ASSESSMENT AND ANALYSIS OF ROAD NETWORK PERFORMANCE USING LONG-TERM SURFACE CONDITION DATA

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ABSTRACT

Road surface condition measurements have been carried out in Sweden in a consistent way since 1987. All results are available in the PMS database. Road surface condition data, integrated with maintenance data and information about the road network has a potential for analyses of the long-term performance of the road network. Therefore, a project with the aim to analyze maintenance effectiveness, based on 25 years of consistent measurement data has been carried out.

The data source is the Swedish PMS-database which includes:

Condition indicators (rut depth and IRI), pavement maintenance treatments and road information (traffic, posted speed, road width etc.).

Based on available data, the following have been analyzed:

- Time interval between treatments. (The term time interval has been chosen instead of durability since the time interval is very much dependent on variations in maintenance standard, available budget etc.)
- Condition before and after maintenance
- Change in condition before and after maintenance
- Yearly change in condition before and after maintenance.
- Influence of surface condition variables in decision about maintenance projects

1. BACKGROUND

Many road agencies collect information about the surface condition of their road network by using sophisticated automatic measurement devices. The measurement devices often use laser technique, but depending on characteristic, other techniques are available. The devices are highly automated and can measure in normal speed with a high level of detail. The results of the measurements are utilized in Pavement Management Systems (PMS) in order to allocate funds, identify maintenance works projects and establish maintenance works programs, but also for research. The potential in the measurements are significantly higher than what usually is used today. The degree of explanation between surface condition and need of maintenance works is not sufficient. An improvement of the degree of explanation can be achieved by better evaluation of existing measurements, new measurement variables, etc.

Road surface condition measurements have been carried out in Sweden in a consistent way since 1987. All results are available in the PMS database. Road surface condition data, integrated with maintenance data and information about the road network has a potential for analyses of the long-term performance of the road network, but only limited analyses have been carried out.

In 2002 a project with the objective to analyze the effectiveness of maintenance, based on data from the Swedish National road network was started. An initial phase in the project is to analyze how well available data can be used to analyze the effectiveness of different maintenance activities, with respect to quality of available data and apparent trends in the data. Even if road condition data is available since 1987 it is not obvious that all available

data can be used to establish expected performance of the road network. The road surface condition of the Swedish National road network has been measured regularly since 1987.

This paper is a short summary of the project.

2. ANALYSIS DATABASE

The data source is the Swedish PMS-database which includes:

- Condition indicators (rut depth and IRI), pavement maintenance treatments and road information (traffic, posted speed, road width etc.). The condition indicators are collected by the same types of device (Laser-RST, Profilograph) by different contractors. All measurements have undergone an extensive quality control. Since 1987 to 2011 app. 1 200 000 km have been measured and stored as averages over 20-m. As the paved Swedish road network is app. 80 000 km most road segments have several measurements and time-series of the performance can be achieved.
- All pavement treatments longer than 100 m are required to be reported. In the analysis app. 300 000 projects have been analysed. The reported maintenance treatments database covers a long period and contains historical information (several treatments at the same segment). However, treatments before 1980 have poorer quality.

In order to analyze the durability, surface condition, change in condition and maintenance effectiveness, an analysis database was prepared. This data base is created from PMS database which in turn is created by data from surface condition measurements, maintenance data and road inventory (Figure 1).

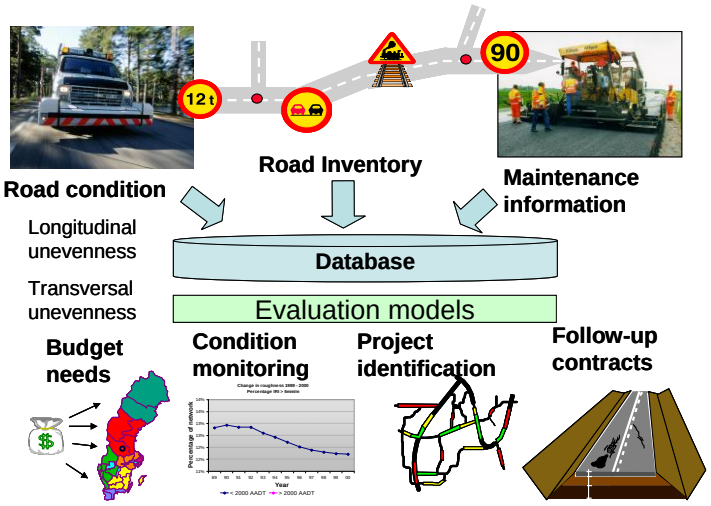

Figure 1: Overview of the Swedish Pavement Management System

The database is divided into homogeneous sections (Figure 2) where each section has the same uniform properties. A homogeneous section varies in length.

