

Study on the Validity of Emergency Brake light Display

1. Purpose

A study has been conducted on the validity and operation conditions of emergency brake light display since 2000.

The purpose of the study was to examine two types of emergency brake light display, one that flashes the brake lamps upon sudden braking and the other that enlarges the lighting area of the brake lamps.

2. Effects on the Response Time of Emergency Brake Light Display

An indoor experiment was conducted using a simplified simulator that allows the subject seated in a vehicle to control the distance, etc with a preceding vehicle projected on a screen placed ahead with the accelerator and steering wheel. The subject was instructed to respond, by pushing an electrical switch at hand, to the lighting or flashing of brake lamps (red LEDs) placed 80° to the left, 40° to the left, directly in front, 40° to the right, and 80° to the right of the subject, while controlling the vehicle projected on the screen so that it comes within the prescribed frame. The time of the subject's response was measured.

We examined three cases where: 1) After being lit on continuously for some time, the brake lamps flash with a frequency of 1 Hz, 2 Hz, and 4 Hz; 2) After the main lamp is lit on, a lamp is lit on after 1000 ms, 500 ms, or 250 ms (The lighting area changes only once); 3) After the main lamp is lit on, three lamps are lit one after another (The lighting area changes three times).

The experiment showed the following:

- 1) Flashing is effective when the subject was looking aside (when he/she was looking away from the center).
- 2) When flashing, emergency brake light display are more effective with shorter flashing intervals, being most effective when flashing at 4 Hz. (Example: Response time to brake lamps placed to 80° to the right was 0.55 sec. when they flash at 4 Hz while it was 1.08 sec. when they don't flash.)
- 3) With longer flashing intervals, the flashing had the opposite effect, because the subject sometimes overlooked the lighting of the brake lamps. With these frequencies, it was proved necessary to keep the part of the lamps turned on upon braking lit on while the other parts are flashing.
- 4) Change of lighting area is completed in an instant, so it is not effective if the subject overlooks this instantaneous change. Change in lighting area proved effective if there are three times of change.

3. Examination of Operation Conditions of Emergency Brake Light Display

A study was made to know, to use an emergency brake light display without bothering the drivers of the vehicles following behind, at what deceleration the system should work.

We calculated the distribution of deceleration under normal driving conditions and that on sudden braking actions, supposing that the system would not bother following vehicles if it is enabled only on sudden braking actions, remaining disabled on braking actions under normal driving conditions.

3.1 Distribution of deceleration during normal driving

Fig. 1 shows the deceleration on braking actions under normal driving conditions. The figure shows that about 80% of braking actions under normal driving conditions are included in the deceleration range of 3 m/s^2 . (We did not count deceleration of 1 m/s^2 or less, since we did not consider them as those for braking).

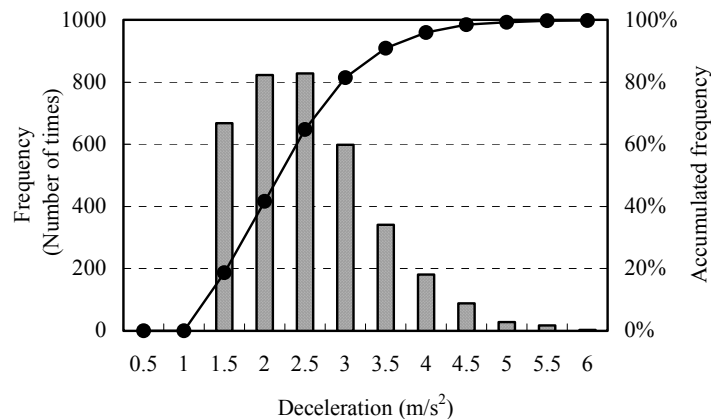
There were no braking actions that caused more than 6 m/s^2 of deceleration.

These results showed that we can consider deceleration of 6 m/s^2 as sudden braking actions.

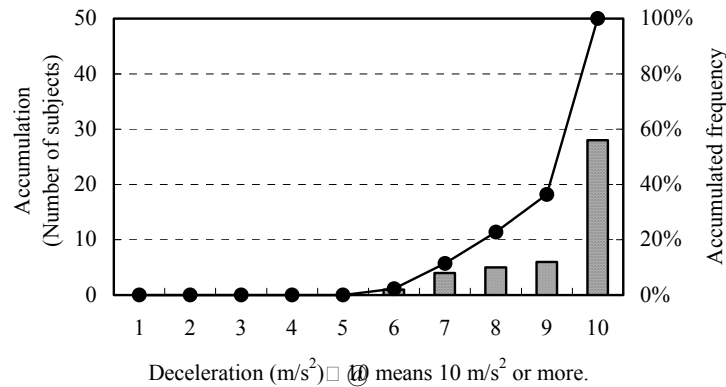
3.2 Distribution of deceleration on sudden braking actions

Fig. 2 shows the distribution of maximum deceleration on sudden braking actions.

It shows that the lowest maximum deceleration was found only once between 6 m/s^2 and 7 m/s^2 (2%). This means that, if the emergency brake light display is designed to work when the vehicle starts decelerating at 6 m/s^2 or more, all sudden braking actions will activate the emergency brake light display. It means also that, if the system is designed to work when the vehicle starts decelerating at 7 m/s^2 or more, 98% of sudden braking actions will activate the emergency brake light display.



