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The Study of Establishing Realistic Road Speed Limits

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Abstract: This study is raised up to be an effective tool to adjust speed limit. These are not scientific rational limits design methods for limits speed management in china, it studies the method for Making Sure Road Limits Value. Summarizes Europe and America and so on the developed country using limit speeds methods such as Statutory limits, Optimum speed limits, Engineering study method with speed limits set near the 85th percentile speed, Expert system-based approach, and analyzes the good and bad points. Unifying our country road condition, further analyzes our country road regulating the factors affected, in this foundation, Using system method proposed, based on the running speed, geometry and safety multi-factors, develops the suited transportation characteristic road limit value design method and gives the concrete implementation flow, which considers the running speed road geometry, design speed, traffic safety and so on factors.

Key words: Free flow speed, operating speed, speed limit, stopping sight distance

INTRODUCTION

Traffic Management is a wide area of controlling or organizing to make traffic more efficiency, which can be classified into many fields of studies. In this study, the speed limit study has been chosen. Speed limit is one of the major factors that affects the drivers and other road users (pedestrians, bikers) in terms of traffic safety, transport efficiency and comfortableness. The speed limit should be presented reasonably according to the road characteristics, road conditions and road safety. The lower or higher speed limit does not only make non-benefit to the driver, but also cause higher number of accidents.

Primary methods of setting speed limits (Transportation Research Board, 1998) statutory limits: Statutory national speed limits were imposed twice in U.S. history,both during times of national crisis. A federal speed limit of 35 mph (56 km/h) was imposed during World War II. More recently, Congress established the NMSL of 55 mph (89 km/h) during the energy crisis of 1973 to reduce reliance on imported oil. In both cases, the objective was to reduce energy costs rather than transportation costs. Safety benefits and travel time costs were a by-product rather than an intrinsic part of the initial determination of an appropriate speed limit.

Optimum speed limits: The method recognized that individual drivers do not always select driving speeds that take into account the risks imposed on others by their choice. For example, driving at high speeds can increase the likelihood of a severe crash, which may involve other road users; it also results in added fuel consumption and higher emission levels, costs that are not entirely borne by the individual driver or even other highway users. Because of these external costs, the optimum speed for an individual driver is different from the socially optimum speed. The problem is typical of most benefit-cost analyses, is the difficulty of quantifying key variables. Considerable work has been done on valuation of travel time as well as on the costs of injury and mortality, but there is no clear consensus on these estimates.

Engineering study method: The most common method for determining speed limits in a speed zone sets the limit on the basis of an engineering study. The study requires data collection and analysis in the determination of an appropriate limit. The data include measurement of prevailing traffic speeds, crash data, and information on highway, traffic, and roadside conditions not readily apparent to drivers.

Expert system-based approach: Several states in Australia have developed an expert system ased approach to setting speed limits in speed zones. Victoria was the first state to embark on this approach in 1987 as the result of its comprehensive review of all aspects of speed management. The goal was to develop a more uniform and consistent approach to setting speed limits within speed zones .The decisions and judgments required to establish speed limits were thought to be particularly amenable to an expert system approach. Expert systems are computer programs that mimic an expert thought processes to solve complex problems in a given field.

FACTORS TO BE CONSIDERED IN ESTABLISHING SPEED LIMITS

Road function (NCHRP, 2001): A first assessment of the speed limit appropriate for a particular road should be obtained by consulting the hierarchy of speed limits which are based on road function. These are the limits which are considered in the first instance to be likely to match driver expectation of the appropriate limit far the application described.

Existing traffic speeds: The existing 85th percentile speed should be taken into account when establishing the speed limit for a speed zone. This measure is taken as representative of drivers eneral perception of a reasonable travel speed on a particular section of road (Xu, 2002).

