



Research on safety and early warning technology of expressway traffic in fog

Chen Duiyong

School of Traffic and Transportation, Shijiazhuang Tiedao University, Shijiazhuang, P. R. China

ABSTRACT

This paper research the freeway safety warning system with fog and analyze the composition and function of each part of the early warning system. Divided the warning level into four grades according to the affect of varying degrees of fog on the freeway safe driving and give the traffic organization management solutions for different warning levels. Reach the set of traffic safety facilities for freeway in fog environment.

Key words: fog freeway, traffic safety, early warning technology

INTRODUCTION

Data show that fog and other inclement weather caused a serious impact on expressway traffic safety, thus resulting accident rate has also increased. According to foreign research findings, although the expressway accident rate due to fog generated 4% of annual, but the mortality rate is as high as 7% to 8% of traffic accident data released by the traffic police department also proved this point^[1]. At present, China has many sections of the expressway fog area was classified as urgent reconstruction of accident blackspots police department.

Therefore, it is necessary to explore the next operation management systems and traffic safety warning key technologies foggy expressway environment, develop appropriate management and control measures, to maximize the level of the expressway traffic safety, road service levels and the ability to respond to severe weather reduce and reduce expressway traffic safety problems caused by fog, reducing personnel, property and economic losses arising therefrom^[2-3].

ALARM MANAGEMENT SYSTEM ESTABLISHED

Under foggy expressway safety warning system environment from expressway maintenance reasonable and efficient operating environment of view, by the impact on expressway traffic safety fog detection and prediction of expressway running status monitoring, to determine the status of road safety and trends, and thus make the management activities appropriate counter measures reactions.

Early Warning System Function

Expressway warning system can be divided into the following sections^[4].

(1) Information Collection System

Object expressway emergency information collection system is fog accident information. Information collection methods include automatic monitoring system or monitoring by observing forecasts, traffic police, road, conservation officers patrol, accident parties, past occupants or other reports and other insiders.

(2) the center of the decision-making system

The central decision-making system is divided into two parts, namely scheduling system and on-site command center. Before rescue workers arrived at the scene, promulgated by the dispatch center of the decision-making; after rescue personnel arrived at the scene, set up a temporary command center, the temporary command center in charge of the rescue work^[5-7].

(3) The emergency response system

Decision of the decision-making control center systems also need to rely on the strength of the various aspects of collaboration, rapid disposal in order to efficiently complete, and systematic implementation of the central authorities of the decision-making system that is composed of emergency services systems^[8-9].

Expressway warning system function according to the early warning management function and combined with its own characteristics can be identified as the alarm function, the function of correction, emergency function, as shown in Fig.1.

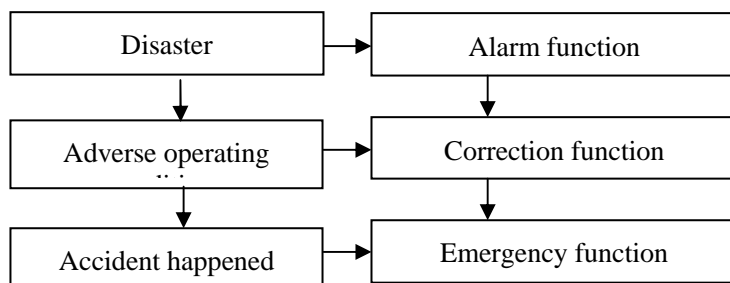


Fig. 1: Early warning system

Early Warning System components

Expressway fog warning system is a huge system, according to the system within the division of labor is different, generally can be divided into early warning information acquisition system, decision-making system, early warning and response system in the center of 3 subsystems, such as shown in Fig.2.