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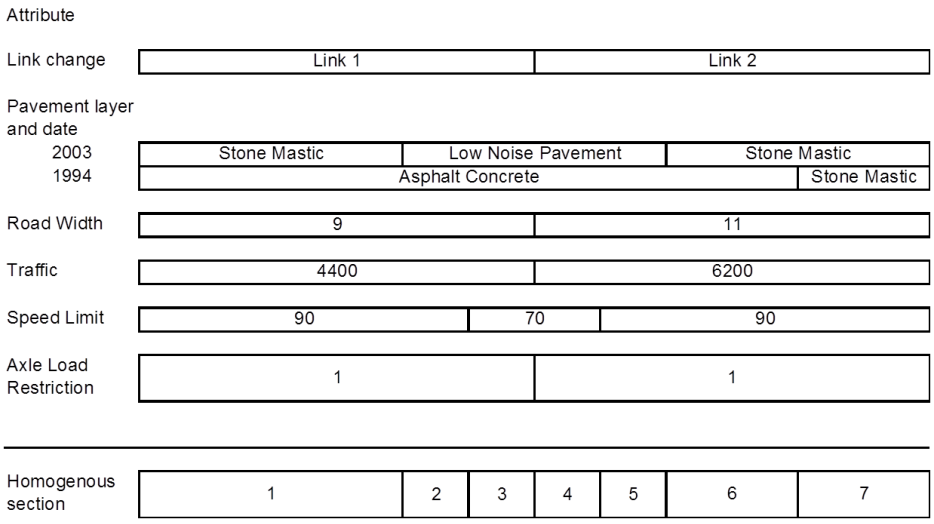

Figure 2: Segmentation in homogenous section

The data have been processed so that:

- Fictitious measures have been added where the condition shows a significant improvement between the two measurements. A fictitious treatment is then considered as a non-reported measure. A fictitious treatment causes a split in time series of condition data.
- Treatments that do not show a significant improvement between the two measurements are noted.
- Treatments that do not show a significant improvement but which is adjacent to a stretch of significant improvement are noted.
- Treatments that are close together in time - within two years - are considered as one treatment. An example can be that first year an adjustment was carried out and the following year a new surface course.

The processing is based on information of predicted condition before and after maintenance treatments. The prediction is an extrapolation, forward or backward, of a trend line of condition time series, before and after a treatment (Figure 3). Predictions for a longer time than 5 years are excluded since they are considered as uncertain.

