Results of luminance measurements of roads at dry, wet and snowy surface

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Introduction

The priority now is saving energy resources and in the context of the conservation funds. To this is using various tools for example, energy labeling. Main task is to enable operators and users to decide for technology in energy intensity. The same trend can be observed also in lighting.
Significant potential savings are hidden in the operation of public lighting networks. It is possible to apply the newer and more efficient technology reducing energy consumption but also can achieve significant savings with management. For designing the control and regulation is required to comply with the requirements and the proposal should be implemented by experts in the field.
Unauthorized intervention in order to save funds, can lead to inappropriate solutions such as switching off every other lamp or the entire system after midnight. Voltage regulation without observance the minimum luminance and illumination intensity is also unacceptably. These and similar solutions are to the detriment of road safety and people.

The most of cities of Slovakia has upgraded street lighting and therefore is focused for solutions to optimize the management. Possible solutions for rational savings without changing the lighting system is the regulation of old lighting system. Current technology are allowed secure control of two basic ways. Central control and individual control in the lamp. Each method has some advantages and disadvantages. Voltage regulation respectively regulation luminous flux is based on the requirements imposed by the user. Exact values are defined in the enacting legislation. For public lighting is mainly about standard EN 13 201th. During the running time of public lighting can occur the regulation, which takes into account the change in external conditions. In order to most effectively use the controller, we proposed several methodologies, which have reduced energy consumption. It was also about regulating, which reflected maintenance factor.
At present, the data for a methodology of management control are collected, which taking into account the road surface. It means, that lighting controller would get the information about weather impact (snow at the road, wet road…) and based on the proposed algorithm would occurred regulation of voltage and luminous flux too. The proposal of such a methodology need mapping the current situation and impact. That is why the measurements on selected roads were made and results of measurements are described in details. The report is the backround for another analysis and also regulation according to the status of the road. In particular the proposal there is necessary to account a huge amount of factors, which influence last application such as the luminance of the backround, colour of the light and so on.

Measurement of luminance on the roads

Measurements has begun in 2013 and not all impacts would be evaluated already. At present are analyzed measured values and in contribution are described just selected measurements. There was analyzed 3 roads in Bratislava (Slovakia).
Measuring was realized luminance analyzers TechnoTeam:

- LMK 98-4 color
- Canon E350D

Measurements was realized in accordance with the document CIE 140, where is described measurement methodology. All evaluated routes have one lane for one traffic direction and unilateral lighting system. Analysator (observer) was located 60 m from measured field. in the middle of driving lane and 1,5 m over roadway.

