On the Minimum Safety Following Distance of the Traffic Stream

Yōichi TAMURA* and Sachio MOGAMI*

Abstract

The rear-end collision accidents are closely related to the speed and the following distance. In this paper, to solve this problem, we studied the relationship between the speed and the following distance, and then we tried to find out the Minimum Safety Following Distance. More details are described in the following articles.

Introduction

The rear-end collision accidents occupy about 30% of the total traffic accidents on the arterial highways. It is mainly caused by the lack of the following distance. And we surveyed and analyzed the relationship between the speed and the following distance of the bunching, and compare its result with the theoretical minimum safety following distance, and we found out that the actual traffic has been serious danger.

The survey of the speed and the following distance were performed on the straight part of the Route 2, the Route 190 and the urban street.

Minimum safety distance

The process of the driver stopping time is shown in Fig. 1[1], and this process is performed in the following three steps, that is, the first step is the perception-reaction time, the second step is the braking lag time and the third step is braking time.

The first step is determined by the limit of the human ability, the second and the third steps, that is vehicle stopping time, is determined by the ability of the car and the condition of the road. The driver stopping time is determined by these three elements.

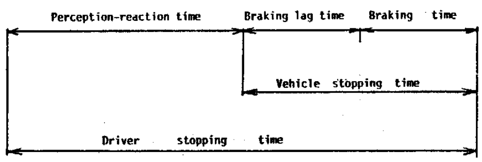

Fig. 1 Driver stopping time.

The most part of drivers have a knowledge of the vehicle stopping time but have not a knowledge of the perception-reaction time. They think that they can react

* Department of Civil Engineering

momentarily, but it is a mistake. Generally this perception-reaction time is from about 0.7 sec. to about 2.5 sec..

The vehicle stopping distance is given by the following equation (1).

$$L=\frac{V}{2gf} \tag{1}$$

where L: vehicle stopping distance
V: speed of the vehicle
g: acceleration of gravity
f: braking force coefficient

From the equation (1) the safety following time is given by the equation (2) and the equation (3)[2].

$$T_1=\frac{1}{V}+r+\frac{V}{2gf} \tag{2}$$

$$T_2=\frac{1}{V}+r \tag{3}$$

where T_1, T_2: following time
l: allowance at the stopping
r: perception-reaction time

Here, T_1 is the most safety following time at the emergency braking of the former car, and T_2 is the most dangerous following time, because in this case, drivers expect, according to their experience, that the former car cannot stop as long as theirs.

In actual traffic stream, there are many bunches following T_2. And it is reasonable that we adopt T_2 by way of minimum following time. Fig. 2 shows the relationship between the following time and the speed.

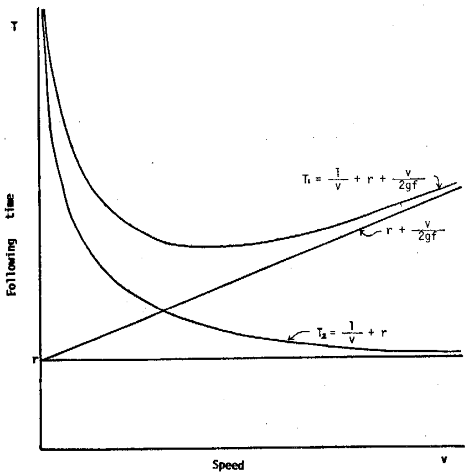

Fig. 2 The relationship between the speed and the following time.

The speed and the following time

The speed distribution is shown in Fig. 3. It is recognized there is some difference between the speed distribution and we studied some reason why this difference is caused.

The Graph 1 shows the speed distribution on the Route 190. On this highway traffic stream flows almost by the free speed, and permitted the overtaking. Therefore the speed distribution is situated comparatively higher situation and the average speed is over the limit speed.

The Graph 2 shows the speed distribution on the Route 2. On this highway, the limit speed is 60 km/h as same as Route 190. But speed is slowed down by the influence of the higher mixing ratio of the commercial vehicle, the overtaking limit and the higher traffic volume.

