



CONDITION ASSESSMENT OF ROAD EQUIPMENT – STATE-OF-THE-ART

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Abstract. Road equipment is used for increasing safety and comfort in traffic. There are 5 main groups of equipment: road lighting, fences and barriers, vertical signs, horizontal signs and traffic signals. Common for all road equipment is that, once they have been installed on the road, the performance must be maintained. Condition assessment is an important tool for determining the maintained degree of performance. Generally, there is a large number of equipment along a road. This means that a measurement method must be fast and practical to use. Even so, not all equipment can be measured, but a sample must be chosen from the population. In other words, condition assessment needs both sampling and an appropriate measurement method. In practice, sampling in-situ can be difficult to perform. Consequently, it might be necessary to deviate from complete randomness when sampling. However, it is important that sampling is carried out in such a way that no systematic errors are introduced. A physical measurement method aimed for condition assessment should preferably be mobile. Unfortunately, only a few mobile methods are described in the literature and, among these methods, solely one physical method has been used for assessment (road marking retroreflectivity characterization). Results from such studies have been published in USA and the Nordic countries. Although the lack of mobile instruments, condition assessments of street lighting, rails, noise shields, glare shields, road signs, raised pavement markers and traffic signals have been documented. Such studies have been carried out using stationary instruments or by a subjective judgement. It is known that quality control improves performance, which has, for example, been documented in a Swedish 6-year study on road markings. Consequently, if checks of road equipment are carried out regularly, there is a reason to believe that this control would improve the road equipment performance, which, in turn, would be a benefit, not only for the road keeper but also the driver. Therefore, development of mobile instruments aimed for all types of road equipment is desirable.

Keywords: road equipment, road lighting, barrier, road sign, road marking, traffic signal, condition assessment, retroreflectivity, visibility.

1. Introduction

For increasing safety, comfort and accessibility, most roads are furnished with different types of road equipment, such as road markings, road signs and street lighting. Generally, immediately after manufacturing, the equipment is tested with respect to appropriate parameters, in order to guarantee that a proper product is delivered. This testing is performed in the factory, and, in some cases, immediately after application. For example, the light distribution of a new armature is checked before delivery and a new road marking after application.

However, after application or set up of road equipment, it is important to check it with regard to short- and long-term performance, which has to be carried out in situ. Generally, such measurements are more complicated and time-consuming compared to laboratory testing. In other words, in most cases it is not realistic to test the population of the equipment, but sampling is necessary.

Sampling of road equipment along a road might be tricky, whilst the sampling procedure must be not only statistical relevant but also practical. In other words, the road keeper must be conscious of the risk of making wrong decision based on sample measurements. Furthermore, the sampling method must be simple enough for use in practice.

The aim of this study was to investigate appropriate physical and statistical state assessment methods described in the literature. In the study, solely methods considered reliable and cost-effective were taken into account.

2. Classification of road equipment

Road equipment can, according to CEN/TC 226 – *Road equipment* (European Committee for Standardization), be divided into 5 groups, which, in turn, can be sub-divided. Furthermore, within each sub-group there can be several different types of road equipment. Table 1 shows main groups, sub-groups and applications.

Table 1. Classification of road equipment (according to CEN/TC 226 – *Road equipment* (European Committee for Standardization))

Main group	Sub-group	Application
Road lighting	Street lighting	Stationary lighting
	Commercial lights	Advertisement signs
	Lead lights	Lighting for increased visual guidance
Fences and barriers	Guard rails	Rails at the road-side
	Barriers	Barriers for separating the 2 driving directions
	Game fences	Fences for protecting animals from getting onto or crossing the road
	Crash protections	Equipment for mitigating the consequence of a crash
	Noise barriers	Barriers used for reducing traffic noise
	Glare shields	Shields for protection of glare from on-coming vehicles
Vertical signs	Road signs	Signs for regulating, leading or informing the road-users
	Post delineators	Posts equipped with a retroreflector, increasing the visual guidance
	Bollards	Posts used for clarifying the road environment
Horizontal signs	Road markings	Markings on the road surface
	Raised pavement markers	Retroreflector on the road surface
Traffic signals	Traffic lights	Signals for regulating traffic flows
	Warning lights	Signals for warning danger ahead

It is worth noting that concerning 4 of the main groups of road equipment (road lighting, vertical signs, horizontal signs and traffic signals), the performance is quantified by some lighting parameter, describing direct or reflected light. Among fences/barriers, solely the effectiveness of glare shields is described in terms of illumination. All other types of equipment in this main group are described by some other physical parameter, eg height or inclination.

