A Simple Approach for Determining No-Passing Zones in Two-Lane Rural Highways

Bongsoo Son, Ph. D[1).

Abstract

Provision of Passing Sight Distance (PSD) is an important component in two-lane highway design and has a critical impact on capacity of highway and safety of drivers. Many models have been developed to estimate PSD reasonably. However, each of them has a number of shortcomings for reflecting the real traffic conditions. This paper introduces a revised model that reflects the characteristics of the passing maneuver. The changes in passing sight distances under different assumptions about acceleration and vehicle length, which are related to vehicle types, are presented. The results obtained by the revised model are compared with those obtained from the existing models.

There is an important link between geometric design decisions which determine the available sight distance and the quality of service which the road provides. In this paper, we examine one aspect of this relationship. That is to determine whether the passing sight distance is provided by improving horizontal alignment for a specific roadway section or passing may be restricted to save the road construction cost. To do so, a simple method for estimating traffic delay in no-passing is introduced.

I. Introduction

The concept of "Stopping Sight Distance (SSD)"is the link between road geometry and concern about safety. One always has to provide a sight distance that is not shorter than the SSD, hopefully much longer. The concept of "Passing Sight Distance (PSD)" also has concern about safety at its root. However, one does not have to design so as to make the shortest available sight distance longer than the passing sight distance. When to do so is not practical, passing may be restricted by appropriate markings for no-passing zone. Restriction of passing causes delay and in this manner detracts from the quality of service of the road. Thus, there is an important link between geometric design decisions which determine the available sight distance and the quality of service which the road provides. In this paper, we examine one aspect of this relationship.

Provision of Passing Sight Distance(PSD) is an important component in two-lane highway design and has a critical impact on capacity of highway and safety of drivers. In Korea Highway Capacity Manual (KHCM) published in 1992, no-passing zone is defined as any marked no-passing zone or any section of road wherein Passing Sight Distance is 450m or less. However, KHCM has no rationale for that value.

Many models have been developed to estimate PSD. However, each of them has a number of shortcomings for describing driver' s passing maneuvers properly. A necessary condition for the model to be a valid surrogate of its real counterpart is that its behavior should correspond to that of the actual system at some reasonable degree of acceptability. In order to develop a reliable model to meet this condition, it is, in fact, essential that all the assumptions employed in the model should be sound and reasonable for reflecting the real phenomena. In this respect, three important models will be mainly reviewed in this paper. Other detailed reviews of the existing models can be found in Forbes (1990).

---

1) Department of Urban Transportation, Seoul Development Institute, Seoul, Korea

This paper introduces a model which is able to reflects the characteristics of passing maneuver. The changes in passing sight distances under different assumptions about acceleration and vehicle length, which are related to vehicle types, are also presented in this paper. The results obtained by the revised model are compared with those obtained from the existing models. In order to determine whether the passing sight distance is provided by improving horizontal alignment for a specific roadway section or passing may be restricted to save the road construction cost, it is helpful to estimate the total delay cost incurred by restriction of passing. For this purpose, a simple method for estimating traffic delay in no-passing is developed in this paper.

II. A Brief Review of AASHTO Model for Estimating Passing Sight Distance

The first model for estimating the passing sight distance was developed by AASHTO (1984) based on traffic data observed in 1940's. The model has been used as the warrants for highway design in US in order to ensure an adequate level of service on the completed highway. Key assumptions employed in the model are as follows:

(1) When the passing section is reached, the driver requires a short period of time to perceive the clear passing section and to react to start his/her maneuver.
(2) The average speed of the passing vehicle is always 15-16 km/h higher than that of the impeding vehicle, and the vehicle on the opposing lane travels at the same speed as the passing vehicle.
(3) Passing is accomplished under what may be termed a delayed start and a hurried return in the face of opposing traffic.
(4) The gap between passing and impeding vehicles before passing is the same as after passing, and when the passing vehicle returns to its lane, there is a suitable clearance interval between the vehicle and an oncoming vehicle in the other lane.
(5) All the passing vehicles at each design speed accelerate with the same rate during the passing maneuver.
(6) The PSD is defined as the sum of the following four distances (see Figure 1) :

d_1 = distance traversed during perception and reaction time and during the initial acceleration to the point of encroachment on the left lane.
d_2 = distance traveled while the passing vehicle occupies the left lane.
d_3 = distance between the passing vehicle at the end of its maneuver and the opposing vehicle.
d_4 = distance traversed by an opposing vehicle for two-thirds of time the passing vehicle occupies the left lane, or 2/3 of d_2 above.

