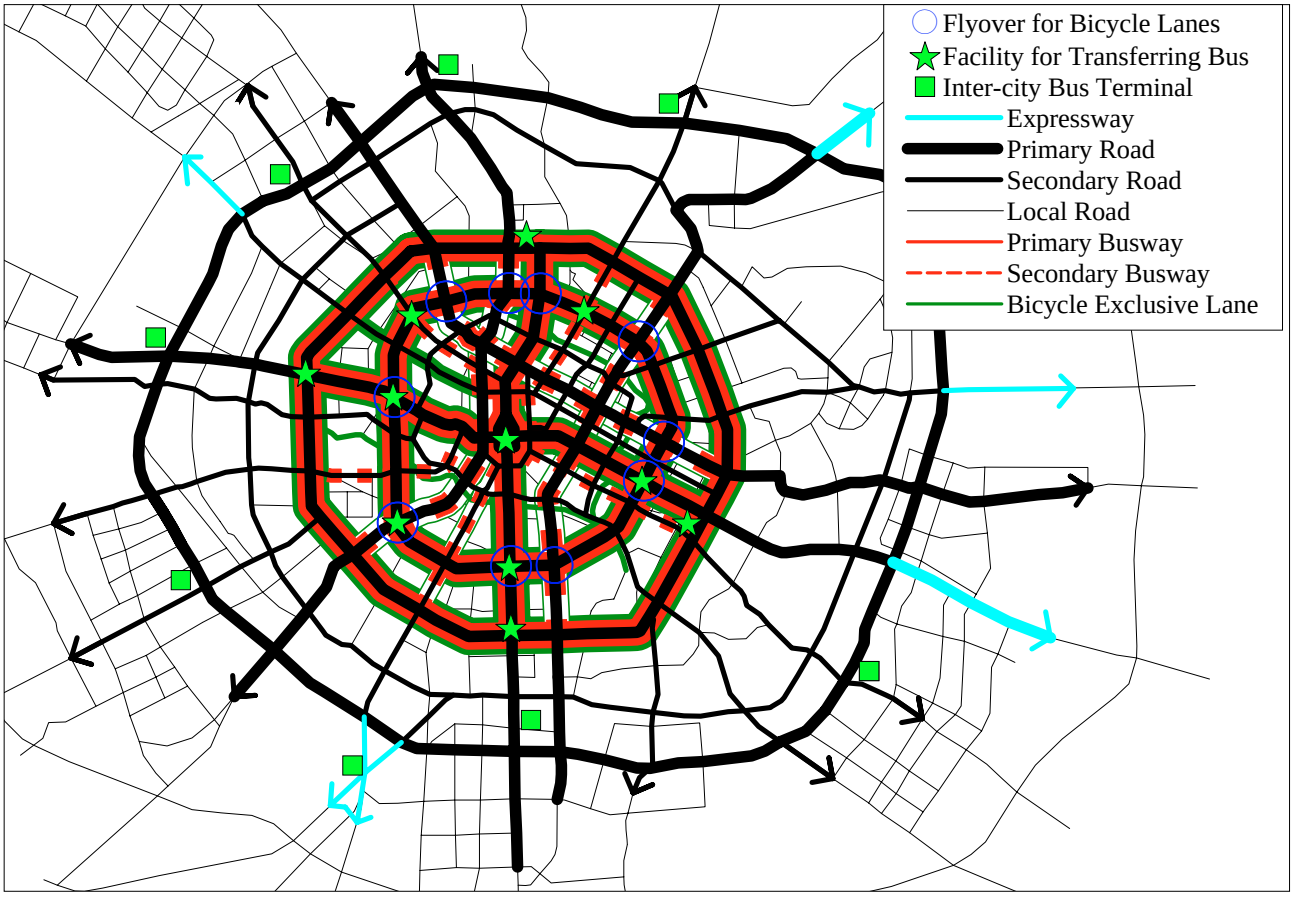
- Transforming into intra-city bus terminals
- Selling to the public
- Transforming into public facilities such as park, etc.

In addition to transfer function, bus terminals should provide the following facilities to secure bus users' comfortability and safety and improve bus operation:

- Bus berth, transferring space, waiting facility, ticket selling place, store and comfort rooms.
- Gas station and bus repair facility
- Linkage with commercial, business and public facilities

As for operation of inter-city bus terminals, Chengdu City has a plan to provide them by private sector. However it seems to be difficult because of strategic location and implementation problems. Thus it may be recommended that the city government provide and improve the inter-city bus terminals and then lease the facilities to the private sectors. The city government can cover expenses for operation and maintenance with profits from the lease of the private sector and related facilities. Further integrated development with commercial, business and public facilities could contribute to the increase in the profits and, as a result, the expansion and improvement of the terminals.

Figure 7.2.4 Intra-city Bus Transfer Facilities and Inter-city Bus Terminals Development Plan



7.2.5 Terminal and Transfer Points Facility Development

Public transport passes through designated routes at designated time and carries passengers to designated places. Even though the public transport services are provided to reflect the users' characteristics and demand, as much as possible, it is impossible to provide the same services as private transport, which enables door-to-door trip, due mainly to the features of the public transport such as transfers, waiting, access, egress, and so on. In order to reduce users' reluctance to the public transport and attract as many passengers as possible, it is absolutely needed that users' convenience, comfort and safety be assured through well-managed terminal and transfer points facility development. In addition, integrated development with land use will be a key to sustainable transport development.

Table 7.2.7 summarizes types and functions of public transport terminals and typical concepts are illustrated in Figures 7.2.5 to 7.2.7.

Table 7.2.7 Types and Functions of Public Transport Bus Terminals

Types	Main Functions	Facilities
Suburban Bus Terminal (Inter-urban Bus Terminal)	Starts or terminals of bus lines, operation management, check and fuel supply for vehicles.	Berth, waiting rooms, comfort rooms, ticket selling facility, parking lots (for bicycles and automobiles), offices of public transport companies, fuel supply facilities and facilities for driver's rest
Multi-modal Public Transport Terminal	Joints of public transport system, different from subway or railway	Broad linked passages, central squares, walkers' squares, ascent and descent facilities, wickets, waiting rooms, toilets, comfortable space, restaurants, groceries
Public Transport Interchange Plaza	Joints of main public transport lines, highly required, expected to combine with commercial activities	Descent and ascent facilities wickets, waiting rooms, restaurants, comfortable space
Public transport square	Ensure passengers' comfort and safety on main lines and joints of lines where many passengers transfer	Descent and ascent facilities, overhead walkways, public transport bus users' square, toilets

