Study of the Coordinate Design Method of Urban Streets and Environment

Yu Bai
Department of Road and Traffic Engineering, Tongji University
Shanghai, China
rabbitby@263.net

Wenqing Chen and Kun Xue
Department of Road and Traffic Engineering, Tongji University
Shanghai,China
kyo00712@126.com, xuekun126@126.com

***Abstract*—Urban streets should not only meet the travel demand, but also provide with users the safe, expedite, convenient and beautiful travel environment. In this paper, the coordinate design method traffic and landscape on urban street is put forward. Because the traffic design and landscape design are done separately by different professionals before, this new method coordinates the traffic design and landscape design basing on the benefits of travelers to get better traffic and harmonious road landscape.**

***Index Terms*—Urban Street, Traffic Environment, Coordinate Design, Human-centered**

I. INTRODUCTION

Over a long period of time, professionals have been striving to explore for purpose of constructing urban traffic system and the relative facilities to a higher level. We have to admit that what we have done is only emphasized on the civil engineering technology of traffic facilities and treatment technology for landscape on the surface. In case we give it a study from the point of function and effect, it is hard for the transportation infrastructure construction in most of our cities to meet requirement for a high quality urban construction.

From another sense, with the rapid development of Chinese economy and society, great changes are taking place in our cities (especially in the newly developed urban areas) in term of traffic mode and system structure. As far as we have realized that the demand for motor traffic is continuously increasing and the development of public transportation is being paid much more attention while the use of bicycles is trending to decrease. Hence, the landscape and environment construction of urban streets has become one of the most important parts in urban construction. A problem occurs that the in-coordination between road traffic and landscape, resulting in countless traffic problems and landscape discordance.

Thus, it becomes one of the cores for our recent years' urban construction in how to find ways to make road traffic and landscape most harmonious for purpose of being safe, expedite and convenient for traffics as well as for a beautiful urban environment.

Aim of this text is set at making significant improvement to traffic environment so that the dynamic landscape along the roads will be created with the precondition of fully utilizing the road traffic function while reasonably arranging the various landscape facilities of roads for win-win effect.

II. GUIDELINE OF COORDINATE DESIGN

In the research of this coordinate design, we have put more emphasis on the multi-subject consideration in respect of optimization of traffic environment, PTP policy, reasonable arrangement of static traffic and improvement of transportation facility construction for the realization of rationalization of traffic system (public traffic, pedestrian traffic, bicycle traffic and motor traffic) inside the area, human-centered traffic and public transport priority, smooth and safe traffic order, traffic efficiency and dynamic landscape featuring in harmony and comfort between traffic, landscape and environment (ecological and psychological environment).

III. PRINCIPLE OF COORDINATE DESIGN

A. Consideration of Systematicness

To make traffic design combined with landscape design and to put convenience, quickness and safety of road traffic operation at the very first place, we try to construct a harmonious road traffic environment from the view point of landscape.

B. Consideration of Human-orientation

The nature of traffic is the movement of people and objects. The utilization of different traffic methods as well as the various traffic phenomenon come into being in accordance with different demands of people, in which, people is the most active element in traffic system, especially that the object for traffic management is also people instead of traffic tools(e.g. vehicles). Hence, the

Manuscript received Dec. 1, 2010; revised Apr. 5, 2011; accepted Apr. 12, 2011.
Project number: 50708080

doi:10.4304/jsw.7.3.626-631

improvement of traffic system should be human-centered, i.e. to increase safety, convenience and efficiency for man's movement in traffic system.

C. Consideration of Improving Traffic Efficiency

By reasonable traffic organization, channelization design as well as the improving measures connected with traffic management, we reduce the road bottleneck and increase traffic efficiency of road.

D. Consideration of Improving Traffic Safety

By adopting channelization of various traffic modes, warning signals and mark lines, traffic signal control as well as the proper lightings (Refer to landscape design), we reduce the potential safety hazard of black-spot and increase traffic safety.

E. Consideration of Improving Traffic Convenience

By combining with landscape design of road and by adopting barrier-free design, control to pedestrian crossing on road section, lounge facility design for pedestrians, bus shelter design and road environment design, we create a convenient and comfortable road traffic environment and urban living space for the travel of residents.

F. Consideration of Improving Road Land Scape

On the basis of road nature determination, we give it an integrated consideration to traffic facilities by combining road landscape so as to make the urban road more appreciative.

