STUDY FOR SPEED MANAGEMENT OF G324 NATIONAL HIGHWAY

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ABSTRACT

Speed limit is an important factor to enhance the overall safety and efficiency of the national highway system. The purpose of the paper is to produce a speed management program for national highway G324 in Guangdong by investigation the status of speed, harmonizing the benefits of many related parts, resolving social conflicts, which can not only improve traffic efficiency and capacity of G324, but also promote service level to ensure people's safe and convenient travel. The paper discussed the distribution of spot speed, analyzed the influence factors of speed and safety, and then build model to bring forward the plan of post speed.

1. INTRODUCTION

National highways assume important transportation tasks. But with improving dynamic capability of vehicle and high quality of pavements, the driver's speed usually does not match the actual post speed in Gongdong province, which raises many social problems [3][5][7]. Although speed management of the Law of the People's Republic of China on road traffic safety provides overall principles of speed limit value, problems of speed limit often vary with road conditions and are more complex and hard to decide reasonable limited speed value [2][4].

The purpose of the paper is to introduce a speed management program for national highway. The paper takes the speed management plan of the highway G324 in Guangdong as a practice paradigm. To integrate with drivers' speed demand, the paper provides a new method to decide the post speed, which can help to answer the practical questions, like 'where to limit speed, what is the limit speed value, how to limit speed and what is the effect'. The authors discussed the distribution of spot speed, analyzed the influence factors of speed and safety (such as design parameters, roadside environment, vehicle composition), and then build model to bring forward the plan of post speed. It is proved the new post speed could harmonize the benefits of many related parts, resolve social conflicts, and promote highway service level to ensure people's safe and convenient travel.

2. FIELD STUDY AND DATA COLLECTION

Field data were collected at 36 segments in G324 in order to identify characteristics of spot speed, to understand the problem related to speed limit, and to know the capacity of speed supply[11][12].

There was unrestricted (no speed limit) in BL （K859+070～K909+979）section of G324. Slow sign was used to warn driving slowly and carefully, which was substituted for posted speed to guarantee traffic safety. 60 km/h was used as speed limit in HC section of G324, where most percent of the section was used as city street and was installed signal lamps. And 60 km/h was used as speed limit in HY section of G324, which was nearly 10 km rural highway. In HD section, speed limit range from 40km/h in downtown to70km/h in suburb.

The field data survey including different segments, such as rural tangent segments, roadway segments near border of villages and towns or schools, sharp curve segments, steep downgrade segments, continuous downgrade segments combining with sharp curves, narrow bridge segments, and crash prone segments . Data were collected with radar guns. It required more than 3 hours to collect 150 vehicles on each sample spot. The general criteria used to select study sites are summarized as follows:

Site : rural highway from BL to HD section
Grade : -4%~4%
Surface condition: fair to good
Width of cross section: 9m or 12m for two-lane highway, 24.5m for four-lane highway
Number of lane: two-way two-lane, two-way four-lane
Roadside: low, medium or high pedestrian activity, no-control access
Design speed: 40km/h, 60km/h, 80km/h
Speed limit: 40km/h, 60km/h,70km/h
Weather: sunny and dry

3. CHARACTERISTICS OF SPEED

Speed Representative sample: K802+950(Two-way two-lane segments near center of villages and towns in HD, Posted speed 40km/h, see Figure 1)

The average per hour traffic volume is 561 vehicles, whose proportion of traffic composition (car：bus：light truck：mid truck：heavy truck：motorcycle) is 155：56：32：69：59：192. The average speed is 52km/h, the max speed is 87km/h, the mid-speed is 51km/h, operating speed is 85km/h, and the 90th percent speed is 66 km/h. According to the field data, the proportion of speeding vehicles are near 90 percent, which indicates the posted speed is far lower than drivers' speed demands.

Figure 1 - K802+950 Section

Speed Representative sample: K816+200 and K821+480 (Two-way two-lane rural tangent segments without roadside disturbing, Posted speed 60km/h or 70km/h, see Figure 2 and Figure 3).

The average per hour traffic volume is 600 vehicles, the most proportion of vehicle is car and mid truck. The average speed of K816+200 is 58km/h, while the value of K821+480 is 61km/h. The max speed of the two sections is 104km/h. The operating speed is between 66 km/h and 73km/h, and the 90th percent speed reaches 75km/h. According to the analysis, the proportion of speeding vehicles are near 10 percent if the posted speed is 70km/h, which could meet most drivers' speed demands.

Figure 2 - K816+200 Section

Figure 3 - K821+480 Section

Speed Representative sample: K802+950 (Two-way two-lanewithout roadside disturbing, sharp curve combined with downgrade segments on the outskirt of HZ, Posted speed 50km/h, see Figure 4) The horizontal curve radius is 200 m and the dowgrade is 6%. To prevent head-on crashes, a clambing lane is added and double-yellow- line is used to avoid overtake in this segment.

