METHODOLOGY FOR MEASURING TRAFFIC SIGNS RETROREFLECTION

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Abstract

Increase of traffic congestion and speed, as a result of the development of modern society require high-quality solutions in the field of traffic signalization. Modern traffic signalization needs to enable right decision making in order to secure a safe and optimal traffic flow. One of the key elements of traffic signalization is timely detection which, followed by reading and understanding its meaning, allows drivers to make proper response in accordance with the requirements of the situation. Quality solutions in the field of traffic signalization, especially traffic sings, can be achieved with relatively small investments through application of modern technologies and continuous inspection and maintenance. Important element of traffic signs maintenance is their retroreflectivity measurement. In order to ensure a satisfying level of retroreflection, continuous measurements in accordance with prescribed standards and technical requirements, should be carried out. The aim of this paper is to analyze the importance of traffic sings retroreflection measurement as a part of standard maintenance program in order to increase road safety.

Keywords: Traffic sings, retroreflection, traffic safety

Introduction

Roads must be equipped with adequate traffic signs that warn road users about potential danger and threats that are in users near distance, providing them with clear information's about limitations, prohibitions and obligations which must be respected. Sign information can be conveyed through the legend, which can be compromised of words, symbols, and arrows. Roadway users can also extract information from a sign's unique appearance as size, color, and shape are critical components.

In road traffic, the impact of direct information is of the greater importance than in other traffic modes due to the large number of participants, the intensity of traffic flows and participant's individual decision making in different situations, either as a driver of the vehicle or pedestrian.

It has been scientifically proven that with a use of modern technologies and proper implementation of traffic signs, a significant impact on the traffic flow of the entire network, enhancement of traffic safety and motivation of road users to cooperate can be achieved.

Quality of traffic signs is especially important in night and in conditions of difficult or poor visibility. In these conditions there is very little light available and overall visibility is decreased which directly impacts traffic safety and traffic flow.

In order to perform its task properly, traffic signs retroreflection and visual inspection should be performed at least once a year. For the measurement of retroreflection portable or mobile retroreflectometers are used. Portable retroreflectometers contains an internal light source and photoreceptors and relies on the method of substitution calibration.

This paper will analyze the importance of traffic sings retroreflection measurements and give guidelines for this type of measurements with the examples of measurements conducted in Croatia.

Definition and basics of traffic sings retroreflection

The only way an object on the road is visible at night is if it is artificially illuminated or if part of light that falls on the object is reflected back to the driver's eyes. The amount of light entering driver's eyes from a certain object will have a great impact on how bright that object appears to the driver. At night, light comes from sources such as streetlights or vehicle headlights. In areas without streetlights, the vehicle is the only possible light source. Because the light from a vehicle is generally aimed in a downward direction, little light is directed upward towards traffic signs. With so little light directed at them, traffic signs must be very efficient at returning light back to the vehicle and driver so they can be visible. This property of returning light back to the source is called retroreflectivity.

From all of the above, retroreflection can be defined as a phenomenon of light rays striking a surface and being redirected back to the source of light[10]. Principle of retroreflection in shown in Figure 1.

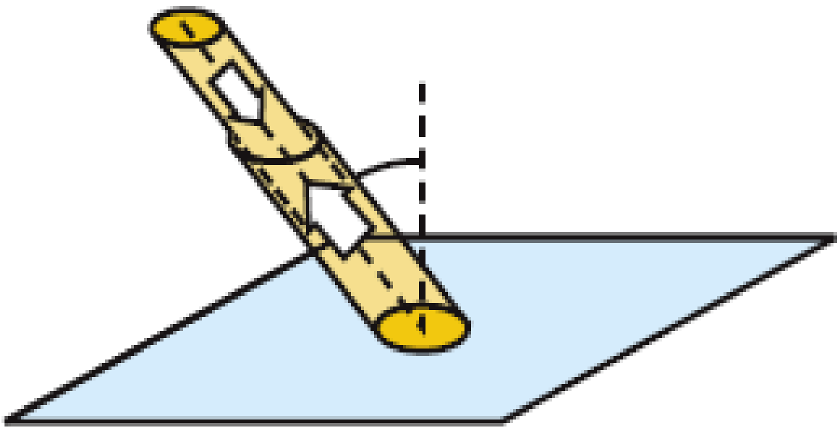

Figure 1. Principle of retroreflection
Source: http://www.roadvista.com/retroreflection/ (19.11.2013.)