Figure 7.2.5 Conceptual Development Plan for Inter-Urban Terminal

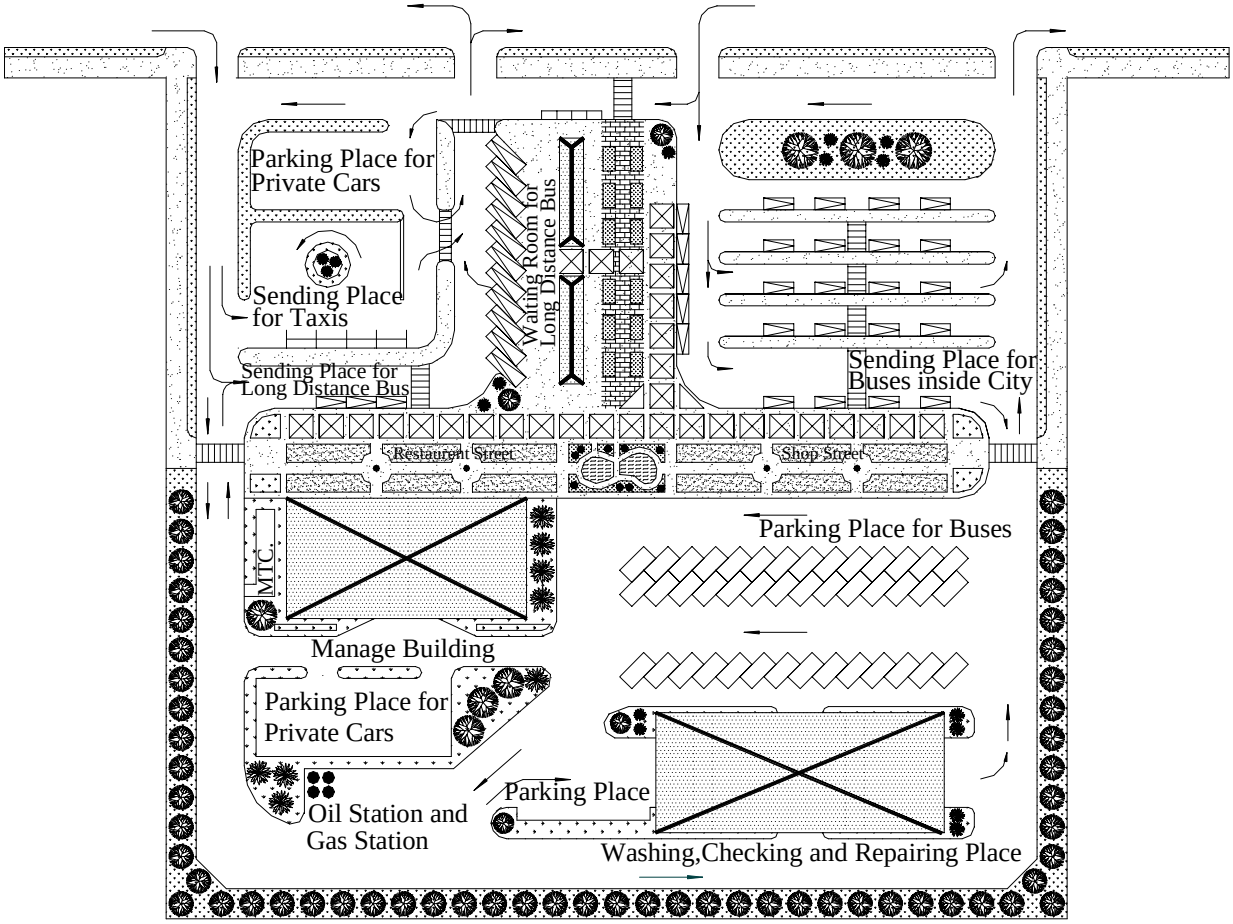


Figure 7.2.6 Conceptual Development Plan for Public Transport Interchange Plaza

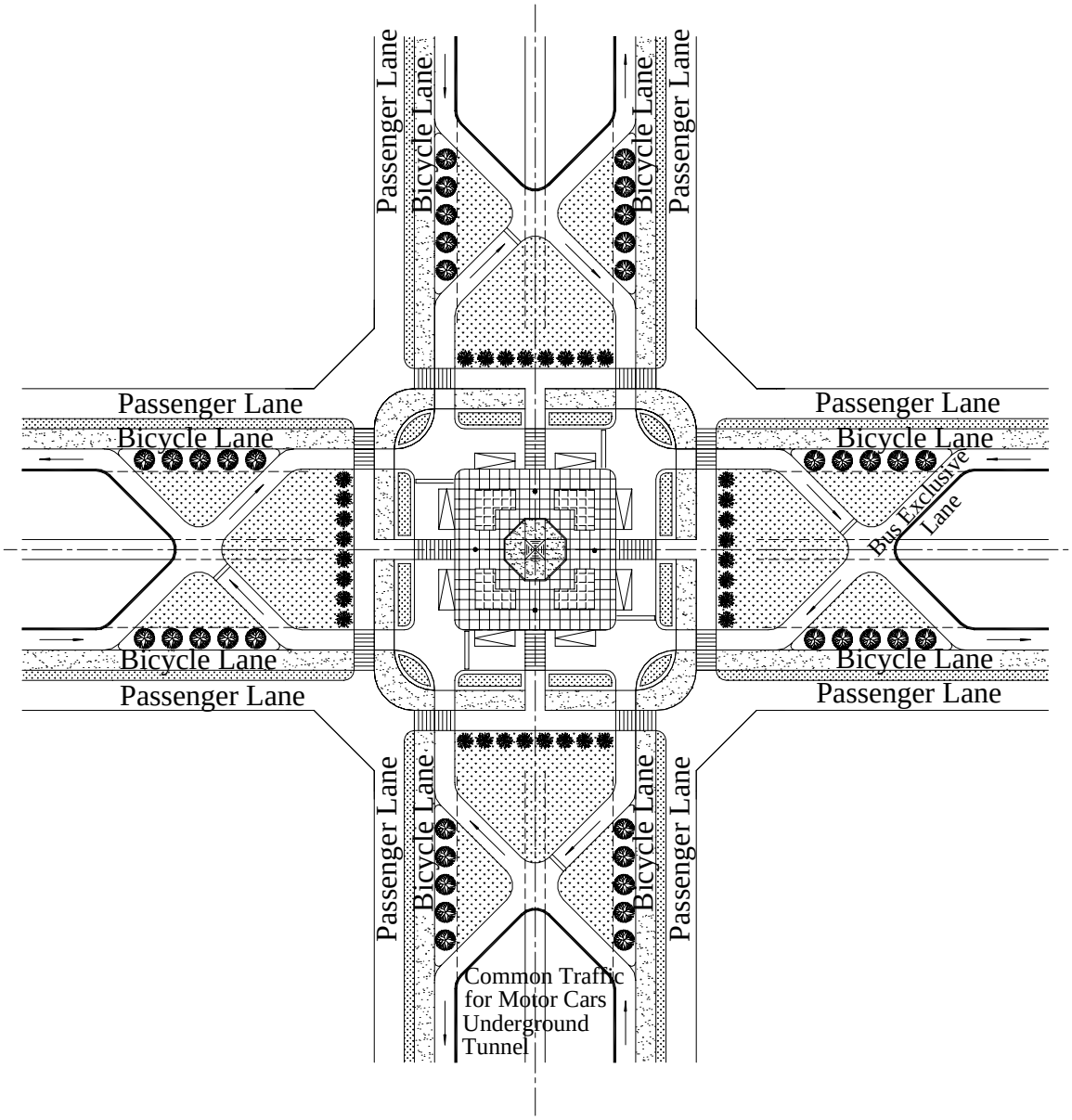
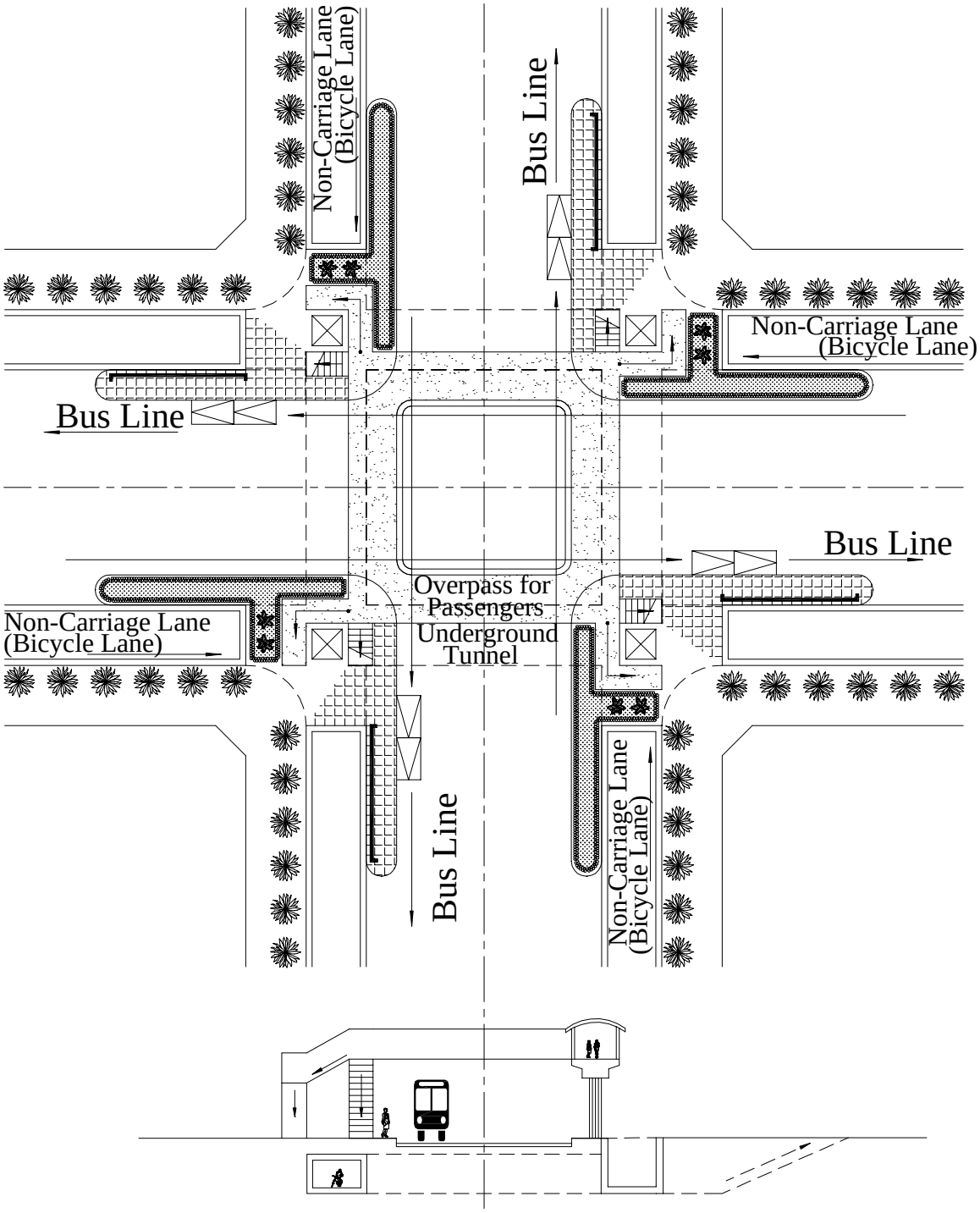


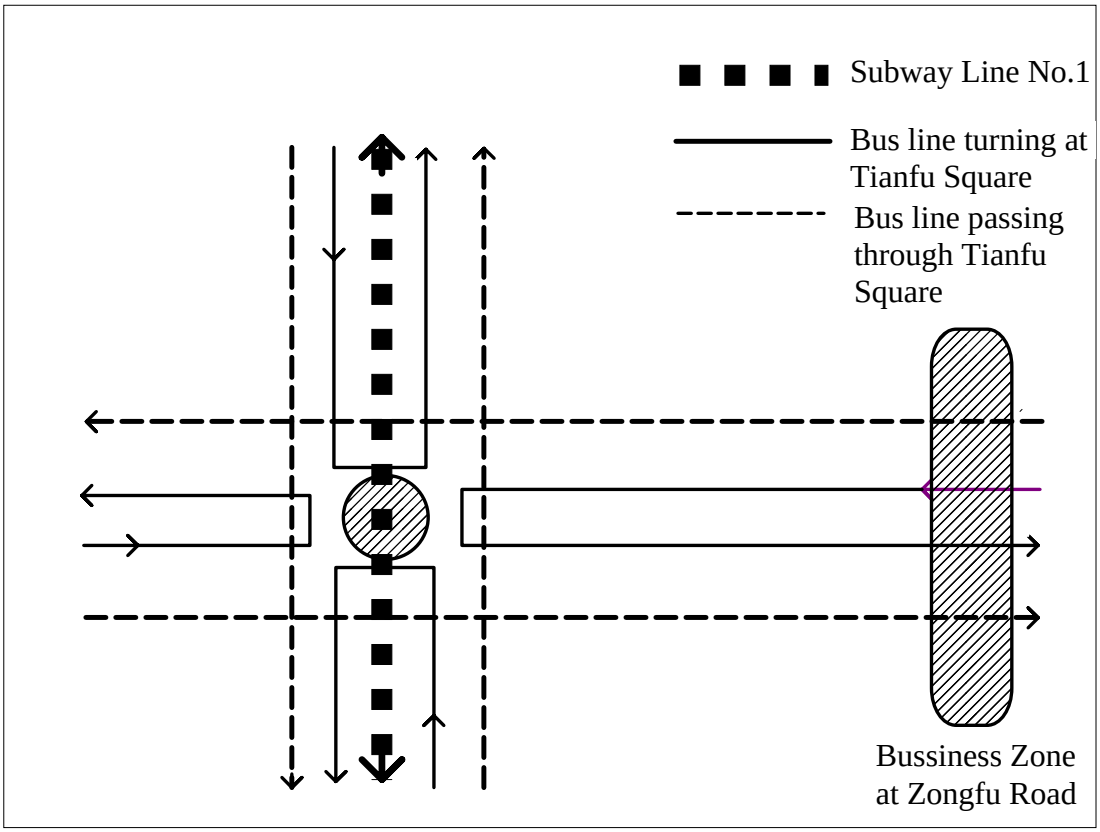
Figure 7.2.7 Conceptual Development Plan for Public Transport Square



The transformation of Chengdu's subway system is presently being developed. At the initial stage, Subway Line 1 is to be set up under Chengdu's north-south axis line, which links North Railway Station with Tianfu Square and South Railway Station. This line is Chengdu's central area and key transport line. The intersection of Tianfu Square and Shudu Road, the east-west main line of the Chengdu, becomes the central business district, causing a number of key inter-phasing of various public transport lines.

Figure 7.2.8 shows the concept of Tianfu Square multi-modal public transport terminal development.

Figure 7.2.8 Concept of Tianfu Square Multi-Modal Public Transport Terminal Development



7.3 Plan of Improving Bus Stops

7.3.1 Structure and Problems of Existing Bus Stops

(1) Structure

As shown in Figures 7.3.1 and 7.3.2, most of the public traffic lanes are in the outer lanes of the four-lane roadways. Normal bus stops make use of the footpath (Figure 7.3.3). The distance between two bus stations is 500m to 600m. The bus stops in the main road with dedicated lanes for bicycles are always near most crossings/intersections, and the bus road is separated from bicycle road by an outer segregator (W=2.0 to 1.50m).

Figure 7.3.1 Structure of Existing Bus Stop (1)

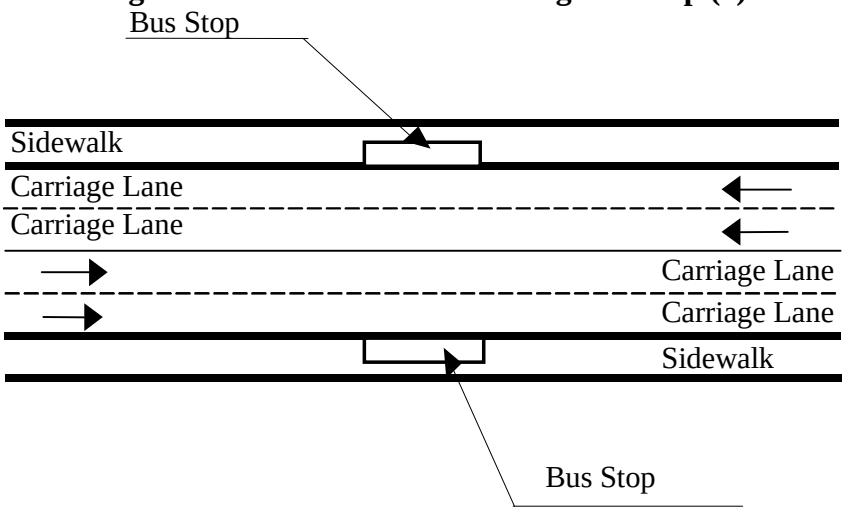
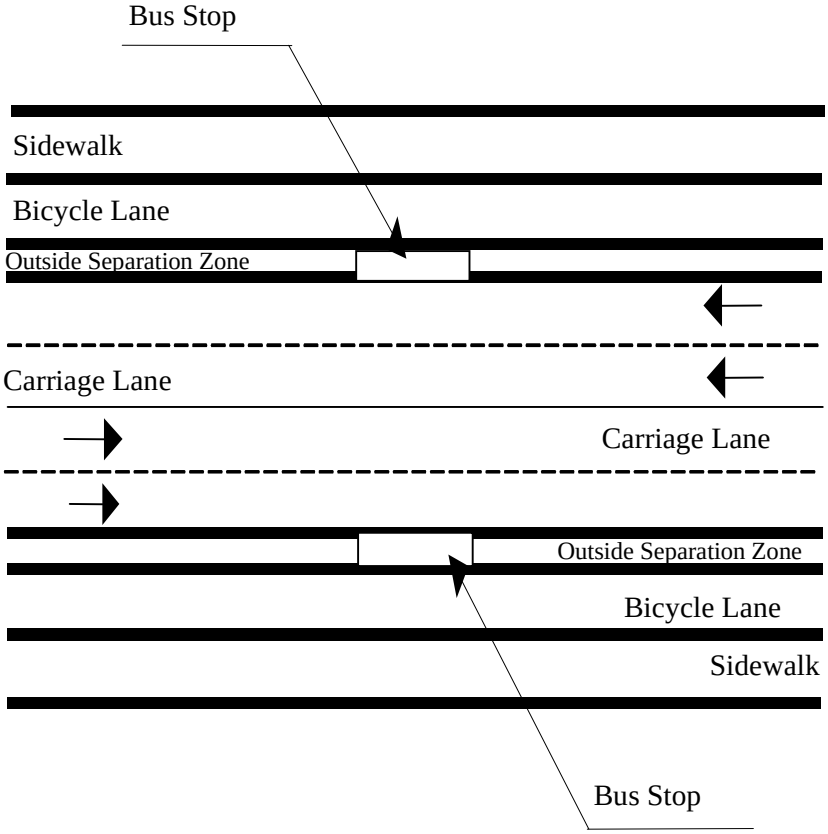


Figure 7.3.2 Structure of Existing Bus Stop (2)



(2) Problems and Issues

The bus stops are in the outer lanes of the four-lane roadway without dedicated lanes for bicycles. The two middle lanes are for cars while the two outer lanes are for bicycles. Thus, buses have to pick up passengers on the bicycle paths which in turn causes the bicycles to enter the car lanes further causing vehicular traffic to slower driving speed. Another effect of this arrangement is the high rate of accident, especially when buses pull in the stops mostly during rush hours in the morning and evening. Traffic capacity of roads is eventually decreased when obstructions happen anywhere in the trunk road. Thus, based on the described traffic scenario, the following conclusions and proposed arrangements are as follows:

1) Bikers are usually threatened when bus pulls in the bus stops, which are in their path. Thus, the following can be concluded:
    a. Accidents are highly probable with this arrangement
    b. Traffic capacity is eventually decreased by probability of accidents and traffic obstructions.
    c. Lower velocity for buses and bicycles
    d. Causes insufficient capacity for bicycle traffic
    e. Causes traffic congestion

2) There should therefore be separate lanes for vehicular and bicycle traffic basically due to the difference in their speed.

3) The results of the separation are as follows:
    a. Decrease traffic accidents, insuring safety of traffic.
    b. Increase capacity of traffic.
    c. Increase travel speed for both cars and buses.
    d. Reduce traffic congestion.

7.3.2 Improvement Plans for Bus Stops

(1) The Basic Policy and Precondition for Improving Bus Stop Plan

Considering problems of bus stops, traffic situation and land use, the basic policy and precondition of improving bus stop plan was established as follows:

1) Complete separation of buses and cars
2) No additional land acquisition
3) Preserving environment
4) No large-scale reconstruction

(2) Bus Stops Improvement Plans

Based on the basic policy, problems, existing land use, traffic conditions, etc., the following improvement measures are being proposed:

1) Improvement of bus stops plan, without dedicated bicycle lane (Figure 7.3.3). (Improvement Plan Type-1)

   a) Set lines with 3.0m width for bus bay.
   b) To accommodate the lane for bus stops in the existing roads, the width of the
   c) four-lane roads should be reduced from 3.25m to 2.75m (4*0.50=2.00m), and the width of sidewalks should be reduced from 4.50m to 4.00m（2*0.50=1.00m）.
   d) Bus stop set up within existing sidewalks.
   e) Bicycle lanes are cancelled, and bicycles will use new bicycle roads as planned in the Study.
   f) The existing trees at sidewalks will be transferred and replanted at 0.5m inside of the sidewalks.
   g) The trees will extend about 100m after replanting.