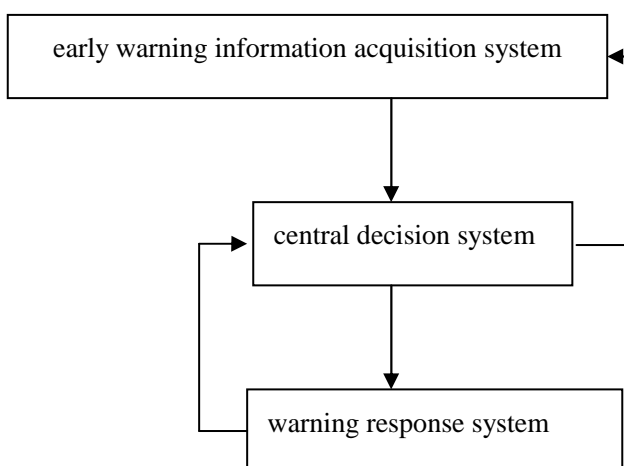


Fig. 1: Composition of expressway fog warning system

(1) information acquisition system

Information collection system is an important basis for early warning system can be achieved only effective, timely and comprehensive information and data collection system in order to provide data protection for the next job. The role of information acquisition system is collected on-site visibility, weather and traffic conditions and other data. Configuration information collection system shown in Fig. 3.

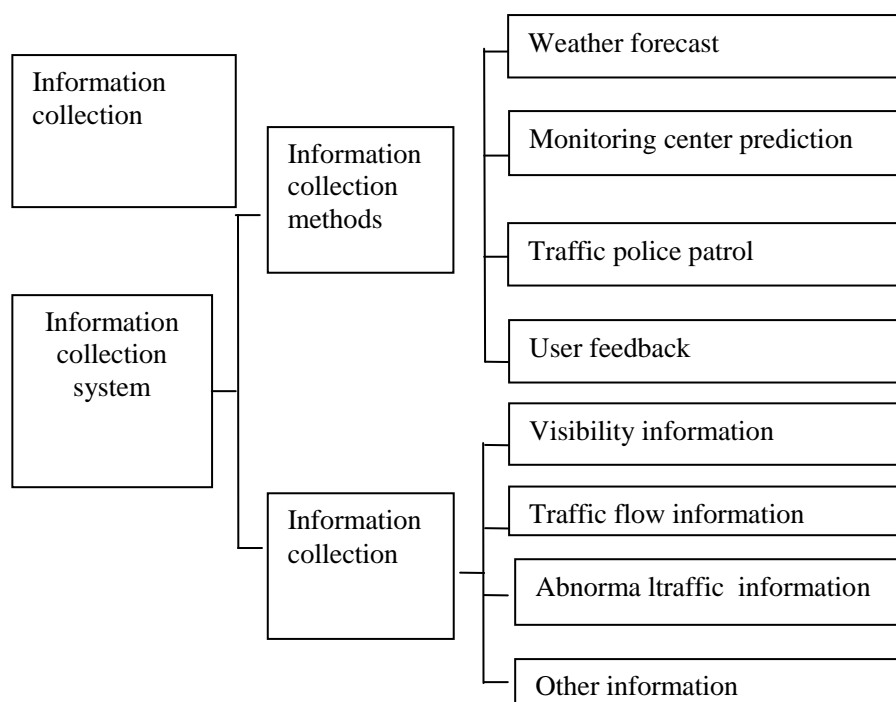


FIG 3: Information Collection System Configuration

(2) the center of decision-making system

The central decision-making system is the core of early warning system, the whole system plays a vital role. After receiving the warning information fog should immediately start center decision system, while continuing to always pay attention to the status of the development of fog through the information collection system, on the other hand, according to the occurrence of fog collected time, place, scope and visibility information, develop coping strategies, and coping strategies in a timely manner to the relevant units of the emergency notification system, allowing them to take timely action or emergency preparedness. With the development of the fog zone of the situation, the central decision-making system should promptly adjust coping strategies^[10-11].

(3) early warning and response system

All decisions dispatch center also need to rely on the decision-making system the forces collaboration, rapid disposal in order to efficiently complete. Early warning system is to implement the system in response to the directives issued at the center of decision-making system of the main control systems and traffic organization system.

Traffic control system is composed of variable message signs (VMS), fixed information marker, linear inducing sign and marking etc.. Variable message signs (VMS), fixed information marker and radio will be monitoring strategy into specific warning, control commands issued to the driver through the OTC equipment; fog lights, active reflective raised pavement markers and active luminous linear induction sign indicates the way forward for the driver.

The main contents of traffic organization in fog area is the flow of information through the visibility and road known traffic; comprehensive utilization of the road traffic control system; road, traffic police, rescue, medical rescue and the coordination of various departments coordination; the use of mobile phones, radio and various means of communication, on-site command and other corresponding measures according to the different value of the visibility, the formulation of the traffic organization plan accordingly, in ensuring road traffic safety situation, as soon as possible evacuation of stranded vehicles, handling traffic emergencies, make the traffic flow to return to a normal state^[12].

