International Conference ILUMINAT 2009

FLICKER DOSE IN THE ROAD LIGHTING

Virgil MAIER, Sorin G. PAVEL

TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

Flicker phenomenon

Definition: the impression of instability of the visual sensation, produced by a luminous stimulus whose luminance or spectral distribution fluctuates with time, *in the range (0,01÷50) Hz*.

Causes:

- luminous fluxes fluctuations emitted by the lighting systems;
- the fluctuation in time of the spectral composition of the received light;
- *the human subject movement* in a visual field, variable from the photometric variables point of view, but which is repeating it self in the space;
- *shift of some successive lighting sources* versus the human observer.

The luminance fluctuations amplitude

$$\delta L_{vj} = \frac{|L_{vj} - L_{vj+1}|}{L_{vj}} \cdot 100, \%$$

L_{vj} - the luminance for which the eye is accommodated in the moment t_j ;

L_{vj+1}- the luminance which is to accommodate the eye in the moment t_{j+1}.

The observer passes from the maximum luminance point L_M to the minimum luminance one L_m

$$\delta L_{Mm} = \frac{|L_M - L_m|}{L_M} \cdot 100, \%$$

The observer passes from the minimum luminance point L_m to the maximum luminance one L_M

$$\delta L_{mM} = \frac{|L_m - L_M|}{L_m} \cdot 100, \%$$

Flicker dose

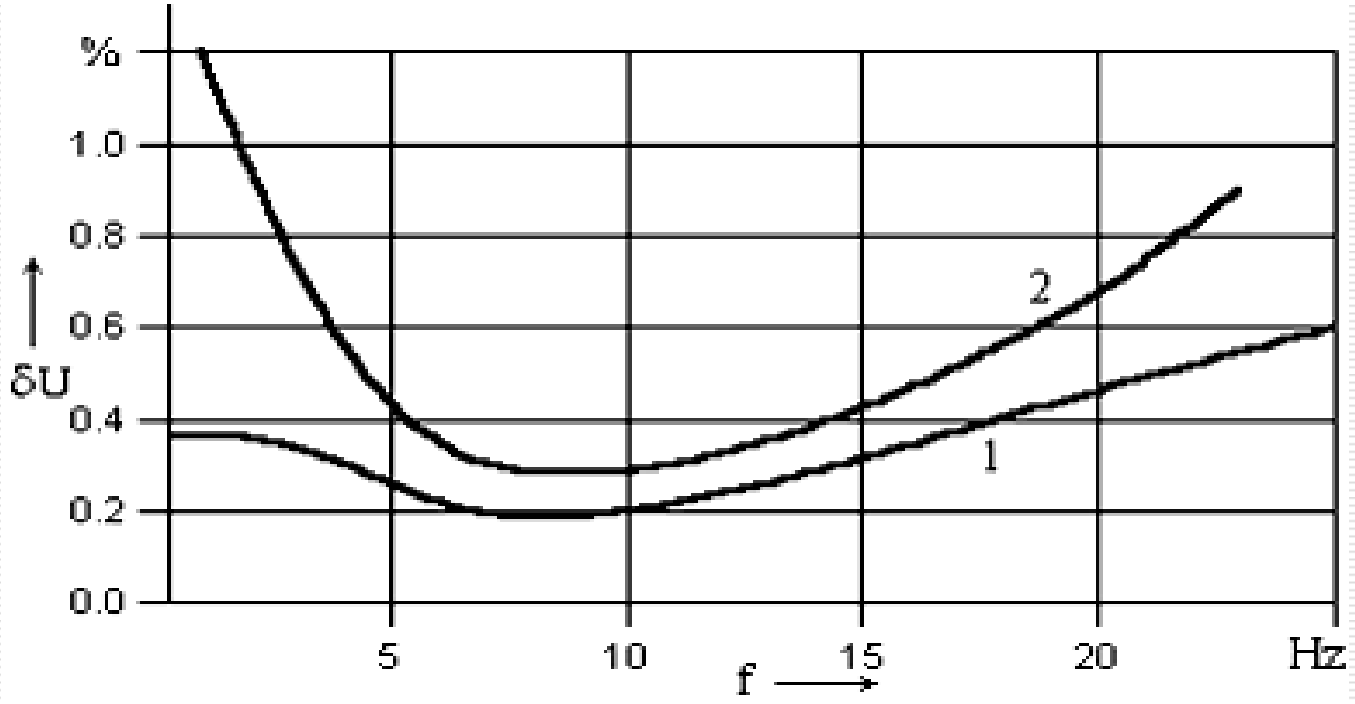


Fig. 1. Variation of the sensibility threshold of the human sight with the modulator signal amplitude and frequency for: 1 - rectangular modulation; 2 - sinusoidal modulation.