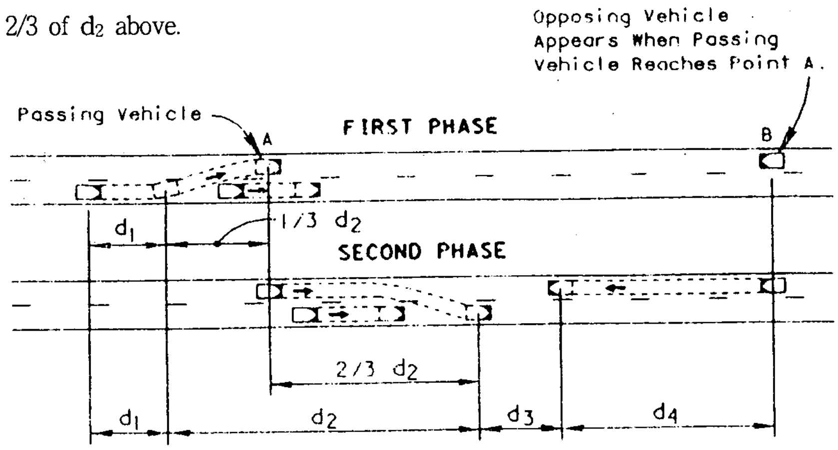

Figure 1: Elements of passing sight distance for two-lane highways.

The second and fifth assumptions seem to be inadequate to reflect the real traffic conditions for the following reasons. The first reason is that the difference between the speed of passing vehicle and that of impeding vehicle is dependent on impeding vehicle's speed and the acceleration rate of the passing vehicle which varies by vehicle types. The second reason is that the model considers only passenger cars passing other passenger cars, so the model is not appropriate to consider the effect on passing sight distance and passing zone length requirements if the impeding vehicle, the passing vehicle, or both are large trucks.

Under the sixth assumption, the PSD estimated by the model includes the distance that the passing vehicle traversed during perception and reaction time and during the initial acceleration to the point of encroachment on the left lane. The time period counted for this distance is between 3.7 and 4.3 seconds. However, it is unreasonable to include the distance that the passing vehicle traversed during perception and reaction time, since the driver does not actually take any action for passing the impeding vehicle.

In this paper, a model which makes up for the AASHTO technique is developed. The revised model is able to consider the effect on passing sight distances under different circumstances about acceleration and vehicle length, which are related to vehicle types.

III. A Revised Model for Estimating Passing Sight Distance

The revised model employs the following assumptions:

(1) Opposing and Impeding vehicles travel at a constant speed, where the opposing vehicle's speed is near the design speed and the impeding vehicle's speed is much lower than the opposing vehicle's speed, where the speed of opposing vehicle is the same as design speed and the impeding vehicle's speed is lower than the design speed.

(2) The driver of the passing vehicle decides whether to proceed passing maneuver or to abort it when the driver reaches just behind the impeding vehicle in the left lane (Saito, 1983).

(3) The passing vehicle travels at the impeding vehicle's speed before the passing maneuver and then accelerates to pass the impeding vehicle.

(4) The passing vehicle keeps on accelerating until the passing completion.

(5) The driver's reaction time is considered for estimating the clearance interval between passing vehicle and opposing vehicle and the gap between passing vehicle and impeding vehicle.