Speed environment: The speed environment, described as the elements of the road and traffic environment which collectively influence a driver's perception of an appropriate maximum travel speed, should also be taken into account. These elements include the following (West and Dunn, 1971) and (Fildes and Lee, 1993):

- Road type, i.e. urban , rural, residential, commercial, industrial; specialuses.
- B: density of development.
- Road characteristics, including-Standard of design and construction, i.e., alignment, cross section, lane widths and sight distance; type and frequency of intersections, including sight distance and provision For turning traffic; type and frequency of accesses from shutting development; speed environment on adjoining seasons of the road; and parking provisions and activity.
- Traffic characteristics, including- traffic volume and pattern; and traffic composition including presence of non-motor traffic.

Road crash history: The history of road crashes should only be taken into account when there is a need to resolve inconsistencies in the speed limit determinations separately obtained from the factors considered. A poor crush history will often indicate the need for counter-measures other than changes to the speed limit (Fred and Goldenbeld, 2002).

CALCULATION PROCEDURES OF SPEED LIMIT

According to the experiment, the drivers always drive 10-20 km/h higher than posted speed limit on roads. Drivers behavior could be recognized that posted speed limits are lower than their satisfaction. Consequently, the speed limit in summer and winter should be adjusted to make it more reliable. Usually, the speed limit is estimated as the 85th percentile speed, which is recognized by the traffic engineers as the optimum level at which to set speed limits. However, the experiments have been conducted with high cost of equipments (Global Road Safety Partnership, 2008).

Calculation procedures: As mentioned above, most of studies use the 85th-percentile speed as the speed limit, which have to conduct the experiments, e.g. spot speed measurement. In this method, the spot speed data are obtained and plotted as a cumulative distribution curve to obtain the 85th-percentile speed. In this study, the types of road are classified into three types, which are highways (two-lane and multilane), urban highways and expressways. In terms of speed limits on the roads, they are classified into two types, i.e. long straight road and circular curve. Then, the road conditions are considered, i.e., dry (summer) and snow/icy (winter) road conditions.

Calculate the speed limit according to the changes in road characteristics. Free-Flow Speed (FFS) definition is the speed of traffic at low volume and low density. It is the speed at which drivers feel comfortable traveling under the physical, environmental and traffic-control conditions on an uncongested section of multilane highway. Here, the speed limit will be calculated automatically after input the road characteristics. The required road characteristics are as follows:

- Design speed or Base Free Flow Speed (BFFS)
- Number of lanes; Lane width; Lateral clearance
- Median
- Access-point density; Interchange density (Freeway)
- Coefficient of friction between tire and road surface
- Road location

For the speed limit on a circular curve, the additional data are radius of curvature and superelevation. Therefore, this section is separated into three parts up to the calculation processes, which are Free Flow Speed (FFS), Stopping Sight Distance (SSD), and speed limit on circular curve.

Free Flow Speed (FFS): The Free Flow Speed equations of each type of roads are defined below:

$$V_{85} = \begin{cases} 17.82\ln(r) - 2.17 (100 \le r \le 1500) \\ 128\ \left(r > 1500, or\ long\ straight\ road\right) \end{cases} \quad (1)$$

where, r: circular curve radius, (m).

Stopping Sight Distance (SSD): Calculating the speed limit in winter (snow condition), the road condition is worse due to narrower of lane width and lower friction between tire and road surface. Thus the Free Flow Speed equation and Stopping Sight Distance (SSD) equation are introduced to calculate the speed limit in winter. Here, the