The cumulative principle

- The equivalence of a fluctuation of f_i frequency and δU_{fi} amplitude with a fluctuation having 10 Hz as reference frequency and the equivalent percentage amplitude:

$$(\delta U_{10})_i = g_{fi}\ \delta U_{fi}\ ,\%$$

- The superposition of the effects of different frequencies fluctuations:

$$\delta U_{10} = \sqrt{\sum_i \left(g_{fi}\ \delta U_{fi}\right)^2}\ ,\ \%$$

- **The flicker dose**:

$$\varepsilon_F = \int_0^{T_0} \left(\delta U_{10}\right)^2 \cdot dt\ ,\ (\%)^2\ min$$

Admitted flicker dose

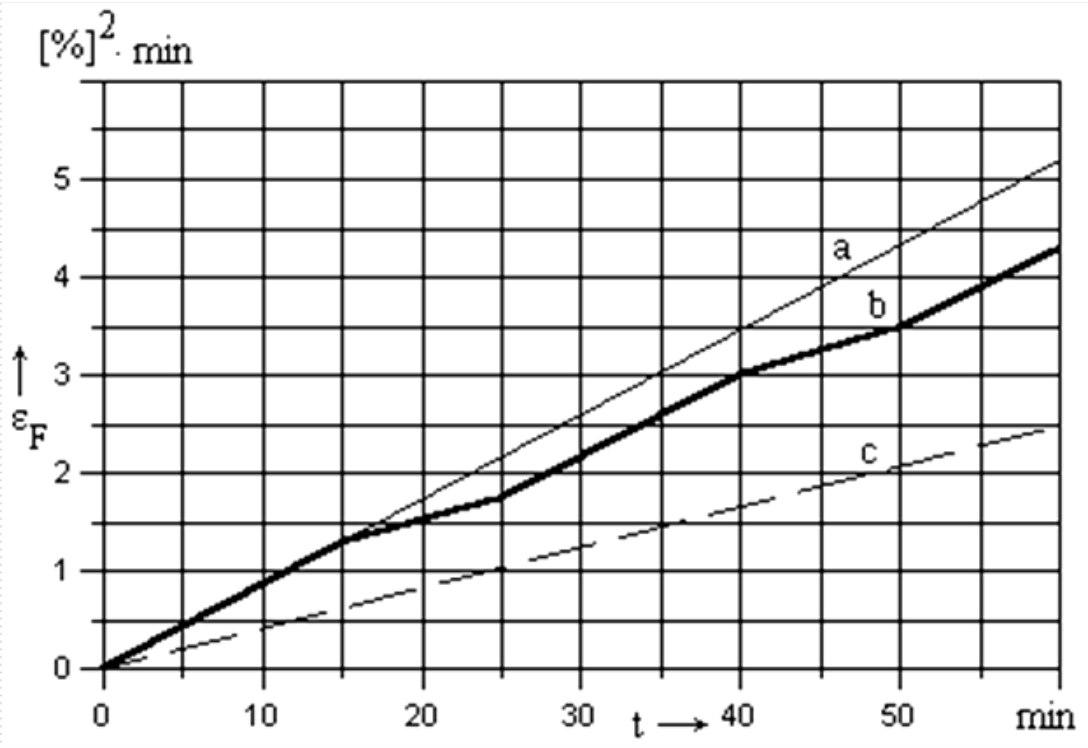
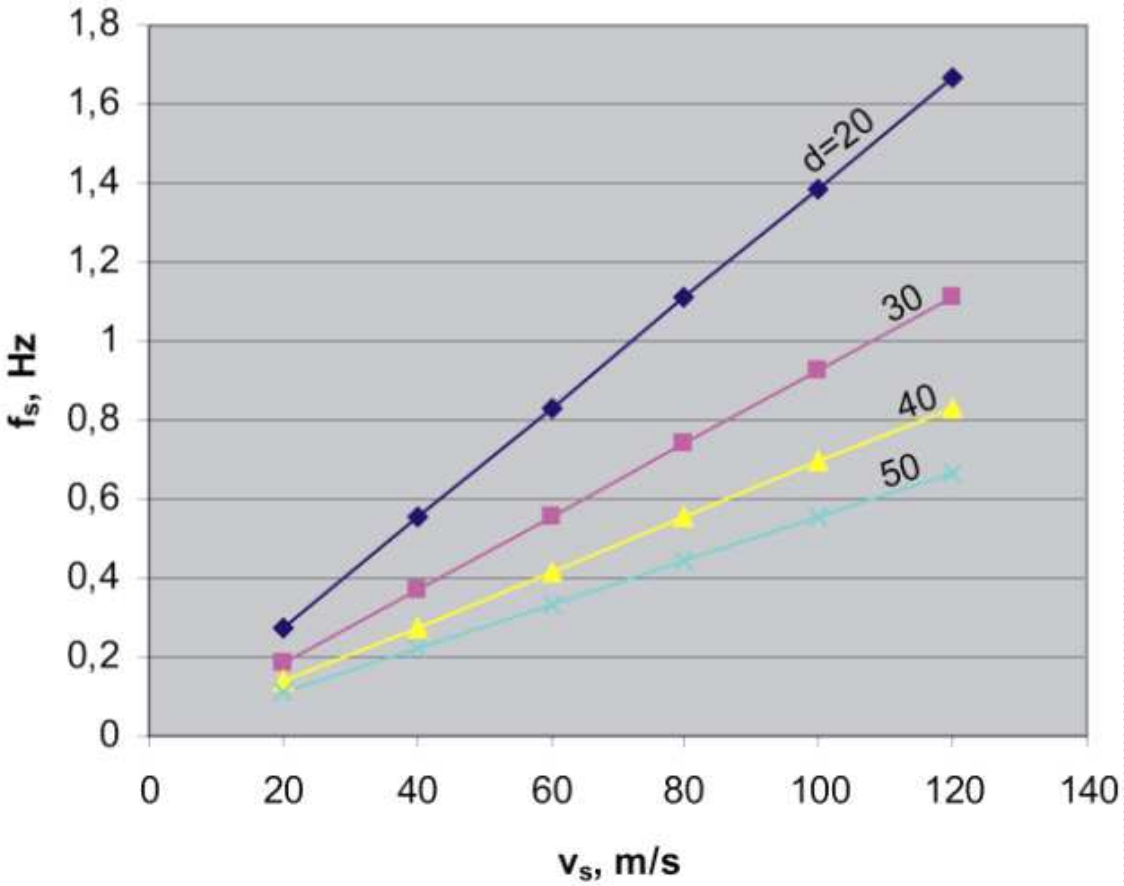