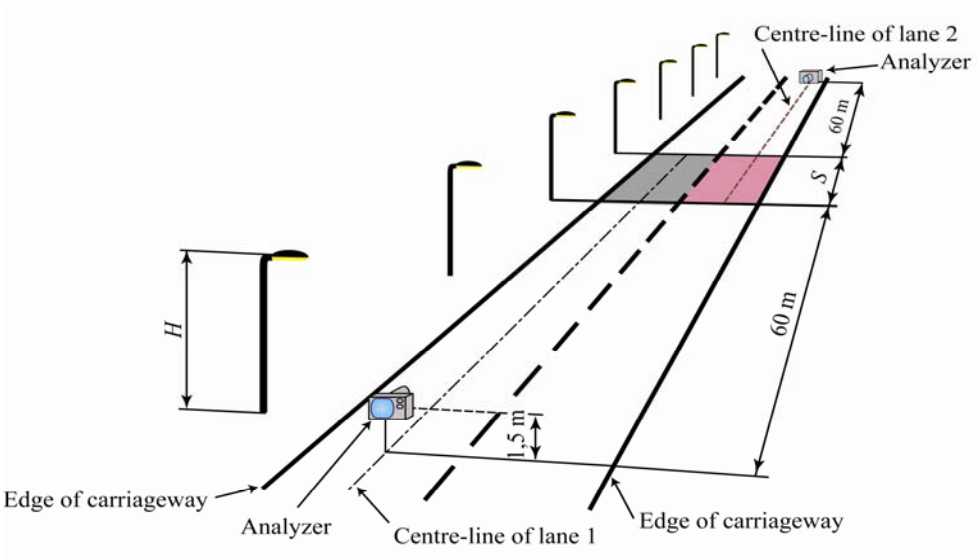

Fig.1. Situation in measurement of luminance

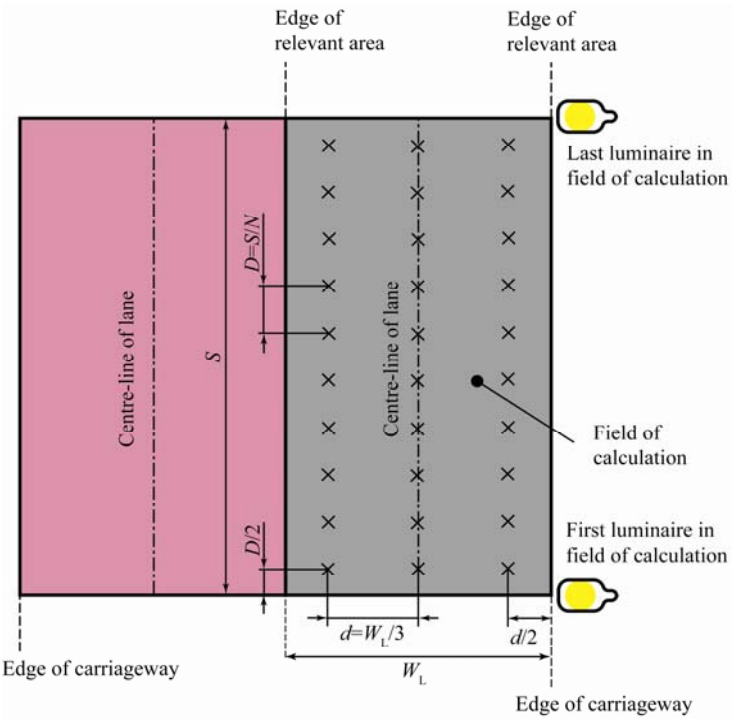

Fig.2. Layout of measuring points in the analyzed field

Analyzed roads belongs to ME5 class. For purpose of study was chosen roads with low traffic. Characteristics and light requirements for ME/MEW classes results from standard EN 13 201-2.

Table 1. The parameters of roads

Street parameters	**Street**		
	Žižkova	**Ilkovičova**	**FIIT**
Width $2W_L$ [m]	4,8	6,9	5,8
Distance between two poles S [m]	30	25	30
Luminaire mounting height H [m]	6	5,5	5,5
Overhang [m]	0,7	1,2	0,5
Network parameters	**Street**		
	Žižkova	**Ilkovičova**	**FIIT**
Voltage U [V]	227	224	219
Date and time of measurement	11.12.2013, 18:20	11.12.2013, 19:00	11.12.2013
Temperature [°C]	-1°C	-1°C	-2°C
Lamp parameters	**Street**		
	Žižkova	**Ilkovičova**	**FIIT**
Producer	Siemens		Elektrosvit
Type	Siteco		OP OPAL
Light source wattage [W]	70	70	125
Light source	Highpressure sodium	Highpressure sodium	Highpressure mercury

Ziskova street is located on the estate among residential houses with low speed of cars, where the cyclists and pedestrians move.
Ilkovičova street is located in the proximity of the Faculty of electricial engineering and informatics in Bratislava, which is primary designed for cars, but there is also increased movement of people and cyclists. The street headed to the FIIT is the access road to the parking a lot, where the cyclists and pedestians move.

Measurement results

The measured values show an increase of luminance in snowy conditions. Differences may arise from inequalities of snowy conditions. Snow was parted out but were there slight ripple. Another effect, that is complicate to evaluate in measurement is luminance of surrounding building and from public lightning. Even though was choosen roads with consideration to eliminate effect of surrounding lightning and luminance from surrounding objects, was impossible completely eliminate this impact. One of the reason is that public lighting was measured in town and next reason is that public lighting is not located separated but is part of public lighting nets.
The most essential impact of surrounding luminances is in snowy countryside. Reflections are significants from snow on trees or on parked cars near the road.
It is also necessary consider the impact of power supply.