The Graph 3 shows the speed distribution on the urban street. On this street, the limit speed is 40 km/h and the traffic volume is comparatively higher. And the average speed is under the limit speed and this point is the lowest speed distribution in these three points.

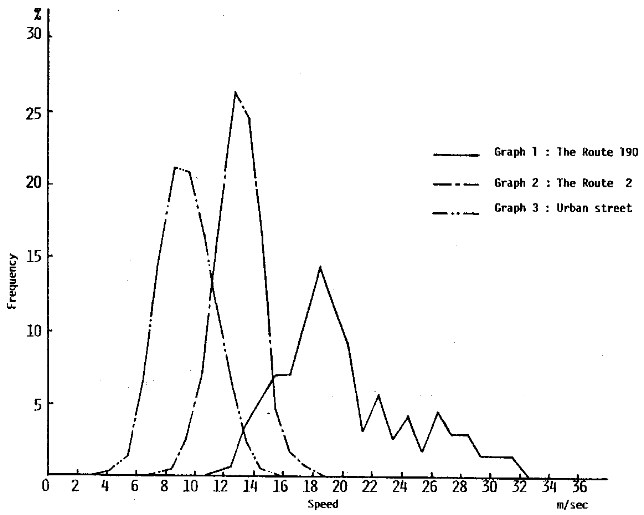

Fig. 3 Speed distribution.

The relationship between the speed and the following distance are shown in Fig. 4. By this result it is known that the following distance increase according to the increase of the speed on the respective cases.

The relationship between the speed and the following time is shown in Fig. 5. By this result it is known that contrary to the following distance, the following time has a tendency to decrease within a certain range according to the increase of the speed. It is satisfactory, from the former discussion, to consider that if the speed is over a certain limit, the following time increase according to the increase of the speed.

Table 1 shows the average speed and the average following distance and the average following time on the each highways.

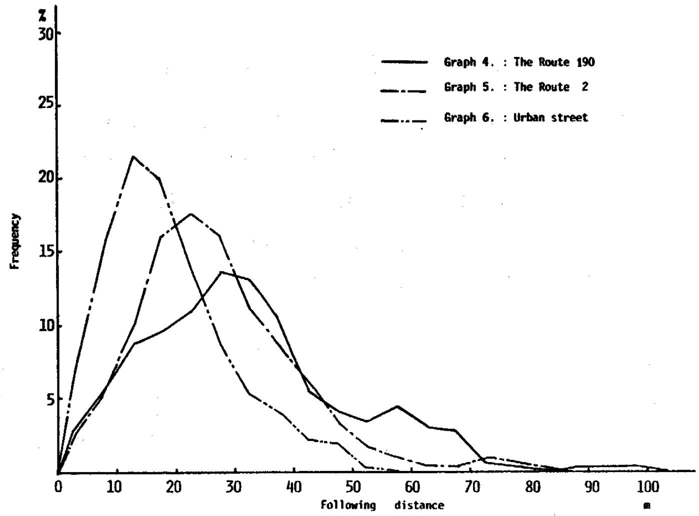

Fig. 4 Following distance distribution.

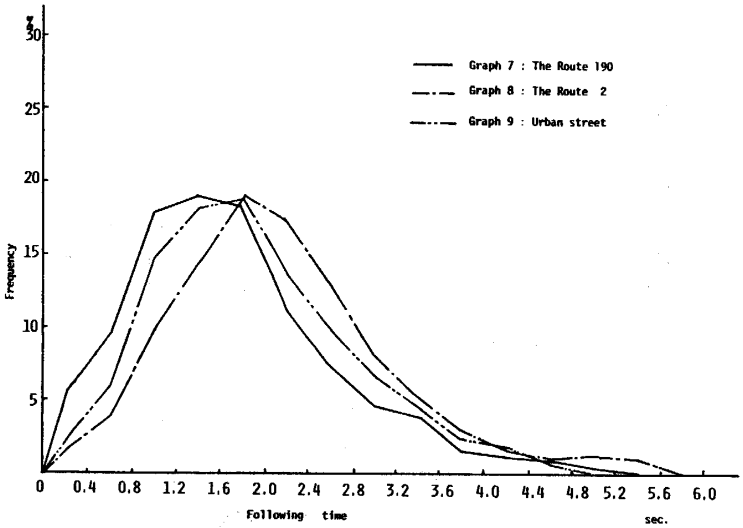

Fig. 5 Following time distribution.