2) Improvement of bus stops plan, with dedicated bicycle lane (Figure 7.3.4). (Improvement Plan Type-2)

   The following items are improved.

   a) Set up bus bay lane with 3.0m width.
   b) Bus stop set up at zigzag system.
   c) Width of bus plat form is adopted at 2.5m considering traffic safety.
   d) For 3.0m bus bay set up, to reduce the existing lane width 3.5m to 3.0m and to reduce the existing bicycle lane width 7.0m to 6.5m.
   e) Roadside trees at the divider should be re-planted.
   f) Length of re-plantation is about 100m.

Figure 7.3.3 Improvement Bus Stop Plan in Trunk Roads Without Dedicated Bicycle Lanes (Type-1)

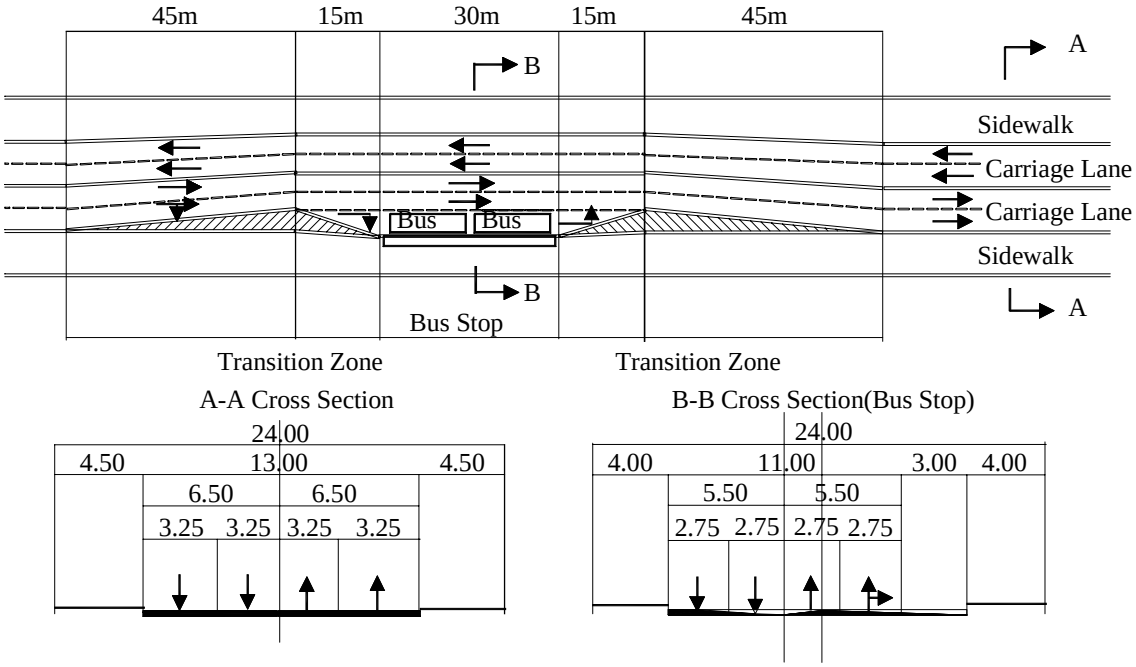
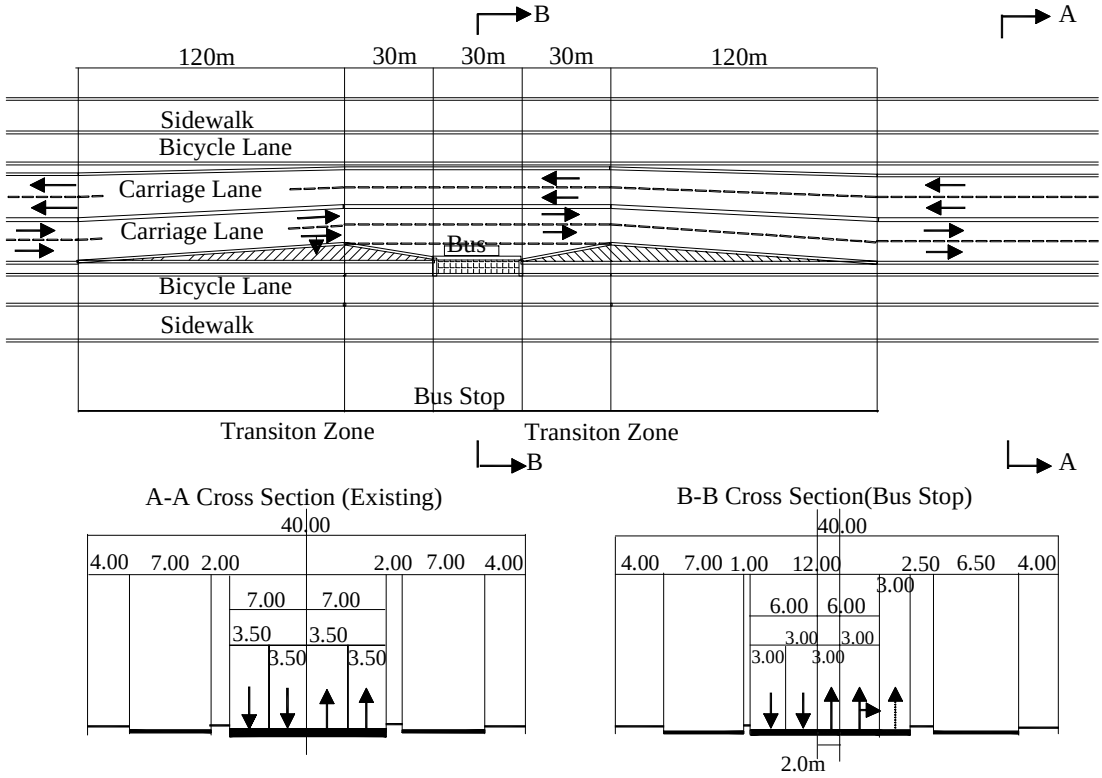


Figure 7.3.4 Improvement Bus Stop Plan in Trunk Roads With Dedicated Bicycle Lanes (Type-2)



7.3.3 Location Bus Stops to be Improved

In the previous section, the primary bus ways are set up on the following four (4) roads.

a) Renmin Bei-Lu － Renmin Zhong-Lu － Renmin Nan-Lu (The main road of South-North direction)

b) Shudu Road (The main road of East-West direction)

c) The First Ring Road

d) The Second Ring Road

The above four (4) roads will be widen from four-lane to six-lane roads, with the outer lane dedicated for buses. Since the lane occupied completely by buses in one direction should be insured, provision of additional road space for new buses pulling in line is already not feasible. So the roads needing bus stop improvements include the roads preceding bus lanes and the main roads which has big traffic volume. The following roads needing preceding Secondary Busway include:

a) New Renmin Nan-Lu, Hongxing Lu, Fuqing Lu

b) Shuanglin Lu, Shawan Lu

c) Caojin Lu

d) Wuhouci Da-Jie

e) Ximianqiao Lu

f) Old Cheng-Yu Highway

g) Jiefang Lu

h) Chadianzi Lu

The main roads which have big traffic volume and need improvement are as follows:

a) The Inner Ring Road

b) Taisheng Bei-Lu

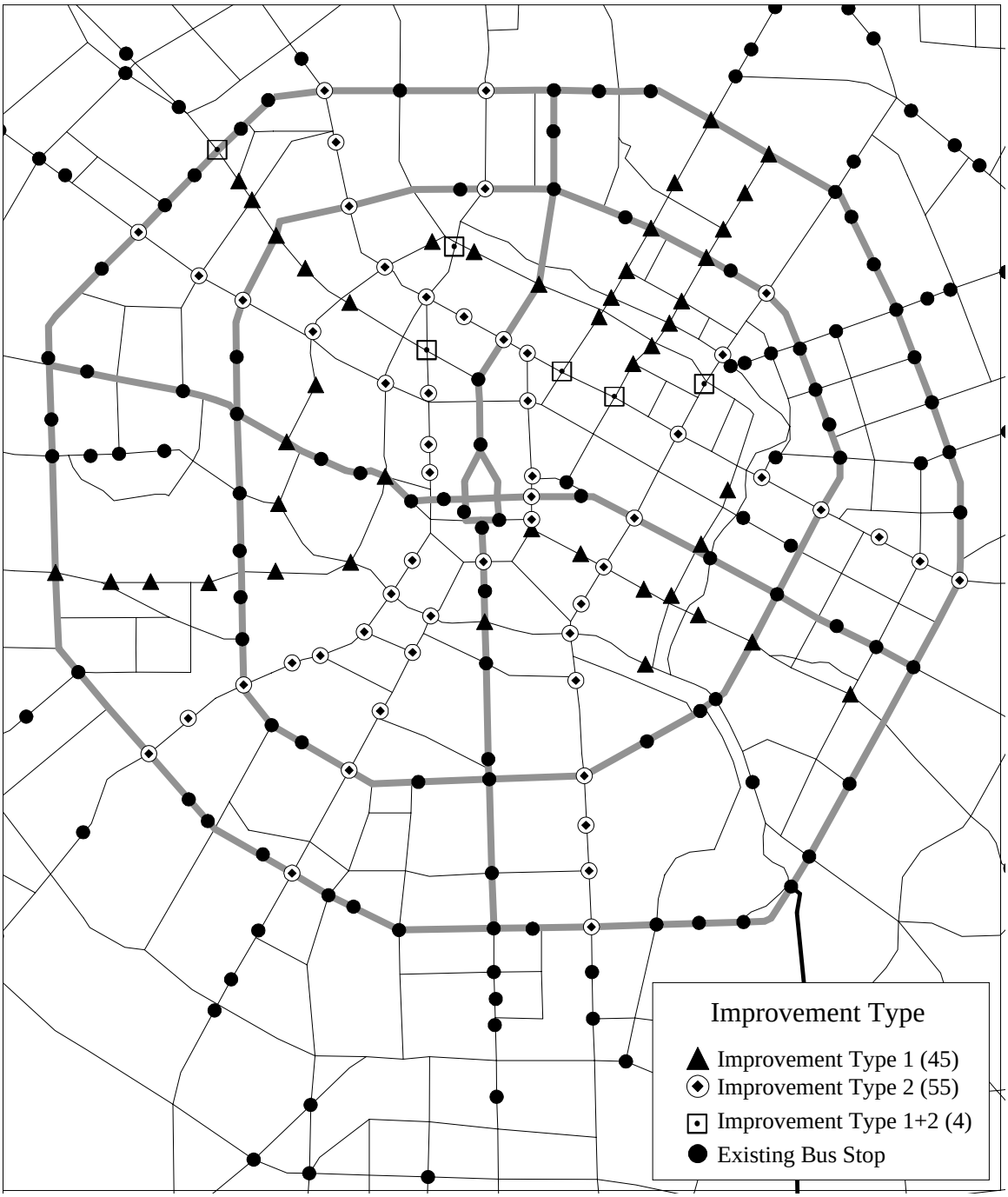
c) Fuqin Lu

The bus stop improvement plan type-1 is adopted at the Primary Roads with dedicated bicycle lanes, and type-2 is adopted at the Primary Roads without dedicated bicycle lanes. The place and number of bus stop needing improving is shown in Table 7.3.1 and Figure 7.3.5.

Table 7.3.1 Roads Needing Bus Stop Improvement

Name of Road	Related construction	Adopted improving plan (type)	Number of Places Where Bus Stops Need Improvement	Application
Ⅰ. Roads where Primary Busway will be set				
• Main road of South-North direction	with bicycle lane	————	————	widening 4 to 6 lanes
• Main road of East-West direction	with bicycle lane	————	————	widening 4 to 6 lanes
• 1st ring road	with bicycle lane	————	————	widening 4 to 6 lanes
• 2nd ring road	with bicycle lane	————	————	widening 4 to 6 lanes
Ⅱ. Roads where preceding Secondary Busway will be set				
• Xinnan Lu —Hongxing Lu —Fuqing Lu	with bicycle lane	Improving plan—2	13*2=26	Improving both directions sides
• Shuanglin Lu	with bicycle lane	Improving plan—2	16*2=32	Improving both directions sides
• Caojin Lu	_____	Improving plan—1	7*2=14	Improving both directions sides
• Wuhouci Da-Jie	with bicycle lane	Improving plan —2	16*2=32	Improving both directions sides
• Ximianqiao Lu	with bicycle lane	Improving plan—2	5*2=10	Improving both directions sides
• Old Cheng-Yu Highway extended	_____	Improving plan —1	8*2=16	Improving both directions sides
• Jiefang Lu	_____	Improving plan—1	7*2=14	Improving both directions sides
• Chadianzi Lu	_____	Improving plan—1	6*2=12	Improving both directions sides
Ⅲ. Other main roads				
• Inner Ring Road	_____	Improving plan—1	22*2=44	Improving both directions sides
• Taisheng Bei-Lu	_____	Improving plan—1	9*2=18	Improving both directions sides
• Fuqin Lu	with bicycle lane	Improving plan—2	6*2=12	Improving both directions sides
• Improving plan — Type-1 total	_____		118 locates	
• Improving plan — Type-2 total	_____		112 locates	

Figure 7.3.5 Location of Bus Stops to be Improved



7.4 Bicycle Road Network Development Plan

7.4.1 Facilities and Capacities of Bicycle Road

Basically, there are two types of facilities for bicycle traffic; the bicycle lane and segregated bicycle road.