**Fig. 1 Distribution of deceleration under normal driving conditions
 (Data on 30 drivers)**

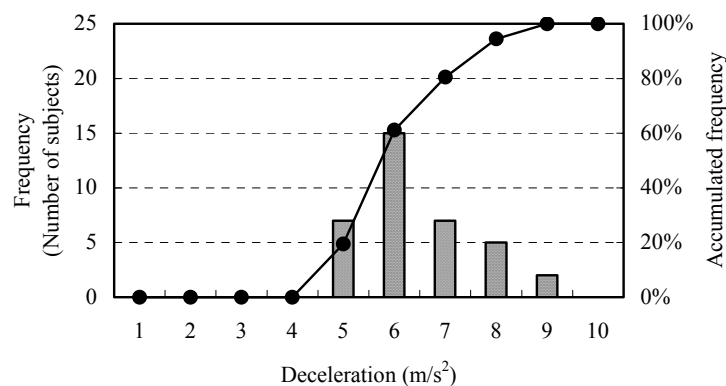


**Fig. 2 Maximum deceleration on sudden braking actions
 (Data on 44 drivers)**

3.3 Evaluation of flashing brake lamps

The subjects were instructed to follow a vehicle equipped with emergency brake light display and running at about 50 km/h and to indicate at what deceleration he/she felt flashing is preferable when the preceding car started to slow down. The experiment was conducted on 36 subjects.

The results showed that more than half of the subjects (60%) answered it was preferable for the preceding car's emergency brake light display to flash when it slowed down at a deceleration of 6 m/s² or more, while 80% felt so when it slowed down at 7 m/s² or more.



**Fig. 3 Deceleration at which the subjects felt it preferable for Emergency Brake light
 Display to flash
 (Data on 36 subjects)**

3.4 Summary of Review on Emergency Brake Light Display 's Operation Conditions

The distribution of deceleration under normal driving conditions and that on sudden braking actions showed that, if an emergency brake light display is designed to work on a deceleration of 6 m/s^2 or more, the system would work only on sudden braking actions, while remaining disabled on braking actions under normal driving conditions. In subjective evaluation tests also, more than half of the subjects answered that it was preferable for emergency brake light display to work at a deceleration of more than 6 m/s^2 .

Therefore, we think that we can operate an emergency brake light display effectively and without bothering the drivers of the following vehicles if it is designed to work at a deceleration of 6 m/s^2 or more.

4. Study on Photosensitive Epilepsy Caused by Flashing of Emergency Brake Light Display

To introduce flashing of braking lamps, it is necessary to examine possible negative effects in advance. For example, sufferers from photosensitive epilepsy (PSE) may have an epileptic fit in reaction to flashing light. In Japan, accidents supposedly caused by PSE have been reported: On December 16, 1997, several children who watched an animation TV program for children felt sick.

Although the flashing of braking lamps does not seem to give the following vehicles (the drivers and other occupants) as much stimulation as that given by TV monitors, it is necessary to examine the question before launching emergency brake light display into the market.

A study of medical literature on PSE shows the following:

- The seizure of PSE is closely related with the flashing frequency of the light source. To reduce the risk of the seizure, it is necessary to keep the flashing frequency of the light source to 5 Hz or less, preferably to 3 Hz or less.
- Red light used in brake lamps is apt to cause PSE seizure.
- If the duration of photic stimulation is limited to 2 sec. or less, PSE hardly occurs.

Based on this fact, we calculated the time required for a vehicle to pass from the initial speed of 60 km/h to 10 km/h at a deceleration of 6 m/s^2 . The time required was 2.3 sec. Accordingly, we suppose that the risk of PSE seizure would be low if the flashing of emergency brake light display is disabled once the vehicle slows down to a speed of 10 km/h or less. Further, while the vehicle is running at 60 km/h or more, we think the effect on PSE will be low, because the distance between two cars is longer.

5. Summary

The experiments showed that the flashing of the preceding vehicle's braking lamps has the effect of shortening the response time in the following driver's peripheral fields of vision. They also showed that shorter flashing intervals are better. It was also shown that, a change in area or additional lighting of a lamp is not effective if the following driver overlooks it at the moment of change, since the change is completed in an instant.

The examination of operation conditions of emergency brake light display showed that, if emergency brake light display is designed to work at a deceleration of 6 m/s^2 or more, the system would operate effectively and without bothering the following drivers.

It was shown, however, that, in consideration of possible effects on sufferers from PSE, it is necessary to limit the duration of flashing, for longer interval modes, to less than 5 Hz or less, preferably to 3 Hz or less.

It was shown that, even with rapid flashing, the risk of PSE seizure would be low if the duration of flashing is limited to 2 sec. or less. Accordingly, we suppose that the risk of PSE seizure would be low if the flashing of emergency brake light display is disabled once the vehicle slows down to a speed of 10 km/h or less.

6. Conclusion

Based on the above results, we think that the optimal operation conditions of an emergency brake light display are as follows:

- (1) The emergency brake light display should automatically start its flashing on a braking action that causes a deceleration of 6 m/s^2 or more or an ABS or BA action that expectedly causes an equivalent deceleration. It should stop flashing when the vehicle slows down to 10 km/h or less.
- (2) The flashing frequency should be 4 Hz or more ($5 \text{ Hz} \pm 1 \text{ Hz}$). When using electric bulbs, the frequency should be $5 \text{ Hz} \pm 1 \text{ Hz}$, because they would not look like flashing beyond 7 Hz.