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# resentation of Nordic road urface measurements

# Outline

- THE MEASUREMENT DEVICE
- DANISH ROAD SURFACE MEASUREMENTS
- FINISH ROAD SURFACE MEASUREMENTS
- SWEDISH ROAD SURFACE MEASUREMENTS
- CONCLUSION

# Motivation

Road surface reflection data in the form of standard r-tables serve as input for design calculations of road lighting installations on traffic roads. However, in several countries the use of the standard r-tables has not been verified by measurement in a long period of time, while the types of road surfaces in use have changed. (since the 1970s and 1980s)

Because of this, a co-operation between the road administrations of the Nordic countries (abbreviated NMF) decided to construct a portable instrument to be used on selections of traffic roads within these countries in order to provide updated knowledge.

This instrument have now been used for measurements in three Nordic countries, Denmark, Finland and Sweden. The results will be presented in this presentation.

# The measurement device

The instrument only uses the values of $r_1$ and $r_2$, but does it with strong control of sources of error such as angular spreads, level of illumination and location of the measured field. It uses these values to calculate the specular factor S1, average luminance coefficient Q0 and the luminance under diffuse conditions Qd values using the following linear expressions:

$Q0 = (0{,}957 \times r_1 + 0{,}746 \times r_2 + 104{,}5)/10.000$

$Qd = (0{,}981 \times r_1 + 0{,}323 \times r_2 + 86{,}1)/10.000$

$S1 = r_2/r_1$

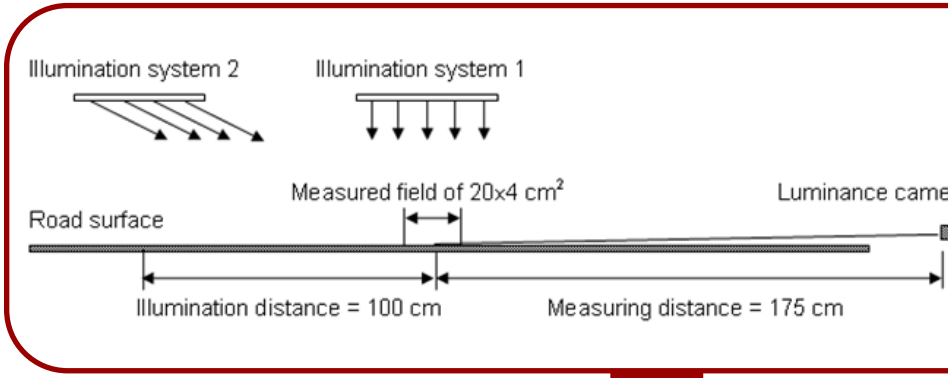
The two linear expressions for Q0 and Qd have been derived on the basis of 285 samples of road surfaces for which the r- tables were measured at the Danish lighting laboratory in 1975.

These r-tables are considered to be of a good quality and have been used for several purposes over the years including construction of the N- and C- series of standard r-tables.

Reference: Corell, D, D, Sorensen, K, AN INSTRUMENT FOR THE MEASUREMENT OF ROAD SURFACE REFLECTION PROPERTIES

# The measurement device

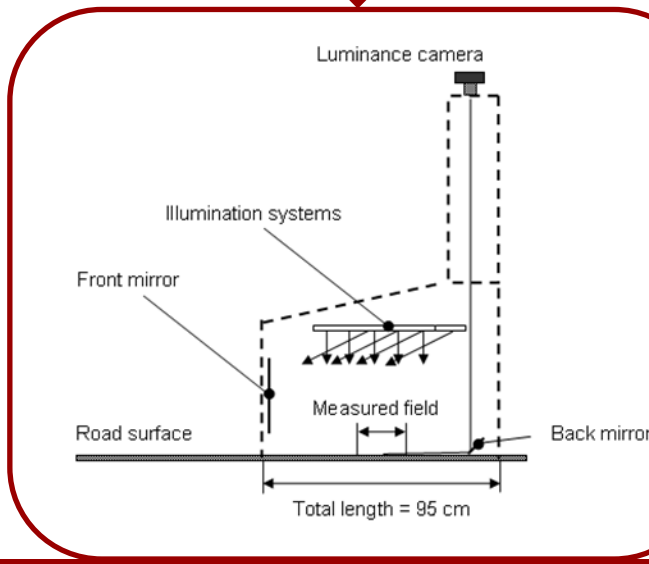
Measument are done with a luminance camera.



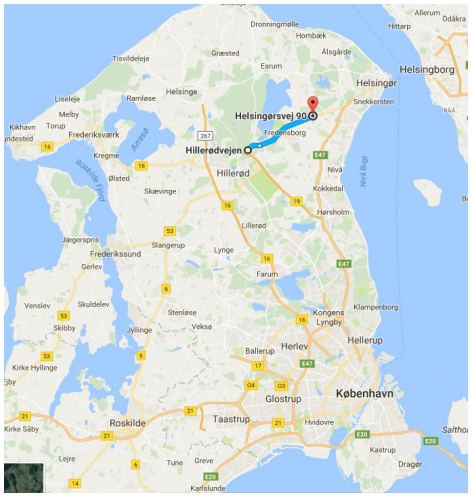

The two illumination systems are for the measurement of $r_1$ ($\gamma = 0$ and $\beta = 0$) and $r_2$ ($\gamma = 63.44$ and $\beta = 0$) respectively.

The paths of illumination and measurement are fairly long in order to keep angular spreads sufficiently low. This, in particular is necessary for the measurement of $r_2$.

The camera has three positions that provide observation angles of respectively 1,0°, 1,5° and 2,29°.



# The Danish results




A total of 11 locations were selected in the northern part of Zealand.

As the target was road surface measurements an observation angle of 1,0° was used.

The measurements was carried out in dry weather and on dry road Surfaces in the evening in April 2017 .

