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INTELLIGENT ROAD LIGHTING AND EFFECTS OF WEATHER CONDITIONS ON ROAD LUMINANCES.

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Background

Road lighting is an effective tool in providing efficient and safe traffic movement and making driving conditions more comfortable. So far, the road lighting intensity has mostly been based on standardized lighting classes, using only one static lighting level (e.g. 2,0 cd/m², 1,5 cd/m², 1 cd/m² or 0,5 cd/m²). However, the actual intensity of road lighting is very dynamic and instable and depends on many external factors such as ambient brightness, weather conditions etc. Far too often during night time the intensity of road lighting is excessive in relationship to the actual need. Recent increases in the cost of electrical energy have caused actions to minimize energy costs. Activities of technological research and development have been carried out in order to find solutions and coherent guidelines for intelligent road lighting. The main purpose of an intelligent lighting system is to save electricity without adversely affecting either safety of driving or quality of road lighting.

Objectives of the work

This paper focuses on road lighting dimensioning and lighting quality of traffic lighting. The work sets out to investigate the factors that are important in creating optimal and energy-efficient intelligent road lighting system. Dynamic road lighting is being optimized by taking different weather circumstances and their effects on road luminances into account. The work also introduces a new method for road luminance measurements and analysis. The work is part of a current research project “ValOT” carried out by HUT Lighting Laboratory.

Road lighting luminance measurements with a CCD photometer

Luminance measurements of road lighting are needed to get data from the field and analyze the luminous environments from the driver's point of view. Road luminance measurements are also a way to secure the quality of road lighting. Conventionally, road lighting measurements have been done with spot luminance meters. In this work road lighting luminance measurements were made with a luminance photometer ProMetric 1400, which offers new ways to measure and analyze lighting conditions in night-time traffic.

Road lighting calculations and measurements in Europe follow the European standard EN 13201-3. Measuring road luminance with conventional spot meters is however troublesome and time consuming to conduct, because there are usually hundreds of luminance points to be measured. With the conventional luminance measurement system some details can also escape from the analysis or positional errors can appear. With a CCD-based luminance photometer the road lighting measurements become more accurate and faster, and the measurement system offers new possibilities in data analysis. The luminance photometer also gives significantly more measurement information than the conventional spot luminance meter.

At HUT Lighting Laboratory a new computer program Road LumiMeter has been developed for road lighting measurements. It calculates the road lighting parameters from the photometer’s measurement results according to the European standard EN 13201-3. The photometer’s numerical data can be imported into the Road LumiMeter and all calculations of quality characteristics can be made.

Intelligent road lighting

Intelligent road lighting system has been installed on two highway sections in Finland: VT1 between Kolmperä and Lohjanharju and Helsinki Ring Road III near Tikkurila. The pilot section on VT1 is 17 km long and altogether 807 luminaires (HPS and MH lamps) are controlled via the intelligent road lighting system. Ring Road III section is 4 km long and consists of 492 luminaires (HPS lamps). The system collects traffic, weather and luminance information and controls road lighting based on received data.

The objective of intelligent road lighting is to provide road lighting that is dynamically adjusted to the prevailing circumstances, so that an appropriate lighting intensity is chosen. The lighting class with performance requirements is specified in relationship to the functional class of the road and the average daily traffic. During night time the average luminance varies depending on the actual status of traffic conditions and luminance levels of the road surface. Practical control is based on real-time measurements of luminance (luminance meter) and traffic flow (vehicles/5 minutes). Luminance meters monitor the luminance level on the road surface and compare it to the required level. The control system tries to keep the luminance level of the roadway constant.

With this kind of intelligent road lighting system it is possible to achieve considerable savings in energy costs without decreasing the quality of road lighting. The first trial experience has been promising and has shown that the lighting control system is beneficial even though some challenges remain.

Measuring effects of weather conditions on road luminances.

Luminance levels of road surfaces are usually very dynamic and depend to large extent on weather conditions. In this work road lighting measurements are made to study the choice of the luminance levels during different states of weather. Through the measurement results, weather effects on road luminances can be investigated and taken into account. Measurements are made in several pilot locations including VT1. Pilot locations are measured exactly in the same way during different seasons and weather conditions (dry, wet, snowy) so that comparative research can be done. All measurements are made using the luminance photometer ProMetric 1400 and the computer program Road LumiMeter.

The measurement experience has so far shown that by taking weather effects on road luminances into account there is a lot of potential to achieve considerable energy savings. For example in Finland during wintertime luminance levels are usually far too excessive in relationship to the actual need because of the snow. When road surface is very snowy luminances are even four, five times higher than in dry summer conditions. And even if there is a minor amount of snow and snow clearance is done, luminance levels are still about 50 % higher than without any snow. In the case of wet surface, luminance levels are also higher than in dry conditions whereas luminance uniformities are usually lower.

Dimensioning and investigating different weather circumstances and their effects on road luminances offer new ways to optimize intelligent traffic lighting and to make it more efficient. With an effective control system and real-time measurements, luminance levels can be reduced without adversely affecting the quality of road lighting.