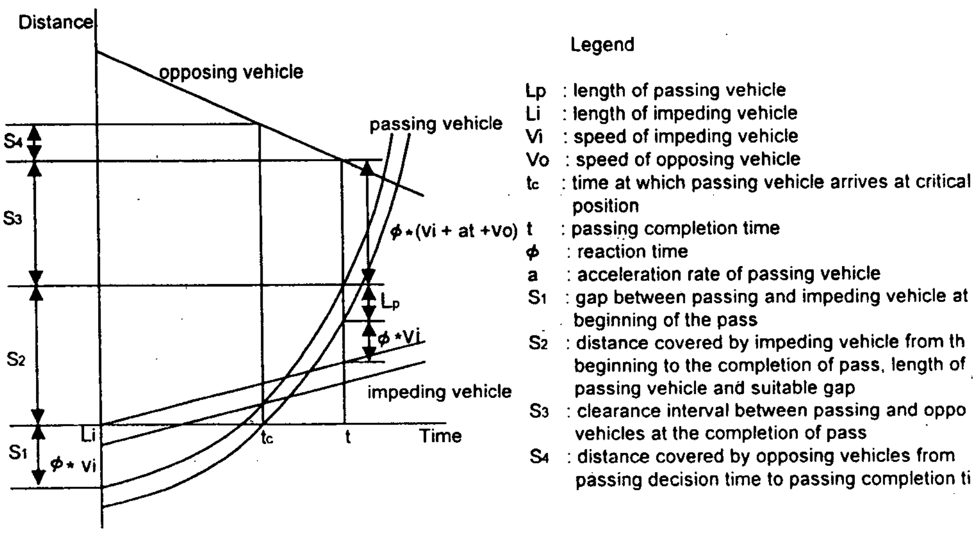

Figure 2 : Vehicle trajectories on the time-space plane.

Figure 2 presents the trajectories of passing, impeding and opposing vehicles on the time-space plane. In the figure, the trajectory of passing vehicle is not straight, since it is assumed that the passing vehicle keeps on accelerating until the passing completion. This trajectory can be represented by $0.5\alpha t^2 + V_i t - (Li + \phi \times Vi)$. The trajectory of the impeding vehicle is described by Vi t. At the beginning of the passing maneuver, the gap between passing vehicle and impeding vehicle, S_1, is equal to $Li + \phi \times Vi$. When the passing vehicle completes the passing maneuver, the gap between passing vehicle and impeding vehicle is equal to $Lp + \phi \times Vi$.

In the model, it is assumed that the driver of the passing vehicle decides whether to proceed the passing or to abort it when the driver reaches just behind the impeding vehicle in the left lane at time t_c (Saito, 1983). This time can be determined from the two vehicles' trajectory as follows:

$$0.5a(t_c)^2 + V_i t_c - (L_i + \phi \times V_i) = V_i t_c - L_i ,$$

therefore

$$t_c = \sqrt{\frac{2\phi \times V_i}{a}}$$

The time when the passing is completed can be calculated as follows:

$$V_i t + \phi \cdot V_i + L_p = 0.5a t^2 + V_i t - (L_i + \phi \times V_i)$$

therefore

$$t = \sqrt{\frac{2(2\phi \times V_i + L_p + L_i)}{a}}$$

In Figure 1,

$$S_1 = L_i + \phi \cdot V_i ,$$

$$S_2 = 2\phi \cdot V_i + L_p + L_i + V_i \sqrt{\frac{2(2\phi \times V_i + L_p + L_i)}{a}} - (L_i + \phi \cdot V_i) ,$$

$$S_3 = \phi \cdot (V_i + a t + V_0) , \text{ and } \quad S_4 = V_0 \times (t - t_c)$$

The PSD is the sum of the four distances: PSD = $S_1 + S_2 + S_3 + S_4$.

Table 1 summarizes the passing sight distances which were obtained from three models, AASHTO (1984), MUTCD (1978) and Glennon model (1990). The values obtained from AASHTO are much greater than those obtained from the other models. It seems that AASHTO significantly overestimates the passing sight distance. However, it is not entirely clear whether this conclusion is valid or not, since the models use different input parameters and/or different input values for drivers perception-reaction time, acceleration capacity, and vehicle type. It is noteworthy that Rilett et al (1990) reported that Glennon's results systematically lower than the Canadian standards (Council on Uniform Traffic Control Devices for Canada, 1985), and Weber(1978) has suggested that there is still a need for further increases for the passing sight distance in Canadian.

Table 1: A comparison of the PSD obtained from three models (unit: meter).

