RESEARCH ARTICLE OPEN ACCESS

Research onidentify stadia of interchange exit ramp in mountainous urban freeway

TAN Hai

(School ofCivil Engineering and Architecture, Chongqing JiaotongUniversity, Chongqing,China)

Abstract
Theidentify stadia of interchange exit ramp hasgreat influence on capacity and safety levels of urbanexpressway,combining with car psychological theory and driverscharacteristics,based on design speed and driver's reaction time, driversoperating characteristics and the cause of the accident on interchange exit ramp was analyzed and the identify stadia threshold under different design speedwas determined. The resultindicates that: the requirements of specification for identify stadia has some limitations, it should be modified appropriately.

Keywords: expressway; interchange exitramp; identify stadia

1.Introduction

With the sustained economic and social development, urban population and car ownership is increasing, the number of road traffic accidents also increased year by year. There are always a large quantityof interchangein mountain city, with complex form, low alignment index, a small road width, and the interchange typically contains a short length of weaving section, traffic run complexlyin this section. There aremany traffic conflict points, inadequate identify stadia, easy to cause traffic accident.

After a review of domestic and foreign research, I have rarelyfound domestic and international research for the identify stadiaof Interchange export, and they focused on therelationship between exit ramp alignment and highway safety, there is no experimental study, and not fully consider the actual operation of the vehicle and the combined effects of various factors.

2. The classification of interchange exit ramp

2.1 General ramp

In terms of the whole interchange system, due to a variety of restrictions of the terrain,feature, thereare different requirements of traffic function, the layout form of the exit ramp is complicated.Its basic requirement is not complicated, however, in addition to have linear function, the right side of the shunt,the left side of the shunt traffic function should be added , namely the right shunt rampand left shunt ramp.

2.1.1 Right shunt ramp

Shunt vehicles separated from the on-ramp traffic, leave the on-ramp diversion area through the right shunt ramp.Its feature is, right-turning shunt lane have little influence on the straightlane, shunt is convenient, clear direction, the speed is high, use more widely.

2.1.2Left shunt ramp

Shunt vehicles separate from the inner side of the ramp driveway, through the left shunt ramp, leave the on-ramp diversion area.Its feature is, left-turning shunt lane have biginfluence on straightlane,directly affect the traffic efficiency

of diversion district.

2.2 Successive shunt ramp

In accordance with the order of right shunt and left shunt, the left split, thecombined mode ofinterchange successive exports can be divided into first left then the right, first right then left, first left then left , first right then right these four types.

2.3Mainline constraint export

Mainline constraintexport refers to the interchange export restricted by terrain conditions and have to set in thelower index sections of main or segments hard to identify or unfavorable to vehicle decelerate on.The mainlineconstraint exports mainly have problemsto identify export position, according to different export identify factors, mainline constraint export can be divided into the mainline horizontal alignmentconstraint export and mainline vertical alignment constraint exports.

2.3.1Mainline horizontal alignmentconstraint export

Mainline horizontal alignmentconstraint export refers tointerchange export position athorizontalcurve section,the export position blocked by motorways obstacles, the driver is not easy to identify the export position, prone to rear-end collision, side collision, hit fixtures and other accidents.

2.3.2Mainline vertical alignment constraint export

The mainline vertical alignment constraint exportinclude interchange export locatebehindcurve slope point of smaller Convex vertical curve, the driver always miss the export or emergency braking near the export in this section, easily lead to traffic accident.

3. Traffic flow characteristic analysis in the process of car shunting

Because the vehicle was designed for running from high speed mainline to the low speedramp,in this process,the driver must complete the driveway transform, and it is mandatory lane change. In order not to affect the main line,drivers need to change to theouter lane within a certain distance in front of the deceleration lane , and then in the transition section and slow lanes, reduce the runningspeedofthevehicle within the safe driving speed of ramp, so within the original lane,the velocity of the front car is greater than the speed of back car , therefore, it is almost impossible to rear the end, in this study to ignore the situation, but in theprocess, the safety of the car is still restricted by other conditions, due to the front carwithin the target lane is slower, and the high speed when cars changing lanes , the lane changing car easily rear the end with the front vehicles within the target lane;Due to premature brake or brake acceleration too large, vehicle speed reduce too fast, leading to the car within original lane crash.In both cases, therefore, constitutes the vehicle securityconstraints of safelychange lanes.Only both cases are satisfied at the same time, the vehicle can be safely change lanes.

