International Conference on Traffic and Transport Engineering, ICTTE Belgrade 2012, will be the first conference organized by Scientific Research Center Ltd. and its International Journal for Traffic and Transport Engineering (IJTTE), in co-operation with "Kirilo Savić" Institute, South-East Europe Transport Observatory (SEETO) and Innovation Center of the Faculty of Mechanical Engineering, University of Belgrade. The conference is supported by the Center for the Promotion of Science and Faculty of Transport and Traffic Engineering, University of Belgrade.

For publisher: Dr Srečko Žeželj
Editor in Chief: Dr Olja Čokorilo
Publisher: Scientific Research Center Ltd. Belgrade
Obilićev venac 4/3,
Belgrade, Serbia
Phone: + 381 11 26 23 895
Fax: + 381 11 32 82 076
e-mail: office@ijtte.com
http://www.ijtte.com

ISBN 978-86-916153-0-7
Ladies and gentlemen, distinguished speakers and guests, dear colleagues,

I am delighted to welcome you to Belgrade and to the International Conference on Traffic and Transport Engineering, 2012. It is a pleasure to be here with you today at the beginning of this two-day conference on traffic and transport engineering.

This conference presents the perfect example of globalization in transportation industry. Nothing illustrates this better than the number of papers from more than 20 countries worldwide. I hope that many conclusions made here will be the key drivers of future development in global transport sector for passengers, cargo and infrastructure.

Naturally, we are ready to share our experience of creating what we think is the world's largest and most successful example of transportation industry in all transport modes.

By providing essential transport links, between ourselves, our companies, universities and countries, we are vital part of global community for integrating and connecting regions all over the world.

International Conference on Traffic and Transport Engineering, ICTTE Belgrade 2012, will be the first conference organized by Scientific Research Center Ltd and its International Journal for Traffic and Transport Engineering (IJTTE). My special thanks and encouragement in their work go to our dear colleagues and friends, key speakers, as well as to our partners: City Net Ltd., South-East Europe Transport Observatory (SEETO), "Kirilo Savić" Institute and Innovation Center - Faculty of mechanical engineering, University of Belgrade. And finally, I would like to mention great support from Center for the promotion of science, and Faculty of transport and traffic engineering, University of Belgrade thanks to which we are jointly hosting this conference.

I wish us all fruitful exchanges during these two days; constructive, testing ideas and identification of the steps we will be taking in the future.

Thank you for your attention.

ICTTE 2012 Director

Dr Olja Cokorilo
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IDENTIFICATION OF BEHAVIORAL PATTERNS OF TAXI DRIVERS IN THE CITY OF BOGOTA
ANALYSIS OF THE METHODS FOR TESTING THE QUALITY OF ROAD MARKINGS

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Abstract: Modern traffic demands the safe movement of vehicles under normal conditions and especially at night and in reduced visibility (fog, rain, sleet, etc.). Quality and quantity of participants visual guidance in traffic directly depends on the visibility and the reflective properties of road markings are of crucial importance. Using the latest methods and procedures of testing road markings a high and constant quality level can be achieved, and thus the security level of individual roads can be raised. Road markings are made in accordance with the Regulations on traffic signs and equipment on roads and Croatian and EU standards. One of the most important elements for testing the quality of road markings is testing day and night visibility of road markings. These tests can be done in two ways: method for static test of road markings reflection (daytime and night-time visibility) and dynamic method for testing retroreflection of road markings (night-time visibility).

Keywords: safe, road markings, retroreflection, static method, dynamic method

1. Introduction

Road traffic safety aims to reduce the harms (deaths, injuries, and property damage) resulting from crashes of road vehicles traveling on public roads. Main goal of road traffic safety is protection and security of all those who travel on roads. The reflective properties of road markings are of crucial significance, and represent one of the main factors increasing the safety of participants in road traffic.

Major factors that contribute to the road traffic safety can be grouped in three categories (Dawson, 2007):
- roads
- vehicles
- drivers’ behaviour.

In this paper focus will be on the analysis of the methods for testing the quality of road markings. These methods can be done in two ways: method for static test of road markings reflection (daytime and night-time visibility) and dynamic method for testing retroreflection of road markings (night-time visibility).

Tests are carried to ensure the prescribed quality of road markings are:
- Preliminary examination or testing facilities,
- Your own or running tests,
- Control tests,
- Additional control tests,
- Arbitration tests,
- Tests before the warranty (if the same contract).

In night and in wet conditions, road markings play important role in road traffic safety and because of that different types on road marking have been developed to insure safety.