Design speed (km/h)	AASHTO	MUTCD	Glennon (1990)
32	244	122	99
48	335	152	160
64	457	183	213
80	549	244	267
97	640	305	312
113	762	366	366

The revised model requires the driver's reaction time of passing vehicle for estimating the PSD. The reaction time was estimated from the results of AASHTO in Table 2. As mentioned earlier, AASHTO defines the PSD as the sum of the four distances, d_1, d_2, d_3 and d_4, where d_3 depends on the driver's reaction time and vehicles' speed. AASHTO assumes that the average speed of passing vehicle is always 16km/h higher than that of impeding vehicle, and the average speed of opposing vehicle is the same as the average speed of passing vehicle. Thus, the driver's reaction time can be estimated by using the information about d_3 and speed given in the table: Reaction time = $d_3 \div$[(speed of impeding vehicle + 16km/h) $\times$ 2 $\times$ 1000/3600].

The estimated reaction time is presented in the last column in table 2. Most of the reaction times are between 1.4 and 1.6 seconds. In this paper, the revised model estimates the passing sight distances by using the average value of 1.5 seconds for all design speeds. The revised model's results are summarized in Table 3.

Table 2: Elements of safe passing distance for two-lane highways (AASHTO, p. 131, 1984)

Assumed speed of impeding vehicle (km/h)	Acceleration rate (m/sec2)	Passing time (sec)	d_1 (m)	d_2 (m)	d_3 (m)	d_4 (m)	Driver's reaction time(sec)
40	0.63	12.9	45	145	30	95	1.0
54	0.64	14.0	65	195	55	130	1.4
69	0.65	15.0	90	250	75	165	1.6
84	0.66	15.8	110	315	90	210	1.6

Table 3: The results of the revised model (1).

Assumed speed of impeding vehicle (km/h)	Acceleration rate (m/sec^2)	Passing time (sec)	Assumed average speed of passing vehicle (km/h)	S_1 (m)	S_2 (m)	S_3 (m)	S_4 (m)
40	0.63	12.3	54	23	157	52	74
54	0.64	13.8	70	29	229	65	97
69	0.65	15.1	86	35	312	78	122
84	0.66	16.5	103	41	407	92	151

It can be seen from Table 2 and Table 3 that as the speed of impeding vehicle increases, passing time and the speed of passing vehicle increase in both models. It is interesting to note that the difference between the passing vehicle's speed and the impeding vehicle's speed is not greater than the assumed value of AASHTO, that is always 16km/h. This implies that the effect of the assumption on the passing sight distance is not severe. Table 4 compares the results of the revised model and AASHTO. The passing sight distances of AASHTO are slightly greater than those of the revised model. This would be due to the fact that, as pointed out earlier, AASHTO includes the distance that the passing vehicle traversed during perception and reaction time and during the initial acceleration to the point of encroachment on the left lane.

Table 4: Comparison of the PSDs obtained from the revised model and AASHTO.

Design speed (km/h)	Assumed speed* of impeding vehicle (km/h)	Revised Model (m)	AASHTO (m)
30	29	197	217
40	36	254	285
50	44	321	345
60	51	382	407
70	59	453	482
80	65	512	541
90	73	588	605
100	79	650	670

* : The values are given by AASHTO.

The revised model is able to estimate the passing sight distance for the cases where the impeding vehicle, the passing vehicle, or both are large trucks, while AASHTO use the passenger car as the design vehicle for the passing sight distance. In order to estimate the passing sight distances for the cases, the model use the passenger car's length (6m), the truck's length (23m), and the acceleration rate of the passenger car which are given by AASHTO. The acceleration rate of truck is assumed as 0.3m/sec^2 in this paper. The results obtained from the revised model are summarized in Table 5.

Table 5: The results of the revised model (2).

Design speed (km/h)	Assumed speed of impeding vehicle (km/h)	Passenger car passing Passenger car (m)	Passenger car passing Truck (m)	Truck Passing Passenger car (m)	Truck passing Truck (m)
30	29	197	254	320	384
40	36	254	319	407	482
50	44	321	393	507	591
60	51	382	459	602	696
70	59	453	536	711	813
80	65	512	600	803	914
90	73	588	681	920	1038
100	79	650	747	1019	1144

It can be seen from Table 5 that the passing sight distance for the case that both the passing and impeding vehicles are passenger cars is smaller than the case that truck is involved. Furthermore, the PSD for the case that the passing vehicle is truck is much greater than AASHTO. This may mainly due to the fact that the assumed truck length, 23m, is too long and its assumed acceleration rate, 0.3m/sec^2 is somewhat low.

