

# Study on the application of access management in the 1st-grade highway

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## Abstract

The 1<sup>st</sup>-grade highway is the highest grade highway in the common highway in our country, and it is the very important part of highway network in our country. For us posting our most intention to the road itself rather than the environment along the road in the road design process. So it causes that after the completion of the 1<sup>st</sup>-grade highway, it will undertake the impact of land development beside the road two or three years later, and operating efficiency decreases and traffic safety will not secure. Meanwhile, there is not detailed design standard of exit and entrance of 1st-grade Highway in the Design Code of Highway Route, and the management of access to 1st-grade highway is weak. So traffic accidents often happen in the exit and entrance of 1st-grade highway and the traffic accident rate of 1st-grade highway in our country is the highest. At first the paper analyzes traffic character of 1st-grade highway, then traffic characters of exit and entrance, influential factors of exit and entrance and traffic safety problems in the exit and entrance are analyzed. At last, the paper studies on the application of access management in the traffic safety of exit and entrance in 1st-grade highway from the aspect of policy management and operation design.

Keywords: Access of 1<sup>st</sup>-grade Highway; Traffic Safety; Access Management

## 1. Introduction

The 1<sup>st</sup>-grade highway has such merits. Firstly, the capacity of 1<sup>st</sup>-grade highway is comparatively large. Secondly, it is partly controlled the access, so it is convenient to be used by the people along the highway. Thirdly, the constructing cost per kilometer is comparatively low. So the 1<sup>st</sup>-grade highway plays an important role in the trips between large cities. Due to the feature of partly controlling access, the traffic safety problem of 1<sup>st</sup>-grade highway is very outstanding. The traffic accidents in the access of 1<sup>st</sup>-grade highway hold over 50% of whole accidents, and make the 1<sup>st</sup>-grade highway become the most dangerous highway among the all grade highways. In the year of 2005, there are 272840 accidents in the highway, and 76689 persons died in the accidents. In it, there are 34009 accidents in the 1<sup>st</sup>-grade highway, and 9335 persons died. Although the length of 1<sup>st</sup>-grade highway takes only 1.98% of highway network in our country<sup>[1]</sup>. As the construction of 1<sup>st</sup>-grade highway and development of economic zone along the highway, there will be more and more accesses in the 1<sup>st</sup>-grade highway. So it is necessary to analyze the traffic problem aroused by disordering access and take effective measures to ensure traffic safety.

## 2. Traffic characteristic of 1<sup>st</sup>-grade highway

1<sup>st</sup>-grade highway is the multilane highway that partly controls access and motors can run in isolated direction and the lanes are divided into different uses. From the

field investigation and statistical data, the traffic characteristic of 1<sup>st</sup>-grade highway is that:

(1) The traffic volume is large. The design capacity of 1<sup>st</sup>-grade highway is between 550pcu/h/lane to 1400pcu/h/lane. The 1<sup>st</sup>-grade highway of four lanes can accommodate the daily volume from 15000pcu to 30000pcu. In our country, 1<sup>st</sup>-grade highway generally is arterial highway, and it takes comparatively large volume. Table2-1 shows AADT of some 1<sup>st</sup>-grade highways in the year of 2005.

Table2-1 AADT of 1<sup>st</sup>-grade Highway (veh/d) <sup>[3]</sup>

Highway	G205	S323	S331	G328	S334	G312	S338	S340
Traffic volume	6732	6515	4692	16389	7171	27676	19930	24032

Note: G represents national highway, and S represents provincial highway.

(2) The composition of traffic volume is complex. Due to 1<sup>st</sup>-grade highway has many accesses that crossed with local rural road. So the composition of traffic flow includes auto, bicycle and motorcycle and so on. Table2-2 and table2-3 show the traffic composition of 1<sup>st</sup>-grade highway.

Table2-2 Traffic Composition Percentage of 1st-grade Highway (%)<sup>[3]</sup>

Highway	motor		Non-motor	
	auto	tractor	tricycle	bicycle
G205	63.7	9.3	1.8	24.2
G312	85.7	0.3	0.4	13.6
S331	91.6	8.4	-	-
S340	93.3	6.7	-	-

Note: this table uses the natural number of vehicles.