4. Accident analysis

The road alignment index in mountain city is generally low. When the carapproachthe overpass weaving section，pulled out of the exit freeway interchange intertwined; the car, since the interleaving length is short, confluence of vehicle import and distribution vehicles out of lead to more traffic conflict and more speed discreteness, easy to produce collisions, rear-end accidents；Since exit sometimesbehind a smaller radius convex vertical or horizontal curve, the driver is difficult to detect exit signs and markings, the export position was found when close to exit,the driver will be forced to take emergency brake and change lanes, prone to rear-end collisions and side collisions; Due to the unreasonable exit sign set position, distance and information overload,drivers fail to understand the information, emergency braking or parking read symbol meaning, when miss exports, will back into the target export, these behaviors are prone to crash.

5.《specification》provisions on identify stadia of interchange exit ramp

According to 《Design Specifications for Highway Alignment》JTG_D20-2006，in the exit of interchange, identify stadiais the distance required for safe operation，it is mainly used to detectsomething that may cause visual clutter，or the information source difficult to perceive, danger signs or its potential, select the appropriate speed and route, safe and effective to complete the trip. The specification stated thatidentify stadiashouldbeguaranteed beforethe mainline shunt noseto judge the export，identify stadiavalueshould be more than the prescribed in Table 1,under limited conditions, the identify stadiavalue should be greater than 1.25 times themain line stopping sight distance (as shown in Table 2).

Table1Theidentify stadia of interchanges export

Design speed（km/h）	120	100	80	60
Identify stadia（m）	350～460	290～380	230～300	170～240

Table2Thelimitvalue of interchange exit identify stadia

Designspeed（km/h）	120	100	80	60
Stoppingsight distance（m）	210	160	110	75
Identify stadia（m）	262.5	200	137.5	93.75

6. Identification stadiaof expressway inter change exit ramp

The process ofvehicle left the freeway exitramp involves identifying the exit and vehicle deceleration process, and thus identify stadia can be decomposed into export identifydistance and deceleration distance (as showninformula1), identify stadia L calculated value is as follows:

$$L = L_1 + L_2 + L_3 \qquad (1)$$

Where:

L——identify stadia required for freeway exit (m);

L_1——driving distance when the driver identify export (m)

L_2——deceleration traveling distanceon ramp (m).

L_3——safe distance (m)

Among these, the export recognition distance is made up of reading distance and judge distancesandsafe distance.

6.1 Reading distance

Reading distance is related to reading time, according to the related research, take a picture of time 3 s, because the slow action hasn't been used in the process of reading , so the speed of reading distance (as shown in formula2 and formula3), can be calculated according to the mainline design speed:

$$L_1 = l_1 + l_2 \qquad (2)$$

$$l_1 = vt_1 \qquad (3)$$

Where:

l_1—— reading distance;

v——the main line design speed;

t_1—— time for reading logo.

Table3Reading distance under different design speed

Speed（km/h）	Reading distance(m)	Speed（km/h）	Reading distance(m)
120	100	80	67
100	83	60	50

Judgedistances is the vehicles travel distance that driversmake a judgment afterreadingtrafficsig n information.This process judge distances(asshow n in formula4) is:

$$l_2 = vt_2 \qquad (4)$$

Where:

l_2——judge distances;

v——the main line design speed;

t_2——time forjudge

The time required for driver to judge signis 2.0 ~ 2.5s,in this study，we take 2.5s.By the above formula can be concluded that the judge distance under different design speed is as shown in table 4.

table4 Judge distanceunder different design speed

Speed （km/h）	Judgedistance(m)	Speed （km/h）	Judge distance(m)
120	83	80	56
100	69	60	42