(1) Bicycle lane

Bicycle lane is part of the bicycle-priority lane or the lane with special-purpose passing-through areas with symbols and marks on the ground.

(2) Segregated Bicycle road

Bicycle road is the lane for bicycle use, physically separated from motor vehicle lane by open space or bars. It can be set up within the road or separately. In addition, traffic facilities for bicycle are designed based on the following standard as shown in Table 7.4.1.

Table 7.4.1 Design Elements of Bicycle Traffic Facilities

Width (m)	Height (m) (in navigation)	Length (m)	Height of treadles (m)
1.00	2.50	1.90	0.75

A typical bicycle is 0.60m in structural width. Since it cannot avoid swaying while running, however, the width of bicycle is set to 1.0 m in principle.

The width of bicycle roads and bicycle lanes is based on the minimum width of 1.0 m. Due to other factors such as overtaking and making-way for other bicycles, it can be set to above 2.0 m. To improve the safety and comfort of bicycle traffic, extra space should be kept on both sides. The width should be thus set to above 3.0 m in principle.

There is not much useful information for traffic capacity for bicycle. In accordance with Japan's Act of Road Structure, the capacity was assumed at 1,600 bicycles per hour on a 2.0 m bicycle road. The Highway Capacity Manual of the United States assumes that the capacity of bicycle lanes is set within 1,700-2,530 bicycles per hour per meter. China's technological standard also assumes that the capacity of bicycle lane becomes 2100 bicycles per hour per meter, and that of normal bicycle lane becomes 1800 bicycles per hour per meter. When disturbed by geometric factors, the capacity is reduced to 1200-1000 bicycles per hour per meter and 1,000-800 bicycles per hour per meter for large cities with heavy bicycle traffic and small cities with light bicycle traffic, respectively. According to the above statistics, the standard of Chengdu can be set as shown in Table 7.4.2 and Table 7.4.3.

Table 7.4.2 Bicycle Traffic Capacity

The structure of bicycle space	Capacity (bicycles per hour per meter)
Physically separated bicycle road	1000
Bicycle lane separated by permanent marking	800

Service standard of bicycle lanes in the Technological Standard of China is as follows:

Table 7.4.3 The Service Level of Bicycle Lanes/Roads

Class	Speed (Km/h)	Rate of saturation		Status of traffic
		On road	At intersection	
Premium	>=15	<0.5	<0.4	No clash in all directions, passengers can ride freely
Good	11~14	0.5~0.7	0.4~0.5	Though there's limits for speed and spaces on both sides, passengers can roughly take free ride, with little interruption to pedestrians crossing streets
Medium	6~10	0.7~0.9	0.5~0.8	Bicycle traffic is a little heavy, affected by vehicles around. Pedestrians' crossing streets is limited.
Bad	<6	>0.9	>0.8	Chaos and jams exist, it's hard for pedestrians to cross streets.

Source: The Technical Standard of China.

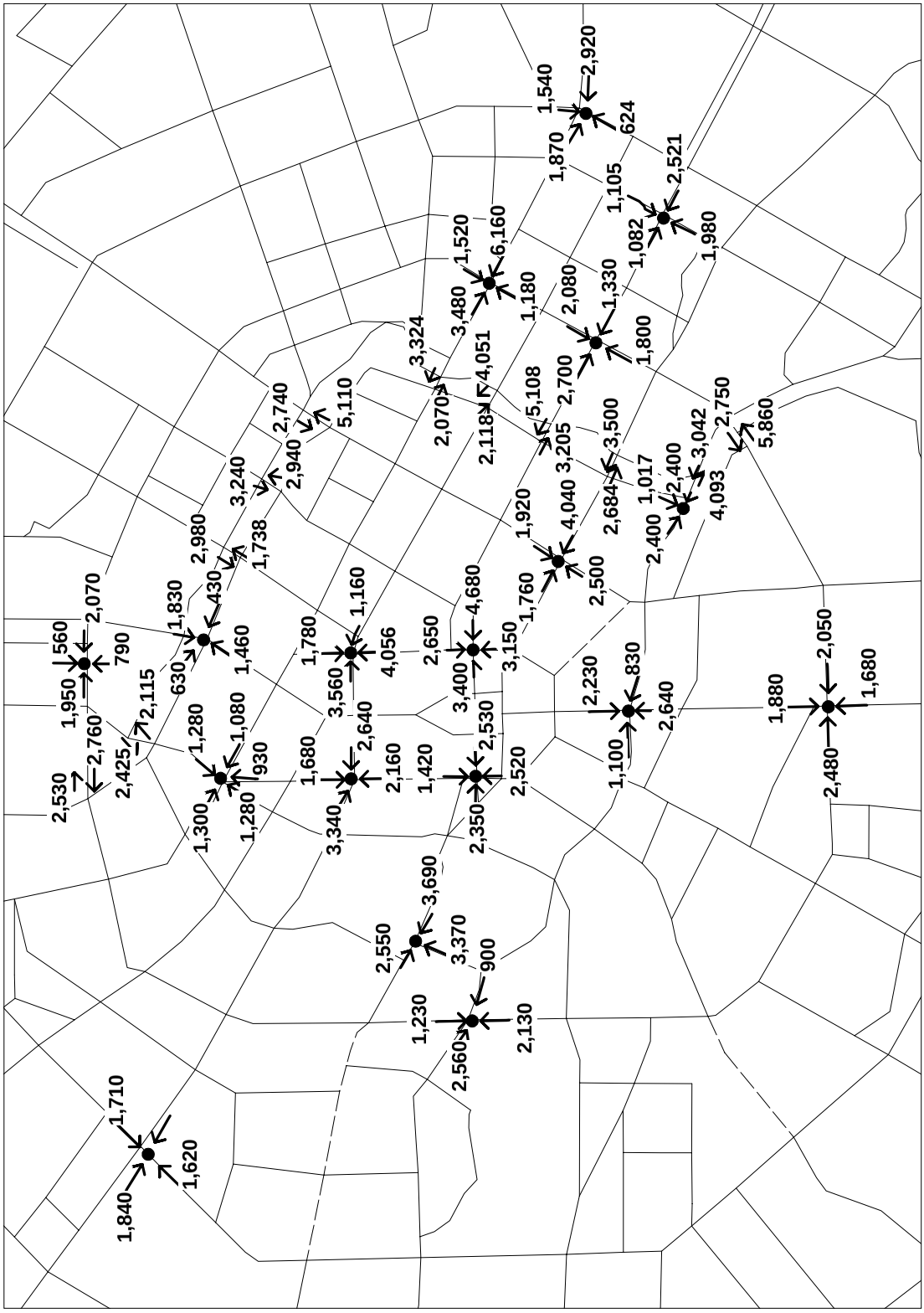
7.4.2 Bicycle Traffic

More than half of the bicycle users use bicycles for "to work" and "to school" purposes while about 40% for business purpose. It becomes evident that bicycle is fully utilized for various purposes. Most of the trips by bicycle are within 15~30 minutes travel time and the average travel time is 28 minutes. Most of the trips are within 2~3 km.

Table 7.4.4 shows the daily traffic volume and bicycle traffic volume at peak hour based on the traffic survey. While Figure 7.4.1 shows the bicycle traffic volume at peak hours based on the results of traffic survey.

Figure 7.4.1 Bicycle Traffic Volume at Peak Hour

(Unit: bicycles per hour)



Source: Traffic Survey on Screen Lines
Traffic Survey on Intersections

Table 7.4.4 Bicycle Traffic Volume on Typical Bicycle Lanes

No.	Location	Daily traffic volume				Traffic volume in different directions					
		Volume (bicycle)	16h/ 24h	Peak rate (%)	Peak hour	East-West (south-north)		West-East (north-south)		Two directions	
						Time	Volume	Time	Volume	Time	Volume
S1	Jinfu Lu	13,946	1.00	12.1	8	8:00-9:00	580	19:00-20:00	438	19:00-20:00	794
S2	Fuheqiao, Section2 of the 2nd Ring Road North	46,261	0.94	14.6	8	7:00-8:00	3,698	8:00-9:00	2,211	8:00-9:00	5,883
S3	Xibeiqiao, Section2 of the 1st Ring Road North	43,606	0.96	12.7	8	8:00-9:00	2,530	8:00-9:00	2,763	8:00-9:00	5,293
S4	Wudingqiao, North Extension of Dongchenggen Jie	33,368	1.00	14.9	8	8:00-9:00	2,115	8:00-9:00	2,425	8:00-9:00	4,540
S5	Wanfuqiao, Renmin Bei-Lu Yi-Duan	43,892	0.97	11.3	8	8:00-9:00	1,820	8:00-9:00	3,000	8:00-9:00	4,820
S6	Beimen-Daqiao, Jiefang Lu Er-Duan	42,899	0.97	10.9	8	17:00-18:00	1,738	9:00-10:00	2,976	8:00-9:00	4,518
S7	Taisheng-Daqiao, Ma’an Nan-Lu	47,630	1.00	13.2	9	9:00-10:00	2,944	8:00-9:00	3,236	9:00-10:00	5,905
S8	Hongxinglu-Daqiao, Fuqing Lu Yi-Duan	67,688	1.00	12.6	8	8:00-9:00	5,114	11:00-12:00	2,735	8:00-9:00	7,734
S9	Xinhua-Daqiao, Xinhua Dong-Lu, Sanhuaishu Lu	49,734	0.94	10.1	17	11:00-12:00	2,069	17:00-18:00	3,324	17:00-18:00	4,911
S10	Xin Dongmen-Daqiao, Yushuang Lu	38,960	1.00	15.0	8	8:00-9:00	4,051	18:00-19:00	2,118	8:00-9:00	5,224
S11	Dongfeng-Daqiao	58,559	0.94	12.1	8	8:00-9:00	5,108	17:00-18:00	3,205	8:00-9:00	6,971
S12	Dongmen-Daqiao, Xia Dong Da-Jie	52,116	0.96	10.5	8	8:00-9:00	3,500	18:00-19:00	2,684	8:00-9:00	5,300
S13	Hejiangqiao, the Inner Ring Road, Binjiang Dong-Lu	38,097	1.00	12.3	8	8:00-9:00	3,042	18:00-19:00	1,793	8:00-9:00	4,093
S14	Jiuyanqiao, Section5 of the 1st Ring Raod East	63,119	0.96	12.9	8	18:00-19:00	5,860	8:00-9:00	2,750	8:00-9:00	7,890
S15	Jiushan Gongluqiao, the 2nd Ring Road	25,625	0.92	11.8	7	7:00-8:00	1,310	18:00-19:00	1,089	7:00-8:00	2,245
S16	Xinghuiqiao	8,823	1.00	12.6	8	8:00-9:00	595	18:00-19:00	414	8:00-9:00	972

7.4.3 Principles for Bicycle Road Network Development

Bicycle is an important means traffic means to support urban transport in Chengdu City. It will be further critical how to improve the environment to increase bicycle usage for the sustainable transport development.

According to the research on bicycle utilization in 80 cities of China, the current situation of bicycle utilization in China is as follows:

1) In cities with well-developed public transportation systems, it takes about 30 minutes to move the length of 6 km, approximately the same as buses.
2) The number of bicycle users reduces only if travel time exceeds 30 minutes.
3) The average travel speed for “to work” trip in suburban area is 10 km per hour.
4) In cities where bicycles are possible to use, bicycle ownership at one bicycle per capita is getting saturated.
5) Trip purpose varies, ranging from “to work” to “to shopping”. Also, primary and middle school student users are increasing.
6) Most of the users use bicycle within the distance of 3 kilometers. It is predicted that bicycle will remain as an important mode especially for short-distance trip.
7) Modal share of bicycle is 40-60 percent of all modes.

The strategies for improvement of the environment can be classified into 3 types, as follows:

(1) Establishing classified bicycle road network;
(2) Safe and comfortable environment; and
(3) Parking facilities for bicycles.

What is important for urban transport facilities is to set up the classified network to support the economic activities, and what is important for the classified network is to link facilities with different functions to each other. For example, urban road network is composed of Primary, Secondary and Local roads, which are classified in accordance with urban activity and land use. The same concept can be applicable to bicycle road network, being at least classified into trunk and feeder bicycle roads.

(1) Trunk Bicycle Road

This road includes the following features:

- Responding to heavy traffic demand
- Comprising of trips with relatively long trip length
- Formulating the frame of bicycle road network
- Giving priority to mobility
- Separating from car or pedestrian

(2) Feeder Bicycle Road

This road include the following features:

- Serving as feeder function
- Being applicable to the neighborhood
- Comprising of trips with relatively short trip length
- Responding to light traffic demand
- Being recommended to introduce car traffic control or traffic calming to secure the safety of bicycle users

Main bicycle roads are set up every 1 km in Holland. Even in Paris, bicycle roads are set up every 2 km, and it is planned to further improve them. These spaces of 1 km or 2 km is based upon the consideration to utilize land with the basic unit of residential quarters around, which is about 1 km in size. Therefore, it is similar with road network planning.

Many non-motorized vehicle lanes in Chengdu have been separated from motorized vehicle lanes and sidewalks. The setting up of non-motorized vehicle lanes along main lanes such as Hongxing Road is planned. It is important to form non-motorized vehicle lanes into a network.

As the short-term and long-term economic development is under way, motorized vehicle traffic will increase dramatically. It is hard to meet the traffic demand in the future if the current main roads continue to be mixed with bicycle lanes. Therefore, it is necessary to create new spaces by making use of roads in residential areas and traffic management measures such as one-way road, etc.

Another problem is the parking facility for bicycles. Large scale offices or commercial buildings provide parking facilities only for their employees. Parking facilities for visitors or customers are usually provided on the sidewalks, with parking fees collected

from them. They occupy pedestrian space and become an obstacle to pedestrian movement. It is important to make full use of bicycles for sustainable transport development. At the same time, it is also important to keep pedestrian space. To utilize both bicycle and pedestrian movement, there is a need to provide and improve off-street parking facilities for bicycles. Close linkage of these facilities with the bicycle road network enables the reduction of collision of bicycle with other transport modes to a minimum level.