2. Static method for testing the quality of road markings

Static testing of road markings can be done by using the static retroreflectometer (Fig. 1). Weighing of device is 52x218 mm. The device simulates the visual distance markings on the pavement 30 meters from the eyes of drivers, with an eye height of 1.2 m and 0.65 m height of the lights from the road surface. Daily visibility module Qd is expressed and measured in mcd•m⁻²•lx⁻¹ observed at an angle of 2.29 ° at a distance of 30 m and represents the value of the diffuse scattered light received by the observer. Night-time visibility or value expressed by the coefficient of retroreflection RL and measured in mcd•m⁻²•lx⁻¹. For measurement night visibility device measures retroreflection luminous rays from the study area at an angle of 2.29 °, the input light angle of 1.24 ° and at a distance of 30 m with a low beam. Measurements are performed according to European standards EN 1436, Materials for Road markings- Characteristics required for road users.

² Corresponding author: dario.babic@fpz.hr
Static testing of day and night visibility can be done by two methods: According to "Kentucky" method (old one), and according to new guidelines and technical requirements of the test procedure, i.e. measurement and valuation of derivative road markings shall be carried out in accordance with the German regulation ZTV M 02.

![Device for measuring retroreflection of road markings](source: Prepared by the authors)

### 2.1. Kentucky method

In Kentucky method (Fig. 2), measurements are performed on a single zone of 500 m on each section, where the section is part of the label performed from one team in one day. Start measuring zone is in the first third of the length of the section. In each zone shall be 10 measurements at distances of 50 m. For all 10 microlocation is carried out by three measurements and obtained an average value of these measurements is taken as authoritative. The main disadvantage of this method is that the test is performed only in the first third of the test section, where you cannot get the value of retroreflection of complete testing section.

![Measurement principle according to Kentucky method](source: Prepared and adapted by the authors)

### 2.2. Method in accordance with the German regulation ZTV M 02

ZTV M 02 (FGSV, 2002) includes measuring the thickness of dry paint film, the assessment day and night visibility derived labels in dry conditions, night-time visibility in wet conditions and the slip resistance expressed in units of the SRT and the measurements are carried not earlier than 30 and no later than 60 days after execution road markings.

The scope of measurements of longitudinal labels is determined by the daily execution of the working group that performed on pavement according. In the diary, for section of road that is necessary to assess, must be specified data when the works are executed and with what daily effect (especially for the central and especially for the edge line), and the number of measurement sequences is determined by the following Table 1.
3. Dynamic method for testing retroreflection of road markings (night-time visibility)

Dynamic method for testing retroreflection of road markings involves the measurement of night visibility with dynamic measuring device throughout its length. It can be performed with dynamic retroreflectometer which is installed on a vehicle measuring and thus allows continuous measurement of the night visibility (RI) road markings while driving vehicles.

Principle of measuring visibility at night with dynamic retroreflectometer is the same as in static measuring device, i.e. at measuring the night visibility of the device measures retroreflection of light rays from the study area at an angle of 2.29°, the angle of input light of 1.24° and at a distance of 30 m at short lights. (Fig. 4)

---

**Table 1**

**Number of measurement sequences**

<table>
<thead>
<tr>
<th>The length of longitudinal markings done in one day (km)</th>
<th>The length of the other markings done in one day (m²)</th>
<th>Number of measuring sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>&lt; 120</td>
<td>1</td>
</tr>
<tr>
<td>1 - 5</td>
<td>120 - 600</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 5 - 10</td>
<td>&gt; 600 - 1200</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>&gt; 1200</td>
<td>4</td>
</tr>
</tbody>
</table>

*Source: Prepared and adapted by the authors*

Measurement sequences are selected according to the principle of randomness. Within each segment measuring selects five (5) measuring points (Fig. 3). For full labels longitudinal measurement points are distributed at 100 m in length at equal intervals (beginning, 25 m, 50 m, 75 m in the end). For discontinuous measurement of longitudinal labels are allocated to the middle point of each other full lines. In relation to the Kentucky method, it is possible to take sequence in the end of testing section, and can get a more realistic view of retroreflection on the entire section.

---

**Fig. 3.**

*Measurement principle according to ZTV M 02*

*Source: Prepared and adapted by the authors*

**Fig. 4.**

*Principle of measuring night visibility with dynamic retroreflectometer*

*Source: Prepared and by the authors*
The dynamic retroreflectometer (Fig. 5) has following features (ZTI, 2009):

- Measurement of road markings night visibility \( R_L \) in the day and night conditions
- It is suitable for measuring all kinds of night visibility of road markings, and profiled benchmark to 9 mm
- It is suitable for measuring night visibility in dry and wet conditions
- Has an integrated surveillance cameras, takes pictures automatically every 25 m, and also has the ability of shooting photos manually
- It has a built-in GPS system that captures the movement of vehicles and has sensors for measuring temperature and humidity
- Has the possibility of sending and processing data in a RetroGrabber software package and the ability to switch data into .xls format that allows statistical analysis of measured values.