The measurements showed that Qd and Q0 did not depend much on the Observation angle. Therefore it is assumed that the results obtained for the observation angle of 1,0° are also applicable for an observation angle of 2,29°. The last angle is used when measuring road markings.

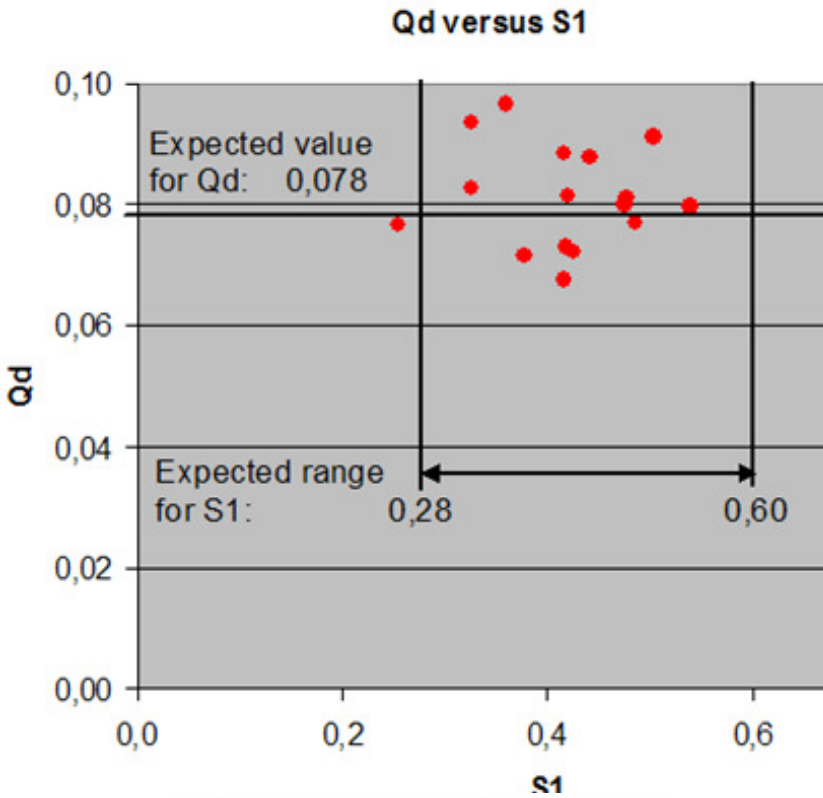
The measurement included a measurement on the wheel track and in-between the wheel track.

# The Danish results

In Denmark, there is a minimum requirement for the reflectance of stone aggregates in road surfaces on major roads, and the stone aggregates are of some minimum size.

The road surfaces are expected to have Qd values of about 0,078 (corresponding to Q0 values of about 0,09) and to be of class N2 with S1 values in the range of 0,28 to 0,60.

Results for some typical road surfaces on major roads, as indicated in the diagram, confirm these expectations in a general manner.





Reference: Sorensen, K, Hafdell, Petter & Ekrias, A

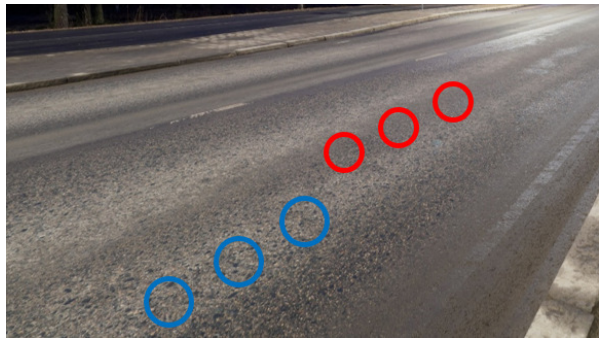
# The Finish results

The measurements was conducted in Finland during August and September 2017.

*Note: The last measurements was done in 1970s and 1980s and conclusion showed that the majority of the road surfaces belonged to the classes R1 and R2.*

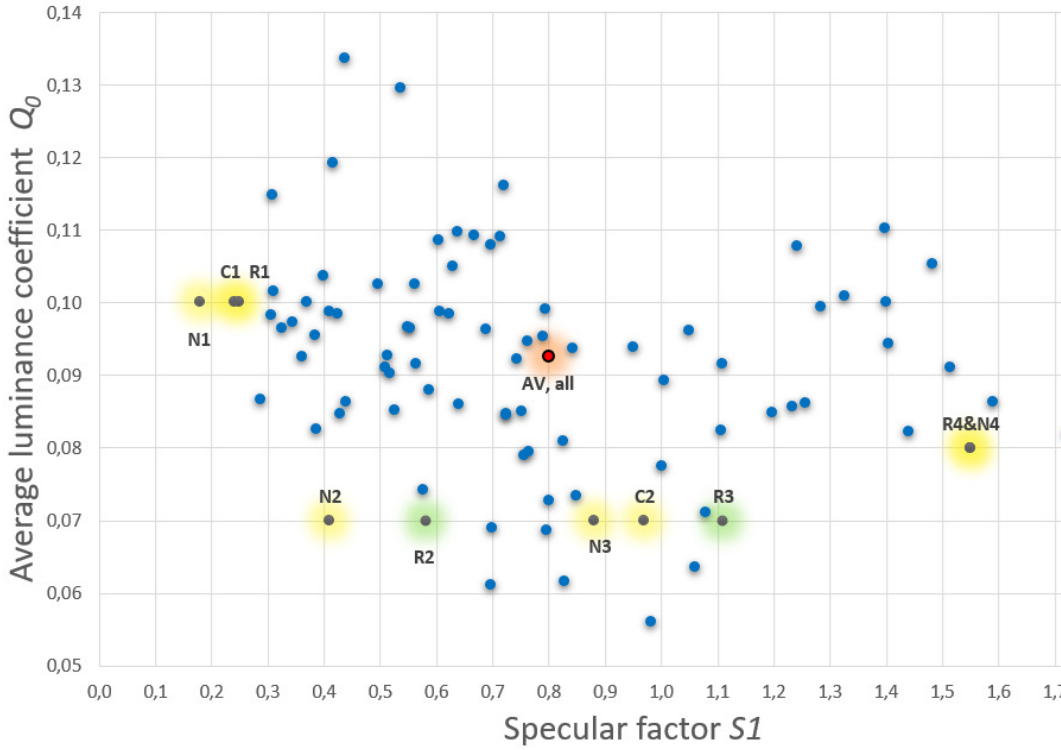
Measurements were carried out at 46 different sites. These comprised 17 roads and 29 streets.

