Evaluation on Glare from Vehicle Lamps and Effectiveness of Road Components as Glare Barriers

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EVALUATION ON GLARE FROM VEHICLE LAMPS AND EFFECTIVENESS OF ROAD COMPONENTS AS GLARE BARRIERS

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ABSTRACT
Vehicle lamps are vital components which are required to ensure the driver's safety, particularly at nighttime. However, vehicle lamps may cause glare which can reduce visibility and create discomfort.
The objectives of this research are to evaluate glare from car headlamp and motorcycle lamps; and to study the effectiveness of road components on highway median, i.e. paddle, vegetation, and jersey barriers (87.5 and 122.5 cm high) as glare barriers. Luminance from headlamps and vertical illuminance on observer's eye were measured to observe glare effect on vehicle drivers, expressed with the de Boer rating.
The experiment results show that car headlamps observed at nighttime by car drivers in highway without barriers, scored 3~5 (disturbing~acceptable) on the de Boer scale; while motorcycle lamps in static position scored 1~3 (unbearable~disturbing). Paddle was found to be the most effective glare barrier in highway, for it might reduce glare up to scale 6 (acceptable).

1. INTRODUCTION

Vehicle (car and motorcycle) lamps are vital components which are required to ensure the driver's safety, particularly at nighttime. However, vehicle lamps may cause glare which can reduce visibility and create discomfort for drivers at the opposite direction.

The objectives of this research are to evaluate glare from car headlamp and motorcycle lamps; and to study the effectiveness of road components on highway median, i.e. paddle, vegetation, and jersey barriers (87.5 and 122.5 cm high) as glare barriers. Luminance from the source, vertical illuminance on observer's eye, and angle between source and line of view were measured to obtain the glare rating, which is expressed with the de Boer scale, between 1 (unbearable) and 9 (just noticeable).

1.1 de Boer Scale

The de Boer scale is commonly used scale for describing subjective glare effect, which can be classified as:

Table 1 The de Boer scale

Rating	Qualifier
1	Unbearable
2	
3	Disturbing
4	
5	Just acceptable
6	
7	Satisfactory
8	
9	Just noticeable

A mathematical model for the scale had been developed by Schmidt-Clausen and Bindels (1974), which can be expressed as:

$$W = 5 - 2\log \frac{E}{0.003\left(1+\sqrt{\frac{L}{0.04}}\right)\theta^{0.46}} \qquad (1)$$

where
- W : de Boer rating
- E : vertical illuminance on observer's eye [lux]
- L : luminance from source [cd/m^2]
- θ : angle between source and line of view [arcminute]

2. EXPERIMENTS

2.1 Car Headlamps Measurement
2.1.1 Without Barriers

The experiments were done at nighttime in Pasteur-Padalarang-Cikampek highways using luminance meter and luxmeter. The instruments were positioned on eye level of the observer, who drove the car at approximately 60 cm from the road median and at height of 108 cm from ground (Paripurna, 2007).

Several types of car, i.e. sedan, jeep/multi-purpose vehicle (MPV), small and large truck/bus from opposite direction (without median barrier) were observed, while luminance from the headlamps and illuminance values on observer's eye were recorded. Light from surrounding background was assumed to be minimal, so that the headlamps could be considered as the most dominant source. The measurement results are tabulated in Table 2.

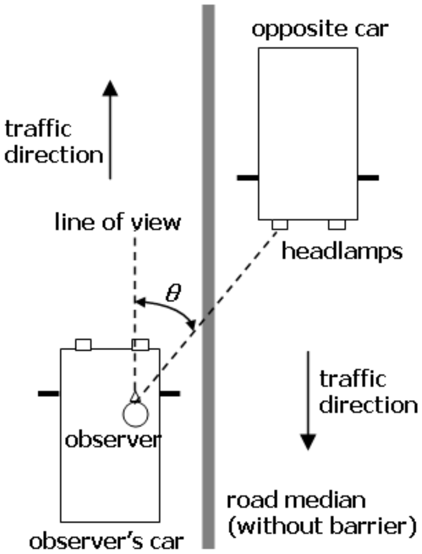

Fig. 1 Layout plan for car headlamps measurement

Table 2 Car headlamps measurement results (without glare barriers)

Car type	*E* [lux]	*L* [cd/m^2]
Sedan	1.0	0.14
Jeep/MPV	1.0	0.88
Small truck/bus	1.0	0.38
Large truck/bus	0.1	0.21

Subjective glare assessments were done by the observers, using 4-scales criteria: A (unbearable), B (disturbing), C (acceptable), and D (just noticeable).

2.1.2 With Barriers

In order to study the effectiveness of road components as glare barriers, experiments were done similarly in the same highways. The exact location was chosen at place where road components, i.e. paddle, vegetation, and jersey barriers of 87.5 and 122.5 cm high, were found as barriers on the road median.

The measurement results are tabulated in Table 3.

Table 3 Car headlamps measurement results (with glare barriers)

Barrier type	Car type	*E* [lux]	*L* [cd/m^2]
Paddle	Small truck/bus	0.1	0.65
	Large truck/bus	0.1	0.41
Vegetation	Sedan	0.1	0.40
	Small truck/bus	0.1	0.21
Jersey 87.5 cm	Sedan	0.1	0.39
	Jeep/MPV	2.0	0.42
Jersey 122.5 cm	Sedan	0.1	0.65
	Jeep/MPV	1.0	0.70

2.2 Motorcycle Lamps Measurement

The experiments were done in static condition using luminance meter which was attached with telescope, luxmeter, and angle protractors. To minimize light coming from surrounding environment, the measurement was taken at nighttime in open field with almost no ambient light. The observed lamps were fog lamps (a pair), low beam, and high beam. Measurements were taken 3 m from the lamp, at angles of 0.1 and 60 degrees from its normal, and at height of 120 cm (eye level for sedan car driver) (Yuniardy, 2008).