7.4.4 Primary Road Network and Bicycle Lane

As the economy develops, motorization will also increase and more attention will be given to motorized vehicle. In Chengdu's comprehensive transport plan, the Ring Roads are defined as primary roads with multi-lanes (at least 4 lanes) and the width of 40-50 meters including bicycle lanes.

But many sections of the roads are not wide enough between the 1st Ring Road and Inner Ring Road. As shown in Figure 7.4.2, they are only between the first 30-40 meters wide, some are even less than 20 meters. Especially, in Hongxing Lu and Xinhua Da-Dao, the mix of increasing motorized vehicles and bicycles causes serious traffic congestion.

Chengdu is now moving towards a motorized society. Since the transport demand will increase dramatically in the future, it is critical to make full use of traffic facilities in primary roads.

For the narrow primary road in the city center, it is necessary to place bicycle lanes in other roads to improve the function of the primary road. This kind of strategy can be implemented in Hongxing Lu, Xinhuan Da-Dao, Dongchenggen Jie, and Dong Da-Jie. Figure 7.4.3 shows the possibility of reforming the bicycle lanes.

Most of bicycle lanes to be planned are 4-6 meters wide. Now they are usually used as market place or parking facility. The recovery of the intended function or movement of these lanes is needed.

Figure 7.4.2 Width of Roads in City Center

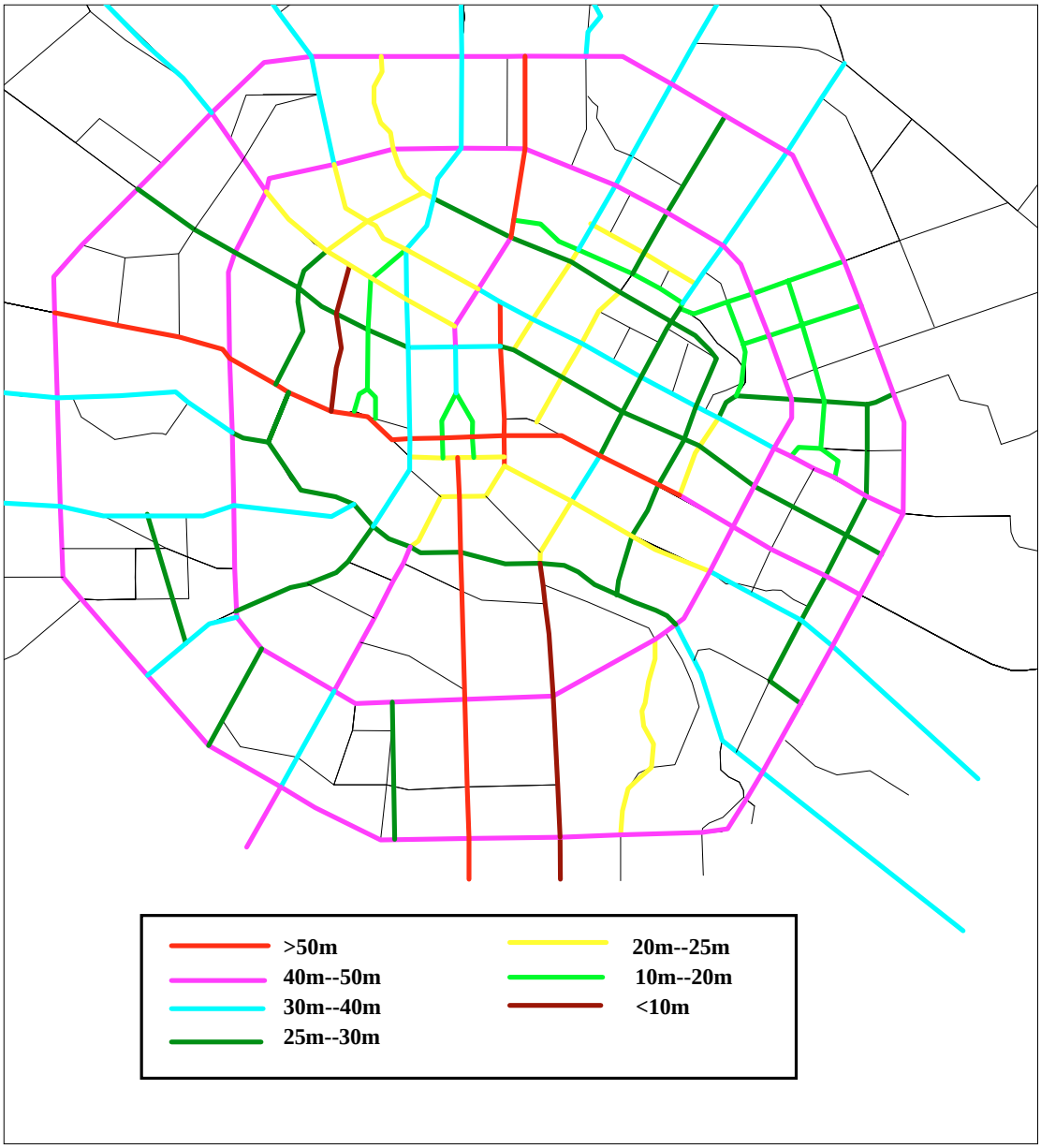
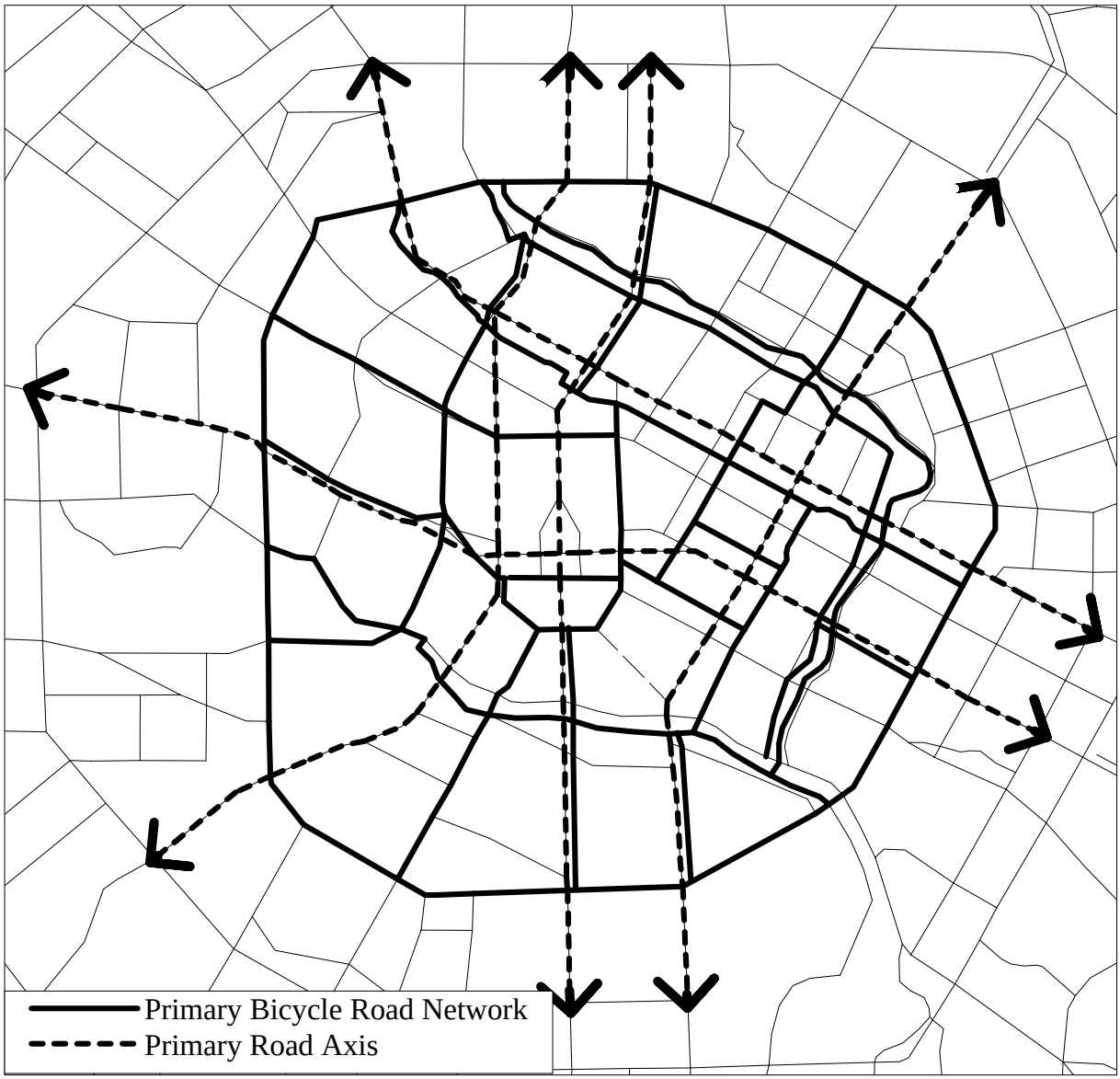


Figure 7.4.3 Separation of Main Bicycle Lanes on Principal Main Lines

(two horizontal and three vertical trunk road)



7.5 Intersection Improvement Plan and Related Traffic Management Options

7.5.1 Intersection Improvement Plans

The main reasons for the poor traffic in Chengdu are the low capacity of intersections and the low speed of buses. In addition, left-turning vehicles and traffic violations such as crossing streets increase the danger of traffic accidents. Thus, improving intersections is a key issue towards improving traffic situation in Chengdu. The Traffic Administration Bureau of Chengdu Public Security Agency has taken various actions, such as separating motorized vehicles and bicycles at intersections, installing signal systems with time display and improving the work of traffic policemen and traffic inspectors. A wide-range traffic inspection system is scheduled for implementation in December 2000, with focus on main streets in the city center. It is expected that the signal processing can be improved and traffic enforcement can be strengthened by this modern traffic inspection system.

In order to improve the current traffic situation, utilize the current intersections and ensure the convenience and safety of public transportation system and bicycle traffic, the following actions should be taken:

1) Grade-separation projects to enhance the traffic function on the trunk road network
2) Bicycle lane grade-separation projects to form bicycle road network
3) Bus (priority) lanes and signal management projects

Details are as follows:

(1) Grade-separation projects to enhance the traffic function on the trunk road network

The improvement project of a radial and ring main road network, which is made up of 2 horizontal main lines, 3 vertical main lines and several ring roads, is under construction in Chengdu. Grade-separation projects are set up at some main intersections (Shudu Road – The 2nd Ring Road, Gaoxin Da-Dao – The 2nd Ring Road).

To meet the increasing demand of vehicles in the future, grade-separation projects should be set up gradually at main intersections of radial lines and ring roads. Especially, the improvement of traffic function in ring roads plays an important role in promoting the effective traffic flow. There are 45 at-grade intersections in 1st Ring Road and 2nd Ring Road where radial main roads cross these two ring roads, and 13 of them are in the 2 horizontal main roads and the 3 vertical main roads. The construction of these grade separation projects should be an independent project, apart from the public transport development project.

(2) Bicycle lane grade-separation projects to form bicycle road network

To ensure the safety of bicycle traffic in Chengdu, grade-separation projects should be set up in bicycle lanes (non-motorized vehicle lanes). Not only motorized vehicle lanes, but also bicycle lanes are separated from each other in the main roads mentioned above to ensure smooth traffic flow for motorized vehicles and bicycles. Grade-separation projects to separate only bicycle (non-motorized vehicle) traffic, as shown in the intersection of Shuncheng Jie and Xi Yulong Jie, are under way.

Though the number of bicycles is expected to decrease as motorized vehicle traffic increases, bicycles will certainly be expected to remain as the main transport mode. It is expected to further promote the improvement of bicycle traffic environment. Especially, grade-separation projects should be set up at intersections of main road and 1st Ring Road, the main road of bicycle traffic. Because of the heavy traffic of both motorized vehicle and bicycle, it is critical to implement grade-separation project in 1st Ring Road.

Figure 7.5.1 shows the location of grade-separation projects with different purposes. Figure 7.5.2 shows the standard structure of grade-separation of bicycle road.