Depending on the purpose of the road equipment and the road environment where it will be used, it can be designed in different ways. Some of the road equipment accounted for in Table 1 is discussed below.

3. Description of some important road equipment

3.1. Street lighting

The purposes of using street lighting are: improved night-time visibility of the road or street environment for traffic safety and comfort reasons, increased visual guidance on major routes, enhanced security in night-time, especially on paths in parks and for aesthetic reasons.

Primarily, 3 types of light sources are used: mercury, metal halogen and high pressure sodium lamps. The first two-mentioned light-sources emit white or bluish light, having the advantage of good colour rendering. The sodium lamp shows a high luminous efficiency, ie it gives more luminous flux per watt, but shows poor colour rendering, which, in turn, means that objects become greyish in this light. This is the reason why, generally, in some countries, the mercury and halogen lamps are preferred in built-up areas, while the sodium lamps are used on major routes.

Other light sources, like incandescent lamps, fluorescent tubes and low-pressure sodium lamps are rarely used today, the 2 first-mentioned having very poor luminous

efficiency, while the low-pressure sodium lamp shows extremely poor colour rendering.

Street lighting interacts with the road surface which in practice means that specular reflection should be kept at a minimum, especially at wet conditions. Fig. 1 shows street lighting, which interacts with the wet road surface in such a way that the luminance uniformity along the road is poor, which in turn might mean impaired visibility conditions.

3.2. Barriers and guard rails

Barriers and rails are used to prevent vehicles from leaving the driving lane accidentally. Traditionally, barriers are made of concrete, used on motorways, preventing head-on accidents as well as glare from oncoming vehicles. However,

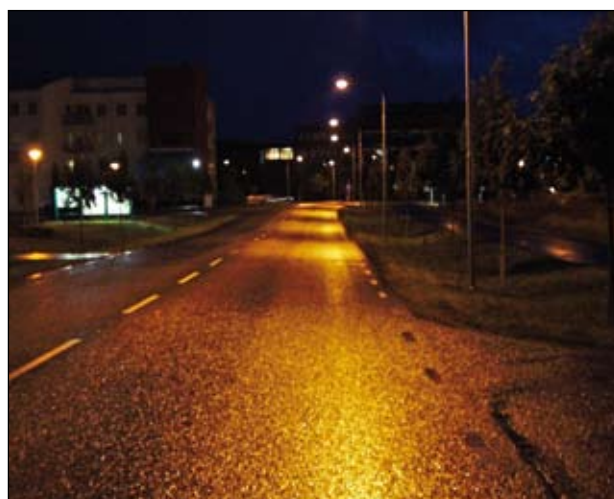


Fig. 1. Luminance distribution on a wet road surface in road lighting

nowadays, wire-barrier (Fig. 2), demanding less space than the concrete barrier, are increasingly used. However, wire barriers show the disadvantage of giving no glare reduction.

3.3. Road signs

Road signs can be divided into 4 groups with respect to message to the driver, namely warning, prohibit, mandatory and directing signs, respectively. Examples of the 4 categories of road sign are shown in Fig. 3.



Fig. 2. Wire-barrier on a 13 m wide 3-lane road

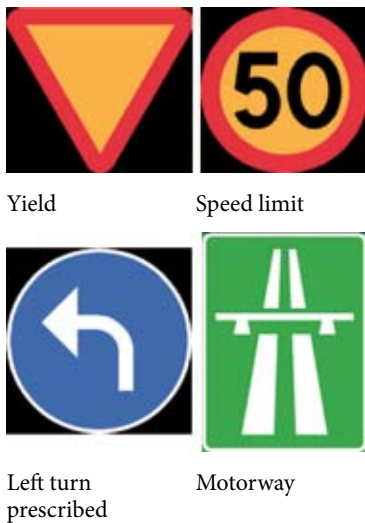


Fig. 3. Examples (from top left to bottom right) of warning, prohibit, mandatory and directing sign, respectively

