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Data quality obtained by the iPAVe during comprehensive measurements of road infrastructure conditions

#ICA4point0

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ABSTRACT

The presentation by Principal Engineer Bjarne Schmidt from ARRB Systems AB, Sweden, President ZAS and Director at Sloman Slovenko Henigman, Slovenia, and Aljoša Luis from NovaGteh, Slovenia focuses on the data quality obtained by the iPAVe (Intelligent Pavement Evaluation System) during comprehensive measurements of road infrastructure conditions.

Accurately identifying and prioritizing road sections requiring maintenance, rehabilitation, or reconstruction is crucial for maintaining a sustainable and safe road network. Comprehensive measurements performed on road networks serve as a robust platform for achieving this objective.

The iPAVe system was initially introduced at the Conference Asphalt Pavements in 2021, and subsequent measurements were conducted in Slovenia in 2022. This presentation will showcase the quality of data derived from iPAVe measurements, utilizing an example from a test section in Slovenia that adheres to Slovenian standards.

Furthermore, the presentation will demonstrate how the iPAVe system can be employed to investigate the impact of seasonal variations on road infrastructure conditions. Through these examples, the audience will gain insights into the effectiveness and potential applications of the iPAVe system in optimizing road maintenance strategies and ensuring the longevity of road infrastructure.

1. INTRODUCTION

Roads are usually designed and built based on strength characteristics or load capacity but are generally managed according to their functional condition, as in the past it was difficult and expensive to carry out regular measurements of the condition of roadway structures. Until now, the overall condition of the roads in Slovenia has been largely determined by the Modified Swiss Index (MSI) methodology.

A complete data set that includes information about the road below and on the surface allows the road manager to better understand their conditions. This dramatically improves decision-making in road network management. Road agencies in North America, Europe, South Africa, China, Australia, and New Zealand now use the Intelligent Pavement Assessment Vehicle (iPAVe) as a tool to collect pavement characteristics at traffic speed annually.

The unique capability of continuous, high-accuracy, high-resolution data allows infrastructure managers to pinpoint areas where the roadway structure is deteriorating and is subject to deterioration. The simultaneous collection of structural and surface data while driving (without obstructing the rest of the traffic) provides a comprehensive assessment of the condition of the infrastructure, which enables efficient and intelligent management of road infrastructure assets.

1.1 iPAVe comprehensive pavement assessment vehicle

The iPAVe Comprehensive Pavement Assessment Vehicle is a fully integrated research vehicle capable of collecting both structural and functional pavement condition data simultaneously and at traffic speeds.

The following data are measured with the vehicle:

- pavement strength through deflection measurements
- cracking
- longitudinal and transverse road profile
- pavement macro texture
- road geometry
- geospatial position
- digital imaging

1.2 Measurements and repeatability of data

To measure the road surface in a total length of 9 km, measurements were made with the iPAVe vehicle. The vehicle made five (5) trips in both directions and with this, the pavement data for both traffic lanes were obtained.

Five passes were made over the entire section to demonstrate the accuracy of measurements. The charts below show the repeatability of the data for individual parameters (IRI, potholes, SMTD, deflection, and cracks).

These parameters are shown because Slovenian standards use before mentioned parameters to determine the condition of their roads.

1.2.1 IRI (International Roughness Index)

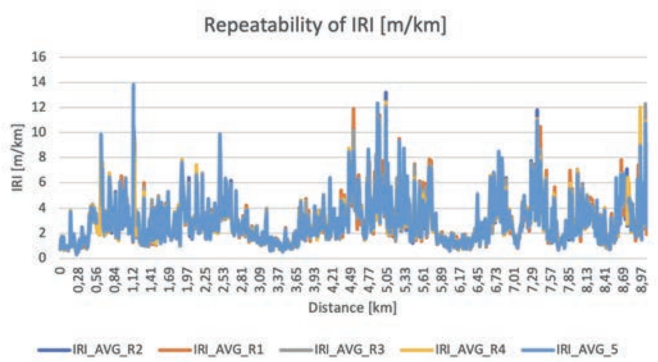

Figure 1: Repeatability of IRI data for 5 runs of the same test section.

The standard deviation for IRI measurements performed on the test section in Slovenia is 0,37 m/km, and the regression R^2 value is 0,98.