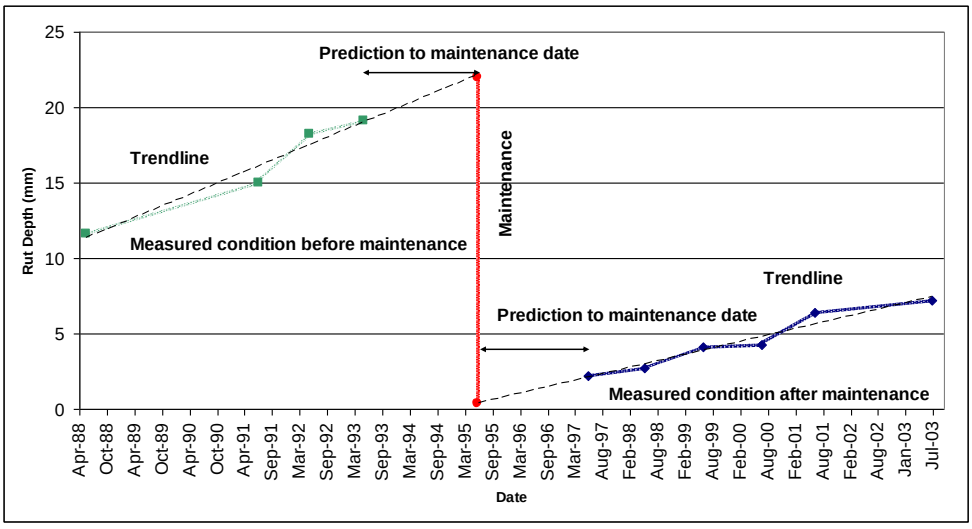

Figure 3: Example of prediction of condition to maintenance date

After processing, the analyse database consist of:

- Predicted condition before a treatment
- Predicted condition after a treatment
- Yearly change in condition before a treatment
- Yearly change in condition after treatment
- Information about treatments, traffic, heavy traffic, posted speed, road type, region etc.

3. RESULTS

Based on available data, the following have been analysed:

- Time interval between treatments. (The term time interval has been chosen instead of durability since the time interval is very much dependant on variations in maintenance standard, available budget etc.)
- Condition before and after maintenance
- Change in condition before and after maintenance
- Yearly change in condition before and after maintenance.
- Influence of surface condition variables in decision about maintenance projects

All analysis has been carried out by traffic classes, treatment types, road types (2-lane, 4-lane etc.), road categories (national roads, county roads etc.) and geographical areas.

Investigations are presented as box plots according to figure 4.

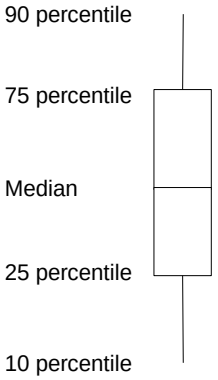

Figure 4: Box plot legend

3.1 CONDITION BEFORE AND AFTER TREATMENT

The condition before treatment is calculated as an extrapolation to the treatment date of the trend line of the measurements before treatment. The condition after treatment is calculated as an extrapolation to the treatment date of the trend line of the measurements after treatment. The maximum time of extrapolation is 5 years. Treatments are grouped and abbreviated according to table 1.

Table 1: Groups of maintenance treatments

CM	Cold Mix
HM	Hot Mix
SC	Seal Coat
SD	Surface Dressing
SHM	Semi-Hot Mix

Figure 5a and 5b shows examples of unevenness (IRI) before and after treatment for different treatment types in traffic class 1000 – 3999 vehicles/day. The median IRI for all

treatments are 3.4 mm/m before and 1.3 mm/m after treatment. The variation for seal coat is very high and either the reporting quality or the treatment selection can be questioned.

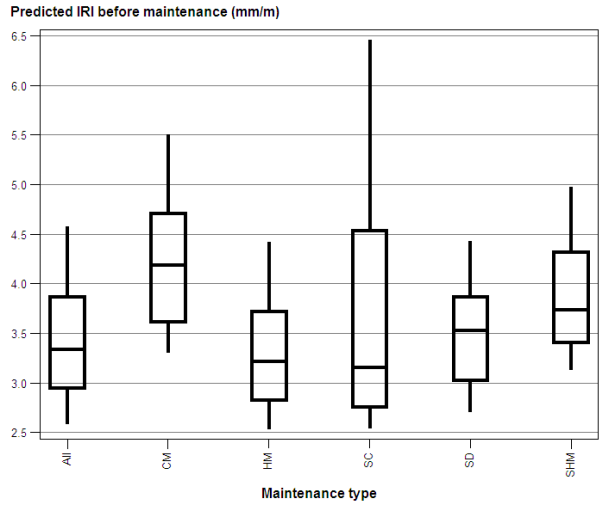

Figure 5a: Predicted IRI before maintenance treatment for different treatments in traffic class AADT 1000-3999