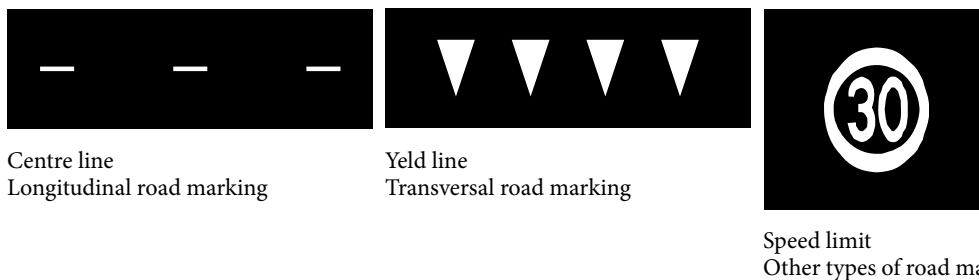


Fig. 4. Three types of road marking

Generally, the sheeting of the road sign is retro-reflective, which means that at night-time driving, a large part of the light from the headlamps is reflected back towards the driver. The sheeting can be made up of either prismatic cubes or micro-beads, of which the first-mentioned shows a higher retroreflectivity compared to micro-beads. The one to prefer in a given situation is dependent on the road environment; the prismatic sheeting shows a comparably better retroreflectivity at long distances, while the micro-bead sheeting is preferred at shorter distances, e.g. in built-up areas.

3.4. Road markings

Road markings can be divided into 3 categories, namely longitudinal, transversal and other types of road marking.

Longitudinal road markings are used in order to give the drivers visual guidance on distances up to approximately 100 m, and, by peripheral vision, helping the driver keeping a correct lateral position within the driving lane. Three important longitudinal road markings are centre line, edge line and lane line (Fig. 4).

Generally, transversal road markings are used to clarify the message of a road sign. As an example, the sign “yield” (Fig. 3) in most cases is supplemented by a yield-line (Fig. 4), which tells the driver where to yield before entering the main road.

Other types of road markings can be used to stress the information given on a road sign. For example, the road sign “speed limit 30 km/h” nearby a school, can be stressed by using the same symbol in the driving lane as shown in Fig. 4.

Road markings can be produced using thermoplastics, spray-plastics or two-component cold plastics material, as well as paints and tapes. On the surface of a road marking material, micro-beads, which improve the visibility in headlight illumination, are generally applied.

On dense trafficked roads, thermoplastics or cold plastics are preferred, as these materials are more resistant to wear from tyres. Furthermore, these types of road markings can be profiled, thereby improving wet weather performance. Generally, on secondary road network, paint or spray-plastic is applied. For temporary road markings in construction zones, tapes are commonly used.

3.5. Raised pavement markers (RPM) and post delineators

The concept raised pavement marker (RPM), also called road stud, retroreflective road marker or cat's eye, refers to a retroreflector attached onto the road surface. Generally, this retroreflector shows slightly longer visibility distance than a road marking, especially in wet-weather condition night-time. However, the peripheral visibility of raised pavement markers is poor, which means that they do not help the driver keep correct position in the lane. Consequently, RPMs cannot replace road markings, but only be a complement.

In order to improve the night-time visibility at distances longer than 100 m, the road is equipped with post delineators which give information to the driver regarding curves ahead, making it easier to plan the driving. The post delineator is a standard equipped with a retroreflector.

3.6. Traffic signals

Traffic signals are used for increasing safety and availability, not only in junctions, but also on links at pedestrian crossings. Generally, modern signals are vehicle controlled, i.e. detectors are regulating the traffic signal. On the other hand, the use of time-controlled signals has decreased, but they are still used for synchronizing signals in two or more signal regulated crossings. In order to minimize delays and number of stops, time-settings in a system of crossings is optimized using some computer programme, for example, TRANSYT.

Modern signals use light-emitting diodes (LED), which compared to traditional bulbs are more reliable and show a longer life. Furthermore, modern signals are computer-supervised and give error indication at malfunction.

4. Road equipment condition assessments

4.1. General aspects

Condition assessment is carried out in order to describe performance of some specific equipment. Regarding road equipment, such a performance might be road marking visibility, road sign legibility and traffic signal conspicuity, described by some indirect measure. As an example, the visibility of a continuous edge line can be described by its retroreflectivity and width.

The aim of an assessment might be characterization of performance of some road equipment, check the quality of work carried out by a contractor, foundation for distribution of maintenance resources and test of performance of road equipment from different manufactures.