Fig. 2. The periodical flicker dose dependence versus the flicker duration:
a - disturbing flicker; b - admitted flicker dose; c - imperceptible flicker.

1. Luminance fluctuations

owed to the lighting system

$$f_s = \frac{v_s}{d}, Hz$$



Luminance measurements results

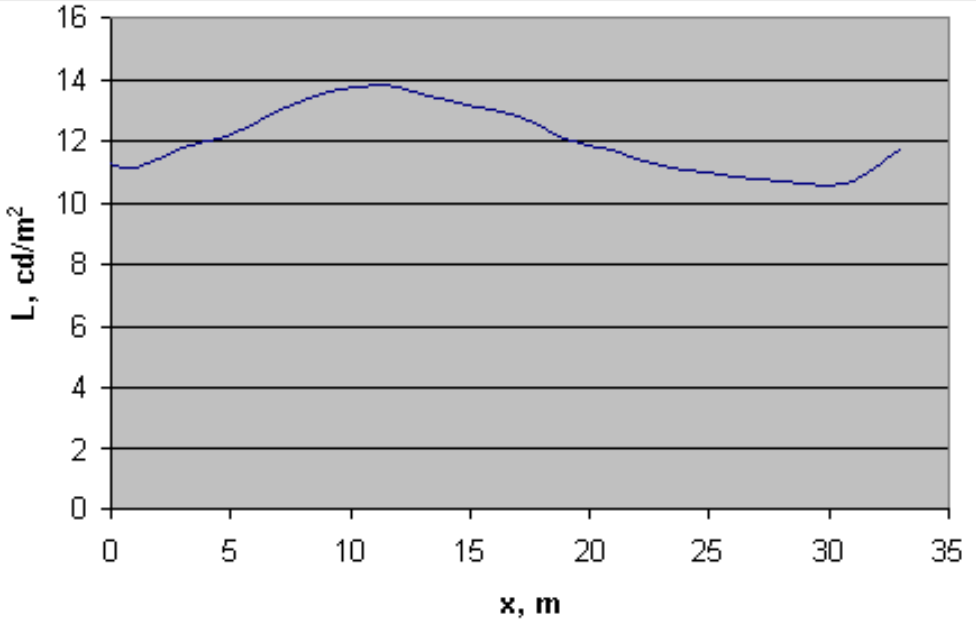


Fig. 4. Profile of the luminance on the longitudinal axis of the first lane.