Classification of warning

According to the visibility and the different influence on expressway traffic degree can be divided into 4 grades of meteorological warning, as shown in TABLE 1.

TABLE1. Warning classification table

warning level	color logo	level description	potential impact on expressway
level 1	blue	fog may have appeared a wide range of visibility less than 500 meters in the next 12 hours	sight distance affected, traffic flow appears instability characteristics, individual areas of dense fog or strong fog severely affect traffic safety
level 2	yellow	fog may have appeared a wide range of visibility less than 300 meters in the next 12 hours	have a certain impact on traffic, traffic speed slowed down significantly, the winter ice road has been formed, reduce the friction coefficient of pavement, pose potential dangers to the high-speed driving
level 3	orange	fog may have appeared a wide range of visibility less than 200 meters in the next 12 hours	have a serious impact on traffic, road visibility can not meet the normal driving conditions, it is difficult to distinguish the road, traffic jams or paralysis
level 4	red	fog may have appeared a wide range of visibility less than 50 meters in the next 12 hours	sections of poor visibility, driving is extremely difficult, a large number of the backlog of vehicles, passengers stranded

Early warning system workflow

Expressway fog warning system is a complex system, according to the organizational structure of early warning system can clear all responsibility department work flow.

FOG AREA MONITORING EQUIPMENT LAYOUT

Fog zone monitoring equipment includes traffic acquisition equipment, visibility and weather detection devices and video surveillance equipment^[13].

Traffic flow collection device which comprises an annular coil vehicle detector, radar, ultrasonic, video type and other types, but in our country expressway, loop coil vehicle detection ceremony most commonly used traffic flow collection device, it can accurately detect the vehicle's average speed, traffic flow and lane occupancy rate information. Little interference factor.

The vehicle detector common spacing between 0.5~5km, according to the degree of importance and application purposes road. The traffic flow is less on the expressway, even setting the vehicle detector only in Interchange near the will. But for the road superexpressway fog area, because of real-time detection of traffic flow state, in order to take the corresponding management measures, vehicle detector need relatively more, its setting density varied with the fog region characteristic. Each spray section one-way comprises at least 5 group vehicle detector, in which 3 groups of detectors are arranged inside the fog section, are respectively arranged on the head, tail and fog area middle section, the other 2 group vehicle detector is arranged on the fog region outside the 2~4km office, fog area before and after each set a group. Fog area inside the vehicle detection in fog area of internal traffic flow state changes, provide the basis for the establishment of monitoring strategy in fog area. The vehicle detector fog area outside for traffic flow state detection of normal meteorological environment, through the contrast of fog inside and outside the area to traffic flow state, correction of traffic control in fog area strategy, make the fog area traffic flow to maintain continuous internal and external consistency^[15-17].

The fog influence area length exceeds 5km sections, then the fog zone should not every 1~2km set up a group of vehicle detector, 2~4km in fog area outside of the position, the fog region before and after the sections each with a set of detector. Sections in the key area of fog, in order to be able to timely discover road congestion and traffic things such as special cases, should every 500m set up a group of vehicle detector^[18].

Visibility monitoring equipment is the most important information acquisition equipment monitoring system in fog area, including digital CCD camera system, the visibility visibility monitoring etc.. Currently in use on the expressway is the most visibility monitoring equipment widely used is the FD12 visibility meter VAISALA.

Layout and fog area characteristics, visibility around the terrain characteristics of expressway tunnel and other facilities is closely related to the location of the road. Each paragraph should be set at least fog features a visibility meter, and should be the core section is arranged in the fog zone. When the fog feature section affect the broader regional traffic characteristics and the characteristic of the road sections within the region have a greater change, should add visibility in each traffic and road characteristics section. When the fog characteristics section is longer, the section of ordinary fog area, should be based on the distance about KM encryption setting visibility meter. For yet the traffic operation, and no historical observational data of the expressway should be according to the local residents described and is conducive to the mist generated special topography and morphology characteristic segment division of fog.

Weather station is a combination of various meteorological detection equipment, including temperature, humidity, wind speed and direction detector detector detector, detector, road condition detector rainfall.