The condition assessment should be seen as a tool for quality control of road equipment, thus making sure that the equipment ensures traffic safety and comfort. Furthermore, regular checks should lead to better performance, which, in turn, would indicate cost-effectiveness of the assessment.

Generally, it is impossible, or at least unrealistic, to check all equipment along the road or in a geographical

area, which means that the check is not carried out on the population, but on a sample. By definition, a sample is taken randomly from the population, which in practice might be a problem regarding road equipment. Therefore, it is desirable to find a practical sampling method, which allows some deviation from complete randomness. As an example, if testing intermittent road markings, the 1st marking to test is chosen randomly, then every 10th road marking is measured. In this way, no systematic errors are introduced.

Along with practical sampling method, it is necessary to use a quick and simple method for collecting data. In practice, this means that the measurement or observation method preferably should be mobile, i.e. the measurements are carried out at speed. Generally, for physical measurements, this data collection might be a problem.

4.2. Performance parameters

The driver gets most of the information regarding traffic environment from the visual field in front of the vehicle. This information originates from other road users, as well as road equipment and road surface. It is important that road equipment shows good performance. In daylight, visibility problems are relatively small, but in night-time, effective road equipment means good conspicuity, visibility and legibility. Consequently, the regulation concerning road equipment in many cases involves some parameter which, directly or indirectly, quantifies brightness. Some important parameters used in regulations to quantify visual properties of road equipment are defined in Table 2.

All parameters in Table 2 can be measured, directly or indirectly. Illuminance can easily be measured, using a luxmeter. Light intensity cannot be measured, but calculated from illuminance at the surface and distance between surface and light source. Stray-light luminance is calculated using the empirical formula given in Table 2. Luminance, luminance contrast and CIL-value are measured using a luminance or spot meter, but carrying out such a measurement is difficult and slow. For measuring retroreflectivity, daylight luminance coefficient and colour, specially designed instruments have been developed. A short discussion of equipment and test methods is given in Section 4.3.

National standards are used to secure good performance of road equipment regarding driver needs. Generally, such standards are based on the corresponding international standard, which allows the road keeper to choose appropriate performance class, dependent on type of road. As an example, European standard EN 1436: *Road marking materials – road marking performance for road users* allows the road keeper to choose between 5 classes of wet road marking retroreflectivity, where the lowest class (RW0) means no requirement at all, and the highest class (RW4) that the retroreflectivity must be at least 75 mcd/m²/lx. For dry road markings, most European countries use class R2 (100 mcd/m²/lx) as requirement of retroreflectivity.

Other standards exist for other type of road equipment, such as European standard EN 13201-1: *Road lighting – Part 1: selection of lighting classes*, which deals with

Table 2. Illumination and reflection parameters used for describing the performance of road equipment

Parameter	Denotations*	Formula*	Application
Illuminance	E (lux, lx)	$E = \frac{\Phi}{A} \times \cos \alpha$	Street lighting on minor streets, walking paths, etc
Light intensity	I (candela, cd)	$I = \frac{\Phi}{\omega}$, $I \approx \frac{E \times r^2}{\cos \alpha}$	Traffic signals
Luminance	L (cd/m ²)	$L = \frac{I}{A}$	Street lighting on major roads
Retroreflectivity	R (cd/m ² /lx)	$R = \frac{L}{E}$	Road markings, raised pavement markers, sign sheeting
CIL-value	CIL (cd/lx)	$CIL = R \times A$	Post delineators
Daylight luminance coeff.	Qd (cd/m ² /lx)	$Qd = \frac{L}{E_d}$	Road markings
Stray-light luminance	L_s (cd/m ²)	$L_s \approx 9,2 \times \frac{E}{\Theta^2}$	Road lighting, glare shields
Luminance contrast	C (-)	$C = \frac{L_o - L_b}{L_b + L_s}$	**
Colour	x, y, z (-)	***	Sign sheeting, road markings, traffic signals

Notes:* d – diffuse (illumination); o – object (luminance of); b – background (luminance of); s – stray-light (luminance); ** quantifies visibility, but is not used in regulations because luminance is unpractical to measure; *** described by using the tristimulus values, defined by the International Commission on Illumination (CIE); α – angle between incidence light and the perpendicular of the surface, °; ω – solid angle within which light is emitted, srad; Θ – angle between line of vision and glare source, °; r – distance between light source and illuminated surface, m; A – area of illuminated surface, m²; Φ – luminous flux, lm.

street lighting. Typical lowest luminance levels used are 1,5–2,0 cd/m² on motorways and 1,0–1,5 cd/m² on other main roads. On small streets, illumination requirement is typically 20 lx.