The average per hour traffic volume is 540 vehicles. The average speed of K802+950 is 56km/h, the max speed is 78km/h, the mid-speed is 57km/h, operating speed is 86km/h, and the 90th percent speed is 67 km/h. According to the field data, the proportion of speeding vehicles are near 30 percent under the 50km/h posted speed condition, which indicates the 50km/h posted speed is too conservatively.

Figure 4 - K802+950 Section

Speed Representative sample: K810+900 (Two-way four-lane segments in HZ , Posted speed 40km/h, see Figure 5)

The average per hour traffic volume is 800 vehicles, whose proportion of traffic composition are most of bus, car and motorcycle. The average speed is 44km/h, the max speed is 70km/h, the mid-speed is 43km/h, operating speed is 53km/h, and the 90th percent speed is 56 km/h. According to the field data, the proportion of speeding vehicles are near 50 percent, but most speeding magnitude is not more than 10 km/h, which indicates drviers relatively accept low post speed limit in downtown areas.

Figure 5 - K810+900 Section

Speed Representative sample: K916+800 (Two-way four-lane tangent segment in HZ, Posted speed 80km/h, see Figure 6).

Mid concrete barrier and access managment are used to avoid opposite traffic confict and pedestrian disturbance, and yellow signal lampes installed at crossing are used to warn drivers to take care of other vehicles.

The average per hour traffic volume is 1200 vehicles, whose proportion of traffic composition are most of car, truck and motorcycle. The average speed is 65 km/h, the max speed is 113 km/h, the mid-speed is 64 km/h, operating speed is 78km/h, and the 90th percent speed is 82 km/h. According to the field data, the post speed is near operating speed, and most drivers think the post speed is meet their demands of speed.

Figure 6 - K916+800 Section

4. SPEED LIMIT

4.1 Speed limit model

The resonable speed limit is coincident with the following three conditions:
1) To minimize speed difference of traffic volume, and lowest crash probability.
2) To meet most drivers speed demands and keep high quality transportation efficiency.
3) To reduce speeding and increase the ratio of driver's complying with speed limit.

To get reasonable speed limit, the author not only consider the regular possible speed limit (the speed limit is decided by operating speed, traffic volume, highway geometric design, roadside development and roadside disturbing, road pavement, traffic control facalities, speed limit enforcement, and history accidents[6][10]), but also consider the drivers' speed demand. Speed limit relationship can be denoted the following model .

$$Speed\ \text{limit}=\alpha g(V_{\text{drivers' speed demand}})+(1-\alpha)f(V_{\text{possible speed limit}})-V_{Adjust\ crash\ \text{experience}} \quad (1)$$

$$V\text{possible speed limit}=V_{BFFS}\times f(traffic)\times f(geometric)\times f(roadside)\times f(pavement)\times f(\text{control device}) \quad (2)$$

Where:

α: the weight factor of possible speed limit and drivers' speed demand, α is decided by drivers' and specialists' advice. In this paper, $\alpha = 0.2$.

$g(V_{\text{drivers' speed demand}})$: the function of capacity of speed demand, which is strong associated with drivers' characteristics, such as driving age, experience, traits, trip time, etc.The value is usually recommended by the drivers' questionnaires.

$f(V\text{possible speed limit})$: the function of possible speed limit , which is related to road design and road conditions, roadside development, traffic volume and its components, vehicle type and characteristics, and weather, etc.

$V_{Adjust\ crash\ \text{experience}}$: the factor of speed adjustment based on crashes experience, which involves with crashes prone, crashes and crashes severity related to speeding, etc. The value is usually recommended by the police.

$f(traffic)$: adjust speed effect by traffic function, involved proportion of traffic composition, traffic volume.

$f(geometric)$: adjust speed effect by geometric design function, involved limit minimum radius, superelevation, max grade, running sight distance etc.

$f(roadside)$: adjust speed effect by roadside function, involved proportion of density of access, pedestrian crossing road.

$f(pavement)$: adjust speed effect by pavement maintenance condition function, involved road smoothness, friction factor.

$f(\text{control device})$: adjust speed effect by safety facility function, involved traffic control, safety sign and mark.

4.2 Drivers' speed demand

Drivers' speed demand differs from various segments on highway G324 based on driver's questionnaires. It is presented by Table 1 that drivers need 74.8km/h at tangent segments, which is highest of all segments. When driving on uncertain risky segments, drivers become more cautious and the magnitude of drivers' speed demand decrease. Table 1 shows the speed demand at segments near center of villages and towns or schools is 46.3km/h, and around 50km/h~62km/h at sharp curve segments or steep downgrade segments respectively. The data of speed demand contributes to the development of above model of speed limit.