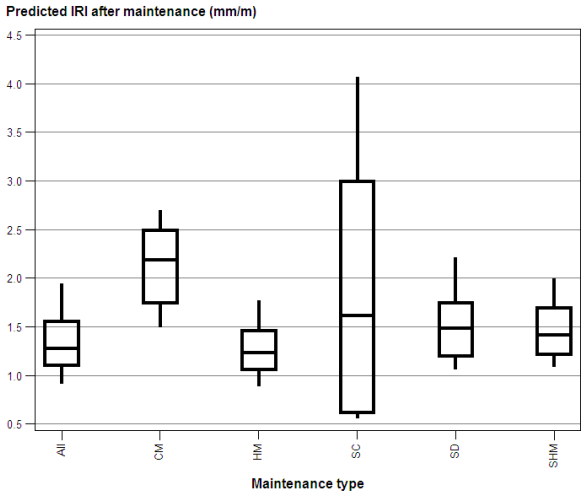

Figure 5b: Predicted IRI after maintenance treatment for different treatments in traffic class AADT 1000-3999

The ratio of condition after and before treatment shows the initial effect of a treatment. If the ratio is low, the initial effect is high and if the ratio is high, initial effect is low. Figure 6 shows an example of ratios for IRI in traffic class 1000-3999.

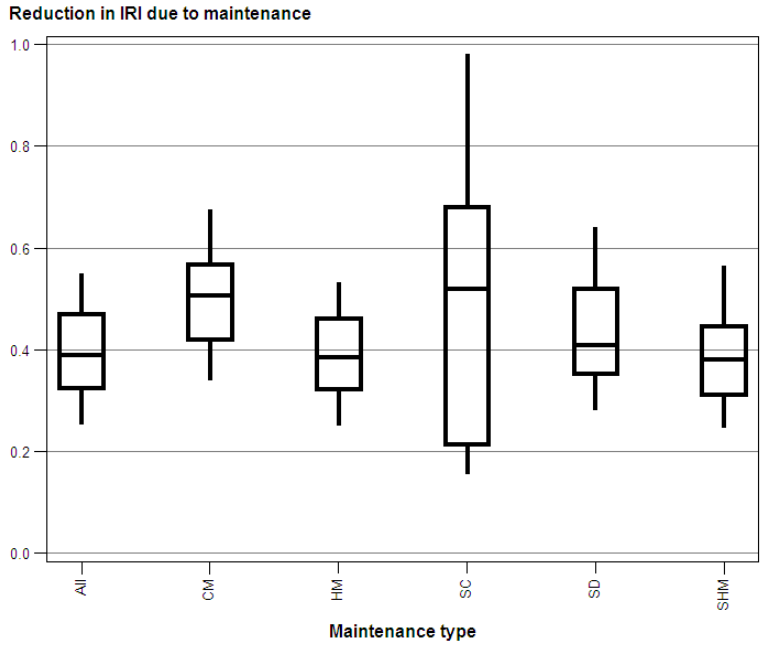

Figure 6: Ratio IRI_{after} /IRI_{before} in traffic 1000 – 3999 vehicles/day

It should be noted that decisions of treatments are affected by other factors than IRI. It should also be noted that before e.g. Surface dressing most often preparatory work has been undertaken before the surface dressing. The effect is therefore remarkable high.

The ratios also show that IRI after treatment is dependant of IRI before treatment. The conclusion could be that the selection of treatment seldom is sufficient.

Similar results for rut depth show a different result. The rut depth after treatment is most often between 2 mm and 4 mm, independent of the rut depth before treatment.

3.2 YEARLY CHANGE IN CONDITION

Analysis of the yearly change in condition is based on a straight line regression analysis of time series of measured data. It should be pointed out that the results are intended for short-term predictions (max 5 years). For longer prediction, the straight line model is not sufficient.

Figure 7 shows the yearly change of unevenness (IRI) in different traffic classes. For all roads, the yearly change is 0.06 mm/m/year. The change is higher on low traffic roads and lower on high traffic roads.

Figure 8 shows the yearly change in rut depth in different traffic classes. For all roads the yearly change is 0.6 mm/year. The change is higher on high traffic roads and lower on low traffic roads. The yearly change in rut depth is affected by the number of vehicles with studded tires.