IV. Method of Coordinate Design

A. Selection of Road Section

According to traditional theories, the three-block roads and four-block roads may be of help in separating traffic flows from the point of physics and be of use in pipeline arrangement. With development of urban areas and degree improvement of motorization, there are less and less non-motor-driven vehicles going out, leaving non-motor vehicle ways idle for nothing. Because of limitation to motor and non-motor separators and of that the non-motor vehicle ways could not be used to increase the number of motor vehicle ways, the road resources are greatly wasted, resulting in inadaptation to the demand for a steady urban development. Besides, since the separators are too atomized, the greening and landscape facilities are separated and the overall effect could not be reflected, influencing expression of city style.

Based on the practice, we suggest that: the two-block roads (See Fig.1) will be more suitable for the need of urban development, which should be treated as the design mode to build a new city or to rebuild a road. Specifically speaking, the related advantages include the following:

- By arranging non-motor lanes on the pedestrian way, we are able to make motor vehicles and non-motor vehicles separated via difference in elevation, avoiding mixed traffic at intersection to influence traffic efficiency of motor vehicles.
- By arranging protecting zone for pedestrians at central separators, we area able to ensure safety of pedestrian crossing.
- By setting space aside for motor vehicles via green belts, it will be of use for the widening lanes in the future changes of traffic flow.
- By arranging bus shelters.
- For places where the green belts are concentrated, it will be of use both the plant growth and for convenience of arranging all kinds of landscape facilities.

B. Design Method of Pedestrian Way

In our past designs, we plant roadside trees at the place where the side of pedestrian way is close to the side of vehicle lane, with street furniture of traffic signs, telephone booth, etc, arranged in the center of tree pits. Due to the reason that trees are densely planted that the traffic signs are blocked out and could not be easily recognized by drivers, resulting that the guiding efficiency of these signs are greatly decreased.

In modern cities, the number of non-motor vehicles is getting smaller and smaller. It is in consideration of ride characteristics of non-motor vehicles that it will be more preferable to account them with pedestrians. Hence, the pedestrian way shall be designed according to section standard as described in Fig. 1. Such design has involved the following optimum design contents:

- By separating non-motor vehicles and motor vehicles at difference in elevation, we only set connections at intersections via barrier-free design, ensuring safety of non-motor vehicles and reducing interference onto motor vehicles caused by non-motor vehicles.
- On the outermost of green belts, it is better to plant lower shrub in which the traffic signs and lights are arranged so that they could be clearer instead of being blocked. Meanwhile, the lower green fence will increase difficulties when pedestrians and non-motor vehicles cross the road as well as will block the vision between motor vehicles and non-motor vehicles, providing the two with a quiet and safe traffic space.
- For roadside trees between pedestrians and non-motor vehicles, it is desirable to choose shade arbor which could both separate pedestrians and non-motor vehicles for safety protection of travelers and, at the same time, arrange landscape of telephone booth, garbage bins, green light for pedestrians and leisure goods by making use of the space between tree pits. Planting distance could be ser at a range of 4-10 meters according to types of trees and demand for arranging landscape facilities.
- For benefit of future development, an extra width could be reserved which is equal to one traffic lane by utilizing the outermost of green belts. When traffic flow of future motor vehicles increases, an additional motor vehicle lane will be respectively added. When such work is being done, pipelines and drainage facilities should be arranged at the side near non-motor vehicle lane, avoiding repeated investment.
- Considering factors of setting blind walk way as well as the travelling characteristics of pedestrians and non-motor vehicles, the design of pedestrian way should meet the request listed in Table 1.