The total amount of measurement in this study was 276, giving 552 images to be analysed. A single measurement was a result of the average of three. This was done separately on and off the wheel track.



# The Finish results – all the results

- Measurements marked with blue dots
- CIE standard tables marked with yellow dots
- The R tables used in Finland marked green




It is seen that there is a large variation,
That is greatly depending on the site

It is also seen that there is a a poor correlation with the CIE standard road surfaces used in simulations.

Reference: Ekrias, A

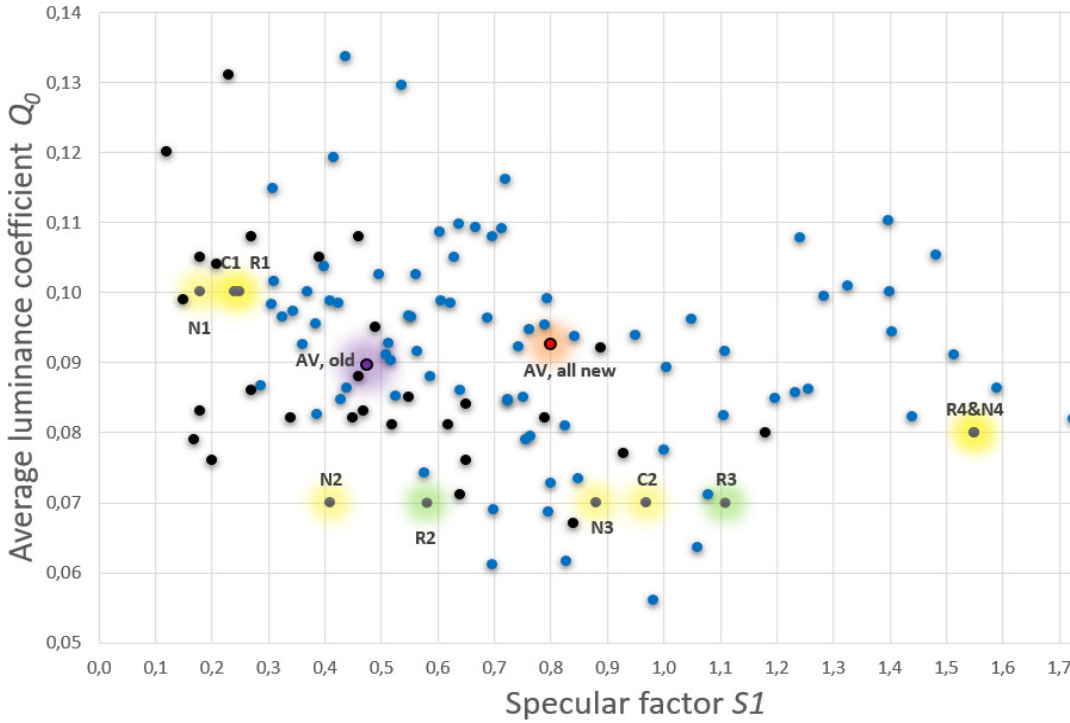
# The Finish results – comparison with the old measurements

- New measurements with blue dots
- Old measurements with black dots

It is seen that the average luminance Coefficient Q0 values is on par with the Measurements on old road surfaces.

The specular factor S1 is significantly higher.

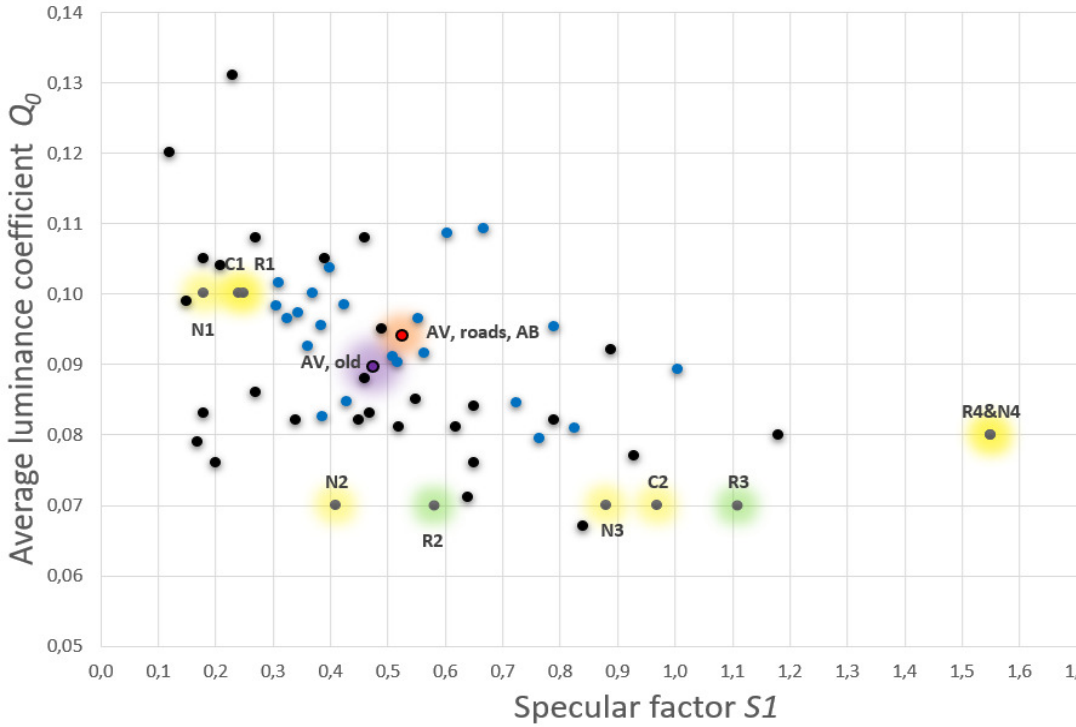
The reason for this was that the old measurements primarily came from asphalt concrete (AC), in the new study both AC and stone mastic asphalt (SMA) was measured.