Weather station is aided prediction and forecast of fog formation, as the management strategy of the service. In the section of Expressway fog zone set the number has decreased, spacing should be selected in the 5~20km is arranged between the fog section, in the fog less areas, can not set the weather station or just set a weather in each administrative district within the station.

In addition to the conventional meteorological detection equipment, at the weather station is usually need to be equipped with a visibility meter. Located in the visibility meter meteorological station can not only filter into the fog monitoring and early warning function, through combining the analysis of observation data and other meteorological visibility data, meteorological law can obtain fog generation, to provide services for the fog forecast.

On the expressway, CCTV camera video surveillance equipment is the most commonly used, although in the heavy fog weather conditions, due to reasons such as visibility, video surveillance range will be affected to a certain extent, but the fog condition is very favorable for rapid confirmation.

Fog conditions confirm the length of time to take measures to timely is crucial, according to the influence of fog on traffic safety, the initial formation of Seafog is time the most prone to traffic accidents, the timely confirmation fog conditions can reduce the probability of traffic accident generated early in the fog. Typically, the traffic police arrived at the scene to fog condition time confirmed in more than 10min, and if the fog formation location in video monitoring range, then received the report, within 1min can confirm the fog condition. Therefore, it is very necessary to set the video monitoring system in the section of Expressway fog zone.

Because of the fog section is the key part of the expressway, in the economic conditions permit, should the whole video monitoring, even if temporarily do not have to set the whole video monitoring conditions, should also be reserved interface for the future implementation of the whole video monitoring, and with the need of traffic growth and traffic monitoring system, gradually expand the scale.

FOG AREA TRAFFIC ORGANIZATION AND MANAGEMENT

According to the influence of different degree of fog on expressway traffic safety, take the corresponding traffic organization and management plan in different warning grade.

(1) an early warning of traffic organization pipe plan

Appear in the abnormal condition, road and traffic will be abnormal condition at the same time to the expressways department and the maintenance station bulletin, the purpose of enabling personnel and maintenance personnel the first time rushed to the abnormal conditions of sections, which officers should increase patrols in the abnormal condition of road; through the vehicular broadcast to remind drivers to pay attention to traffic safety; vehicle speed according to the rate limiting scheme datasheet the strict implementation of the prohibition of indiscriminate parking and; the timely processing of the faulty vehicle, and the abnormal condition of the road length every definite kilometers place traffic warning signs or temporary speed limit sign.

(2) two level warning traffic organization pipe plan

In the second level degree of fog occurs, driving the car on the expressway will become relatively difficult. When the traffic volume is too large, the expressway will appear the phenomenon of traffic jams, likely to cause the traffic accident causes the accident rate increased the specific management content is: when the abnormal events, should the speed limit signs placed in the upstream and downstream of the abnormal sections, the abnormal situation to drivers notice through the LED variable information board or temporary mark, to remind the driver to maintain an appropriate distance between vehicles and vehicle velocity control. When obstacles appear on the road, should timely inform road maintenance personnel to timely treatment. The road alignment is poor and accident prone sections, should set the chevron alignment markings to help drivers have better recognition of road linear in low visibility conditions, and set up a warning sign temporary.

(3) three level warning traffic organization pipe plan

When visibility drops below 200m, the road traffic condition severity sharply, serious safety problems running the low visibility on expressway vehicles face. The specific management content is: when the abnormal event, should the speed limit signs placed in the upstream and downstream of the abnormal sections, the abnormal situation to drivers notice through the LED variable information board or temporary signs, remind the driver to maintain a proper distance between vehicles and vehicle velocity control. Should set the speed limit signs in abnormal road ahead kilometers, visual distance and open the lighting facilities to improve the fixed sign sign.

(4) four level warning traffic organization pipe plan

When visibility is less than 50m, sections of poor visibility, traffic is extremely difficult, a large number of vehicles backlog of passengers stranded. The specific management measures: traffic control center should be released through the network, broadcasting a variety of means of communication for real-time weather and traffic information, try to limit travel vehicle is not necessary to enter the expressway. At the same time, considering the closure of the expressway lanes according to the actual situation, to stop the vehicle into the fog zone. Using a patrol car to lead the fleet organization way in fog area the vehicle left the road patrol, patrol car along, police, medical and Rescue Department on standby.