$$\delta L_{Mms} = 23{,}2\ \% \qquad \delta L_{mMs} = 30{,}2\ \%$$

Calculation of the flicker dose for a lighting system

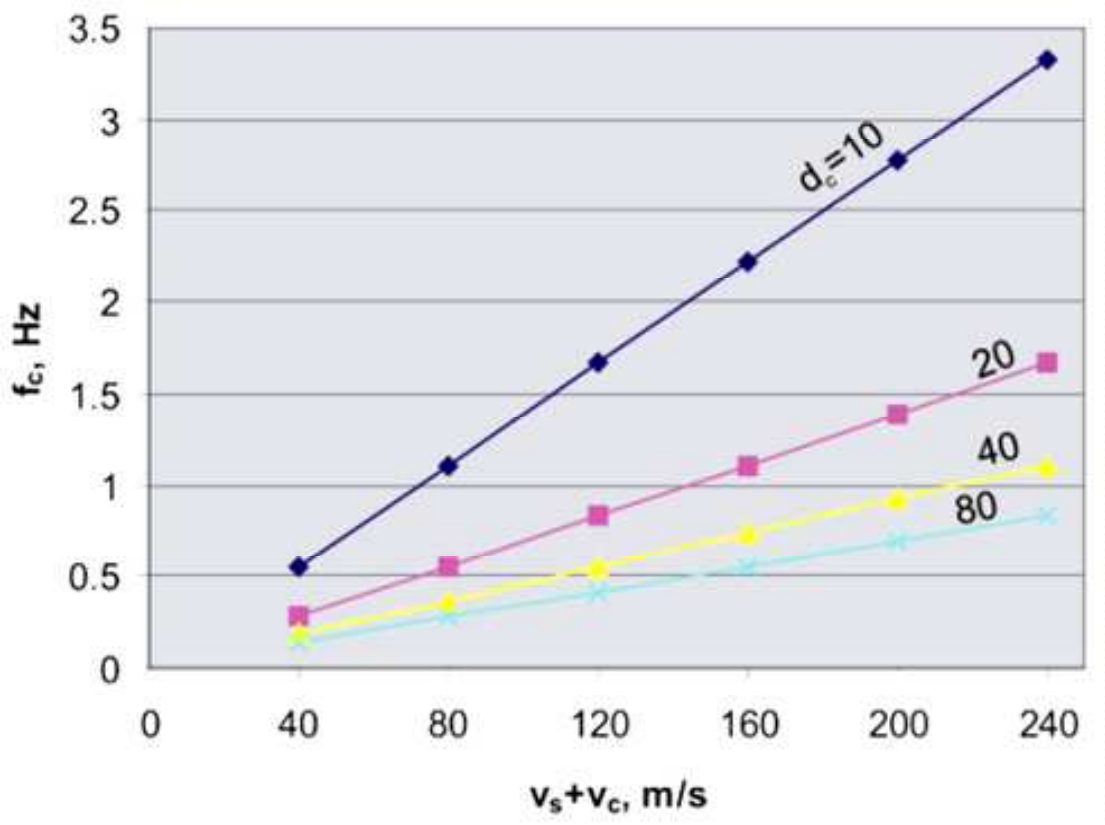
Table 1

Speed of traveling, km/h	Traveled distance, km	Time, min	Frequency of fluctuations, Hz	Equalization coefficients, g_f	δL, %		Flicker dose, $(\%)^2$min	
					δL_{Mm}	δL_{mM}	calculated	admitted
50	3	3,6	0,42	0,08	23,2	30,2	33,4	0,32
	9	10,8					100,2	0,97
	18	21,6					200,5	1,60
60	3	3	0,50	0,09	23,2	30,2	35,2	0,27
	9	9					105,7	0,81
	18	18					211,4	1,50
70	3	2.6	0,58	0,10	23,2	30,2	37,7	0,23
	9	7,7					111,7	0,70
	18	15,4					223,3	1,39