Reference: Ekrias, A

# The Finish results – Asphalt concrete comparison

When comparing the new measurements done on AC with the old measurements it is seen that there is almost no difference in the results.

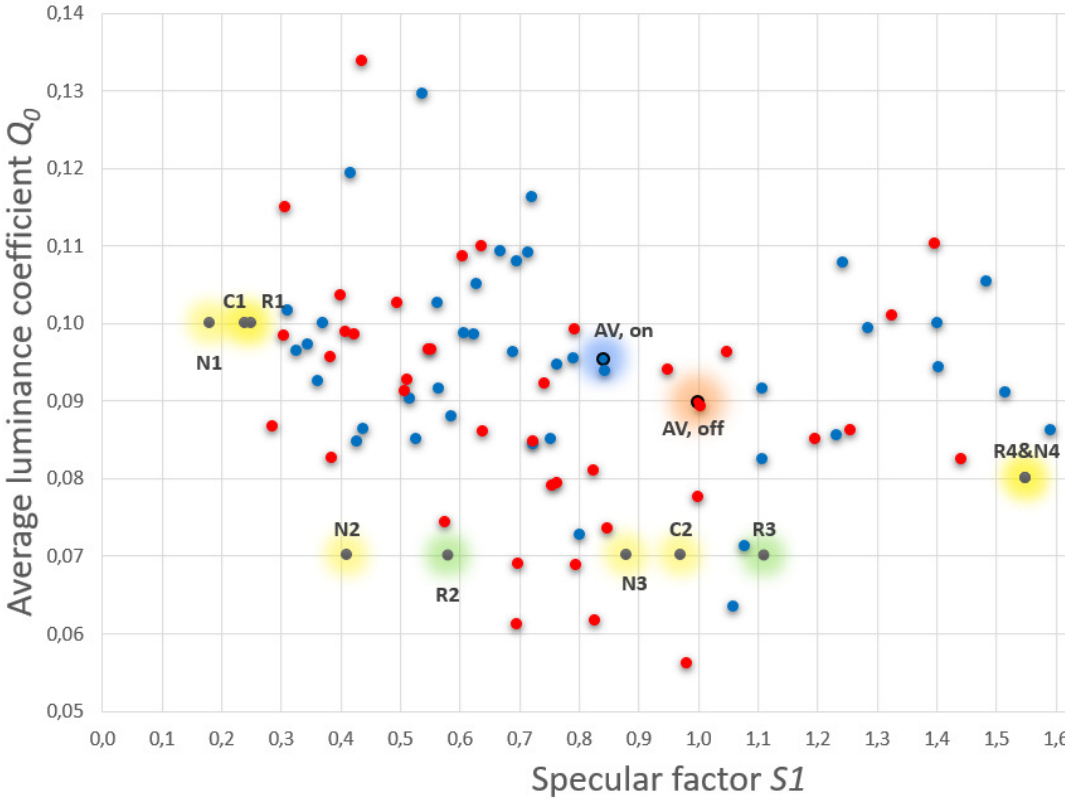



Reference: Ekrias, A

# The Finish results – Comparison on and off wheel tracks

- Blue dots shows measurement on wheel track
- Red dots shows measurements off wheel track

It is seen that the the wheel track has a slightly higher average luminance coefficient $Q_0$ value and a slightly lower specular factor *S1* value than the road surface off the wheel tracks



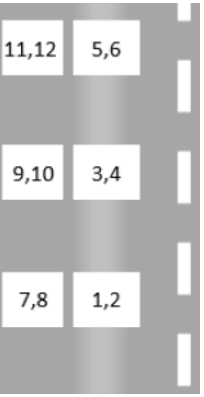

This is mostly explained by the coarsening of the surface, the loosening of small aggregate granules and the wearing of the bitumen on the wheel tracks. This is known to slightly increase the average luminance coefficient and slightly reduce the specular factor.