Retroreflectivity of traffic signs is achieved by specially manufactured materials or sheeting's that are applied on the traffic signs face. Today, three types of retroreflective materials for traffic signs are used:

a) Materials class I

Materials class I are retroreflective sheeting's made of a durable material with the bounded glass micro beads or prisms. Retroreflection of materials class I with glass micro beads is about 70 $cd \cdot lx^{-1} \cdot m^{-2}$ and because of its low retroreflection it is in most cases used in areas with low-speed and calmer traffic flow. Materials class I that have bounded micro prims have significantly higher retroreflection (around 200 $cd \cdot lx^{-1} \cdot m^{-2}$) than materials with glass micro beads.

b) Materials class II

Materials class II are retroreflective sheeting's that contains encapsulated glass micro beads or prims that are three times brighter than materials class I. The signs made from materials class II are clearly visible, even from a wide viewing angle, and the lighted environment, effectively warning drivers of approaching danger on the roads. Retroreflection

[10] http://www.roadvista.com/retroreflection/ (19.11.2013.)

of materials class II with glass micro beads is around 250 $cd \cdot lx^{-1} \cdot m^{-2}$ and 500 $cd \cdot lx^{-1} \cdot m^{-2}$ for materials with micro prisms.

c) Materials class III

Materials class III are retroreflective sheeting's that are made of highly effective micro prisms that enables retroreflection around 700 $cd \cdot lx^{-1} \cdot m^{-2}$. Therefore, they provide the drivers with adequate visibility in all day and night and adverse weather conditions.

There are several types of reflective materials class III:

- V.I.P. (Visual Impact Performance) - enables maximum efficiency over short distances and is ideal for signs in city traffic.
- L.D.P. (Long Distance Performance) - developed specifically for the use on motorways and main roads and, therefore, the signs made from these materials are visible from greater distances.
- Fluorescent - provides increased visibility during the day, not just at night, with a usage of fluorescent dye.
- Diamond Grade Cubed - combines the best features of VIP and LDP so it can be used either in the city or on the highways.

Methodology of traffic signs retroreflection measurement

As mentioned before, traffic signs should be inspected at least once a year to verify their retroreflection properties and quality. For the measurement of retroreflection handheld or mobile (dynamic) retroreflectometers are used.

Mobile retroreflectometers for measuring traffic sign retroreflectivity is highly advanced and automated system which represents a new technology which is still in the testing phase. System is equipped with high sensitivity cameras installed onboard which measures the luminance[11]. The response curve of the cameras is equivalent to the human eye and allows luminance measurement consistency. Also, cameras are geometrically calibrated to measure distances and dimensions together with the multiple sensors onboard[12].

With a further development of mobile retroreflectometers could provide the following advantages[13]:

- measurements could be made while driving down the highway and therefore no equipment would have to be in contact with the sign
- measurements would be made at real roadway geometries rather than prescribed geometries that do not always represent the real world
- twisted and leaning signs would be measured as seen from the roadway perspective and can be easily identified as needing routine maintenance
- images of signs could be recorded at highways speeds, although post-processing the images would be needed, this would minimize the exposure and risk of the technicians
- all signs can be measured, including overhead and difficult-to-reach shoulder mounted signs
- using image analysis, the entire retroreflective area of the sign can be measured rather than a few 1-inch diameter areas.

Because the mobile system is still in the testing phase, for the measurements of traffic signs retroreflectivity, handheld retroreflectometers are used. There are several types of these instruments depending on manufacturer: Zehntner ZRS 6060, Delta RetroSign, Road Vista 922 etc.. These instruments, in the measuring process, are placed on the surface of the sign in

[11] Luminance - the quantitative measure of brightness of a light source or an illuminated surface, equal to luminous flux per unit solid angle emitted per unit projected area of the source or surface

[12] Carlson, P.: Evaluation of sign retroreflectivity measurements from the advanced mobile asset collection (AMAC) system, Texas Transportation Institute, Texas 2011.

[13] Ibidem

order to exclude the impact of daylight and the measuring method is based on substitution calibration because of which they need to be regularly calibrated.

Instruments have a internal light source that corresponds to the standard source A according to CIE-in, and photoreceptor that have a spectral sensitivity that fits standard photo-optical observer according to CIE[14]. Geometry should be selected so that it corresponds to the values that are listed in national specifications which in the European specifications means observation angle of 0.33° and the entrance angle of 5° (Figure 2.).

Entrance angle is primarily determined by the position of the sign in the edge of the road and geometry of an oncoming vehicle and it is formed between a light beam that falling on the surface of the sign and the line that comes out vertically from the surface. Observation angle is the angle between the incoming light beam and reflected light beam and it is a function of the height of driver eye compared to the vehicle headlights. As it is assumed that most of the retroreflection materials reflects light directly back to the source, the optimal observation angle is zero. However, in reality it is not so considering that the driver's eye is higher than the vehicle headlights[15].