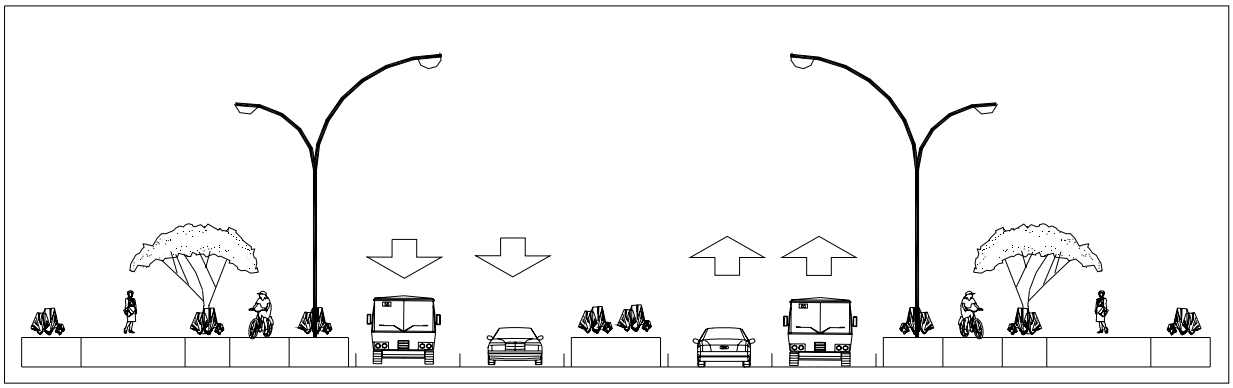

Figure 1. The standard roadway cross-section

TABLE I. LIMITATION ON WALKWAY DESIGN

Road Type	Width of dividing stripe of motor and non-motor vehicle (m)	Width of bicycle lane (m)	Width of street Tree(m)	Width of walk way (m)
Newly built	>1.5	>4.0	>2.0	>4.0
Re-built	>0.5	>2.0	>1.5	>2.5
Remarks	Dividing fence could be arranged for re-built road	Design could be made With consideration of Street tree for re-built road		With inclusion of blind walk way

C. Design Method of Roadway

1) Width design method of roadway

For urban traffics, because of limitation for vehicle type and speed, especially that the vehicle body occupies a relatively smaller lane width and a smaller safety distance at horizontal direction, the lane width of urban road could possibly be reduced for full use of road resources. Practice shows that 3.5-3.75 meters will be a suitable range for lane width of urban road section, lane width for exists of intersections should not be less than 3.25 meters and for areas with limitation, 3.0 might be taken.

2) Determination method of stop line position

In traditional theory, the smaller the intersection area is, the less the time loss will be when motor vehicles pass through intersections. From this point, it is encouraged to minimize central area of intersections by means of setting physically channelized island and moving forward stop line. Practice has proved that this point of view contains certain limitation which may reduce the reliability of safe drive for traffic flow. Hence, position of stop line should ensure that the area between the two neighboring pedestrian ways is adequate enough for the stop of two right-turn vehicles so that the non-motor vehicles and pedestrians could pass.

For center point of stop line (a distance between stop line and crossing point of road central line) and center point of intersection (a distance between crossing points of intersected road central lines), Ls could be decided by the following (See Fig.2):

$$L_s = \frac{\cos\frac{\alpha}{2}}{1-\sin\frac{\alpha}{2}} \bullet d_r + \frac{L_v}{2\sin\alpha} + L_c + d \qquad (1)$$

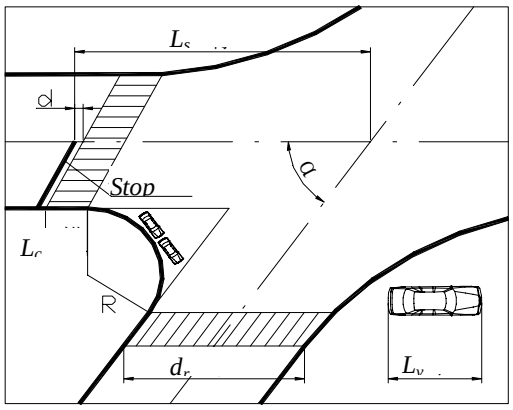

Figure 2. The design of stop-line in intersection

In which: Ls is the distance from center point of stop line to center point of intersection. dr is the width of intersected roads at inside of intersection. Lv is the length of vehicle (10m is for large vehicles, 7m for medium and \ 5 m for small), a weighted average is taken on the basis of flow ratio for different types of vehicles at entrance lane. Lc is the width of pedestrian crossing. d is the distance between stop line and pedestrian crossing, in which 1~2m is usually taken. α is the inclined angle between the road of current phase and intersected road.

D. Design Method of Central Dividing Sstripe

Central dividing stripe may function to separate traffic flow of opposition direction to avoid occurrence of traffic incidents. At the same time, means of greening could be used to strengthen efficiency of urban landscape. In designing central dividing stripe, the followings should be noted with are:

- To meet traffic requirements for dividing stripe. This should not only separate the two-way motor vehicle

flow from the point of physics, but also meet requirements for arranging U turn lanes.

- To meet requirements to set protecting area for pedestrians. For sake of setting waiting area for pedestrians on the central dividing stripe, the width of central dividing stripe should be bigger than the width of a bicycle.
- To meet requirements for landscape of dividing stripe. In another sense, it needs to take the greening and arrangement of various landscape articles into consideration.