6.2 Action distance

Action distance is the distance traveled by cars exported from expressway to slow down amid, generally includes two phases: the first stage is the driver loosen the accelerator pedal, without using brake deceleration and transferred to the deceleration lane, the phase using engine slow down, the speed change fromv_0 to v_1 ;The second stage is to use the brake to slow down, when arrive at interchange export, the speed change from$v_1$to v_2.Therefore, vehicle action distance is the sum of the two stages in the car distance,(as shown in formula5 toformula8) namely

$$L_2 = l_1' + l_2' \quad (5)$$

$$l_1' = v_0 t_1 - 1/2 a_1 {t_1}^2 \quad (6)$$

$$v_0 = v_0 - a_1 t_1 \quad (7)$$

$$l_2' = \frac{{v_1}^2}{2a_2} - \frac{{v_2}^2}{2a_2} \quad (8)$$

Where:

l_1'——driving distance in thefirst stage process of deceleration;

l_2'——driving distance in the second stage process of deceleration;

t_1——the time needed for the first stage process of deceleration，apply 3 s;

a_1——the acceleration in the first stage process of deceleration, the values shown in table 5;

v_1——vehicle speedafter the first deceleration phase；

v_2 ——the speed in the process of vehicleleavemainline export;

a_2——the acceleration in the second stage process of deceleration, the values shown in table 5;

Table5 Theaccelerationvaluesunder different design speed

speed （km/h）	Deceleration（m/s^2）	
	a_1	a_2
120	1.0	2.0
100	0.9	1.8
80	0.8	1.6
60	0.7	1.4

Table6 Theaction distanceunder different design speed

Design speed（km/h）		Actiondistance（m）
mainline	ramp	
120	60	256
120	50	277
120	40	295
100	60	177
100	50	200
100	40	220
80	60	99
80	50	126
80	40	147
60	60	23
60	50	54
60	40	79

6.3 Safe distance

According to the related research, researchers usually take safe distance for 15 ~ 100 m, in this paper, we take a median of 50 m.

Table7 Identify stadia of interchange exit ramp

Design speed（km/h）		Identify stadia（m）
mainline	ramp	
120	60	489
120	50	510
120	40	528
100	60	379
100	50	402
100	40	422
80	60	272
80	50	299
80	40	320
60	60	165

60	50	196
60	40	221

7. Conclusion

Through comparison, we can know that the calculateidentify stadia value of interchangeexitra mpis bigger than the specification givenvalue,This indicate that in interchange design, in orderto ens ure traffic safety, we should try toadopt Abigger identify stadia value than the value thespe cification given. But in mountain cities, thereare interchanges with complex form, low linearindex, a small road width, and the interchange typicall y contains a short length of weaving section, traf fic run complexlyin this section,thedentify stadia value can't satisfy the requirement of safe operati on,under the condition, weshouldstrengthen the tr affic safety facilities setting.

Reference

[1] Manual on Layout of Highway Traffic Signs and Markings，JTG D82-2009 [S].

[2] Alexander,GJ.AndH.Lunenfeld.Positive guidance in traffic control, Washington D.C:U.S.departmentoftransPortation,Federal highwayadministration,1975

[3] QiangruShen, YifeiZhao, Zhangyong Chen,Hui Cao, Study on the identify stadia of restrictingexportson highway interchange [J], Journal of China & Foreign Highway, 2012, 32 (6): 305-307

[4] Yan Wu, Study on the identify stadia of freeway interchange export [J], Highways Automotive Applications, 2014 (162): 109-112

[5] Hongliang Xu,Bomingtang,TaixiongZhan g, Signproblem analysis of Chongqing ren he interchange and corrective countermea sures [J]. Highway, 2010 (11) : 141-144

[6] American Association of State Highway and Transportation Officials. A policy on geometric design of highways and streets[R].American Association of State Highway and Transportation Officials,2001.

[7] GUO Tangyi, DENG Wei, LU John,Safet y Evaluation for Freeway Exit Ramp Ba sed onSpeed Consistency[J].Journaloftrans portation systems engineering and inform ation technology, 2010, 10(6), 76−81

[8] Hongyun Chen,, Pan Liu, Jian John Lu,BijanBehzadi, Evaluating the safety impacts of the number and arrangement of lanes onfreeway exit ramps[J]. Accident Analysis and Prevention, (2009) 543−551

[9] McCartt, A.T., Northrup, V.S., Retting, R.A.,2004. Types and characteristics of ramprelatedmotor vehicle crashes on urban interstate roadways in northern virginia.Journal ofSafety Research 35, 107-114.

[10] Garcia, A., Romero, M.A., 2006.Experimental Observation of Vehicle Evolution on aDeceleration Lane with Different Lengths.Transportation Research Board,Washington,DC.