In order to make road signs visible and legible, European standard EN 12899-1: *Fixed, vertical road traffic signs*. Fixed signs, regulates retroreflectivity of the road sign sheeting. The Swedish recommendation says that the white symbol of a ground mounted sign must show at least 20 cd/m²/lx (Schmidt 2002). In USA, Federal Highway Administration (FHWA) requires a minimum retroreflectivity of 55–65 cd/m²/lx, dependent on type and size of the sign (Carlson, Hawkins 2003). For comparison, new prismatic sheeting show values higher than 500 cd/m²/lx. This means that prismatic sheeting show retroreflectivity far above specified values.

Most European standards use the same principle as the examples above, allowing the road keeper to choose between several performance classes. Furthermore, the standards are not connected with a specific instrument but measurement method.

4.3. Sampling and characterization methods

When carrying out assessment, it is important to decide what measurement objects to be selected and how to define the size of the sample. Concerning road markings, this is described in the European standard EN 13459-3: *Road marking materials – quality control – Part 3: performance in use*, but this standard can also be applied to other types of

road equipment. Forsman (2001) describes sampling plans, which were used for street lighting, as well as rails and road signs. General sampling plans have also been described by Odeh and Owen (1983). Irrespective of sampling method and the distribution of data, it is necessary to keep control of errors of Type I (α -errors, producer's risk) and Type II (β -errors, consumer's risk). Many statistical books deal with errors of Type I and Type II, e.g. Johnson (2004). A condition assessment should always include a power analysis in order to clarify the above described risks.

As stated above, it is important that methods used for condition assessment are not solely valid and accurate but also easy to use. In practice, this means that a mobile method is preferred to a static one, even if static methods generally are more accurate. Most assessment methods found in the literature deal with street lighting, road signs and road markings. Such methods have mainly been used in USA and Scandinavia.

In street lighting, the parameter of most interest is the luminance of the road surface. However, this parameter is difficult to measure directly, but could be estimated based on illuminance and reflection properties of the road surface. As early as 1978, Øbro (1978) described such predictions, but the method did not come to use, as no mobile, reliable instrument was available at that time. Later, Zimmer (1988) described a method by which illuminance, using a photocell on the roof of a moving vehicle, was measured. However, at that time, no instruments for measuring reflection properties of road surfaces had been developed and, therefore, it was not possible to trans-

late illuminance of the surface into luminance. A digital camera method for characterization of road surface luminance was described by Todd (1990) and later by Glenn *et al.* (2000). Glenn *et al.* compared luminance obtained in this way with traditional measurements and found a systematic relative difference of approximately 25 %. The accuracy of the method was found to be 3,5 %. However, the camera-based method just described is not suitable for condition assessment as it is complicated and expensive to use. Other parameters of interest, such as the condition of lamp poles, can be measured as described by Lozev *et al.* (1997). The last-mentioned study is a good inventory of useful methods for detecting the pole corrosion, such as audio inspection, ultra sound inspection and electrical potential measurement. An American delegation made a round-trip in Europe to study maintenance of street lighting. This delegation found that the situation in Europe was alike the one in USA, i.e. no effective means of maintaining the photometric performance were used and this lack of maintenance causes a rapidly deteriorating of the lighting system. This was reported by Wilken *et al.* (2001).

Fences and barriers can in most cases be inspected visually, which was documented by Svedlund (2001). In this study, height and inclination of guard rails were judged, and in doubtful cases also measured manually. Key *et al.* (2001) carried out visual inspection of noise shields and report that life-length of such shields rarely is more than 25 years. Later, Watts *et al.* (2002) described a physical method for determining effectiveness of noise barriers. This method, denominated “Maximum Length Sequency” (MLS), uses a loudspeaker emitting white noise, detected at the other side of the shield. White noise means that the measurements are not influenced by traffic noise, i.e. measurements can be accomplished independent of disturbances from the surrounding. Tests showed that the

method is reliable and robust, but must be improved if surrounding noise is high.