Table 1. The average values of the speed, the following distance and the following time.

	Average (m/sec.)	speed (km/h)	Average following distance (m)	Average following time (sec.)
Route 190	20.1	72.4	31.8	1.6
Route 2	12.8	46.2	25.9	2.1
Urban street	9.4	34.0	18.2	1.9

Fig. 6 shows the comparison of the following time with T_1 and T_2 (the reader should refer to previous article). We compute T_1 and T_2, under the supposition, that is $r=1.0$ sec., $l=2.0$ meters and $f=0.6$[3),4)]. A good many drivers drive with the following time under T_2 and a great many drivers drive under T_1. It is known that the more the speed, more the increase of dangerous vehicles. If the following time is less than 0.7 sec., so very small impact shall cause the rear-end collision accidents. And moreover the dangerous vehicle have a tendency to increase with the increase of the speed. This tendency is according to that the drivers don't know the danger on the high-speed driving. From this investigation it is necessary to re-educate the drivers, and to offer the exact information for the safety driving.

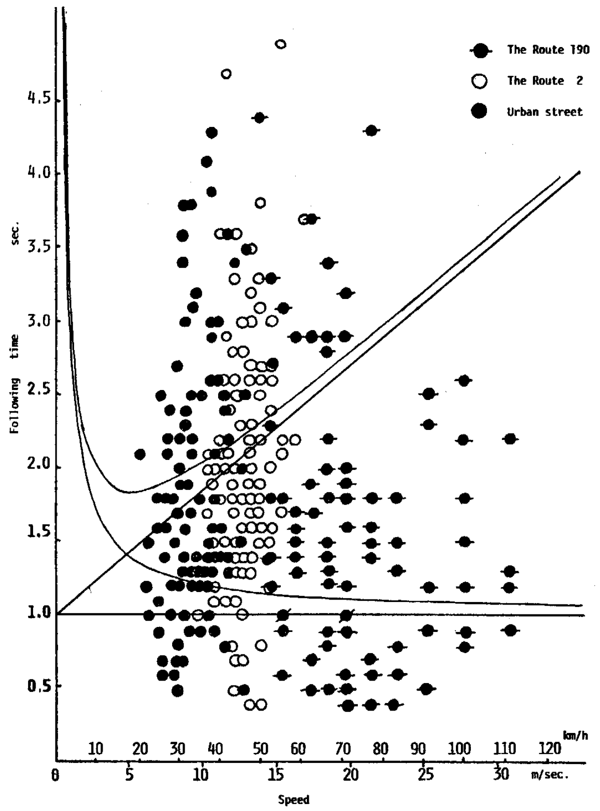

Fig. 6 The relationship between the speed and the following time.

Conclusion

In order to solve the problem of the traffic accidents, especially the rear-end collision accident, we investigated the relationship between the speed and the following distance, and the following conclusion are obtained.

(1) The following distance increase according to the increase of the speed.

(2) The following time has a tendency to decrease according to the increase of the speed within a certain range of the speed, but it is necessary to make more traffic stream survey for this problem.

(3) In the actual traffic stream, there is a good many dangerous vehicles, and the more the speed, the more the dangerous vehicles.

It seems to be probable that very small impact shall cause the serious rear-end collision accidents or other accidents. It is necessary to re-educate the drivers, and to offer the exact information for the safety driving.

Acknowledgement

The author is deeply indebted to Mr. Eiji Mihara, graduate of our university, for his aid in the present traffic stream survey.

References

1) Traffic Engineering Dictionary, Gijutsu-Shoin, 208 (1972)
2) H. Takada and Y. Kurimoto: On the Characteristics of Queues in Road Traffic Flow, Japanese Papers and Reports of the Defense Academy, Volume 2, No. 2, 175–189 (1964)
3) A. Yoshimoto: Highway Engineering, Gakkensha, 57–59 (1971)
4) Traffic Engineering Hand-Book, Gihōdō, 316–319 (1973)