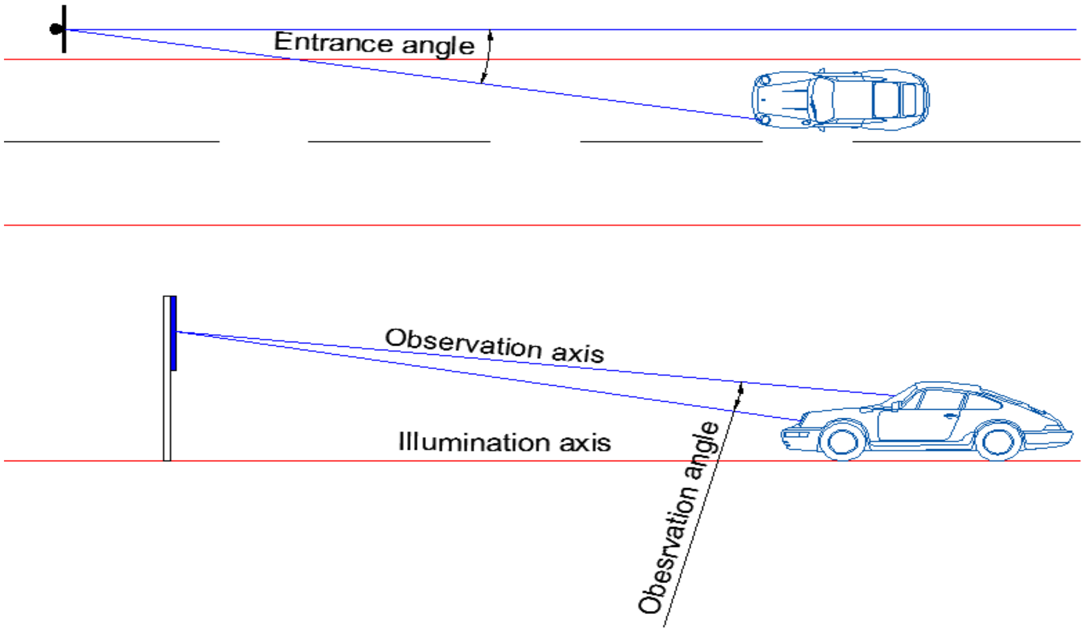

Figure 2. Entrance and observation angle for a traffic sign

Source: Ščukanec, A., Krleža, J., Vidović, T.: New software for testing the quality of road signs, Planning and development of sustainable transport system, Zagreb 2013., ISBN 978-953-243-064-6

Minimum initial coefficient of retroreflection R_A (cd•lx^{-1}•m^{-2}) of traffic signs measured in accordance with the procedure using CIE standard light source A, must match the values in Table 1., 2. and 3.

Table 1. The coefficient of retroreflection R_A: Class I units cd•lx^{-1}•m^{-2}

Geometry of measurement		Color							
α	β1 (β$_2$=0)	white	yellow	red	green	blue	brown	orange	gray

[14] CIE, Meintained Night-time Visibility of Retroreflectivity Road Signs, Brussel, 1995

[15] Ščukanec, A., Krleža, J., Vidović, T.: New software for testing the quality of road signs, Planning and development of sustainable transport system, Zagreb 2013., ISBN 978-953-243-064-6

12´	+5° +30° +40°	70 30 10	50 22 7	14.5 6 2	9 3.5 1.5	4 1.7 0.5	1 0.3 #	25 10 2.2	42 18 6
20´	+5° +30° +40°	50 24 9	35 16 6	10 4 1.8	7 3 1.2	2 1 #	0.6 0.2 #	20 8 2.2	30 14.4 5.4
2´	+5° +30° +40°	5 2.5 1.5	3 1.5 1.0	1 0.5 0.5	0.5 0.3 0.2	# # #	# # #	1.2 0.5 #	3 1.5 0.9

# Signifies "Value greater than zero but not meaningful or not applicable " 	
α = observation angle ; β = entrance angle									

Source: EN 12899-1: Fixed, vertical road traffic signs - Part 1: Fixed signs, 2008.