Some hand-held instruments for measurement of the retroreflectivity of vertical signs are available on the market. Such instruments have primarily been used for measurement of road sign sheeting retroreflectivity, in order to obtain a relation between legibility and the luminance of the sign symbol. Studies carried out by Jenkins and Gannaoui (1993), Frank and Ewalds (1995) and Helmers *et al.* (1999) showed similar results: an optimal luminance level is between 10 and 100 cd/m². Hatzi (2003) and Lagergren (1987) described a procedure for mobile visual inspection of legibility of road signs in low beam illumination. In Lagergren's study, trained subjects were used for assessment, and judgments were found to be valid. It could also be mentioned that Maerz and Niu (2003) have described a vehicle-mounted mobile system prototype. However, no description of application of this system has been found in the literature.

Concerning horizontal signs, especially road markings, there are 2 types of mobile reflectometer commercially available, Ecodyn and Laserlux, manufactured in France and USA, respectively. These 2 mobile instruments, evaluated by Bernstein (2000), measure the retroreflectivity of the markings. Some hand-held instruments which measure both retroreflectivity and daylight luminance coefficient, are also available on the market, as also a hand-held instrument for measurement of raised pavement markers (RPM's), described and tested by Ullman and Rhodes (1996).

No instrument specifically developed for performing measurement of traffic signals have been found in the literature. Light intensity of a signal can be predicted from the luminance, which can be checked using a photometer. However, this instrument is not suitable for condition assessment.

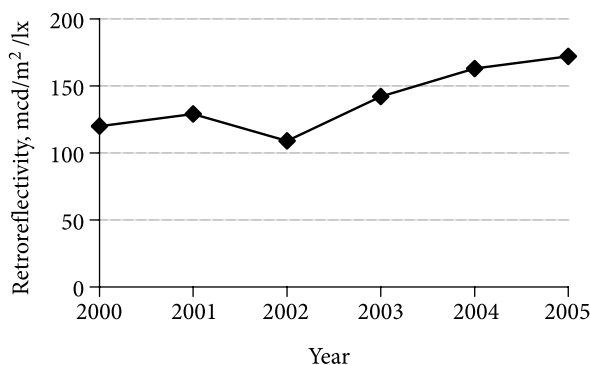
Table 3 gives a state-of-the-art on road equipment condition assessment.

Table 3. Parameters and types of method used for their performance characterization

Type of road equipment	Parameter	Visual inspection	Hand-held measurement	Mobile measurement
Street lighting	Luminance	No	Yes, but not practical	No
	Illuminance	No	Yes, but not practical	Yes, but not in use
	Stray-light luminance	No	Yes, but not practical	No
	Condition of poles	Yes	Yes	No
Guard rails	Condition	Yes	No	No
Glare and noise shields	Effectiveness	No	Yes	No
	Retroreflectivity	No	Yes	Yes, but not in use
Road signs	Colour	Yes	Yes	No
	Visibility	Yes	No	No
	Damages	Yes	No	No
Post delineators	CIL-value	No	Yes, but not practical	No
Road markings	Retroreflectivity	No	Yes	Yes
	Daylight lum. coeff.	No	Yes	No
	Colour	No	Yes	No
RPMs	Retroreflectivity	No	Yes	No
Traffic signals	Light intensity	Yes	Yes, but not practical	No
	Colour	Yes	Yes, but not practical	No

Table 4. Summary of published studies accounting for condition assessment of road equipment

Main group of road equipment	Sub-group	Parameter	Essential outcome	Reference
Road lighting	Street lighting	Dist. between poles and lane	32 % of lamp poles failed	(Svedlund 2001)
	Rails	Tilting	7 % of guard rails failed	(Svedlund 2001)
Fences and barriers	Noise shields	Efficiency	2 out of 30 noise shields failed	(Key et al. 2001)
	Glare shields	Efficiency	All tested shields reduced glare to 0	(Jaquett, Gudum 1993)
Vertical signs	Road signs	Retroreflectivity of sheeting	No relationship between sheeting retroreflectivity and age	(Black et al. 1991; Frank, Ewald 1995; Helmers et al. 1999)
			Most sheeting of age 10–15 years passed the test	(Frank, Ewald 1995; Helmers et al. 1999)
		4 % of sheeting failed FHWA requirement	(Nuber, Bullock 2002)	
		Most sheeting of age 15 years failed FHWA requirement	(Wagner 1989)	
Visibility	Most sheeting showed poor visibility in night-time	(Mohan et al. 2004)		
Horizontal signs	Road markings	Retroreflectivity	Most road markings in the Nordic countries passed the test	(Lundkvist 2003; Nygårdhs, Lundkvist 2004)
			No relationship between retroreflectivity and age of marking	(Kopf 2004)
	Raised pavement markers	Retroreflectivity	A majority of RPM's performed well	(Ullman 1994)
Traffic lights	Traffic signals	Light intensity	One out of three products of age 5 years failed	(Helmers, Werner 1992)
		Malfunctions	Low light intensity and non-working detectors	(Kronborg 1999)