Glennon model (1990) is also able to estimate the passing sight distances for the cases where the impeding vehicle, the passing vehicle, or both are large trucks. It would be, therefore, interesting for the readers to compare the revised model's results and Glennon's results. For this, the revised model estimates the passing sight distances by using the same values of input parameters as Glennon used in his model with the exception of the acceleration rate of passing vehicle. More specifically, the driver's reaction time and acceleration rate for truck are assumed as 1 sec. and 0.3m/sec^2, respectively, and the vehicle lengths and the acceleration rate for passenger car are the same as AASHTO criteria.

Table 6 compares the results of Glennon model with those of the revised model. The values in ( ) are associated with the revised model. The design speeds in this table are converted as km/h unit from mph unit in Glennon's paper. It is noteworthy that when both passing and impeding vehicles are passenger cars, Glennon's resluts are almost the same as MUTCD standards (Refer to Table 1) which is used as marking criteria for no-passing zone in US. However, when truck is involved in the passing maneuver, Glennon's passing sight distances are much greater than MUTCD standards. This is due to the fact that MUTCD does not consider the impact of truck.

It can be seen from the table that all the passing sight distances obtained by the revised model are much greater than those obtained by Glennon model. As the design speed increases, the difference between the two models becomes greater. Furthermore, when trucks are involved in the passing maneuver, the difference is much severe. There are two possible reasons for this.

First, Glennon has not use the speed of the impeding vehicle but speed differential of two vehicles to convert time headway, that is 1 sec., into a distance headway. A correct approach would be to multiply the time headway by the speed of the impeding vehicle and, therefore, Glennon model underestimates the passing sight distance (Rilett et al, 1990). Second, as shown in Figure 1, the passing sight distance estimated by the revised model includes the distance S_1 traversed during the initial acceleration period, while Glennon model does not consider this distance, though not the same. Besides, it is generally known that Glennon model underestimates the passing sight distance, as mentioned earlier.

As the design speed increases, the difference between the revised model's results and Glennon model's results becomes greater. (It should be noted that the difference between the two models' results are dependent upon the input values assumed, so the difference may be changed.) The emphasis of this discussion is on that the current standard for the no-passing zone markings is not appropriate for reflecting the effect of heavy vehicles on passing maneuver. In conclusion, although the test results presented in this paper are quite limited, it can be said that current passing and no-passing zone marking criteria for two-lane highways should be re-examined.

Table 6: The results of Glennon model.

Design speed (km/h)	Passenger car Passing Passenger car (m)	Passenger car passing Truck (m)	Truck Passing Passenger car (m)	Truck Passing Truck (m)
32 (30)*	99 (165)	107 (225)	107 (290)	107 (357)
48 (50)	160 9266)	175 (345)	183 (452)	206 (543)
64 (60)	213 (315)	244 (401)	267 (534)	297 (636)
80 (80)	267 (420)	312 (518)	343 (707)	389 (827)
97 (100)	312 (531)	381 (641)	419 (889)	480 (1027)

*: The values in ( ) are of the revised model.

IV. Passing Restriction and Delay

Consider two vehicles : a slow vehicle (vehicle 1) travelling speed v_1 and a fast vehicle (vehicle 2) travelling speed v_2. When passing is restricted, fast vehicles tend to bunch up behind slow vehicles as is shown schematically in Figure 3.