Since the time difference between the measurements was less than half a year, was maintenance factor negligible.

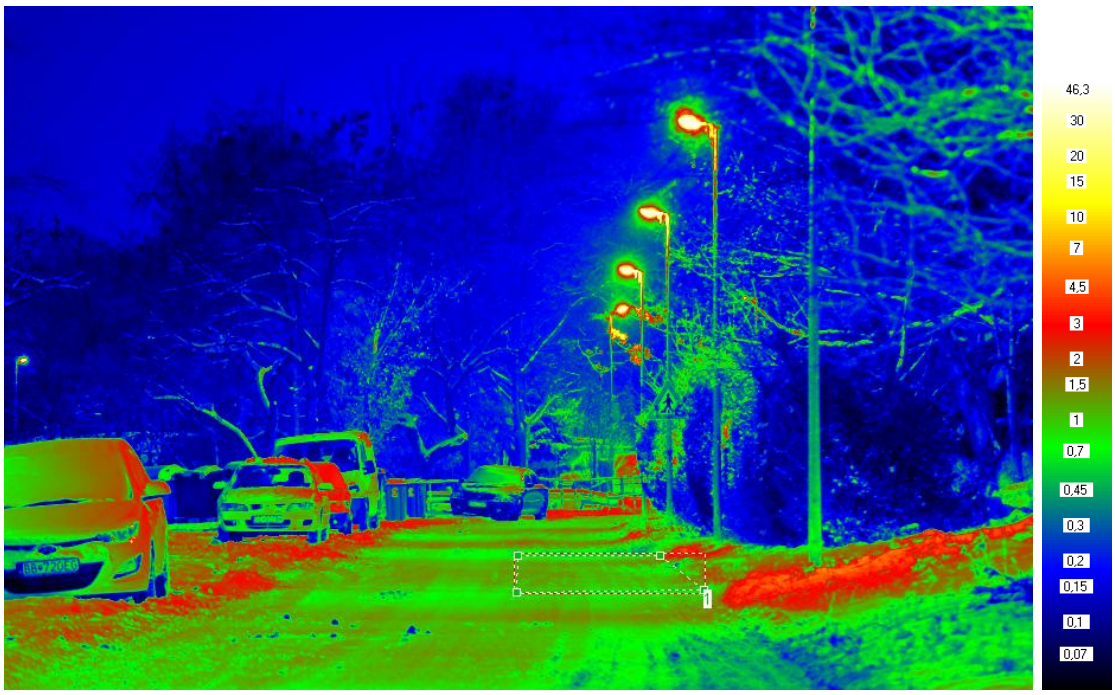

Fig.3. Luminance analyzed of snowy street(Žižkova)