Table 2. The coefficient of retroreflection R_A: Class II units $cd{\bullet}lx^{-1}{\bullet}m^{-2}$

Geometry of measurement		Color								
α	β1 (β_2=0)	white	yellow	red	green	dark green	blue	brown	orange	gray
12´	+5° +30° +40°	250 150 110	170 100 70	45 25 15	45 25 12	20 15 6	20 11 8	12 8,5 5,0	100 60 29	125 75 55
20´	+5° +30° +40°	180 100 95	120 70 60	25 14 13	21 12 11	14 11 5	14 8 7	8 5 3	65 40 20	90 50 47
2´	+5° +30° +40°	5 2,5 1,5	3 1,5 1,0	1 0,4 0,3	0,5 0,3 0,2	0,5 0,3 0,2	0,2 # #	0,2 # #	1,5 1 #	2,5 1,2 0,7

# Signifies "Value greater than zero but not meaningful or not applicable " 	
α = observation angle ; β = entrance angle										

Source: EN 12899-1: Fixed, vertical road traffic signs - Part 1: Fixed signs, 2008.

Table 3. The coefficient of retroreflection R_A: Class III units $cd{\bullet}lx^{-1}{\bullet}m^{-2}$

Geometry of measurement		Color					
α	β1 (β_2=0)	white	yellow	red	green	blue	orange
10´	+5° +20° +30°	850 600 425	550 390 275	170 120 85	85 60 40	55 40 28	260 130 95
20´	+5° +20° +30°	625 450 325	400 290 210	125 90 65	60 45 30	40 30 20	140 100 70

33′	+5° +20° +30°	425 300 225	275 195 145	85 60 45	40 30 20	28 20 15	95 65 49

# Signifies "Value greater than zero but not meaningful or not applicable " 	
α = observation angle ; β = entrance angle							

Source: EN 12899-1: Fixed, vertical road traffic signs - Part 1: Fixed signs, 2008.

Current practices of traffic signs retroreflection measurement and maintanance in Croatia

In the Croatia, traffic signs retroreflection measurements are conducted by the Department for Traffic Signalization at the Faculty of Transport and Traffic Sciences for more than ten years. In the capital city of Croatia, Zagreb, traffic signs were measured on all newly constructed roads in the least ten years for clients like Zagreb Roads d.o.o., Viadukt d.d., Hidroelektra d.o.o., etc. Measuring retroreflection of road signs have been carried out also on state roads for Croatian Roads d.o.o. and on some county roads for County Roads Administration[16].

Measurements are conducted using handheld retroreflectometer Zehntner ZRS 6060 in accordance with the European and National standards and specifications. When measuring retroreflection each sign is measured four times: up, down, left and right. The relevant value of retroreflection represents the average values of all four measurements. Except the retroreflection value, several other elements are analysed:

- sign name and code
- graphic display (sign picture)
- dimension and height and distance from the edge of sign
- colours of surface, edge and symbols
- way the sign is implemented and fixed
- information about the producer of sign
- retroreflective material etc.

For the maintenance purposes, Department for Traffic Signalization, have developed online based software “Retrorefleksija” which consists of two fields: road markings and traffic signs.

Field traffic signs allows clients easy and quick overview of retroreflection measurements conducted by the Department. Data access is possible with the user name and password that is assigned to the authorized personnel involved in the process of traffic sign maintenance. The aim of the software is to provide a data base of traffic signs on particular road and clearer overview of measured values.

Data base provides personnel’s involved in the sings maintenance with the inside view into the state of traffic signs on specific road enabling them to optimize whole maintenance process which as a result should have increase of road safety and decrease of maintenance costs. Optimization is achieved by prioritization of maintenance, optimization of replacement of existing sings, reviewing “black spots” or critical places on the road and by enabling the authorities to create a long and short term maintenance plan.

[16] Shcukanec, A., Krleza, J., Vidovic, T.: New software for testing the quality of road signs, Planning and development of sustainable transport system, Zagreb 2013., ISBN 978-953-243-064-6