2. Luminance fluctuations

due to the traffic from the opposite sense

$$f_c = \frac{v_s + v_c}{d_c}, Hz$$



Flicker dose

owed to the traffic from the opposite sense

Table 2

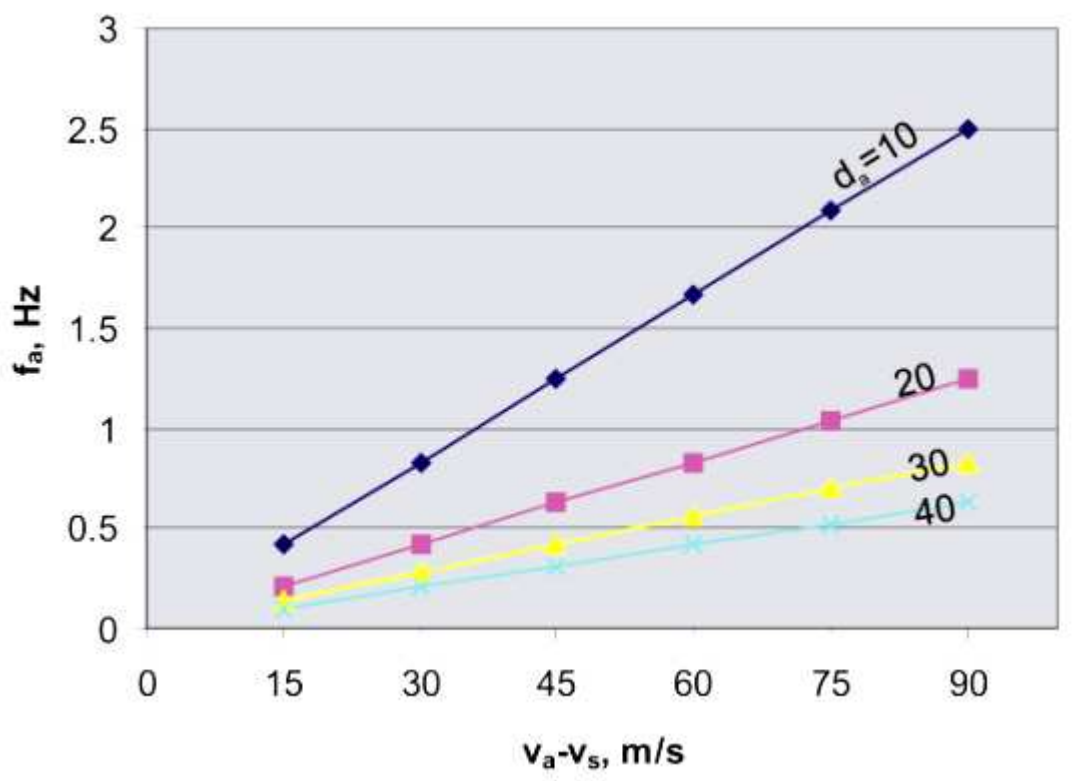
Traveling speed v_s, km/h	Traveling distance, km	Time, min	Fluctuations frequency, Hz	Equalization coefficients, g_f	δL, %		Flicker dose, $(\%)^2$min	
					δL_{MM}	δL_{mM}	calculated	admitted
50	20	24	0,56	0,095	5,77	6,12	15,31	1,70
	35	42					27,80	3,10
	50	60					38,28	4,30
70	20	17,1	0,65	0,105			13,34	1,40
	35	30,0					23,40	2,20
	50	42,9					33,46	3,20
100	20	12	0,79	0,110			10,27	1,10
	35	21					17,98	1,60
	50	30					25,68	2,20

The speed of the vehicles travelling on the opposite lane v_c=70 km/h

3. Flicker dose

due to vehicles traveling in the same sense

$$f_a = \frac{v_a - v_s}{d_a}, Hz$$



Flicker dose due to vehicles traveling in the same sense for the situation v_a=90 km/h and d_a= 70 m

Table 3

Traveling speed v_s, km/h	Traveling distance, km	Traveling time, min	fluctuations frequency, Hz	Equalization coefficients, g_f	δL, %		Flicker dose, $(\%)^2$min	
					δL_{Mm}	δL_{mM}	calculated	admitted
40	20	30	0,71	0,107	9,55	10,6	69,9	2,20
	30	45					104,9	3,30
	40	60					139,9	4,30
50	20	24	0,57	0,097			46,0	1,70
	30	36					69,0	2,70
	40	48					92,0	3,45
60	20	20	0,43	0,082			27,4	1,55
	30	30					41,1	2,20
	40	40					54,8	3,00

CONCLUSIONS

• The discomfort caused by the flicker is felt at the level of the human brain, based on the variation of the visual perception received by the human eye;

• the **definition of the luminance fluctuations amplitudes**, given in the paper [4], takes into consideration the essence of the flicker phenomenon;

• three **causes of the flicker** on roads have been indicated: one due to the lighting system, one due to the vehicles traveling in the opposite sense and one due to the vehicles traveling in the same sense;

• the **experimental data** indicated that the luminance fluctuations amplitudes are a few times higher than the admissible values, as they were set in standards;

• the **flicker dose** calculated for the three situations is also out of admitted limits set in regulations;

•the responsible authorities must to take **appropriate measures** in order to lower significantly the flicker on roads, during nighttime.

Thank You!

Happy anniversary !