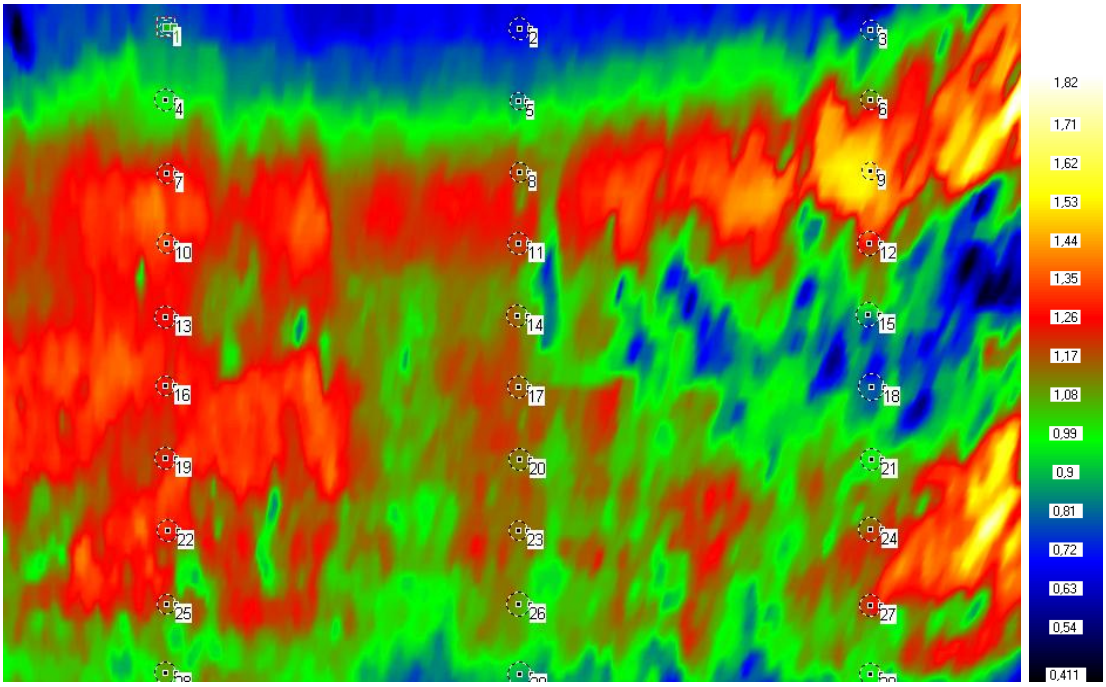

Fig.4. Layout of measuring points in the analyzed field (field analyzed from the perspective of te observer was reflected in a rectangular shape)

All roads had spacing of masts 30m or less, grid has only 30 of analyzed points. For all cases was points deployment in grid the same. Changed was only spacing.

Table 2. Measured values

	Žižkova				Ilkovičova			
	Road line 1		Road line 2		Road line 1		Road line 2	
Measured point	Luminance L [cd/m2] Dry	Luminance L [cd/m2] Snow	Luminance L [cd/m2] Dry	Luminance L [cd/m2] Snow	Luminance L [cd/m2] Dry	Luminance L [cd/m2] Snow	Luminance L [cd/m2] Dry	Luminance L [cd/m2] Snow
1	1,081	0,807	0,5322	0,634	0,2221	0,7352	0,5766	0,6173
2	0,7528	0,6751	1,29	0,7802	0,2089	0,7721	0,4753	0,7266
3	0,9118	0,771	0,4077	1,409	0,1781	1,438	0,3837	0,893
4	1,167	0,9699	0,7654	0,744	0,2621	0,784	0,5766	0,5816
5	0,7308	0,859	1,33	0,9007	0,2275	0,7796	0,4735	0,7102
6	0,9547	1,141	0,4959	1,184	0,1783	1,148	0,3758	0,9449
7	1,219	1,258	0,9878	0,974	0,2678	0,8025	0,4255	0,5443
8	0,8029	1,167	1,402	1,007	0,2393	0,8725	0,4954	0,8194
9	0,9525	1,509	0,7025	1,339	0,1786	1,279	0,376	1,334
10	1,176	1,326	1,281	1,248	0,2754	0,9257	0,4592	0,5499
11	0,7799	1,204	1,395	1,405	0,2427	0,9165	0,5291	0,8388
12	1,034	1,252	0,8158	1,528	0,1846	0,9902	0,3675	1,407
13	1,071	1,261	1,377	1,686	0,2718	0,8674	0,4528	0,5726
14	0,8564	1,133	1,452	1,756	0,2397	0,8963	0,5154	0,8274
15	1,002	0,8984	0,9496	1,428	0,1882	0,9035	0,3479	0,7187
16	1,028	1,254	1,282	1,743	0,2702	0,8457	0,5632	0,5458
17	1,079	1,161	1,31	1,575	0,2359	0,8848	0,4592	0,6984
18	1,106	0,793	0,8632	1,256	0,1837	0,7407	0,3105	0,5255
19	0,9793	1,243	1,149	1,431	0,2747	0,7844	0,5524	0,5606
20	1,046	1,132	1,173	1,352	0,235	0,7722	0,4088	0,7132
21	1,142	0,9914	0,8079	1,01	0,1862	0,8574	0,3074	0,5992
22	0,8964	1,29	1,072	1,062	0,2807	0,7457	0,5237	0,6083
23	0,7302	1,145	1,095	0,9931	0,235	0,686	0,3941	0,5506
24	1,079	1,17	0,9226	1,063	0,1923	0,6362	0,3065	0,7454
25	0,8263	1,17	1,023	0,8679	0,2915	0,4929	0,5261	0,7409
26	0,6656	1,085	1,006	0,9271	0,2364	0,6543	0,4013	0,6361
27	0,9914	1,225	0,8157	0,7268	0,1974	0,5785	0,3143	1,013
28	0,8366	1,065	0,9634	0,7044	0,2985	0,5579	0,5292	0,7992
29	0,6766	0,8973	0,9946	0,9657	0,241	0,6215	0,4385	0,7973
30	0,7478	0,9814	0,7268	0,8849	0,2057	0,6309	0,3514	1,019