FOG ACCIDENT EMERGENCY RESCUE

Because of the traffic accident is random, even in the fog warning in time and take corresponding measures under the condition of factors by some uncontrollable or there will be a traffic accident emergency warning system in the function then began to play a role in.

Fog freeway emergency rescue system is a subsystem of the management system in fog area, attached to the expressway early warning system, the 3 part also consists of information collecting system, central decision making system and emergency service system.

(1) information collection system

The object of freeway emergency rescue information acquisition system is a fog of traffic accident information. Information acquisition way including the monitoring system of automatic forecast or control personnel through observation, the traffic police, road, maintenance personnel patrol, the parties involved in the accident, passing drivers or other insiders report etc..

(2) the center of decision system

The central decision-making system is divided into two parts, namely scheduling system and on-site command center. Before rescue workers arrived at the scene, promulgated by the dispatch center of the decision-making; after rescue personnel arrived at the scene, set up a temporary command center, the temporary command center in charge of the rescue work.

(3) emergency response system

Decision of the decision-making control center systems also need to rely on the strength of the various aspects of collaboration, rapid disposal in order to efficiently complete, and systematic implementation of the central authorities of the decision-making system that is composed of emergency services systems.

When the fog, the effective range of the video system is very limited, although the use of some expressway incidents automatic monitoring system, but the speed of the vehicle at a low fog, the automatic monitoring system is also very difficult to predict the traffic accidents in a short time existence, when the event automatic monitoring system to monitor the time of the accident, the expressway traffic accident may have occurred, or a chain of the most accident. Therefore, information gathering fog rely mainly on traffic accidents, road patrol and accident parties, road users report to achieve. In the fog should increase with the traffic police, patrol officers and vehicles in order to be able to detect and confirm the accident.

When there is fog, expressway traffic police and Expressways Department should step up inspection of the road, on the accident-prone sections focus on inspections, for early detection of accidents. In the fog zone sections, certain police laid interval within the service area, parking areas and other facilities on the spot roadside stand, you can save time confirmed the accident, but also be able to spot the early implementation of traffic control, reducing the probability of occurrence of secondary accidents.

The traffic police and road to arrive at the scene to complete the severity of the accident, influence scope, need to type and number of rescue vehicles, should be timely traffic control measures on the road. Monitoring center through the variable information board to remind the driver in front of chronic or the nearest accident must slow down off the expressway.

TRAFFIC SAFETY FACILITIES UNDER FOGGY CONDITIONS LAID

Fixed facilities

(1) fixed signs

The fog on the road under the condition of fixed sign setting function mainly has to remind drivers to pay attention to traffic safety and restricted speed. The setting position should be selected in the mist of the upstream multiple sections, in order to play the role of warning to drivers and the speed limit effect.

Because of the fog adverse effect on visibility, consideration should be given to the fixed sign correlation processing to extend the sign visibility distance. As in the logo on the smear of reflective materials or in the fixed sign is arranged beside the auxiliary lighting equipment, can extend a sign of effective visibility distance.

(2)the variable information board

The driver of a timely understanding of the traffic situation, the need for real-time notification of road traffic conditions, variable information board layout place mainly for fog prone and multiple sections, the release of information is mainly there to remind drivers to pay attention to the speed limit, and forecast the downstream effect of road traffic conditions.

(3)induction sign

On the expressway, chevron alignment sign is an important facility for specification vehicle trajectory, the main reference facilities is also a driver in driving process. According to the survey, driving in fog, pilots rely on induction sign distinguish road profile and alignment to the front, so we can see that its importance in driving in fog.

Linear induction flag should be set to the following principles:

- ① linear induction flag should be set to change in the direction of travel sections, such as sections of small radius curves, ramps, roads and other sharp turns;
- ② linear induction flag should be set consistent and linear and perpendicular to the vehicle traveling direction;
- ③ linear induction flag set spacing should ensure that there is always the driver's field of vision has two linear induction mark;
- ④ any curve, just set the linear induction flag is set to at least 3;
- ⑤ linear induction mark set a minimum height for: lower edge of the flag from the ground 1.2m.

In low visibility weather conditions, the driver can see the linear inducing sign quantity not only depends on the position of the obstacle or bend radius size, but also depends on the fog visibility. Fog section linear inducing sign setting density should ensure maximum visibility in fog 85% visibility conditions or can see 2 linear inducing sign in the case of 50m. Thus calculated spacing should not be more than 25m linear inducing sign.