Reference: Ekrias, A


# The Swedish results

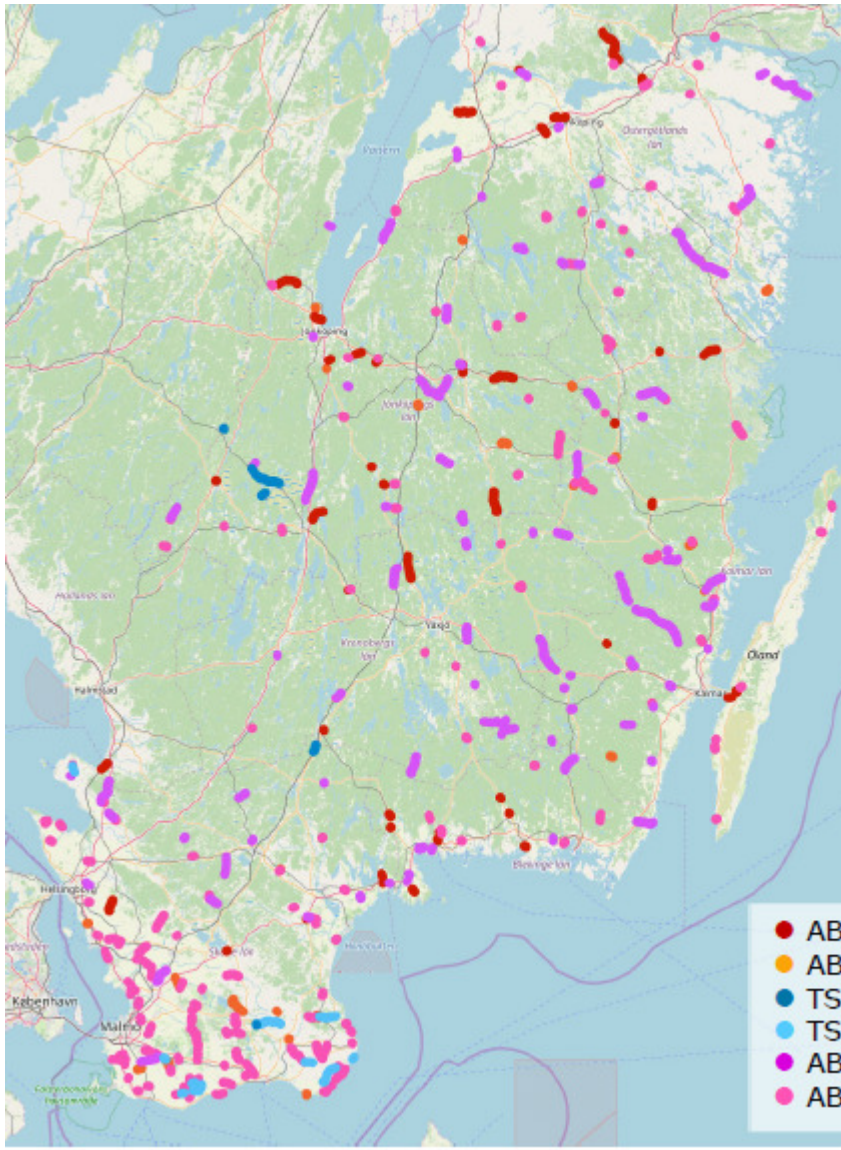
The measurements was done June – Oktober 2019

A total of 180 road surfaces was measured covering the most common occurring road surface in Sweden
•maximum stone sizes in the road surface measured 11 mm and 16 mm




Six measurements was done at each site, three at the wheel track and three in between. With an average of These six measurements gives a good representative image of the entire measurement site.

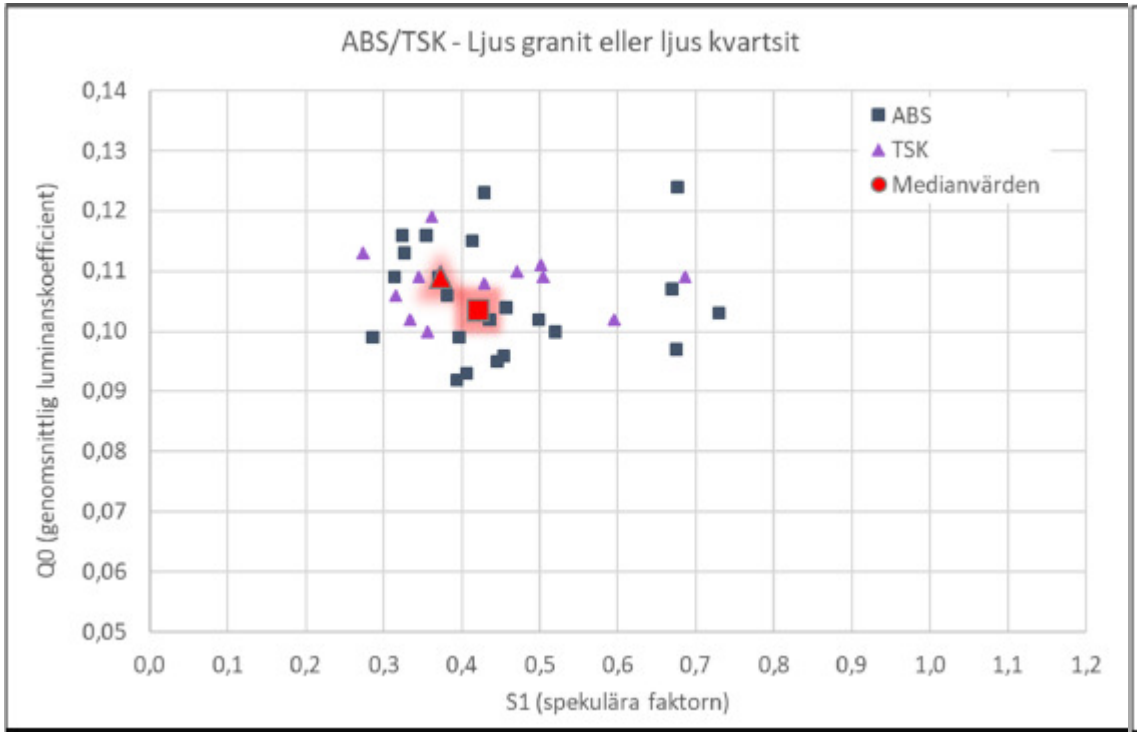
Three types of asphalt was measured
ABS: “skeleton asphalt” for roads with very low traffic levels
ABT: Asphalt concrete
TSK: Thin layer