The Dynamic Retroreflectometer \( R_L \) System consists of several elements that are necessary for operation:

- Measuring head
- Cockpit installation
- Laptop
- Carbox
- Wiring of the car

The laptop is used to operate the measuring system. With its installed Retro-Grabber software it is able to communicate with the measuring head and record measured data to its hard drive. For measuring, the laptop needs to be in the docking station in the car.

Measurements are done in a way that the measuring vehicle moves along the road surface and reads the coefficient of road markings retroreflection along which it moves. Before the measurements it is necessary to select the length of the measurement interval at which the device will measure the average value of each measurement section (i.e. the length of the measurement interval of 100 is set, this means that the device while measuring the shares for every 100 m will give an average value of visibility in this night measurement interval). Our experience shows that the optimal length of measurement interval is 50 or 100 m.
On the Faculty of Transport and Traffic Sciences, specifically in the Department for traffic signalization we have developed the new software (Fig. 6) that will significantly enhance and accelerate the course of preparing reports and interactive viewing the results of measurements.

Main advantages of the newly developed software:
- On-line review of the results on an interactive map, complete with a report made (Fig. 7)
- data entry and data delivery to end user
- eliminating the use of CDs or DVDs that have been used as a medium for the delivery of results
- ability to analyse data from previous years with more recent data
- enter the amount of reconstructed line on a particular road in a given county by the contractor marks on the road
- currently easier business end users with better insight into the current state
- Automatic itinerary (software itinerary creation) in a given county, according to the amount of reconstructed line on a particular road

Fig. 7.
The appearance of the interface after the selected region (county of Zagreb)
Source: Prepared by the authors

4. Comparison of methods for testing the quality of road markings

As already stated, the reflective properties of road markings are of crucial significance, and represent one of the main factors increasing the safety of participants in road traffic. In order to achieve a better quality of road markings, measurements should be done in compliance with internationally recognized methods. Also, methods for testing the quality of road markings must be recognized by the road authorities and in accordance with the technical requirements in each country.

Each of these methods has its advantages and disadvantages and it is on the employer to conduct the measurements by a particular method in accordance with their own needs. However, for the detailed control of road markings quality the best method is of dynamic method. Table 2 shows the main advantages and disadvantages of each method.

Table 2
Advantages and disadvantages of each method for measuring the quality of road markings

<table>
<thead>
<tr>
<th>METHOD</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>KENTUCKY</td>
<td>- enough measurements in the first third of length the section (10 out of every 50 m), which gives a better insight into the quality of the road marking</td>
<td>- only the first third of length of the section is being measured</td>
</tr>
<tr>
<td>ZTV M02</td>
<td>- gives a more realistic picture of the quality of road markings on the entire length of the section in relation to the Kentucky method</td>
<td>- measurement sequences are selected according to the principle of randomness</td>
</tr>
<tr>
<td>DYNAMIC</td>
<td>- measures of night visibility throughout the whole length of the section or road - provides an overview of results in computer application displaying GPS coordinates and pictures from the field</td>
<td>- does not measure day visibility</td>
</tr>
</tbody>
</table>
5. Conclusion

Testing road markings with a measurement vehicle (dynamic method) equipped with dynamic retroreflectometer offers the possibility of obtaining a continuous measurement results for the whole section intended to be measured, in a short time. At the static method Measurement sequences are selected according to the principle of randomness. In the dynamic method selected road section is examined in its entirety while static method tested only selected sequences of selected road.

At the same time, the process of testing, measuring vehicle with dynamic retroreflectometer performs accurately, and disruption of traffic is reduced to a minimum (the operating speed of testing the quality of road markings is 60 km/h). All the above suggests the possibility of systematic testing the quality of road markings on the Croatian roads and getting quality results for individual sections which represents a solid basis for the optimal maintenance plan, and savings in the maintenance of road markings.

The results obtained in tests enable you to:
- efficient maintenance of certain roads,
- review of critical places,
- prioritization of maintenance,
- optimize the order of applying the markings on the roadway.

Using this measurement method it is possible to organize a system of road maintenance, which provides a constant high level of visibility markings on the roadway, which affects the safety of drivers, especially when driving in adverse weather conditions.

From the above it can be concluded that the static methods for measuring the quality of road markings are appropriate for certain quality checks, but for a systematic and detailed analysis and monitoring of the quality of road markings dynamic method should be performed.

References