Temporary facilities

Due to the fixed sign setting is hard to cover sections of intact, a hand so temporary sign setting is also essential. The increase in input fewer cases of temporary signs can also be set to play a better role.

Fence set

There are mainly three kinds of widely used at home and the form of barrier: flexible guardrail, semi-rigid guardrail and rigid guardrail. In this three types, semi-rigid guardrail is corrugated guardrail used widely. The main reason is the characteristics of corrugated guardrail with rigid flexible and economic, after the collision of plastic deformation is large, easy to repair after damage, line of sight guidance and strong, and can com. and road alignment. But when the specific use of guardrail form, not lump together, or to the characteristics and performance of each barrier forms are considered, a comprehensive analysis of the driving safety, the driver's psychological oppression, have a good line of sight guidance and coordination with the surrounding environment, but also to consider the economy, ease of construction and maintenance so, the ideal fence to reduce the occurrence of roadside accident and reduce the severity of accident is very important. In simple words, only to be able to reach the crash strength, make the vehicle safe stop, but also save the cost. Therefore, in the choice of the guardrail of the time want to consider various factors.

CONCLUSION

This paper analyzes the composition of Expressway fog security early warning system, the warning level of different degree were divided, and puts forward the traffic organization and management schemes of different degree of fog conditions for different levels of weather, foggy environment Expressway fixed signs and temporary signs and fence settings.

Acknowledgements

This paper was supported in part by a grant from research project of education department of Hebei province, This paper obtained the Hebei Province Department of education funding, project number SQ141121.

REFERENCES

- [1]Spaid,J.Impacts of weather on expressway construction.84th Annual American Meteorological Society Meeting[C].Seattle,Washington, January 11-15,2004

- [2]Pengtao Jia,Jun Deng,Shuhui Liang. *Mathematical and Computer Modelling*.**2014**, volume 18, №7
- [3]A. Hamish Jamson, Frank C.H.Lai, Oliver M.J.Carsten. *Transportation research Part C, Emerging Technologie*.**2008**, Vol.16c (No.4): 471-484.
- [4]Xiaonan Zhang,2,Xiaoyong Lu. *Mathematical and Computer Modelling*.**2014**, volume 18, №8
- [5]Liu Qing, Wu Yanzi. *Journal of Wuhan University of Technology*,**2003**,27(3):421-424.
- [6]Wang Fei,Ding Songbin. *Computer Engineering*,**2005**,31 (7):246-248.
- [7]Hogemoal.H. *Raffice Engineering and Control*,**1996**, 37 (10):629.632
- [8]Yutian Liu,Junjie Hu. *Mathematical and Computer Modelling*.**2014**, volume 18, №9
- [9]Roach W.T., Brown R., Caughey S.J., etal,*The Physics of radiation fog Part I:A filed study*[M].Quart.J. R. Meteor Soc.,**1976**, 102, 313-333
- [10]Yan Li,Zhe Zhang,Xiaofeng Cui. *Mathematical and Computer Modelling*.**2014**, volume 18,№7
- [11]Jiusto J.studies,E, Lala, Grieser, J.G.G., Radiation fog field Programs[J].*recent ASRC.SUNY*.**1983** Publ No. 869
- [12]Fuzzi,S., *Acta Meteorologica Sinica*, **1994**, 8(3):316-328
- [13]Dan Li,Ting Yang,Guangsheng Chen.A *Mathematical and Computer Modelling*.**2014**, volume 18, №8
- [14]Jonathan Koopmann, Wassim G.Najm.Identification of TrafficStates From Onboard Vehicle Sensors[C].*2003 SAE World Congress*, Detroit, Michigan. 2003.SAE Technical Paper Series No: **2003**-01-0535.
- [15]Xiaochun Zhao. *Mathematical and Computer Modelling*.**2014**, volume 18, №9
- [16]Paul Pisano.Best Practices for Road Weather Management U.S. DOT[R].*Federal Expressway Administration*. **2003**, (7):37-39
- [17]Xue Bingbing.Study on the Traffic Safety warning System of Dangerous Sections of Freeway[D].*Jilin University*,**2007**,8,51-59 (in Chinese).
- [18]Yang Caiqing.Expressway traffic safety system in fog area[C].*Chang'an University*,**2011**,45-53(in Chinese).