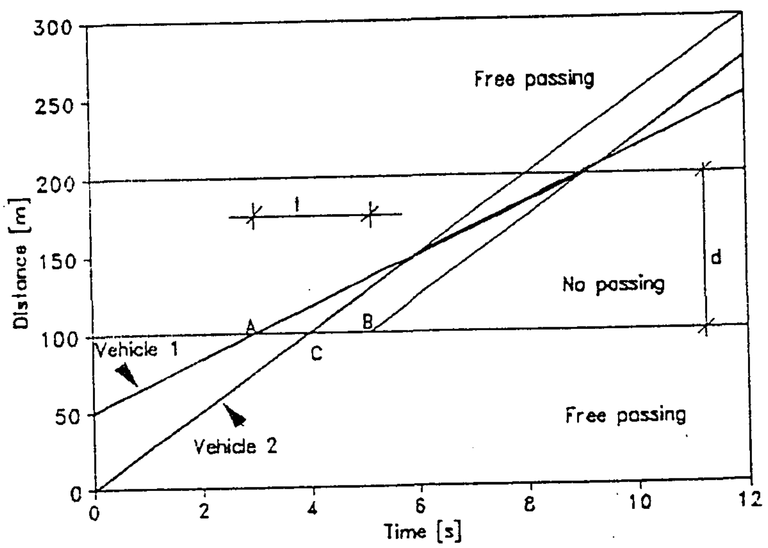

Figure 3 : Passing and delay

At point A, the slow vehicle enters the no-passing zone where passing of the fast vehicle is prohibited due to the absence of PSD to make his/her passing the slower vehicle safely. The fast vehicle enter the no-passing zone at point C. Were it free to pass, its trajectory on the (x, t) plane would be a straight line. However, as passing is not allowed in the no-passing zone, vehicle 2 catches up with vehicle 1, slow down, trails it till the end of the no-passing zone, and then passes. When at the end of the passing zone, vehicle 2 is where it would be had it entered the no-passing zone at point B. Thus, vehicle 2 has been delayed by the time which corresponds to the horizontal distance between points C and B. This delay is attributable to the presence of the no-passing zone. An important thing to know here is that only those "fast" vehicles which enter the no-passing zone between the instants corresponding to points A and C will be delayed. Let t denote this time and d be the length of the no-passing zone. The relation between t and d can be expressed as

$$t = d(1/v_1 - 1/v_2).$$

The first question of interest is : what proportion of the first vehicles will be delayed by slow vehicles. To answer, we begin by a description of the arrangement of the "slow" and "fast" vehicles on the road. Let q_1 and q_2 denote the flows (i. e., vehicles per unit of time) of "slow" and "fast" vehicles. For example, if the road carries 500 vehicles per hour in one direction, 10% of which are trucks, and if trucks are construed as "slow", $q_1 = 50$ vph (vehicles per hour) and $q_2 = 450$ vph.

Imagine that you are standing at the point where the no-passing zone begins with a stop watch in your hand. You note the time of passage of each truck and each car. These can be shown on a time axis as Figure 4 where the passage of a truck is shown as a full square and the passage of a car by asterisk.

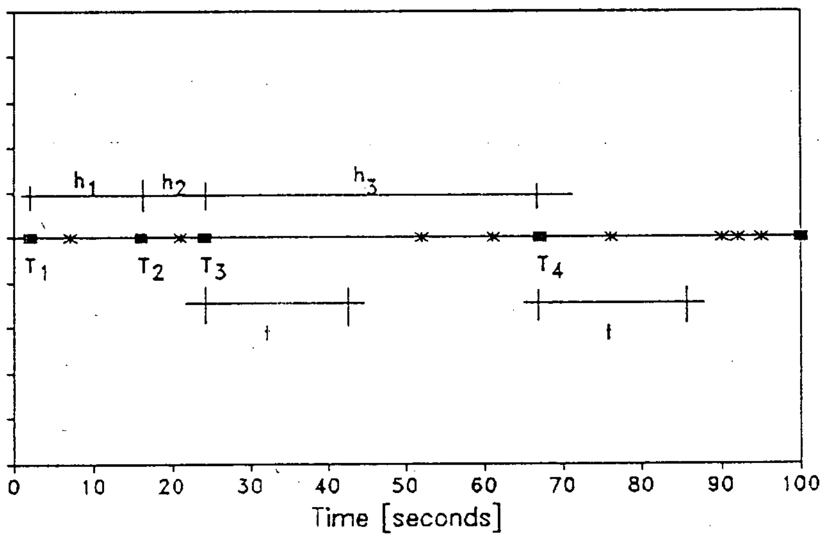

Figure 4 : Vehicles' headway diagram

The time between the passage of two consecutive trucks is a "truck headway". It is a "random variable" and we will denote by H. Specific values of H will be denoted by h.