Each observed fog lamps were 10 watts incandescent at height of 76 cm from ground, while the low and high beam were 32 watts incandescent at height of 98 cm from ground. Each lamps were assumed to have symmetrical light distribution of 120 degrees horizontal angle, thus angle of 60 degrees was taken as the minimum criteria for the measurement.

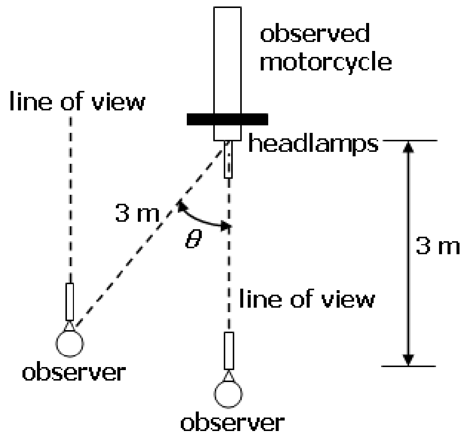

Fig. 2 Layout plan for motorcycle lamps measurement

The measurement results are tabulated in Table 4.

Table 4 Motorcycle lamps measurement results

Angle [°]	Source	*E* [lux]	*L* [cd/m^2]
0.1	Fog lamps	4.00	0.06
	Low beam	10.33	1.37
	High beam	13.67	1.67
60	Fog lamps	2.33	0.06
	Low beam	3.33	0.09
	High beam	3.67	0.15

Subjective glare assessments were also done by the observers, using the same 4-scales criteria as in car headlamps.

3. ANALYSIS

3.1 Glare from Car Headlamps

3.1.1 Without Barriers

Glare effects from each car headlamps (without barriers) were determined by calculating the de Boer rating (W), by assuming 3 degrees as the value of angle θ. Compared with the qualitative scores obtained by subjective assessments, the results are tabulated in Table 5.

Table 5 Glare ratings for car headlamps (without glare barriers)

Car type	W	Score
Sedan	3	B
Jeep/MPV	4	B
Small truck/bus	3	A
Large truck/bus	5	D

The results show that headlamps of sedan and small truck/bus gave the lowest de Boer ratings (3 – disturbing), in agreement with the qualitative scores. Large truck/bus gave the least glare effect (5 – just acceptable), most probably because its lamps wattage were not as great as sedan and small truck/bus'.

3.1.2 With Barriers

Glare effects from each car headlamps (with barriers) were determined in a similar manner with the ones without barriers. Compared with the qualitative scores obtained by subjective assessments, the results are tabulated in Table 6.

Table 6 Glare ratings for car headlamps (with glare barriers)

Barrier type	Car type	W	Score
Paddle	Small truck/bus	6	D
	Large truck/bus	6	D
Vegetation	Sedan	5	D
	Small truck/bus	5	C
Jersey 87.5 cm	Sedan	5	D
	Jeep/MPV	3	B
Jersey 122.5 cm	Sedan	6	D
	Jeep/MPV	4	C

The results show that glare barriers might reduce the subjective effect of glare. The highest de Boer ratings were given by paddle barrier (6 – acceptable), in agreement with the qualitative scores. Jersey barrier of 87.5 cm high was not as effective as the other barriers, scoring down to 3 (disturbing) on the de Boer rating, most probably because its height was not sufficient to block the light path coming from the headlamps in opposite direction.

However, the results could be irrelevant for curved and/or sloped highway, since the conventional glare barriers might not be effective enough to block the light path. In those cases, specially designed anti-glare modules should be installed on the median.

3.2 Glare from Motorcycle Headlamps

Glare effects from each motorcycle lamps were determined in a similar manner with the ones without barriers, using 0.1 and 60 degrees as the value of angle θ. The results are tabulated in Table 7.

Table 7 Motorcycle lamps measurement results

Angle [°]	Source	W	Score
0.1	Fog lamps	1	D
	Low beam	1	C
	High beam	1	B
60	Fog lamps	3	D
	Low beam	3	C
	High beam	3	C

The results show that at angle of 0.1 degrees, motorcycle lamps gave the lowest de Boer ratings (1 – unbearable). At angle of 60 degrees, the lamps gave higher de Boer ratings (3 – disturbing). Based on qualitative assessments, the greatest glare effect was caused by high beam, while the least was given by fog lamps. The results are in agreement with facts that fog lamps had the least electric power. Compared with low beam, high beam had a greater vertical angle light distribution, thus resulted in more glare effect on vehicle drivers.

CONCLUSION

The experiment results show that car headlamps observed by car drivers at nighttime in highway without barriers, scored 3 (disturbing) to 5 (acceptable) on the de Boer scale. Headlamps of sedan and small truck/bus gave the lowest de Boer ratings, in agreement with the qualitative scores, while large truck/bus gave the least glare effect.

Motorcycle lamps in static condition observed by car drivers scored 1 (unbearable) to 3 (disturbing). The greatest glare effect was caused by high beam, while the least was given by fog lamps.

Paddle was found to be the most effective glare barrier for car headlamps, for it might reduce glare up to scale 6 (acceptable).

NOMENCLATURE

W : de Boer rating
E : vertical illuminance on observer's eye [lux]
L : luminance from source [cd/m^2]
θ : angle between source and line of view [arcminute]

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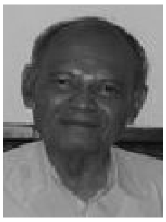

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