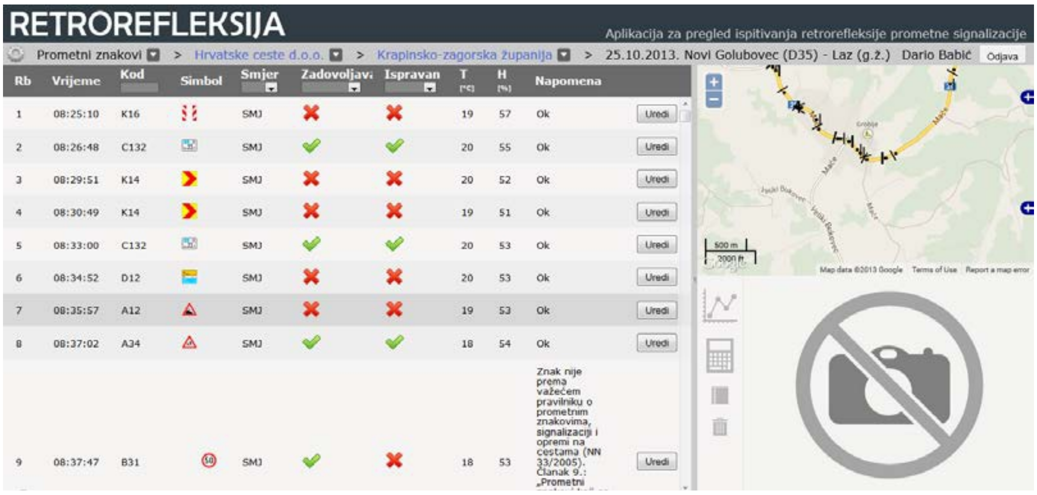

Figure 3. Data base of traffic signs in software ''Retrorefleksija''
Source: http://ispitivanja.fpz.hr/#!sign-measurement:526f7786e4b0371ab15a7352 (26.11.2013.)

Figure 3. shows a date base of traffic signs on one road in software ''Retrorefleksija''.

Data base includes all sings on road, their retroreflection and technical characteristics, time of the measurement, temperature and humidity, digital map with correct location of the signs etc.. Also, data base provides a picture of the sign when particular sign is chosen for a detailed view as shown on figure 4.

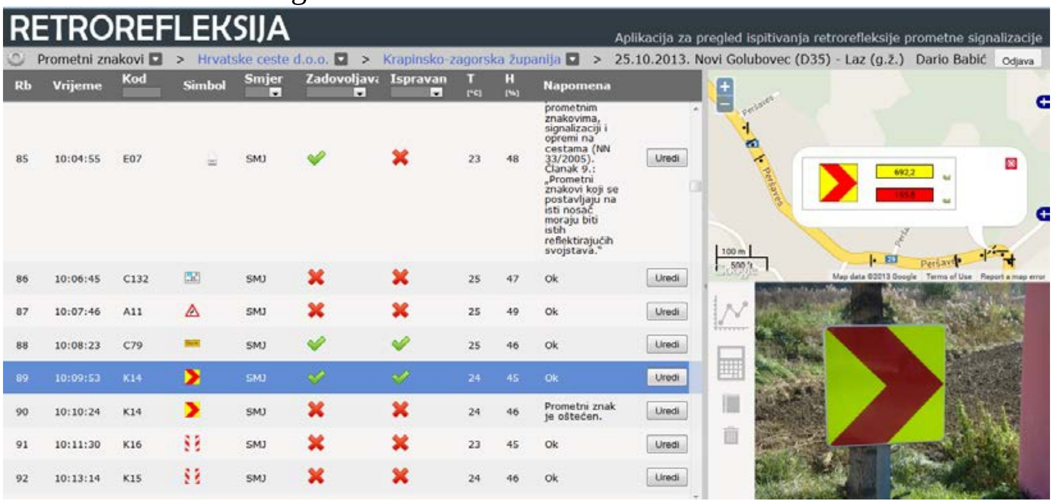

Figure 4. Detailed view of chosen traffic sign
Source: http://ispitivanja.fpz.hr/#!sign-measurement:526f7786e4b0371ab15a7352 (26.11.2013.)

Conclusion

Traffic experts interpreted road accidents as a result of the constant increase in the number of vehicles, a high percentage of defective vehicles in traffic, insufficient traffic culture of road users, lack of road adaptability to the requirements of the modern traffic, inadequate traffic signs and signalization, etc.. Modern road traffic demands safe movement of users under normal circumstances and especially at night and/or in circumstances of reduced visibility. One way to ensure safer road traffic is with implementation of modern and innovative technologies for traffic signalization. Quality solutions in the field of traffic signalization, especially traffic sings, can be achieved with relatively small investments and continuous maintenance.

Traffic signs should be inspected at least once a year to verify their retroreflection properties and quality. For the measurement of retroreflection handheld or mobile (dynamic) retroreflectometers are used. Although mobile retroreflectometers, in theory, have several advantages over handheld due to the lack of practical use and tests handheld retroreflectometers are commonly used in traffic sings retroreflection measurements.

In the Croatia, traffic signs retroreflection measurements are conducted by the Department for Traffic Signalization at the Faculty of Transport and Traffic Sciences for more than ten years. Methodology of measurement is based on the European and National standards and specifications. When measuring retroreflection, each sign is measured four times (up, down, left and right) and the relevant value represents the average values of all four measurements.

To achieve quality level of maintenance, except the retroreflection value, several other elements must be analysed so the data base of traffic signs on a specific road can be created. Data base provides personnel's involved in the sings maintenance with the inside view into the state of traffic signs on specific road enabling them to optimize whole maintenance process which as a result should have increase of road safety and decrease of maintenance costs.

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