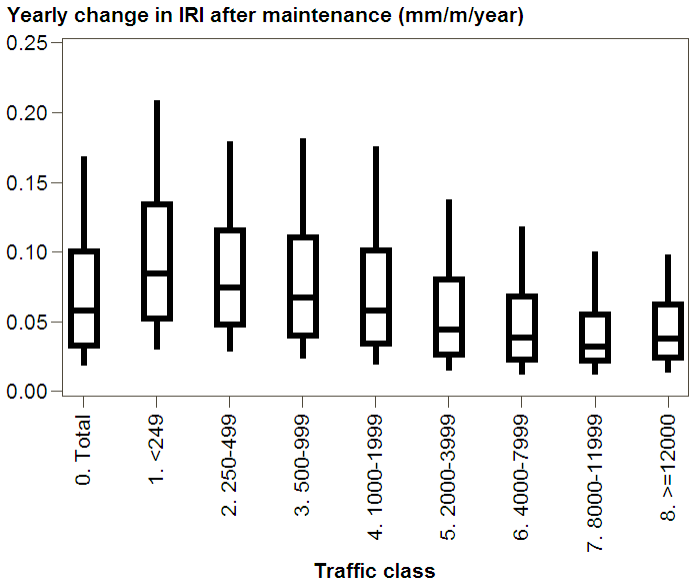

Figure 7: Yearly change in condition for IRI

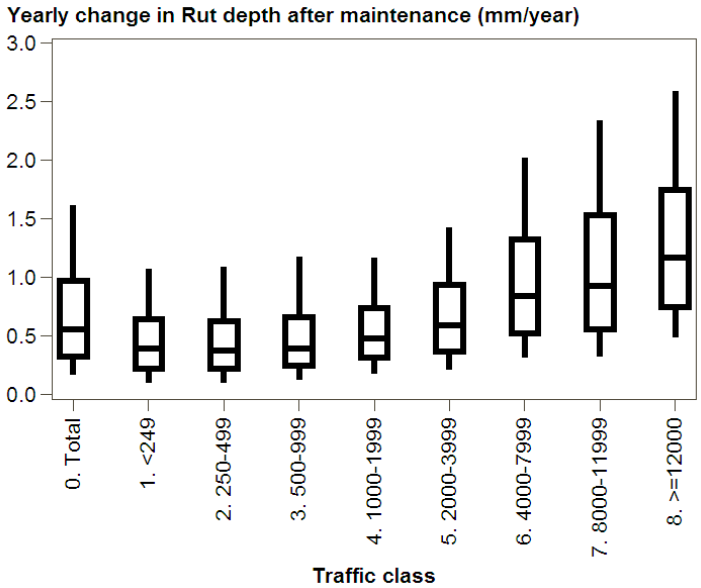

Figure 8: Yearly change in condition for rut depth

3.3 INFLUENCE OF SURFACE CONDITION VARIABLES IN DECISION ABOUT MAINTENANCE PROJECTS

Everything that affects decisions about maintenance works is not measured and an interesting question is: To what extent can decisions about maintenance works be explained by automated measurements?

Analysis based on the predicted condition before treatment and the Swedish Maintenance standard was carried out. The analyses also include an age trigger based on analysis of time interval between treatments. The term "consistency" is used for road segments that not have a poor condition but are adjacent to poor segments. It also should be noted that in practice seldom the length of a project is only road segments with poor standard (figure 9).