Table 1 - Speed demand on G324

Type of rural highway road segments	Speed demand (weighted value) [a]
Tangent segments	74.8km/h
Roadway segments near center of villages and towns or schools	46.3km/h
Sharp curve segments	54.6km/h
Continuous downgrade segments combine with sharp curves	50.0km/h
Narrow segments because of bridge	50.3km/h
Steep downgrade segments	61.6km/h
Crash prone segments	58.9km/h
Car drivers	60~100km/h
Truck drivers	35~70km/h

Note: Speed demand (weighted value) = ∑percentage of sample × corresponding speed demand

4.3 Speed limit plan

The other parameters and functions in equation (1) and equation (2) are varied by concrete characters of highway and calibrated by authors. But because space limit of paper and the process and result are intricate, more details may not discuss here, and the following part of the paper will be focus on discussing the speed management plan in the paper. With the above model, speed management plan is as follows:

1) General road segment of G324 (far away from villages and towns segment): Car speed limit (below 19 seats) is 80km/h, other vehicle speed limit is 70km/h (see Figure 7).

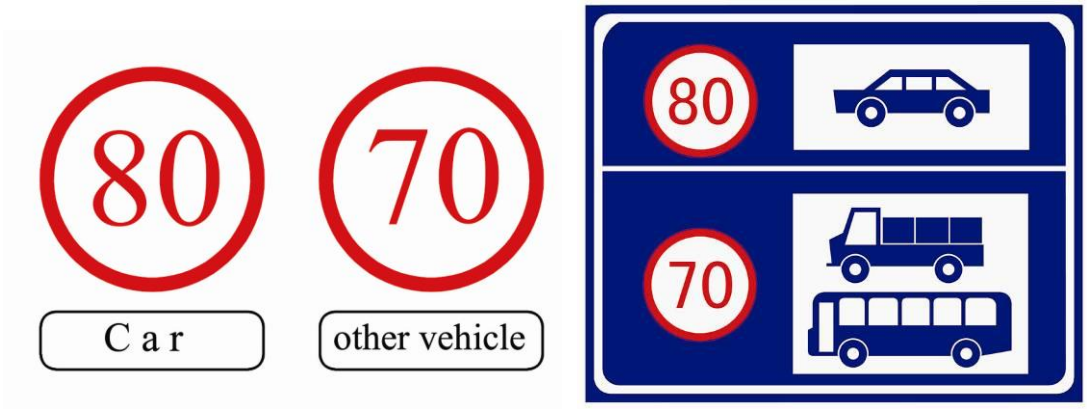

Figure 7 - speed limit signs of general road segment

2) Center of villages and towns segment of G324: All vehicle speed limit is 50km/h.

3) Serious urbanization segment of G324 with traffic signal large crossing: All vehicle speed limit is 60km/h,

4) Motorcycle and special vehicle should strictly abide by the traffic safety law of the People's Republic of China and the traffic safety regulation of the People's Republic of China.

5) Speed control safety facilities and signs should be set before tollgates of G324, it is mostly used to arouse drivers to pay attention to reduce speed [5].

6) Warning sign, speed control marking and delineation sign should be set in bad alignment design segments; speed limit value for every section may be selected on basis of the actual condition[1] [8].

7) Crosswalk marking, warning sign and speed control marking should be set in dense residential village and town segment.

8) Relevant department need investigate speed limit sign on the road and register, speed limit sign is replaced on basis of road traffic signs and markings (GB 5768-2009) and specification for layout of highway traffic signs and markings (JTG D82 – 2009).

See table 2 for Speed limit plan.

Table 2 - Speed limit plan

Road stake	Location	Speed limit value
K909+979-K870+500	ZC town-BL county	Car :80km/h, other vehicle:70km/h
K870+500-K861+000	BL county	60km/h
K861+000-K854+100	BL county-XJ town	Car :80km/h, other vehicle:70km/h
K854+100-K836+200	XJ town-HZ city	60km/h
K836+200-K827+860	HZ city-HY county	Car :80km/h, other vehicle:70km/h
K827+860-K810+150	HY county-HD county	Car :80km/h, other vehicle:70km/h
K810+150-K803+590	HD county	60km/h
K803+590-K764+233	HD county-XW town	Car :80km/h, other vehicle:70km/h

5. CONCLUSION AND FURTHER STUDY

The paper is to introduce a speed management program for national highway by using the speed management plan of the highway G324 in Guangdong as a practice paradigm. Authors successfully established setting speed limit method integrated with drivers' speed demand, the findings and conclusions of this study are summarized as follows.

1. Speed limit is not reasonable according to field survey and the responses from drivers' questionnaires. It is urgent to adjust the speed limit in terms of safety and traffic efficiency and enforcement.
2. The characteristics of speed demand and speed restrict conditions should be considered during setting speed limit model. The balance between speed demand and possible speed limit will contribute to keep or increase the drivers' satisfaction.
3. The paper brings forward a model of setting speed limit and applys to recommend the speed limit of some segments in G324, however, to decide the parameters and functions in the model has a long way to go.Strictly speaking, these conclusions only pertain to the specific datasets that were analyzed and the particular geographic areas from which their data were collected.

Further research related to speed choice model and safety and non-safety impacts of speed limit changes are encouraged in the future.

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