**Fig. 5.** Retroreflectivity of road markings in Stockholm County, Sweden

4.4. Survey of published condition assessment studies

As indicated in the previous section, very few instruments suitable for road equipment condition assessment are commercially available. However, some condition assessment studies are described in the literature and summarized in Table 4.

As can be seen from Table 4, the number of condition assessment studies of road equipment found in the literature is relatively low. However, although no mobile instru-

ment for road signs is available, as many as 8 assessment studies have been found in the literature. This indicates that there is a great interest in assessment of road signs, probably because the cost of investment and maintenance of this equipment is high.

The only mobile method in regular use concerns road markings, but still the number of published assessment studies is low. Solely in the Nordic countries and USA a few studies have been reported.

As mentioned in Chapter 3, one reason for carrying out condition assessment studies is to check the quality of a contractor's work. In Stockholm County, during the last 6 years (2000–2005), the retroreflectivity of road markings has been measured using a mobile method (Fig. 5). These measurements were performed in late summer or early autumn, after completion of road marking maintenance, to find out the quality of maintenance executed. Each year, a number of 12 roads were randomly chosen for measurement. On each road, edge lines, centre line and lane lines (on motorways) were measured on a section of approximately 30 km. Fig. 5 shows the average of retroreflectivity of all road markings (Koucheki, Lundkvist 2006).

Fig. 5 illustrates a tendency of improved retroreflectivity over time. The difference in performance between year 2000 and 2005 is significant at a risk level of 5 % and fur-

thermore, in 2000, 47 % of the measured sections fulfilled the Swedish requirement ($100 \text{ mcd/m}^2/\text{lx}$), while the corresponding number in 2005 was 100 %. At least to some extent the improvement might be explained by the fact that the contractor knew that his work was going to be checked. If it is the case, the assessment has led to an improved nighttime visibility of road markings, which, in turn, would mean better comfort and probably increased safety.

5. Conclusions and discussion

Road equipment condition assessment requires a large number of measurements, which, in turn, means that use of instruments which can collect a lot of data within a short time is in practice a necessity. This, in turn, implies that an instrument aimed for condition assessment should be mobile; i.e. measurements can be carried out at traffic speed. Unfortunately, such instruments are rare.

Today, the only area of road equipment, where commercial available mobile instruments are in use, is road marking. Concerning other road equipment, such as street lighting and road signs, solely prototypes or proposals exist, which means that condition assessment, so far, must be carried out using stationary measurement or subjective judgement. Generally, in such condition assessment studies, the aim has been to establish a relationship between in situ performance and age, but also to investigate to what degree the road equipment fulfils the requirement according to the national regulation.

There is a reason to believe that, if condition assessments are carried out regularly, road equipment performance will be improved, which, in turn, indicates that this type of assessment could be cost-effective. The cost-effectiveness could be estimated by comparing performance of road equipment in 2 regions with similar climatic and traffic conditions, 1 region where measurements are announced in advance and another one without any announcement.

Generally, the mobile method means an introduction of random errors due to the vertical motion of the measurement vehicle. On the other hand, this is compensated for by much more effective data collection, i.e. an average value estimated from mobile measurement data might have as good precision as data obtained from static measurements. Furthermore, from the safety point of view, mobile measurement is preferable.

Based on the information given in this article, the following conclusions can be drawn:

- road equipment can be divided into 5 groups: road lighting, fences and barriers, vertical signs, horizontal signs and traffic signals;
- the number of published road equipment condition assessment studies found in the literature is low;
- physical mobile measurement methods for street lighting, road signs and road markings have been described in the literature;

- commercial mobile instruments are available and used solely for condition assessment of road markings;
- the currently performed studies on road markings have indicated that improved performance can be the result of condition assessment;
- regarding road signs, static methods have been used, with the purpose of finding a relationship between age of sheeting and performance;
- there is a great need of developing new mobile methods for road equipment assessment.

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