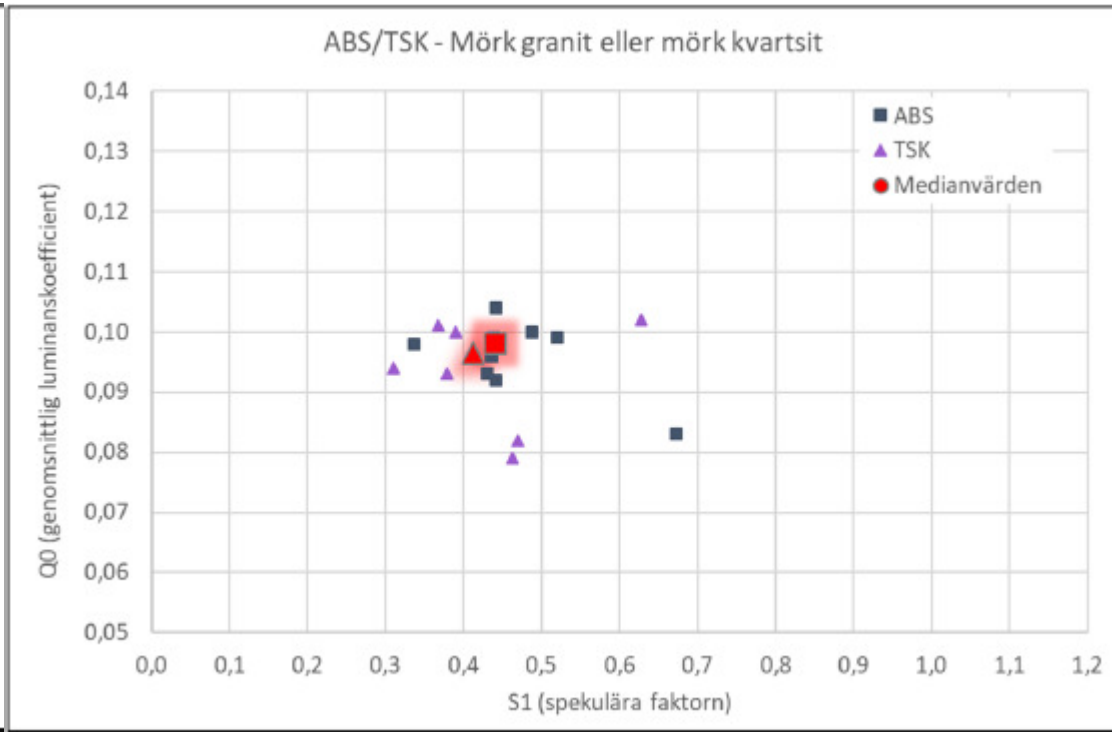



Reference: Nielsen, B & Hafdell, P.

# The Swedish results – comparison with surface types

It is seen that there is no difference between these two road types used in Sweden, as such the same r-table can be used.

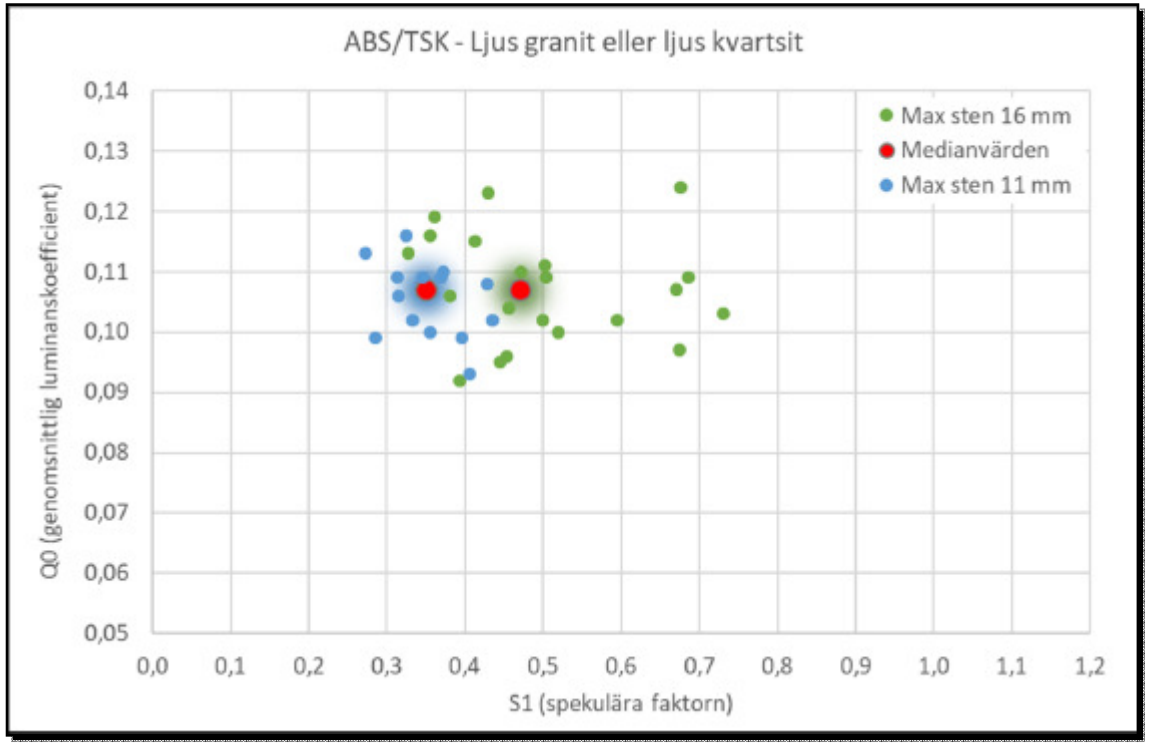



Reference: Nielsen, B & Hafdell, P.

# The Swedish results – comparison with stone sizes

It was seen that the stone sizes used didn't play any large role in the reflection properties. With the exception of light road surfaces, here larger stones lead to a higher specular factor S1