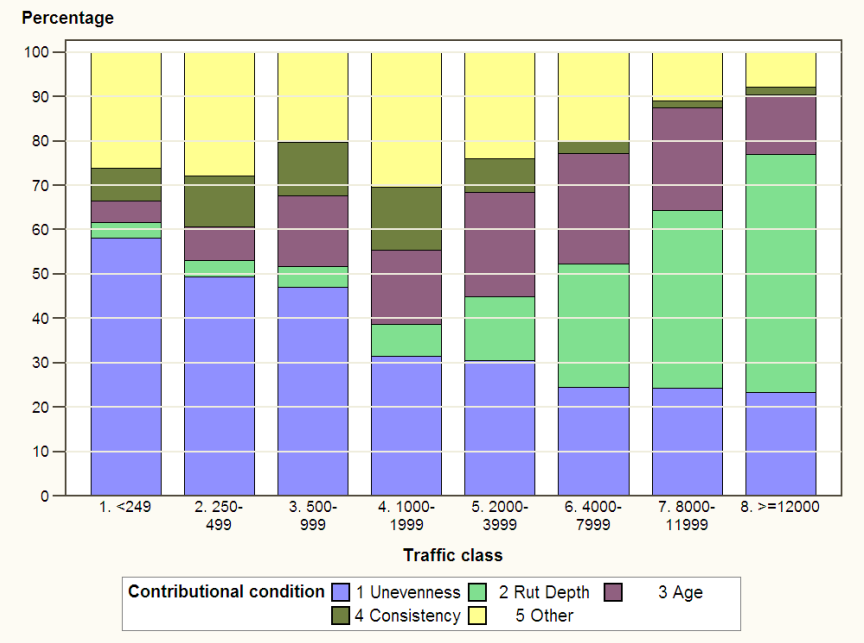

Figure 9: Influence of surface condition variables in decision about maintenance projects

For low traffic roads IRI is a main contributional condition parameter and for high traffic rut depth is a main contributional conditional parameter. It should be noted that the use of studded tires in Sweden very much affect the rut depth. An average of the influence of surface condition variables is 60%.

3.4 TIME INTERVAL BETWEEN TREATMENTS

The time interval between treatments is calculated as the age of a treatment when a new treatment is carried out. This means that the time intervals are valid for treatments that were carried out maybe 20 years ago. Treatments that are carried out today may have a different durability before next treatment. Other methods as survival analysis have been tested but not fully applied.

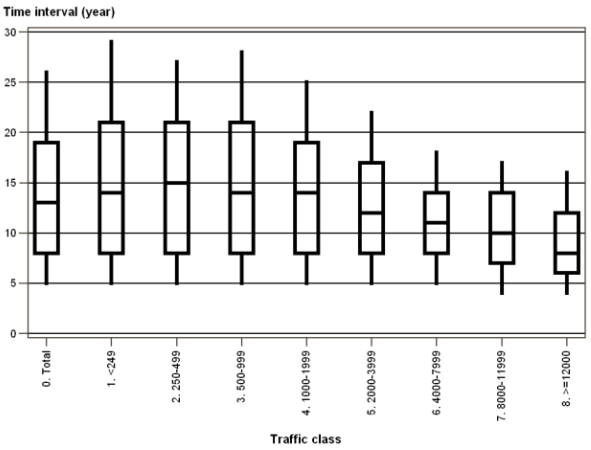

Figure 10a: Time interval between treatments in different traffic classes

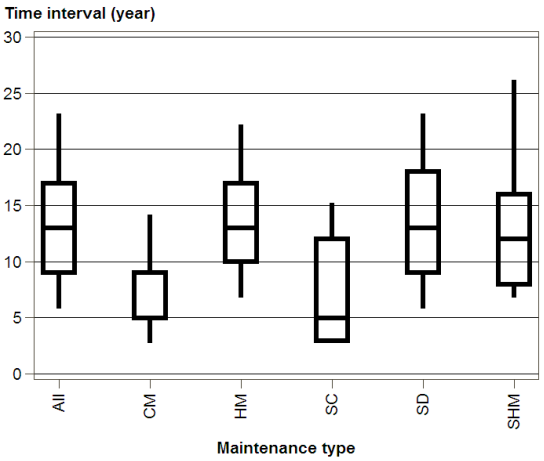

Figure 10b: Time interval between treatments in traffic class AADT 1000-3999 for different treatment types

As expected the time intervals and the variation is higher on low traffic roads than on high traffic roads.

Different treatments have different time interval. It is unexpected that surface dressing have longer time interval than hot mix. But in most cases, preparatory work has been done immediately before the surface dressing. Also, selection of treatments and their performance is dependent on the condition before.

4. DISCUSSION

The analysis of Swedish data has shown several interesting results but also several question marks.

One question mark is the quite large variations in the result. This variation can be caused by lack of information of condition parameters as cracks, bearing capacity etc., but also on in-site variations in the production quality.

Surface condition measurements can be used for analysis of pavement performance together with information of treatments, traffic etc. It is essential to take careful consideration to the quality of used information.

REFERENCE

Lang, J, Assessment and Analysis of Road Network Performance Using Long-Term Surface condition Data (Draft) 2010