We suggest that the width of central dividing stripe should not be less than 2 meters and the design of minimum turning radius should be combined on the roads where the U turn lane is arranged. For future development of entrance lane at intersection, it should not be less than 1.5 meters, ensuring safety of pedestrians and non-motor vehicles. When choosing tree type of central greening belt, it is avoidable to plant arbor with lower crown and the plant distance be made relatively bigger to escape from blocking pedestrians by trees and from misleading drivers to make correct response which is treated as the hidden incidents.

E. Design Method of Bus Stop

Bus stop (Mainly referring to intermediate stops) is defined as the site where passengers get on and off the bus whose design should be done as following:

1) Physical requirement

Size of bus shelters should meet requirement for the stop of public buses, taking into consideration of future development. Detailed length could be gained as following: [1]

$$L_b = 2.5 + n(l_b + 2.5) \quad (2)$$

In which: Lb is the platform length of bus stop. n is the number of public buses simultaneously stop at the bus shelters. lb is the length of public bus.

2) Functional requirements

For bus shelters, they should supply passengers with all kinds of traffic information, including information of bus route, information of surrounding road, interchange information and arrival information, etc. for passenger (especially the new comers)convenience of making right judgment. [2]

3) Environmental requirements

When designing bus shelters, the surrounding environment should be taken into consideration at the same time, including the integrated traffic landscape design of bus shelters, green belts, resting seats for pedestrians, Tele booth, garbage bin and other traffic facilities (e.g. crossing facilities for pedestrians).

F. Design Method of Protecting the Weak of Traffics

Pedestrians and non-motor vehicles, being the relatively weak group in traffic behavior, are easy to get hurt in traffic accidents. Convenience and safety should be given adequate attention to both pedestrians and non-motor vehicles when carrying out urban road design, which should be reflected in terms of man-orientation, making special efforts in barrier-free and pedestrian protection design.

1) Barrier-free design

For drainage identification from road way, land surface of pedestrian way is usually 15-20 cm higher than road way, which brings difficulties to the disabled in wheel chairs and travelers by non-motor vehicles. Stone curb slope way shall be provided at pedestrian way of intersections, urban square as well as at entrances of large-sized public buildings.

At two ends of both intersections of urban road and pedestrian crossing of road section, width of stone curb slope way might be equal to pedestrian crossing, or be slightly smaller than pedestrian crossing, with positions aligned with each other. Inclination of stone curb slope way is 1/10-1/12, which could be 1/10-1/20 where possible. Slope surface should be made smooth, but not slippery.

2) Design of pedestrian protection area

Pedestrians and non-motor vehicles, being the weak group in traffic behavior, easily get hurt in traffic conflicts, which is extremely obvious at intersections. It is quite necessary to establish pedestrian protection area at intersections and pedestrian crossing of road section for sake of providing a shelter to pedestrians who do not have enough time to cross the street and to escape from hurt of motor vehicles. Meanwhile, traffic lights for pedestrians shall be arranged, forcing motor vehicles to give way and guaranteeing time priority of pedestrians. For phase order arrangement of traffic lights at intersections, signals for pedestrians work in the mode of "Late on and early off", for insurance of a safe crossing time or waiting space to pedestrians by end of green lights.

G. Design Method of Static Traffic Facilities

Issue of static traffic, i.e. the issue of vehicle parking is on of the most important factors influencing urban landscape. Absence of reasonable coordinate design will greatly reduce actual effect of urban landscape construction. We have to say that it is quite necessary to give it a coordinate consideration in respect of landscape design and static traffic design.

1) Design of motor vehicle parking area

Parking area for motor vehicles by roadside should be located at a relatively wider walk way (See Fig.3). The following notice should be given:

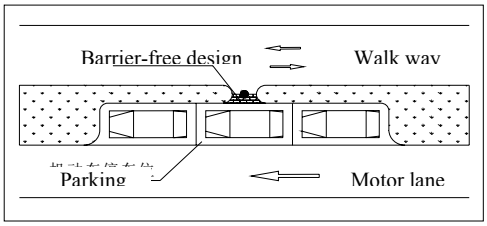

Figure 3. The design of parking lay-by of vehicle

- Both parking area for motor vehicles and motor lanes should be on the same surface, with a height

difference with walk way, avoiding that motor vehicles drive onto walk way.