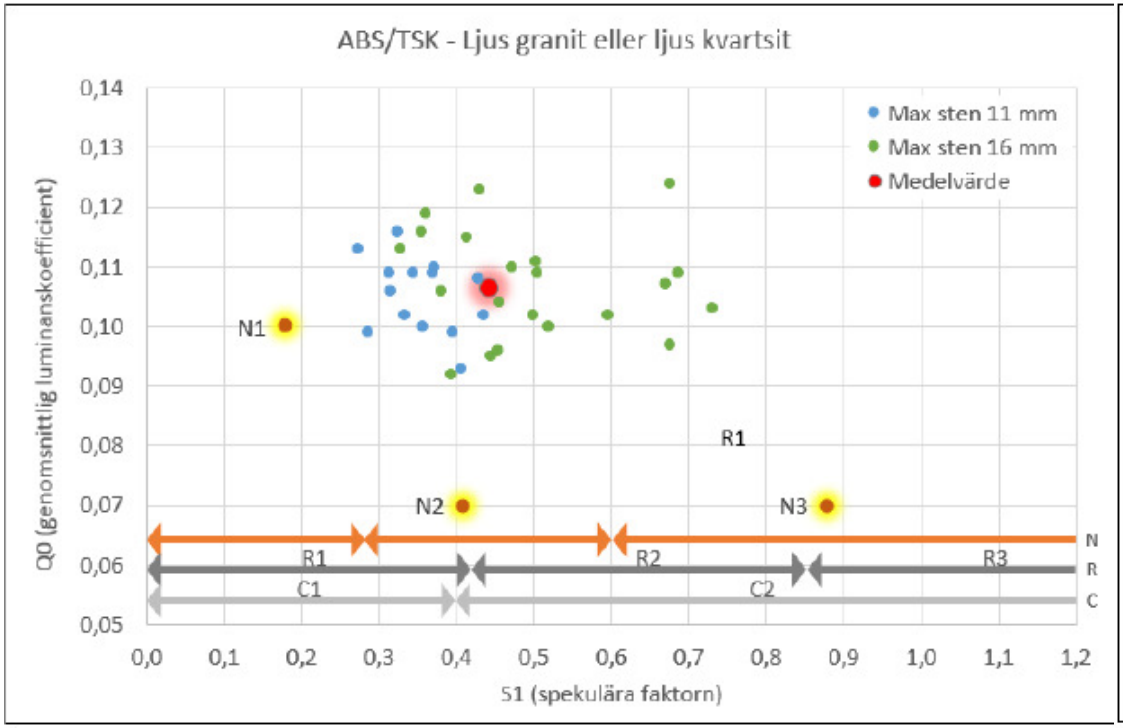


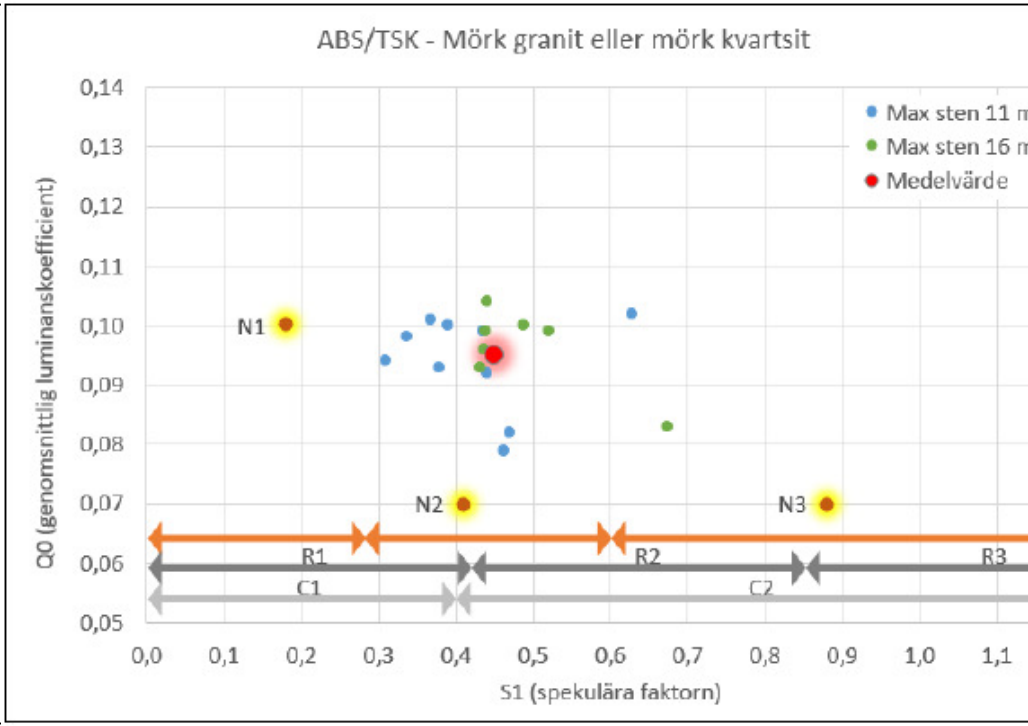

Reference: Nielsen, B & Hafdell, P.

# The Swedish results

Mean values for the light surface Q0: 0.107, Qd: 0.093, S1: 0.443. 83% of the surfaces measured was within N2

Mean values for the dark surface Q0: 0.089, Qd: 0.078, S1: 0.5. 88% of the surfaces measured was within N2