Table 2-3 Composition Percent of Auto Volume (%)<sup>[3]</sup>

highway	vehicle type	Minor truck	Medium-type truck	Large truck	Trailer	Small car	Large coach
G205		25.8	21.1	18.5	14.6	13.8	6.3
S331		12.7	13.6	12.6	2.5	55.2	3.3
G312		13.9	13.8	20.4	1.0	33.9	17.0
S340		19.7	24.1	11.8	3.8	36.8	3.8

(3) The speed is high. As the condition of road line and road surface of 1<sup>st</sup>-grade highway is good, and 1<sup>st</sup>-grade highway has the median, so the speed of small coach often exceeds 100km/h, and large coaches normally run over 70km/h.

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### 3. Traffic characteristic and traffic safety analysis of access

#### 3.1 Traffic characteristic of access

When the driveway that serves the company, residential district or countryside along the 1<sup>st</sup>-grade highway directly crosses with the 1<sup>st</sup>-grade highway, then the access of 1<sup>st</sup>-grade highway generates. The access is an informal T-type intersection, and it is different from the common intersection in such aspects: (1) The normal intersection generates when the grade highways cross with each other and the width of intersection is designed by the criteria. However the width of access is not certain and it is between 3m and 10m. The type of surface is also not certain. Sometimes the road surface of driveway is asphalt concrete pavement, sometimes is cement concrete pavement, and sometimes is sandstone pavement. (2) The generation of intersection has been permitted by the highway administration; however the generation of access has not been permitted by the highway administration. (3) The area that the driveway serves is comparatively small, so the daily volume of driveway is smaller than the highway, and it is normally below 200vehicles per day<sup>[4]</sup>.

In most accesses, the median has opening and the median opening allows all direction turning. This kind of access has serious traffic conflict. It has three diversion conflict points, three merging conflict points and five crossing conflict points. Table 3-1 shows the conflict point of access. The most serious conflict point is crossing conflict point that arouses when the vehicles turn left. Due to the left turn lane commonly not being set in the access, the left turning vehicles wait for turning left, so it generates comparatively serious diversion conflict point.

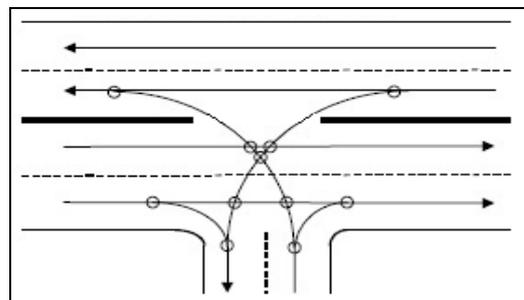


Figure3-1 Traffic conflict of access

The traffic conflict in the access has great influence to the vehicle running speed of 1<sup>st</sup>-grade highway. When there is not vehicle passing in the driveway or out of the driveway, the operating speed of vehicles in the 1<sup>st</sup>-grade highway is between 60 and 70km/h, however when there are vehicles passing in or out, the operating speed of vehicles near the access drops to 30 ~40km/h so as to avoid colliding with the turning vehicles. The declining range exceeds 20km/h, and it is bad to traffic safety.

#### 3.2 Analyzing the affecting factor of traffic safety in the access

From analyzing the design and traffic operating feature of access, we can conclude that the major factors affecting the access traffic safety are these:

- (1) The organizing type of traffic flow near the access. The number and type that every direction of traffic flow merges or crosses determine the conflict number in the access.
- (2) The efficiency of traversing median. The longer the traversing time is, the bigger the possibility that happens collision is. The efficiency relates with the driver performance, the vehicle performance and the location and dimension of median opening.

(3) The changing lane behavior<sup>[5]</sup>. If the driver changes his vehicle to the inboard lane in front of the access, then the vehicle will reduce or avoid the conflict with other vehicles. This relies on that the driver aware the existence of access in advance.

(4) The condition of road line, traffic engineering facilities and sight distance in the access. If the distance between the access and the intersection is short, the organization of traffic flow will be complex. If the operating speed is high and the sight distance is not enough, the seriousness of traffic conflict will aggravate.

### 3.3 Traffic safety problem of access

We can find the traffic safety problems in the access from the survey of access of 1<sup>st</sup>-grade highway:

(1) The access spacing is comparatively small. The 1<sup>st</sup>-grade highway partly controls its access and we lack the standard of approving the access. So the driveway directly crosses with the 1<sup>st</sup>-grade highway for the convenience of organizations along the highway. It leads that the frequency of access is high, and the access spacing is small. This phenomenon is very outstanding in the developed eastern area. Figure 3-3 shows frequent access.