- Parking area for motor vehicles and walk lanes are to be separated by green belt so as to create a relatively independent walking space. A passage for drivers should be left out in the greenings for their convenience of driving in and off from the parking areas.

2) Design for motorcycle parking area

Concerning the mixed phenomenon when motorcycles drive into or out of parking area of road section via walk way, separations could be realized between pedestrians and motorcycle parking area and even the passing area by greening belts. (See Fig.4)

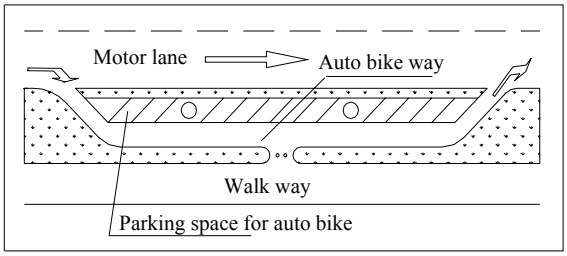

Figure 4. The design of parking lay-by of autobike

Simultaneously, barrier-free design at entrance and exist of passage when motorcycles drive into parking space from motor vehicle lane in order that motorcycles drive into or out at a lower speed. To ensure a smooth driving track when motorcycles drive into or out, a inclination design will be adopted at entrance and exist (as indicated in the above Fig.4) To leave out exists for motorcycle drivers after parking, an opening will be made between motorcycle lane and walk way, with a fence arranged at the opening. Fence distance is only wide for pedestrians to pass, preventing motorcycle from driving into walk way via this opening.

3) Design of bicycle parking area

Due to the fact that non-motor vehicles may drive on the walk way, spacing between street trees on walk way could be used to set parking area for non-motor vehicles (Fig. 5). In the designing, notice should be given that parking area should not be wider than the width of tree pits to avoid influencing passes of non-motor vehicles and pedestrians. If tree pits are not wide enough, mode of oblique parking might be adopted. [3]

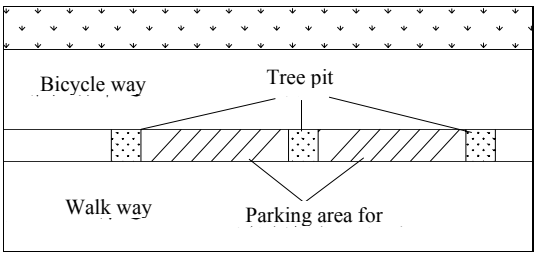

Figure 5. The design of parking set of bicycle

H. Design Method of Road Greening

Being an organic component in the overall urban greening construction, road greening design should not only take account of functional requirements, but also the influence it makes onto road traffic and other facilities. The following principles shall be put in mind in urban road design:

- Road greening should match with nature and function of urban road and road with different features shall vary from the point of tree type selection, height determination as well as planting patterns for road greening.
- Design of road greening shall match with behavior law and vision characteristic of road users.
- Green space shall be well connected with the surrounding street scenes, landform and construction.
- Green space should be designed with consideration of traffic facilities, underground pipelines and drainage on the street.
- Road greening shall meet requirements for sight distance of driving, with function of pre-announcing changes of road alignment and guiding drivers.
- Design of road greening should consider adjustment demands for future road cross section. [4]

1) Design of walk way greening

- With combination of cross section design for walk way, a line of arbor could be planted in the dividing belt between pedestrians and non-motor vehicles, planting space is 4-5 times of tree crown diameter and all types of street furniture are placed between tree pits. To avoid obstacle caused by tree branches on walk way as well as to safeguard pedestrians on the walk way, it is advisable to choose trees with nature of deep-rootedness, higher branch point, thick and big crown, healthy growth and good adoption to road environment whose fruit will be no harmful to pedestrians. [5]

For tree planting in dividing stripe for motor and non-motor vehicles, it is desirable to plant low shrub which are mostly the evergreen hedge. Some flowering shrub might be mingled and the height of which should be controlled less than 1 meter for avoidance of blocking traffic signs and driver vision.

2) Greening design of dividing stripe

Since dividing stripe greening is close to motor vehicle lane, which should construct a good visual environment for driving, i.e. the greening form should be simple and trees be well organized so as to be easier for drivers to recognize pedestrians crossing as well as to reduce visual fatigue of drivers. In contrast, if plants are messily ordered and too much changed, driving vision will be interfered, especially in a rain and foggy day.