Figure 7.5.1 Grade-Separation with Different Purpose

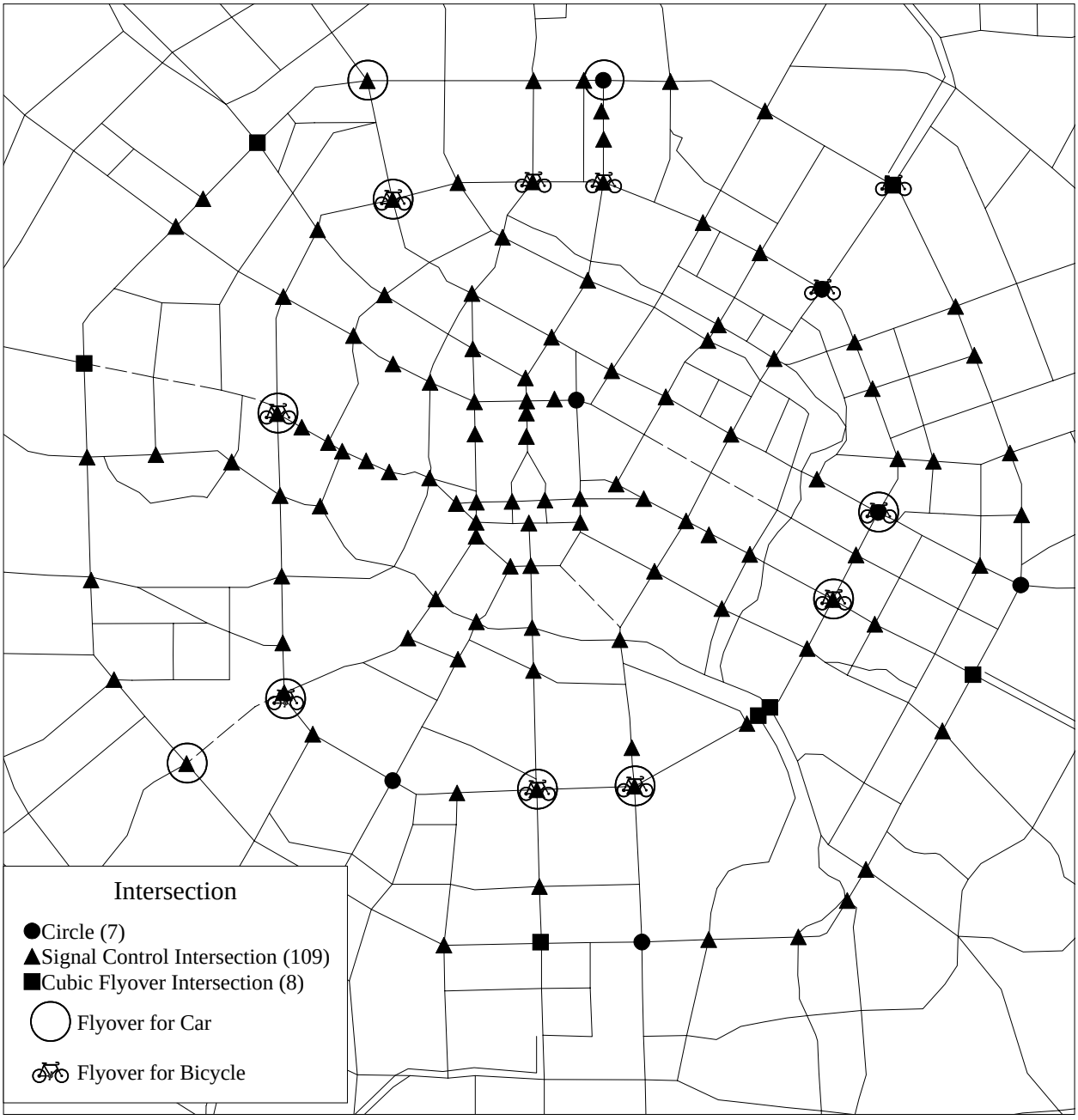
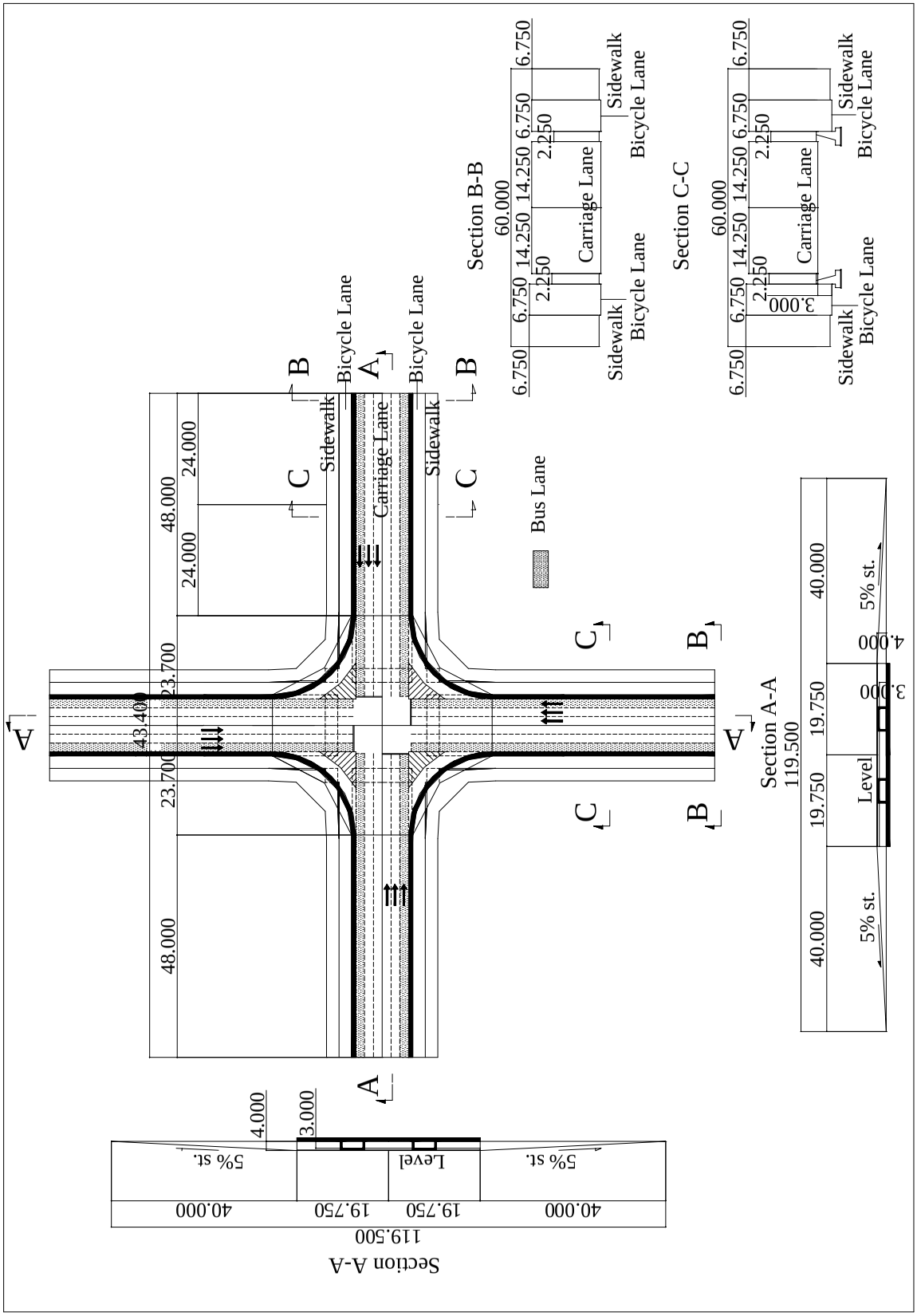


Figure 7.5.2 Standard Structure of Overpasses for Bicycle Lanes



(3) Bus (priority) lanes and signal management project

In designing a public transportation system, exclusive or priority bus lane should be considered an important factor. Figure 7.5.4 shows the standard geometric structure of an intersection after the introduction of the bus lanes. As to signal management, since the right-turn traffic of crosses with the forward traffic of buses, bus signal direction system should be designed as Figure 7.5.3. Right-turn from bus lanes can be handled with this system. But in principle, this kind of system should be implemented at all intersections with the bus lanes.

Figure 7.5.3 Signal Phasing at Intersections with Bus Lanes

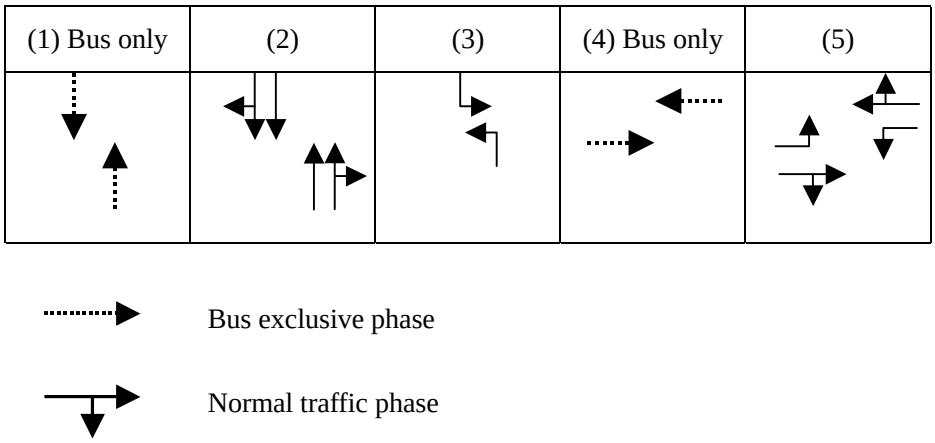
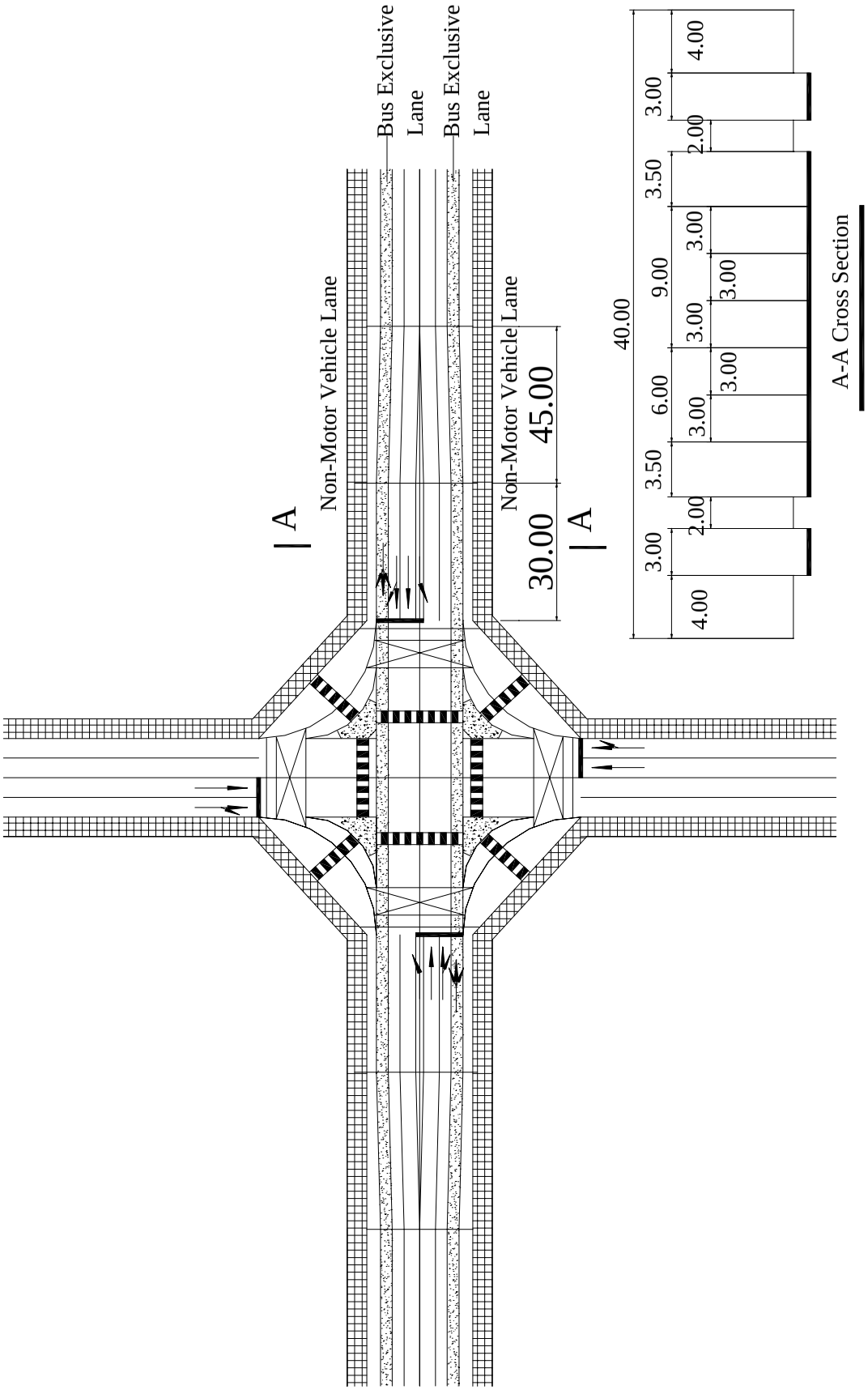


Figure 7.5.4 Standard Structure of Intersections of Roads with Bus Lanes



7.5.2 Related Traffic Management Options

(1) One-way Road System

Since priority is given to public transport and bicycle traffic is possibly protected by physical separation in the proposed master plan, vehicular traffic will have to get along well with smaller road space. Usually ring roads function to detour through traffic instead of entering city proper. However, they are already functioning as such in Chengdu and therefore a new traffic management measure is worth considering within the city proper.

Introducing one-way road system would be one of the alternatives. Although detailed and engineering considerations are necessary before enforcing one-way road system, the Study shows an example to call for related discussions (refer to Figure 7.5.5). This example contains the following intentions to guide smooth vehicular traffic:

- Many of the roads within the Inner Ring Road will be converted to one-way roads to allow more vehicles;
- Particularly east-west vehicle movement will be facilitated with creating several U-shaped traffic circulation points, and
- Tianfu Square will play an important role in vehicular traffic circulation where counter-clockwise circulation is done.

(2) Transit Mall

In order to prevent public concerns such as air pollution caused by growing motorization and to create a better environment favorable to people's health, the role of the public transport will be further strengthened. Public transport, given its reliability and some improvements on embarkation facilities for passenger convenience, is not as convenient private vehicles or bicycles that can provide door-to-door transport service. It is therefore necessary to improve public transport service such as the improvement of accessibility and convenience. Transfer is also one important element to further encourage public transport ridership. Thus, improvement of pedestrian facilities is key to developing sound environment,which can contribute to the quality of life.

Figure 7.5.6 illustrates a transit mall layout plan. Since this mall expels private vehicles, a measure should be considered at a district plan level, i.e., a parallel road exclusively for private traffic. As shown in Nanjing Road, a pedestrian street in Shanghai, more efforts were given to the provision and increase of space of pedestrian space and the subsequent reduction of the road area.