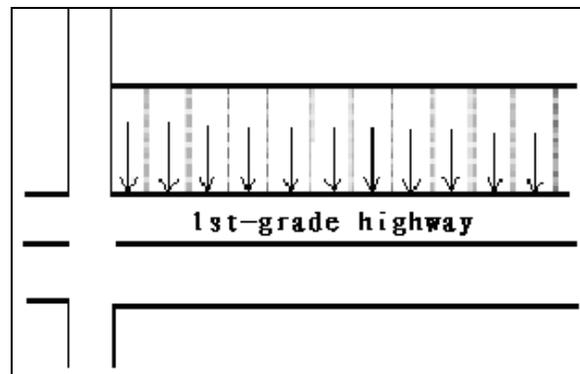


Figure 3-3 Frequent access

(2) The access commonly lacks traffic control device. For example, the stop sign and mark is not set in the access. So the traffic flow does not have the operating rule, then serious traffic conflict will happen. The access lacks the warning sign, so it can not give driver the notice of access, and will reduce the reaction time of driver.

(3) The geometric design of access is not normative. For example, sometimes the width of access is large, and this broadens the conflict area.

(4) The number of median opening is comparatively large, and this increases the number of traffic conflict, so the traffic safety is deteriorated.

(5) The acceleration lane or deceleration lane is not set according the actual condition, and it easily generates rear end accident.

The radical reasons of the above problems are those: (1) we don't systematically consider the traffic safety problem of access in the 1<sup>st</sup>-grade highway plan and design process; (2) we lack the standard of access design and access management policy. So we solve the safety problem of access from the above two aspects.

## 4. Application of access management

It is necessary to take scientific and effective measures to improve the traffic safety of access, when we face the fact that traffic accidents often happen in the access. Access management is the systematic control of the location, spacing, design and operation of driveways, median openings, interchanges, and street connections to a roadway<sup>[7]</sup>. The purpose of access management is to provide vehicular access to land development in a

manner that preserves the safety and efficiency of the transportation system. The core idea of access management is that roadways are classified by function on the basis of the priority given to land access versus through-traffic movement. Access management has been widely applied in the US, and acquires good effect. Table 4-1 shows the effect of access management in the US. Access management also has the value of applying in our country.

Table 4-1 The effect of access density and type of median to traffic accident rate (rural road) (per million vehicle mile)

Number of unsignalized access per mile	Type of median		
	Traversable median	Continuous two-way left-turn lane	Nontraversable median
<=15	2.54	2.06	0.90
15.01-30	2.60	1.26	1.18
>30	4.65	1.67	1.47
all	2.73	1.67	1.02

Source: NCHRP REPORT 420

From the table 4-1, we can see that traffic accident rate has strong relationship with access density and median type. The higher the density and separation extent is, the lower the accident rate is. Now we analyze the application of access management in 1<sup>st</sup>-grade highway safety from the two aspects of access management--policy management and operation design<sup>[8]</sup>.

## 4.1 Policy management

Policy management clearly defines the relationship between land development and highway utilization. So land accessibility, traffic efficiency and traffic safety coordinate with each other, and the general benefit maximizes. Policy management relates with the land block layout plan, the number of access in the block and the internal microcirculation road in the block. It needs the cooperation of transportation and land plan department. The most critical work of policy management is determining the minimum access spacing of 1<sup>st</sup>-grade highway and arranging the driveway. The minimum access spacing considers such factor like vehicle operating speed, perception-reaction time of driver and vehicle length. Table 4-2 shows the recommended minimum access spacing of Nevada State.

In China, we don't have the standard of access spacing about 1<sup>st</sup>-grade highway, so we can establish our standard in the basis of foreign research method and adjusting the foreign spacing value.

Table 4-2 Recommended minimum access spacing of Nevada State

Operating speed (km/h)	Minimum spacing m	Operating speed (km/h)	Minimum spacing m
40	45	80	135
48	60	88	180
56	75	96	240
64	90	104	300
72	105	112	360

Source Access Management System and Standard of Nevada State

There are two methods of arranging the service road that serve the people along the highway. One is setting frontage road; the other is setting internal microcirculation road in the block. The frontage road can gather the trips generated by the people along the 1<sup>st</sup>-grade highway, and then the frontage road intersects with the 1<sup>st</sup>-grade highway. The length of frontage road should be enough. So it can reduce the number of access and increase the access spacing. The buildings orient to the internal microcirculation road, so the road can

gather the trips, and then the internal microcirculation road intersects with the minor road, at last the minor road intersects with the 1<sup>st</sup>-grade highway. Through this method, the traffic flow can transfer in order. Figure 4-1 and figure 4-2 show the two modes.