Communication FIIT was illuminated with diffuse lighting sphere. Impact of reflections from nearly objects is therefore significant. On one side of the road were planted trees and while measuring dry conditions have had a dense tree crown from which substantially reflects light. While measuring achievable on a snowy road was a tree without leaves, and therefore reflections from a tree in winter were significantly lower.

Table 3.Measured values

FIIT				
	Road line 1		Road line 2	
Measured point	Luminance L [cd/m2]	Luminance L [cd/m2]	Luminance L [cd/m2]	Luminance L [cd/m2]
	Dry	Snow	Dry	Snow
1	0,3357	1,828	0,2006	1,629
2	0,2913	1,98	0,1763	1,378
3	0,2113	1,935	0,1592	1,28
4	0,2848	1,874	0,171	1,639
5	0,2534	2,056	0,1513	1,313
6	0,1707	2,051	0,1514	1,473
7	0,2618	1,898	0,1425	1,306
8	0,2139	2,022	0,13	1,011
9	0,1526	1,597	0,1369	0,8402
10	0,256	1,708	0,1272	1,218
11	0,2151	1,801	0,1113	0,8898
12	0,1545	1,54	0,1199	1,102
13	0,2956	1,641	0,1163	1,163
14	0,2454	1,654	0,1059	1,135
15	0,1761	1,794	0,1089	0,9596
16	0,3304	1,586	0,1168	1,21
17	0,2957	1,383	0,1045	1,087
18	0,224	1,009	0,1057	1,099
19	0,345	1,393	0,1231	1,129
20	0,3076	1,356	0,1045	1,206
21	0,2418	1,731	0,1066	1,288
22	0,341	1,045	0,1332	1,587
23	0,2885	1,533	0,1219	1,21
24	0,244	1,699	0,1118	1,359
25	0,2976	1,249	0,152	1,393
26	0,2313	1,382	0,1351	1,325
27	0,1962	1,124	0,12	1,396
28	0,2648	1,272	0,1564	1,459
29	0,2083	1,395	0,1431	1,476
30	0,1677	1,754	0,1324	1,295

Conclusion

The contribution describes the impact of snowy and wet road to change luminance. Impact is shown by measurements that was made on chosen roads. There is no attempt to quantify change luminance but to show how conditions change when you change the properties of roads. Precise quantification would require deeper analysis and comprehensive consideration of numerous factors such as the background luminamce, temperature, etc. Accurate analysis would require an assessment of the impact of light colors. The measurements serve as a basis for further analysis and public lighting control options, depending on external factors. The results of the analysis of wet road were not

included because the processing error occurred. Further analysis should take into account the impact of snowfall or rain.

Acknowledgement

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References

[1] EN 13201-1 Road lighting – Part 1: Selection of lighting classes

[2] EN 13201-2 Road lighting – Part 2: Performance reguirements

[3] CIE Publication 140:2000 Road lighting calculations