To ensure traffic safety of neighboring lanes as well as plant maintenance, for arbors in dividing stripes, distance from trunk center to offside of curbstones of motor vehicle lane should not be less than 0.75 meter.

Appropriate allocation of shrub, shrub ball and green fence which belong to the category of evergreen plants with dense leaves should be made in the central dividing

stripe to effectively avoid driving beam from opposite direction during night.

Arbor along the two sides of road should not be lapped over motor vehicle lane for avoidance of forming greening tunnel, which will be no good for a timely upward diffusion of vehicle exhaust, influencing air quality of the road.

At end of dividing stripe, planting mode of permeability is used, enabling pedestrians crossing road or vehicles combining in to easily recognize the passing vehicles and safeguarding pedestrians and vehicles.

I. Design of Street Furniture Arrangement

1) Layout arrangement of street lamps and traffic signs

Concerning electric wire arrangement, street lamps could be allocated in the greening stripes of motor and non-motor vehicles, for this condition, tall greenings is not advisable to choose. Bi-directional street lamps are suitable under this condition, which should be much more close to the side of non-motor vehicle lane for a future road expanding.

Arrangement of traffic signs should be at offside of motor and non-motor dividing stripe, next to motor lane so that the drivers could timely and clearly recognize information of traffic signs, making proper judgment.

2) Arrangement of drainage and pipelines

It is in consideration of future increase in terms of traffic flow and demand for road widening that the embedding of pipelines and drainage should be at the greening belt which is most close to the side of non-motor vehicle lanes.

3) Layout arrangement of leisure benches, garbage bins and Tele booth

Leisure benches, garbage bins and Tele booth should be allocated at one time, which are to be set in the greening belt between non-motor vehicle lanes and walk way and to be kept in one straight line combining with plants and space utilization. It will be desirable for Tele booth to face greening belt, avoiding space occupation of walk way by queuing pedestrians.

V. CONCLUSIONS

Applicable scope of this coordinate design method covers the newly built and re-built primary and secondary roads in urban areas. To newly-built roads, considerations should be given to the increasing demand for future traffic flow, leaving out additional space for road widening. For designs of various traffic facilities, it is encouraged to be perfect for harmony between traffic, landscape and environment. For re-built roads, it is encouraged to eliminate factors which are in-harmonious from the point of design. On the basis of giving adequate consideration to the right of traffic users, we stress to give priority to demand from the traffic weak group, realizing aim of that traffic initiates from human-orientation.

Being a new design theory, the coordinate design method for urban traffic landscape is used widely in some of the domestic cities. From the effect of actual result, road users to whom the design method is applied, especially the weak group of pedestrians and non-motor vehicles has enjoyed an obvious improvement in terms of traffic environment, with their right of way guaranteed at the same time. Hence, the target of safe, smooth and convenient traffic and a beautiful urban environment has been realized, forming a dynamics and pleasant scenery along with the road.

ACKNOWLEDGMENTS

This work was supported by the National Natural Science Foundation of China (Project No.50708080) and the Specialized Research Fund for the Doctoral Program of Higher Education (SRFDP).

REFERENCES

[1] Shanghai Municipal Commission of Construction and Management, “Design Regulations for Intersections on Urban Street of Shanghai (DGJ08-96-2001) ”, 2001.

[2] PENG guoxiong, “Some Problems in Locating Urban Bus Stop and Countermeasure”, Journal of Traffic and Transportation Engineering, 2001.1, 77-80.

[3] ZHOU Shangwu, “Communication Engineering”, Shanghai Tongji University Press, 1987, 192-193.

[4] WANG Hao, “Green Space Landscape Design of Urban Road”, Southeast University Press, 1999.

[5] REN Fu-tian, “Planning and Design of Urban Road”, China Architecture & Building Press, 1998.

Yu Bai Heilongjiang Province, China. Birthdate: January, 1977, is Transportation Engineering Ph.D., graduated from School of Transportation Engineering, Tongji University. And research interests on traffic design and ITS.

She is a senior lecturer of School of Transportation Engineering, Tongji University.

Wenqing Chen Shanghai , China. Birthdate: August, 1985. is Transportation Engineering bachelor, graduated from School of Mathematic, Central South University. And research interests on traffic design and ITS.

Kun Xue HuBei Province, China. Birthdate: January, 1978, is Transportation Engineering Ph.D., graduated from School of Transportation Engineering, Tongji University. And research interests on traffic design and ITS.