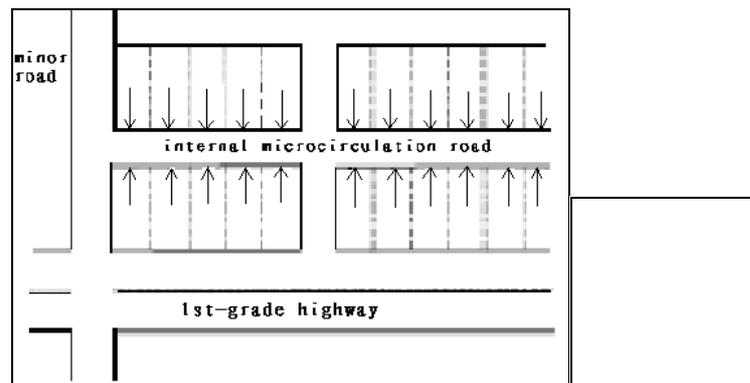


Figure4-1 setting internal microcirculation road<sup>[6]</sup> Figure4-2 setting frontage road<sup>[6]</sup>

## 4.2 Operation design

After the location of access chosen, the operation safety relates with access design. The design should give the rule of right of way, rational organization of traffic flow. The purpose of design is reducing the number of traffic conflict and traffic conflict zone. In the following, the paper illustrates the design method of access from the aspects of median opening, auxiliary lane, and traffic sign.

### (1) Median design

From the above analysis, we can see that the traffic conflict number will increase while the median has opening in the access. This condition will make the organization of traffic flow complex, added to this, the 1<sup>st</sup>-grade highway does not have exclusive left-turn lane. It easily causes rear end accident. So the paper recommends the design of median opening like the figure 4-3.

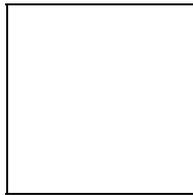
Figure4-3 shows the right turn followed by u turn. This turning type replaces the direct left turn, and it will reduce traffic conflict. The median is used to be exclusive left-turn lane, and it is helpful to avoid rear end accident. The distance between exclusive left-turn lane and access is determined by the safe weaving distance. The length of exclusive left-turn lane is determined by the turning volume and vehicle size.

### (2) Auxiliary lane in the access

1<sup>st</sup>-grade highway basically does not set acceleration or deceleration lane in the access. This condition leads that the speed differentia between the vehicle decelerating to the driveway or accelerating to the 1<sup>st</sup>-grade highway from the driveway and vehicle running through the 1<sup>st</sup>-grade highway is large. Large speed differentia easily causes traffic accident. So we need to consider the volume of 1<sup>st</sup>-grade highway and driveway so as to determine to set the auxiliary lane whether or not. When the volume is high, it is necessary to set the auxiliary lane. Figure4-3 shows the auxiliary lane in the access.

### (3) Traffic sign in the access

It is necessary to set STOP or YIELD sign and mark in the driveway. The sign and mark gives the traffic flow operating rules. The warning sign is necessary to be set in the front of access. The warning sign can give the driver notice of the access, and driver will keep alert. Figure 4-3 shows the traffic sign setting in the access.



Note: S1 is the YIELD sign; S2 and S6 are Be Careful sign; S3 and S5 are U-turn sign; S4 and S7 are DON'T TURN LEFT sign; S8 is T INTERSECTION sign.

Figure 4-3 Design of traffic flow organization in the access of 1<sup>st</sup>-grade highway

#### (4) Location of access

We had better don't layout the access in the slope, horizontal or vertical curve with small radius. The access should keep away from the intersection with enough distance.

## 5. Conclusion

The paper analyses the traffic character of 1<sup>st</sup>-grade highway and access in the 1<sup>st</sup>-grade highway. Then the paper points out the traffic safety problem of access and affecting factors of safety in the access. At last the paper tentatively discusses the application of access management from the aspect of policy management and operation design. I hope the paper will be useful to guide the improvement of access safety.

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