1.2.2 Potholes

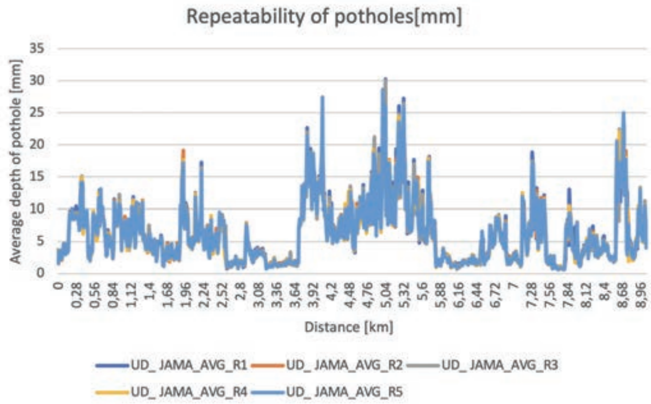

Figure 2: Repeatability of potholes data for 5 runs of the same test section.

The standard deviation for the average depth of pothole measurements performed on the test section in Slovenia is 0.67 mm, and the regression R^2 value is 0,98.

1.2.3 Texture SMTD (Sensor Measured Texture Depth)

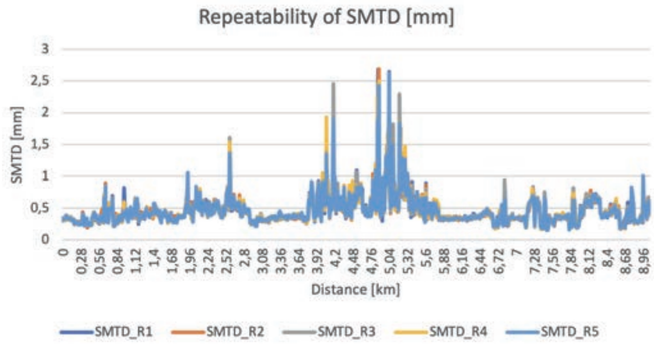

Figure 3: Repeatability of SMTD data for 5 runs of the same test section.

The standard deviation for texture (SMTD) measurements performed on the test section in Slovenia is 0,037mm, and the regression R^2 value is 0,98.

Measured data for SMTD (iPAVe) from 2022 were also compared to the given data of SMTD for the year 2021.

When calculating the deviation of the measurements for the year 2022 from the measurements made in 2021, it was found that the average difference between the results of the two measurements was 0.05 mm.

1.2.4 Deflection

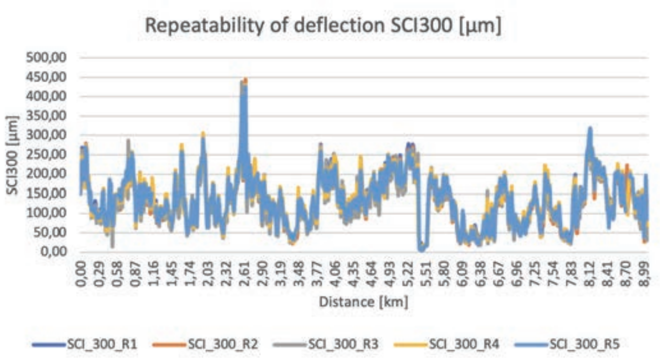

Figure 4: Repeatability of deflection data for 5 runs of the same test section.

The standard deviation for deflection measurements performed on the test section in Slovenia is 8,3 µm, and the regression R^2 value is 0,98.

1.2.5 Cracks of pavement surface

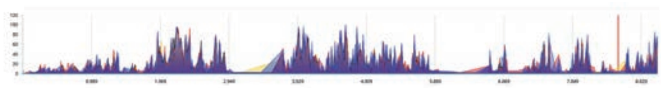

Figure 5: Repeatability of cracks data for 5 runs of the same test section.

1.3 Analysis of the state of the roadway structure

1.3.1 MSI

For determining the state of pavement structure Slovenia uses MSI (Modified Swiss Index) which uses a defined coefficient (based on types of damages) for the type of used pavement (concrete or asphalt), defined damage severity classes for each type of damage, and classes based on the affected area of bellow listed damages.

When calculating MSI, the extent of the affected area is estimated as the severity of the following damages:

- cracks;
- raveling;
- potholes;
- patches;

The calculation of the MSI index for 2021 (without using the iPAVe vehicle) was carried out in the following way:

The person making the measurements performed a visual assessment of the strength and extent of individual injuries with a computer connected to the stationary meter, at a speed of 15 to 30 km/h for 50 m steps of the section. The strength and extent of individual damage are entered in the table, which is then used to calculate the value of the MSI index for the 50m steps of the section. During the "visual assessment" measurements, GPS coordinates and an inventory of road signs were also recorded.