Figure 7.5.5 One-way Road System in Urban City Center (Example)

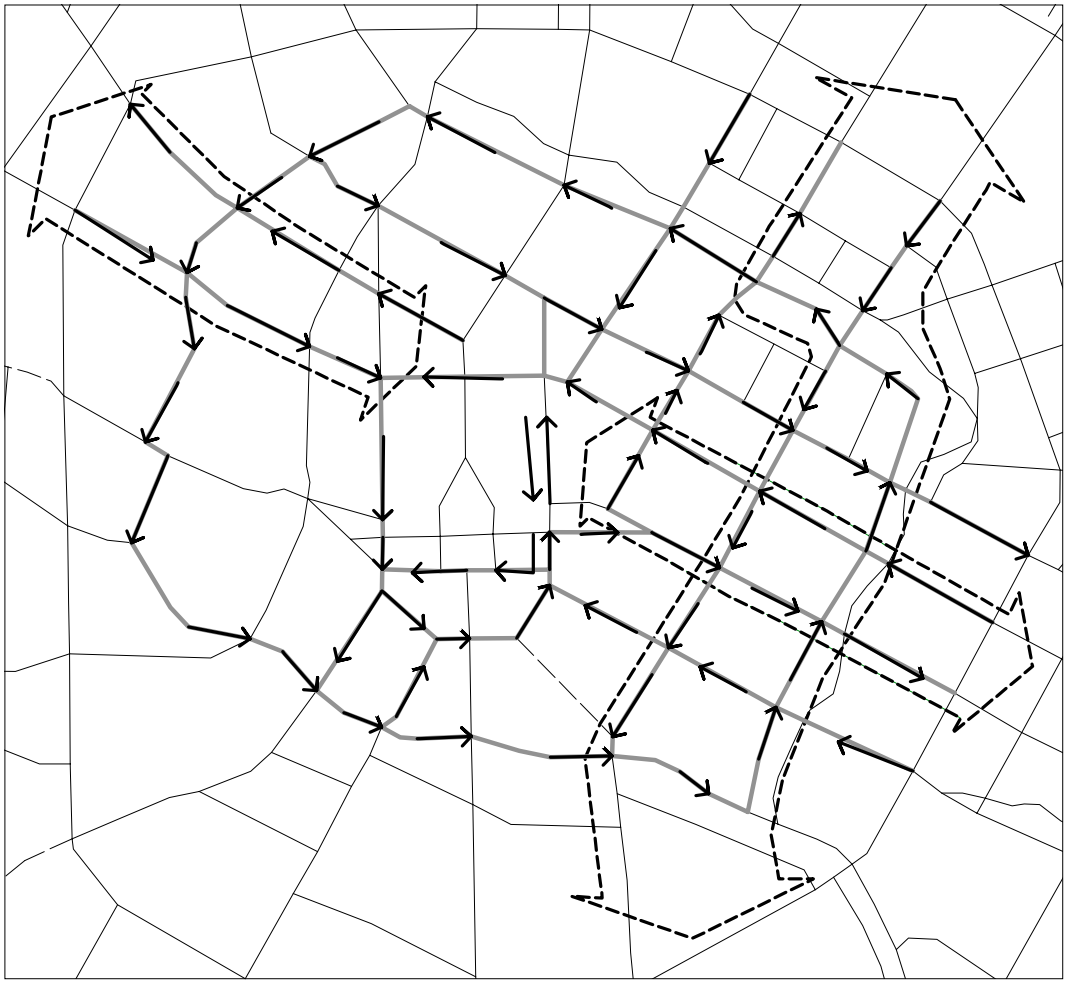
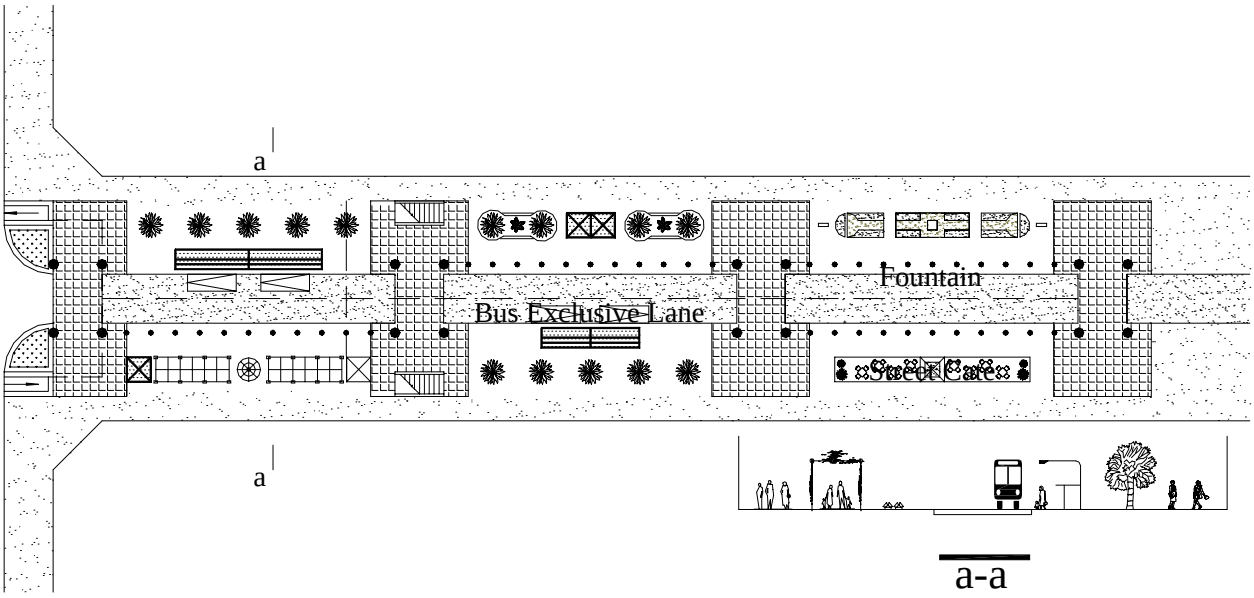


Figure 7.5.6 Transit Mall Layout Plan (Example)



7.6 Traffic Safety Measures

7.6.1 Necessity for the Development of Traffic Safety Plan

In view of the rapid increase of traffic accidents in Chengdu City, the Transport Department of Chengdu Municipality has taken the following measures:

(1) Defining the road markings and canalization at road intersections so as to ensure smooth traffic flow and to relieve traffic congestion, thereby subsequently reducing traffic accidents;

(2) Strengthening and disseminating traffic safety education and carrying out campaigns on traffic safety;

(3) Strengthening traffic patrol and traffic control;

(4) Strengthening traffic police organization;

(5) Learning from advanced technologies and improving the capability of the traffic police in order to build a city with less traffic accidents and traffic congestions, thus satisfying the people living in this city.

Aside from the above-mentioned measures, the Public Security Bureau has likewise learned from the advance experiences from foreign countries. They are carrying out research activities to ensure traffic safety and to relieve traffic congestion. All these will be helpful to improve the present traffic condition and ensure smooth traffic flow. The accidents are mainly caused by the very mixed-nature of vehicle and bicycle traffic. Very poor traffic consciousness and traffic ethics of the road users are also among the major factors causing traffic accidents. However, Chengdu City is now in the process of shifting from bicycle to motorized traffic despite lack of the people's openness and readiness to adapt. Accompanied by increasing vehicle traffic flow, the factors causing traffic accidents will thereby increase. It is therefore very important and necessary to take measures to ensure traffic safety in accordance with the change in the quality and quantity of road traffic.

In June 1970, Japan promulgated the Fundamental Law of Traffic Safety which includes six modifications towards excellent traffic safety measures. Japan basically follows the comprehensive concept of respect for life, that is, taking full consideration of the interconnection among the three factors namely: 1) the people who form the traffic society, 2) traffic tools such as motor vehicles, and 3) their activity environment. The information on traffic accidents and evaluation related to traffic safety measures were adopted as basic references to draw out effective measures adapting to the present condition, as follows:

(1) People safety should be the primary consideration. In order to ensure safe operation of traffic vehicles, there must be a general improvement and enhancement of traffic knowledge and transport skills. The people's traffic safety consciousness must also be

strengthened as well as their traffic controlling skills. Meanwhile the traffic operation and management shall be improved and working conditions shall be optimized accordingly. In addition, in view of the importance of improving the people's consciousness on traffic safety and raise their traffic consciousness, further education and training related to traffic safety shall be provided to guide them.

(2) As one of the measures to prevent traffic accidents caused by vehicles, the safety on the structure, equipment and device of vehicles shall be improved with regular technical development. Consideration shall be given on the social function and ownership of various vehicles, meanwhile actions shall be taken to ensure that the traffic safety measures are of standard level, which later on could be further developed to become standard evaluation procedures.

(3) As the measures relate to traffic environment, regulation shall be carried out to different road network and safety facilities. Further measures shall be adopted to perfect the traffic control, to enrich the traffic rules and to provide more information related to road traffic concerns. On the other hand, in the course of traffic environment regulation especially in the elimination of the danger caused by traffic accidents, proper measures shall be taken to maintain the traffic system. It thus becomes very important to increase the safety of motorized driving.

Aside from the above-mentioned factors, while adopting effective and proper traffic safety measures, a comprehensive study and analysis on the reasons of traffic accidents will be conducted. Focus shall be given to the development of relevant scientific technology and to the full exercise of the scientific achievements. Even though the primary objective is to decrease incidence of traffic accidents, attention shall also be given on activities towards the increase of understanding such as information campaign on the conduct of first aid, etc.

Knowledge on traffic safety is varied and interconnected. A good combination therefore and a comprehensive and effective implementation of traffic measures are very important.

On the other hand, given the varied states and conditions of society and the nature of their respective traffic accidents, measures on traffic concerns shall be flexible. In addition, implementation results assessment shall be considered so that reasonable measures can be taken and effective implementation can be carried out. At present, the characteristic problems in Japan considered in the preparation of basic traffic safety plan are 1) prevention of traffic accidents from elders and 2) assurance of the use of special seats and safety belts for children. If the Chengdu city plans to prepare its basic traffic safety plan, the following principles may be referred to:

(1) Strengthen the traffic consciousness on safe driving among the bus drivers, taxi drivers and truck drivers.

(2) Relieve intersection congestion and strengthen traffic safety measures.

(3) Strengthen the safe-riding consciousness among bicycles users and emphasize the road cross-section for the safety of pedestrians.

7.6.2 Development of the Road Traffic Environment

In order to ensure basic traffic safety, while regulating the road systems according to different functions of the road network from main trunk road to subsidiary roads leading to residential areas, the interconnection between roads and other vehicles must be strengthened. Regarding to the regulation of the road network, proposals are worked out as below:

(1) In order to separate the vehicles at different time or in different places and promote the smooth traffic flow, special motorways, bicycle paths, exclusive walkways and special bus ways shall be constructed accordingly. At present, Chengdu municipality is planning to manage the main road network thus utmost efforts are being taken to separate the volume of traffic by optimizing use of road spaces. In support with the present condition, further regulation measures shall be implemented to manage the main roads and subsidiary roads in the residential areas.

(2) In residential areas surrounded by main trunk roads, management of public roads and traffic facilities for both pedestrians and vehicles shall also implemented to eliminate road traffic and improve the people's living environment. It is worth mentioning that the initial sections implemented are successful, despite road space limitations such as very narrow space which already forms part of the people's living space. Coupled with the increasing volume of motorized vehicles and for the purpose of avoiding traffic congestion on main road, part of the traffic may be diverted into these small streets.

(3) Active road management may control the rapid increase of motorized vehicle traffic and relieve the traffic congestion as well as reduce the danger of traffic accidents. This is the objective of this study and it is hoped that Chengdu city will implement this.

Furthermore, aside from the prevention of accidents and insurance of the smooth traffic flow, the following rehabilitation and improvement works shall also be implemented:

(1) In order to prevent traffic accidents at intersections and relieve traffic congestions, grade-separation and channelization at intersection shall be developed.

(2) Improve the road safety facilities such as road markings, central belt, road lighting, road guard rail, pedestrian bridges, etc. It is very important and urgent to manage the safety facilities of 4 lane or 6 lane roads.

(3) In order to create a safe and smooth bicycle and pedestrian traffic space, much more attention shall be paid to the widening of walkway width, community road/pedestrian-friendly road development, shopping mall development, etc. where

there is a volume of pedestrians and bicycles. The bicycle parking lanes shall also be managed, with pedestrian lanes not allowed for bicycle parking.

The following are suggestions with regard to the improvement of the intersections.

(Promotion of the effectiveness of traffic signal control system at intersections and improvement of other traffic safety measures.)
Accompanied by the increasing volume of traffic at intersections, it becomes more and more important to install intersection signals. For traffic signals to be effective, a signal control system shall be used depending on various conditions at different intersections due to: different forms of intersecting roads (*e.g.* intersect between main roads, sub-main road intersects with main trunk road, etc.), intercross traffic flow, requirement of bicycles and walkers, and land utilization. It should be noted however that the greater irregularity of use of traffic signals might confuse the drivers and cause them to ignore the traffic signals.

In the urban city center, regulation is carried out to the wide area traffic system. Great efforts are taken to achieve signal modernization. At present, traffic control system is mainly applied in the main trunk roads. It is hoped that application of this traffic control system will be expanded.

Taking the traffic safety into consideration, improvement shall be made on the road signals and intersections as follows:

(1) For the traffic signal system installed at the subsidiary road network and the signal system not included in the traffic control system, traffic signals with modern features such as induction, multi-display and left turn induction shall be developed for them to completely adapt to the traffic conditions. Especially for the main trunk road, which has less cross volume of traffic at night, semi-induced or push-button signals at idle time shall be developed. Meanwhile, bus induction system may be installed at the necessary road sections to improve the service level of public transport.

(2) Further improvement is needed on the following aspects: normalization of periodic signal, standardization of sign display and efficiency of left turning traffic. There is a need to improve on existing marked signs so as to avoid traffic lines mixing during the implementation of the traffic control system.