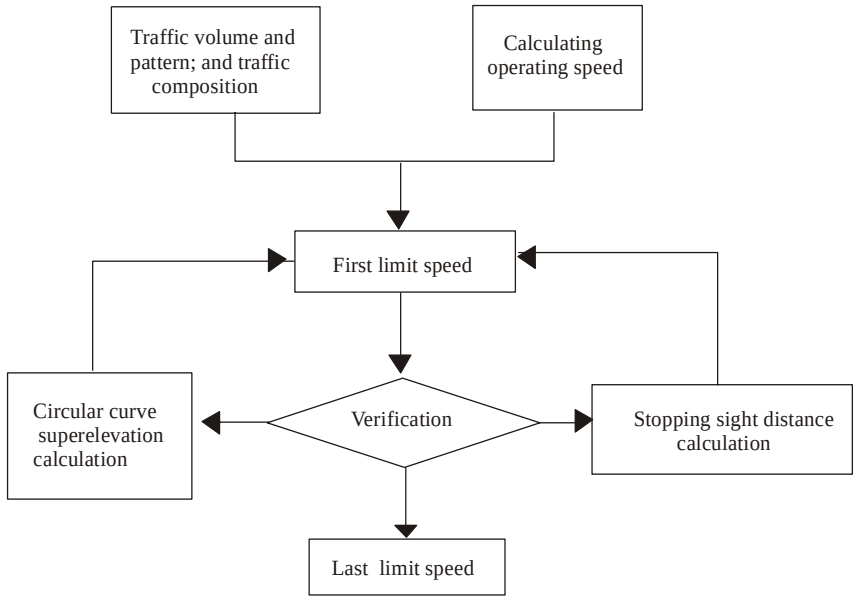

Fig. 1: Calculation procedures of speed limit

snow factors, affecting from the snow and icy, are introduced. The first step for the calculation speed limit in winter is the speed due to the accumulated snow by using FFS equation. After that the speed due to the lower friction is calculated by using SSD equation. The first term indicate the distance from perception-reaction and the second term represents braking distance.The mathematical equations for sight distances in crest vertical curves:

$$L = \left[\cos^{-1}\left(\frac{R}{R+H_1}\right) + \cos^{-1}\left(\frac{R}{R+H_2}\right) R \right] \quad (2)$$

where, L is Sight distances(m). R is crest vertical curve radius. H_1 is height of object(m). H_2 is height of driver eyes(m).The mathematical equations for sight distances in horizontal curve:

$$L = 2R\sin^{-1}\frac{R-b}{R} \quad (3)$$

where, L is Sight distances(m). R is horizontal curve radius(m). B is distances between road and object(m).

Speed limit on circular curve: For the circular curve, the speed limit is derived from the equation of minimum radius of a circular curve as in Eq. (4). Then the effects from road capacity and road friction (winter case) are introduced. This calculation is included before calculation process of the speed limit of the long straight road.

$$V = \sqrt{127(\mu + i_h).R} \quad (4)$$

where, V is speed (km/h). U is coefficient of side friction it is 0.20 for safety,it is 0.11 for comfort. i_h is rate of superelevation.

FFS equation will be employed to calculate the speed limit at the circular curve in summer. However, FFS equation alone is not enough to derived speed limit in winter, SSD equation, considering lower friction coefficient between tire and road surface, is added up.Calculation procedures of speed limit can be concluded as shown in Fig. 1. Three equations and road characteristics are involved. As the speed limit from this study depends on the road characteristics (lane width, shoulder width, coefficient of friction, etc.), the posted speed limit can be increased if the road is modified, e.g. expansion of lane width, application of heattransferred system on roads, etc.

Case study: The NanYou expressways in GuangXI province in china are introduced by case study. The results of speed limit from the speed limit model are shown.The adjusted speed limits in summer are higher than present posted speed limit for expressways (10 km/h). The results of the speed limit on expressways in summer seem to satisfy the responses from questionnaires or the drivers atisfaction. The speed limit is lower than the satisfaction. Therefore, it can be explained that only road characteristics are related to the calculation processes, excluding the environment (or surrounding) and traffic flow.

CONCLUSION

Speed limits are not reasonable according to the responses from questionnaires and the comparison among other countries speed limit. Then, this study is raised up to be an effective tool to adjust speed limit. Here, the speed limit in summer and winter are adjusted reasonable corresponding to the road characteristics (lane width, lateral clearance, number of lanes, coefficient of friction between tire and road surface, and etc.). The Free Flow Speed (FFS) equation is introduced to the process of calculation of the speed limit in summer and winter. Also, the Stopping Sight Distance (SSD) equation is applied to the calculation of the speed limit in winter, which is the speed that affects from the change in friction between tire and road surface. In comparison with the suggested speed limit from questionnaires, speed limits obtained from this study satisfy with the drivers satisfaction, except the speed limit on urban highways in summer and expressways in winter, which are lower than the satisfied level.

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