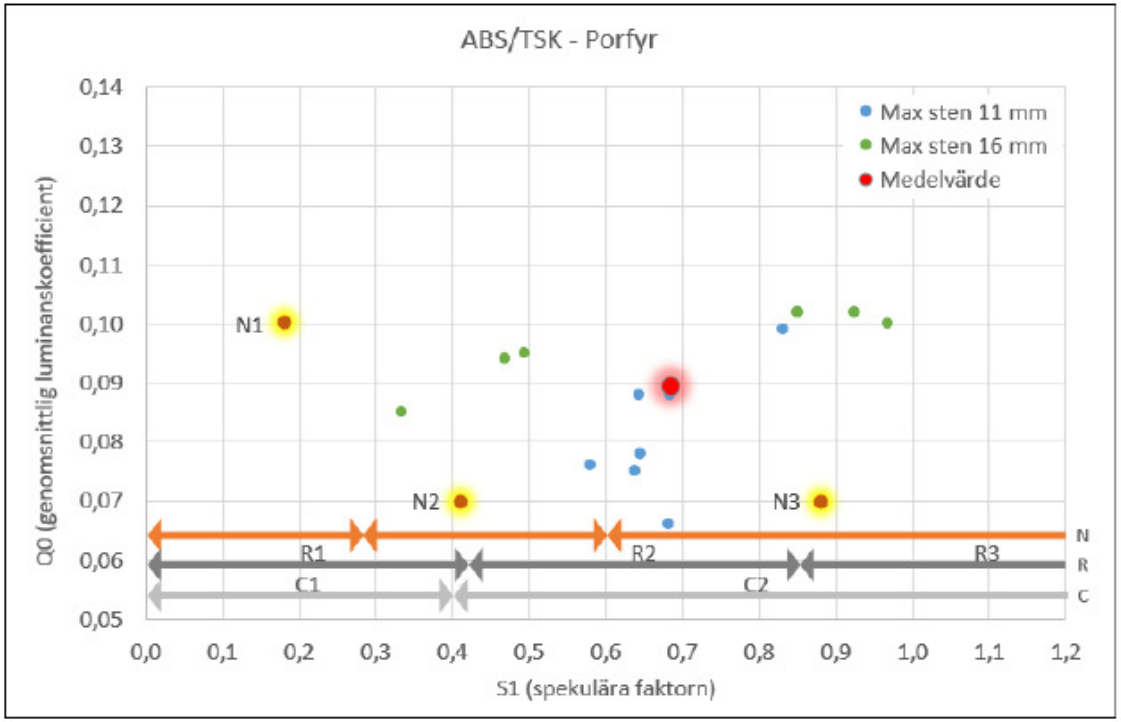



Reference: Nielsen, B & Hafdell, P.

# The Swedish results – Porfyr (redish stone material)

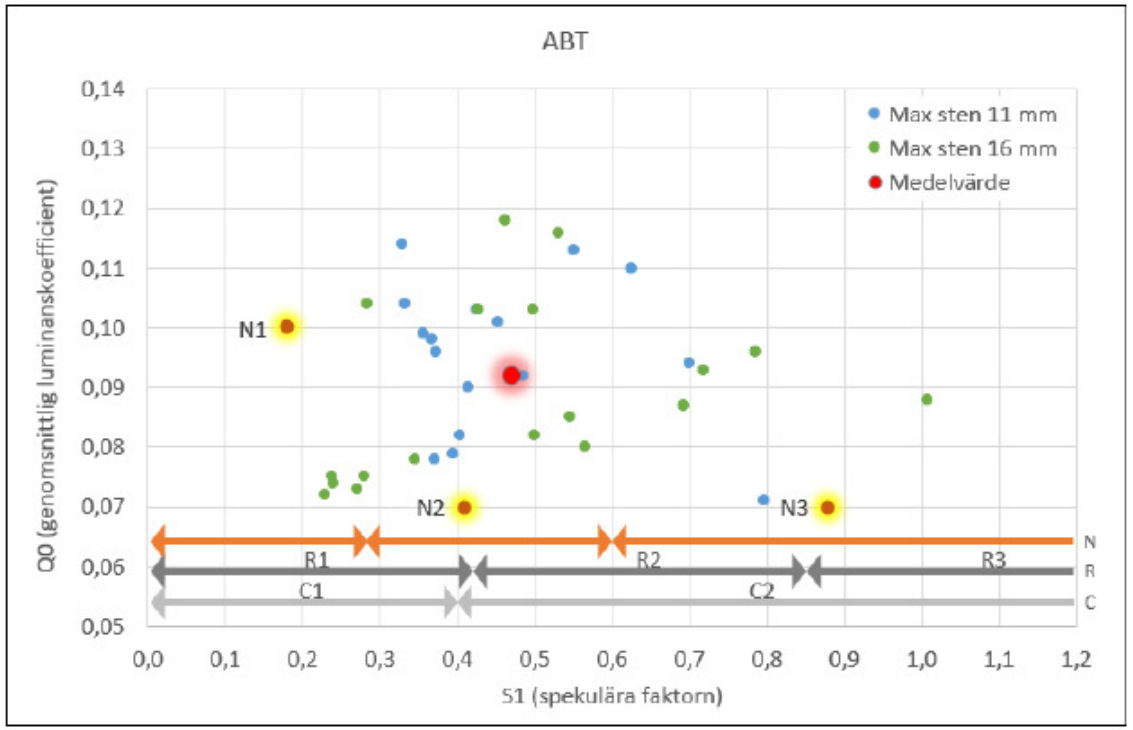
Mean values for the light surface Q0: 0.089, Qd: 0.073, S1: 0.685. 71% of the surfaces measured was within N3. The specular factor varied a lot, one explanation could be that the porfyr material was a mix between different types of materials, another could be that the hard porfyr material was polished over time




Reference: Nielsen, B & Hafdell, P.

# The Swedish results – ABT ”skeleton asphalt”

Mean values for the light surface Q0: 0.092, Qd: 0.080, S1: 0.470. 68% of the surfaces measured was within N2. The span of specular factor S1 was large, the reason for this could be that the stone material still isn’t worn down, despite the fact that its been in use for several years. The reason for this is that this type of material usually is only used in areas with very spares traffic levels.




Reference: Nielsen, B & Hafdell, P.

# Conclusion and Outlook

- The instrument can be used with observation angles of 1.0°, 1.5° or 2.29°. These have all been used in a number of cases with – however - little difference in the resulting values.
- Measurements on roads in Denmark agrees with the standard assumptions of reflection properties of road surfaces in Denmark. Qd ~ 0.078 and S1 value within Class N2 (0.28 to 0.60)
- Measurements on roads in Finland showed a large variation, greatly depending on the site
- Measurements on roads in Finland showed a poor correlation with the CIE standard road surfaces used in simulations.
- Good agreement on AC measurements between the new and old measurements.
- Swedish measurements showed that there wasn't any difference between the to most common used road surfaces.
- Swedish measurements showed that the stone sizes used didn't play any large role in the reflection properties. With the exception of light road surfaces, here larger stones lead to a higher specular factor S1.
- The majority of three road surface types was within N2, but with higher Q0 values.
- Measurements in Norway will be carried out soon.