(3) For the intersections with traffic signals, all the right turn traffic shall be controlled with signal lamps.

(4) Improvement of traffic channeling (to left turning traffic and bicycles traffic).

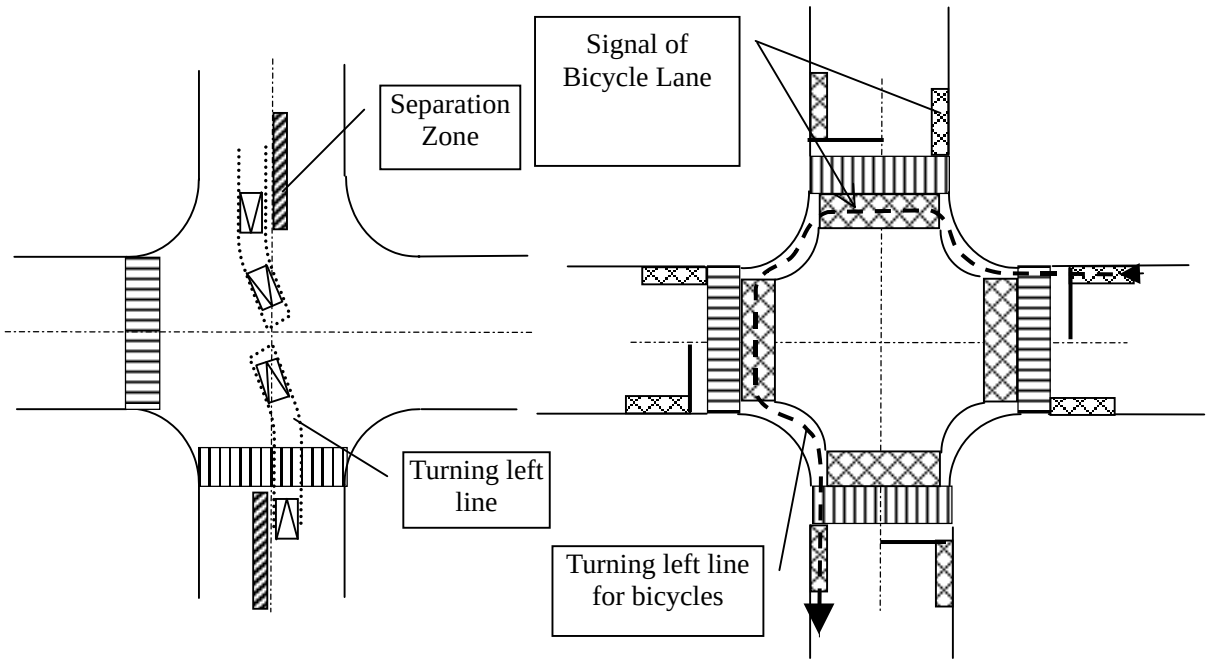
This is not only limited to public transport but also relates to utilization of all intersections. The objective is to increase the traffic capacity of intersections and ensure traffic security.

The intersections have different forms and traffic flows complying with geometrical construction and traffic requirements of intersection roads as well as the present condition of surrounding land utilization.

At big intersections between main trunk roads, the separation of motorized vehicles and bicycles as well as left turning traffic is being implemented smoothly. However, for small or medium intersections, there is still a mix of motorized vehicles and bicycles, with the disregard for left turning traffic causing serious traffic jams. Figure 7.6.1 illustrates a separating belt near the intersections which can prevent disregard for left turning traffic and introduce traffic channeling of left turning traffic from center of intersection. For traffic safety purposes, it is necessary to install warning markings in the separating belt near the intersection.

In addition, the figure on the right illustrates a small or medium sized intersection with left turning bicycle traffic crossing the carriageway two times instead of crossing straight on the road center. Road marks should be clear to guide the passing bicycles. Given the limited space for the road space, optimum land utilization is necessary.

Figure 7.6.1 Left Turning Traffic Measures for Car and Bicycle



7.6.3 Development and Promotion of Traffic Safety Education and Dissemination

Given the present economic conditions in Chengdu, the peoples' living habits and conditions are rapidly changing. Mode of transport is likewise changing where the customary overwhelming bicycle traffic is slowly being replaced by vehicular transport traffic. However, the people still do not realize as much the danger brought about by motorized vehicle traffic that causes the higher traffic accident ratio. Behaviors lacking in safety consciousness, such as speed driving, forced overtaking and disregard for both left turning traffic and pedestrian's safety, are continuously manifested. Aside from these behaviors, there are also bicycles riders and pedestrians using the 6-lane roads without any form of precaution. They ignore the provided traffic signals and go against the traffic rules. It has to be said that these behaviors are feasible only for non-motorized traffic conditions.

An important concern on traffic safety is that most of the traffic accidents are caused by artificial reasons. As members of traffic society, people shall respect other citizens' lives while they are making contribution to improve modern life conditions. Under this principle, people should consciously take responsibility and make efforts to strengthen safety consciousness and improve their traffic morality concept. We must learn to respect others instead of paying attention to ourselves only. Safety education shall be initiated to people of all ages. The present condition indicates that the adults themselves, who have the responsibility to educate their children, have lower level of traffic safety consciousness. It is therefore necessary to adopt administrative measures to strengthen the people's social traffic sense.

There are still a lot to be done in the following areas: instructor training, editing of traffic teaching materials and participation in social traffic activities. Traffic guidelines shall be developed and installed in parks and commercial areas to further facilitate in the implementation of these activities.

The education system in the People's Republic of China can be characterized as pre-school education for children under 6 years old, which is then followed by primary school, junior middle school and high middle school which is popularly known as 6:3:3 education system. Primary school and middle school education are compulsory.

(1) Traffic safety education for children under 6 years old

The objective of the traffic safety education for children is to make them recognize the traffic safety rules and in turn obey these traffic regulations accordingly. This is also intended to develop traffic safety consciousness among them. The education provided to the children in nursery schools or at home shall be integrated with the appropriate education plan to be conducted regularly. The child's family members shall be responsible for pursuing the child's traffic safety education. Traffic education modules shall therefore be prepared for the parents to guide them in their review exercises with their children.

In Japan, development of traffic safety education materials for children uses theater and audio (instructive listening materials) as the media of instruction. Given the present condition of traffic strategies and teaching materials in Chengdu City, it is necessary that improvement and updating of instructive traffic information materials as well as training of teachers should be undertaken.

(2) Traffic safety education for students

The primary objectives of traffic safety education for primary and middle school students are 1) to make them understand the importance of traffic safety; 2) to develop their sense of the possible dangers in the environment; 3) to train them on traffic safety assessment and evaluation; 4) to encourage proper traffic attitudes and practices; and 5) to make them realize that as members of the traffic community, it is also their responsibility to do their share in contributing to the security and safety of the whole traffic community. Since most of these students are potential drivers in the future, it is important for a comprehensive and detailed traffic safety education be available to them this early.

For the primary students, the following activities could be initiated:

Guide them in the observance of traffic safety from a pedestrian's point of view; Make them pay adequate attention on bicycle and other vehicle riding safety; Educate them to fully understand the importance of traffic safety facilities and obeying of traffic rules.

For the junior middle school students, while instilling safety consciousness while walking and bicycle riding, familiarize them on the characteristics of motor vehicles; teach them the basic principles on how to prevent traffic accidents; and most especially, introduce to them the first aid measures on dealing with emergency concerns.

For the high school students, it is necessary to further educate them on the characteristics of bicycles and motor vehicles to prevent them from traffic accidents. It is also very important to train them on how to deal with traffic emergencies and to develop in them the habit of complying with the traffic rules. Again, since most of these students will be potential drivers in the future, it is but necessary for them to master essential traffic knowledge.

(3) Traffic safety education for the adults

Foremost objective of this particular training activity is to develop among public transport drivers a sense of social responsibility. It is also intended to strengthen their protective consciousness for the pedestrian and bicycle riders and to emphasize the

importance of safety belts and motorcycle safety helmets. An evaluation exercise shall be conducted on the cases of vehicular accidents which are usually caused by speeding and drunk driving. The drivers shall be encouraged to articulate their ideas and voluntarily perform safe driving as well as abide by traffic rules.

Given that private car owners are not as many as the public transport drivers, it is believed that the more urgent task is to implement a comprehensive safety driving education to the professional drivers of buses, taxis and trucks, especially drivers of taxis and minibuses. Their roles as members of the public transport society shall be emphasized and they will be encouraged and trained to be responsible drivers abiding by the traffic rules and regulations set by the city.

During the course of this study, it was found out that very few bus and taxi drivers concern themselves with traffic safety. Speed driving, forced overtaking, wrong lane driving, disregard for pedestrians' and bicycle riders' safety are the more common practices observed. It is therefore this study's objective to implement a public traffic safety regulation. Also, Chengdu's Department of Public Transport Affairs shall actively develop traffic safety measures and implement an effective safe traffic management.

(4) Traffic Safety Campaign

This is an activity aimed at popularizing traffic safety theory comprehensively among the people. Organize a local group whose objective is the training and development of good traffic habits and compliance with the traffic rules. At present, Chengdu municipality is adopting traffic safety measures to relieve traffic congestion in the city. They began with the implementation of a "no vehicle day" policy, and they are continuously developing necessary measures accordingly. It is expected that activities such as these can be implemented regularly and more comprehensively.

In order to successfully organize a traffic safety movement, tasks shall be determined according to the annual traffic conditions and accident occurrences ratio. The following are the proposed tasks in view of the present traffic condition in Chengdu City:

- Promotion of the safer bicycle-use
- Establishment of road cross-section to guarantee the pedestrian's safety
- Insuring the operational security of public taxis or buses

(5) Dissemination of the Traffic Safety Manual

An extensive, organized and well-planned promotional campaign for traffic safety using appropriate and effective media shall be carried out to improve the people's knowledge, consciousness and behavior with regards to traffic rules and safety. For example, the television may be used to present the desired information campaign for

families. Information from and coordination with the local police station as well as schools may also be explored so as to make traffic safety campaign available to everybody.

In addition, information campaign should also be strengthened specifically for the drivers of public taxis and buses for them to understand fully their roles in the public transport society, and hopefully by doing so will be able to train them to be exemplar drivers abiding by traffic rules. Therefore if the public transport departments cooperate with Chengdu Administration Government and exercise extensively propaganda on traffic safety, better result may be expected.

(6) Other Traffic Safety Campaign Activities

Aside from those already mentioned in the preceding discussion, the following techniques may be taken into consideration:

(1) To ensure the safety of bicycle riders during the night, their understanding of the importance of using reflective materials should be enhanced.

(2) For the drivers, bicycle riders and pedestrian to be fully knowledgeable of the traffic conditions of their frequently used roads, the sections where traffic accidents always happen shall be published to them for precaution measures.

(3) It is necessary to implement information campaign activities on he proper use of bicycles to improve the bicycle riders' traffic consciousness and standards and to prevent them from traffic accidents and inconvenience.

7.6.4 Improvement of the Operational Management on the Transport Companies

Although there is just a small number of a private vehicle owner, there is a great number of taxis, business vehicles and freight trucks in Chengdu City. Therefore it is very important for the relevant transport companies to strengthen the management of driving and traffic operations, which is regarded as an important concern when working out traffic safety measures.

In the aspect of safe driving management, in spite of the upgrading of training on traffic safety and the improvement of the management capability of the driving administrators, it is the road user's traffic safety consciousness which needs improvement. Meanwhile it is very important to perfect the internal management system of safe driving and improve the management level of safe traffic operations. Public road user report system shall be implemented so as to describe the traffic violation behaviors committed. The road users shall be advised accordingly as to who is guilty for an accident or violation. Furthermore, system standardization shall be made to operation management accordingly.

In the aspect of traffic operation management, focus shall be given on the transport

companies. In line with the objective of preventing from long and tedious driving, overload driving and assurance of safe traffic operation, select traffic operation administrators who not only have grasped of the professional knowledge but also have administration skills shall be trained. In addition, these administrators shall be trained by enriching the transport management content. A good follow-up system may also be set-up to ensure a comprehensive improvement among the operation administrators.

7.6.5 Strengthening Traffic Control and Enforcement

In order to ensure the traffic safety of the bicycle users and pedestrian, reduce traffic accident ratio at sections where traffic accidents usually takes place, strengthen effectively the people's understanding of the traffic management system and improve their traffic standards, it is quite necessary to intensify traffic instruction and supervision.

Together with the rapid volume increase of motor vehicle traffic, the traffic congestion is becoming worse and worse, and danger of traffic accidents is increasing accordingly. In view of this condition, the relevant department of Chengdu City is planning to solve these problems through the improvement of traffic measures and the rehabilitation of signal lamp control system. It is necessary to develop new traffic regulation and implement general information campaigns in anticipation of the expected results of an increasing vehicular transport behavior. At present, traffic police and traffic instructors have been deployed at the intersections where traffic congestions normally occur. The same strategy shall also be adopted from hereon for intersections where there are greater traffic volume, particularly pedestrian and bicycle traffic.

At the sections where accidents frequently occur despite the more severe punishment for traffic violators, public information campaigns shall be carried out actively so as to prevent bicycles from crossing main trunk roads.

At present, the traffic department of Chengdu City is strengthening traffic management by providing pickup cameras for supervision. It shall also improve the traffic accident analysis system and advance the traffic monitoring equipment. Strategies shall continuously be developed and more creative monitoring equipments shall be used based on scientific research.

With regards to traffic safety measures, aside from the aforesaid principles, consideration for other traffic concerns shall also be taken, such as insurance of vehicle safety, improvement of the first aid system and perfecting of the compensation system. In summary, all these factors shall be considered in the development of a basic traffic safety plan. Development of measures to prevent traffic accidents concurs with the study's main objective of improving public transport system. From education of responsible traffic violators, focus should also be given on the strengthening of the management of traffic safety and traffic operations.