The calculation of the MSI index for 2022 (using iPAVe vehicle) was carried out in the following way.

To calculate the MSI index value, the iPAVe vehicle performed measurements:

- the proportion of cracks on the carriageway according to their type (grid, longitudinal, transverse, and wheel path cracks);
- depth and surface of potholes;
- the proportion of raveling or wear and tear of the wear layer of the pavement;
- spatial imaging of the roadway and its surroundings for inspection and determination of the extent and strength of the affected pavement with patches.

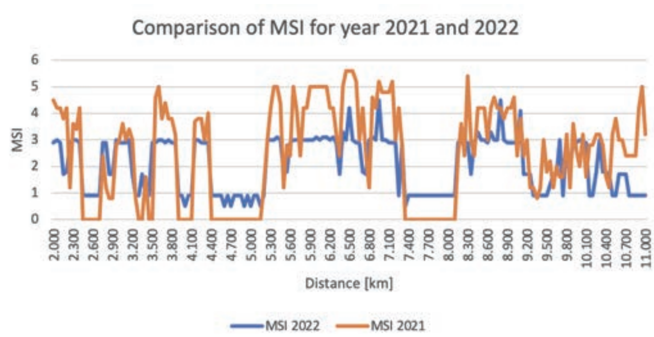

Figure 5: Comparison of MSI for the years 2021 and 2022 of the test section in Slovenia.

Figure 5 shows a comparison of the MSI index values from 2021 and the MSI index values for 2022. The largest share of the difference occurred mainly when recording the extent and severity of damage for potholes, cracks, and wear, which were recorded during measurements in 2022 with an iPAVe vehicle. There are no major differences in recording the strength and extent of the affected pavement with patches, as this required a manual review of the video footage and photos captured by the iPAVe vehicle for the section in question.

From the comparison, it is clear that the values of the MSI index are different for each year, but the data curve moves very similarly, which means that the damage is located in the same places in the section. It is clear from the chart that the parts of the section where the pavement damage is the greatest in our case do not have such a high MSI value, but still belong to the "VERY BAD" rating.

Pavement condition (2022) that corresponds to the individual criterion of the MSI value:

- 50.8% of the section has a very poor rating
- 5.0% of the section has a bad grade
- 14.4% of the section is rated unsatisfactory
- 26.0% of the section is rated good
- 3.9% of the section is rated very good

Pavement condition (2021) that corresponds to the individual criterion of the MSI value:

- 60.8% of the section is rated very poorly
- 5.0% of the section has a bad grade
- 6.1% of the section is rated unsatisfactory
- 2.2% of the section is rated good
- 26.0% of the section is rated very good

When summing up the shares for very bad, bad, and unsatisfactory ratings, the difference between the data for both measurements is only 1.6%.

When evaluating cracks, the biggest difference occurred in determining the extent of the affected pavement with cracks, which in our case was determined by the calculated proportions of cracks on the surface of the pavement. When determining the severity of crack damage, the differences were smaller than for the extent of damage.

When evaluating potholes, it was found that there are more of them in iPAVe measurements, because the system recognizes the depth and extent of the impact pit in millimeters accurately.

When evaluating pavement wear, it was found that there were more in the iPAVe measurements, but they were not as extensive. In particular, wear was present on those parts of the section where they were rated 0 in 2021, but the proportion of MSI for wear was minimal because it was mainly individual grain loss. The extent and proportion of pavement wear were calculated based on the surface of the pavement and the area of grain fallout [mm^2].

There were no major differences in the evaluation of the pavement affected by patches, as it required a manual visual inspection of the pavement and was found to be the most reliable method for assessing the condition of the pavement.

On average, there was an average of 35.0% difference between MSI calculations for individual damages.

2. CONCLUSIONS

Based on the measurements carried out for the test section of the road in Slovenia, we can conclude that the data obtained from the iPAVe vehicle are very precise. This method provides optimal results of the condition of the road surfaces with the smallest traffic disturbances, which can be effectively used for roadway management.

3. BIBLIOGRAPHIC REFERENCES

- **B. Schmidt, S. Tetley, J. Daleiden.** "Intelligent pavement assessment vehicle for structural and functional evaluation of road pavements". Eleventh International Conference on the Bearing Capacity of Roads, Railways and Airfields. December 2021