Since q_1 trucks pass you at your observation post per unit of time, this will also be the number of headways in a unit of time. Therefore, the mean headway is

$$E[H] = 1/q_1$$

To the extent that trucks are randomly interspersed amongst the cars, the probability distribution of truck headways can be often be adequately described by the (negative) exponential probability distribution. If so, the probability density function of H is given by:

$$f_H(h) = q_1 \cdot e^{(-q_1 \cdot h)} \qquad \text{for } h \geq 0$$

If a truck headway is shorter than t, then all cars passing your post between the two trucks that form the headway will be delayed. If a truck headway is longer than t, only those cars passing your post within t of the lead truck will be delayed. Thus, in Figure 4, the cars following trucks 1 and 2 will be delayed, the two cars following truck 3 will not be delayed but the first car following truck 4 will be delayed.

The next step is to calculate what is the proportion of time during which, if cars passed your observation post, they would not be delayed. Naturally, the remainder will be the proportion of time which cars would be delayed. Consider a very large number of headways - N. Among these there will be, on the average, $N \cdot f_H(h)\ dh$ headway which are $[h,\ h+dh]$ long. Therefore, in N headways the amount of time taken by headways $[h,\ h+dh]$ long is $N \cdot f_H(h)\ dh$. When the headway is longer than t, then $h-t$ is the time during which cars will not be delayed. It follows, that of the total time of which the N headways are comprised, during

$$N\int_{h=t}^{\infty}(h-t)\cdot f_H(h)\,dh = N\left[\int h\cdot q_1\cdot e^{(-q_1\cdot h)}dh - \int t\cdot q_1\cdot e^{(-q_1\cdot h)}dh\right] \quad \text{(A)}$$

cars are not delayed. For the first integral in the right hand side of the equation (A), in its indefinite form, we have

$$q_1\int h\cdot e^{(-q_1\cdot h)}dh \;=[e^{-q_1 h}/q_1][-q_1\cdot h-1] = -h\cdot e^{-q_1 h}-[e^{-q_1 h}/q_1].$$

To evaluate it for the upper limit, L'Hospital's rule needs to be applied. Once this is done, the value of the first definite integral is :

$$(t+1/q_1)\cdot e^{(-q_1\cdot h)}$$

For the second integral in the equation (A), in its indefinite from, we have :

$$t\cdot q_1\int e^{(-q_1\cdot h)}dh \;=\; t\cdot q_1\cdot[-e^{(-q_1\cdot h)}/q_1] = [-t\cdot e^{(-q_1\cdot h)}]$$

For the upper limit, its value is 0 and therefore the value of the second definite integral is

$$t\cdot e^{(-q_1\cdot h)}$$

Substituting these results into the equation (A), the time in N headways during which cars are not delayed is :

$$N \cdot [t \cdot e^{(-q_1 \cdot h)} + \frac{e^{(-q_1 \cdot h)}}{q_1} - t \cdot e^{(-q_1 \cdot h)}] = \frac{N \cdot e^{(-q_1 \cdot h)}}{q_1}$$

The total time in N headways is $N \cdot E[H] = N/q_1$. Therefore, the proportion of time during which cars passing the observation post are not be delayed is

$$e^{-q_1 t}.$$

, where $t = d(1/v_1 - 1/v_2)$.

If cars are not bunched up behind trucks when they enter the no-passing zone, but can be found with equal probability in any part of the truck headway, then the proportion of cars not delayed by trucks as they move through the no-passing zone is the same as the proportion of time in equation, $e^{-q_1 t}$.

When the exponent $q_1 t = q_1 d(1/v_1 - 1/v_2)$ is small,

$$1 - e^{-q_1 t} \fallingdotseq q_1 d(1/v_1 - 1/v_2).$$

This means that proportion of cars delayed is approximately proportional to the flow of trucks, q_1, the length of the no-passing zone, d, and the difference of reciprocal speeds.

One can take the analysis a step further. So far we inquired the proportion of cars to be delayed. It is possible to also characterize the average duration of delay to cars.

A car entering the no-passing zone just behind a truck will be delayed by t units of time. If the next truck passes at a headway $h < t$, the car just ahead of it will be delayed by $t - h$. Thus, <u>in headways shorter than t,</u> if cars are anywhere within the headway probability, the delay to a car is, on the average, $(t - h)/2$. However, if the next truck enters the no-passing zone at a headways $h > t$ behind the first truck, the last delayed car is delayed imperceptibly. Thus, <u>in headways longer than t,</u> the delay to cars which are delayed is $t/2$.

Already we can make some informed guesses. The average delay to delayed car does not exceed t nor is less than $t/2$. Therefore, if q_2 is the flow of cars and $q_1 t$ is the proportion which are delayed, $q_2 \cdot q_1 t$ cars will be delayed per unit of time. If each of those is delayed, on the average, by an amount between $t/2$ and t, the total delay to cars per unit of time is expected to be between $q_2 \cdot q_1 t^2/2$ and $q_2 \cdot q_1 t^2$.

Thus, without more detailed analysis it appears that the delay to cars is proportional to the products of car and truck flows and to the square of t. Since t is proportional to d, delay to cars grows with the square of the distance along which passing is not allowed.

V. Summary

This paper introduces a revised model that better reflects the characteristics of the passing maneuver. The revised model is able to estimate the passing sight distance for the cases where the impeding vehicle, the passing vehicle, or both are large trucks, while AASHTO use the passenger car as the design vehicle for the passing sight distance.

If the passing and impeding vehicles are passenger cars, the passing sight distances obtained from the revised model are slightly smaller than AASHTO standards, but much greater than Glennon's results. If the passing vehicle, the impeding vehicle, or both are trucks, the revised model's results are greater than AASHTO standards as well as Glennon's results. As the design speed increases, the difference between the revised model's result and other results becomes greater. Although the test results presented in this paper are quite limited, it can be said that current passing and no-passing zone marking criteria for two-lane highways should be re-examined.

Proportion of cars delayed by slow moving vehicles in no-passing zone is approximately proportional to the flow of trucks, the length of the no-passing zone, and the difference of reciprocal speeds of fast and slow vehicles. Based on this, traffic delay in no-passing zone can be estimated simply by the model presented in this paper.

In practice, traffic engineers are looking for the model which is simple and reliable for the analysis. Two models proposed in this paper may be helpful for determining no-passing zones in two-lane rural highways.

References

1. American Association of State Highway and Transportation Officials, A Policy on the Geometric Design of Highways and Streets, 1984.
2. Council on Uniform Traffic Control Devices for Canada (1985), Manual of Uniform Traffic Control Devices of Canada. Roads and Transportation Association of Canada, Ottawa, Canada.
3. Forbes, G. J., "The Origin of Minimum Passing Sight Distances for No-Passing Zones" , ITE Journal, December, 1990.
4. Glennon, J. C., "New and Improved Model of Passing Sight Distance on Two-Lane Highways" , TRR 1195, 1989.
5. Harwood, D. W. & Glennon, J. C., "Passing Sight Distance Design for Passenger Cars and Trucks" , TRR 1208, 1990.
6. Rilett, L. R., Hutchinson, B. G. and Whitney, M., "Mechanics of the Passing Maneuver and the Impact of Large Trucks" , Transportation Research, Vol.24, p.121-124, 1990.
7. Saito, M., "Evaluation of the Adequacy of the MUTCD Minimum Passing Sight Distance Requirement For Aborting the Passing Maneuver" , ITE Journal, January, 1984.
8. Transportation Research Board, Highway Capacity Manual, Special Report 209, 1994.
9. Weber W. G. (1978) Passing sight distance and no-passing zones: present practice in the light of needs for revision. ITE Journal, 48(9), 14-18.
10. Bongsoo Son et al, "A Development of a Model for Estimating Passing Sight Distance", Traffic and Transportation Studies, Proceedings of ICTTS '98, p.571-580, 1998.
11. Bongsoo Son and Sangjin Han, "A Development of a Model for Estimating Traffic Delay in No-Passing Zone", Journal of Korean Society of Transportation, Vol. 16., No. 2, p. 133-144, 1996.