Science and development - IR study for GPR Quality Control

Comparison of Asphalt Pavement spreading technologies
and quality control of thermography
the applicability of the study

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INTRODUCTION

Asphalt Pavement wear layer construction cost the State Highways in Estonia annually an estimated 40 to 50 million euros (About 300 km). These coatings will for various reasons fall apart and need after some time recovery and reconstruction.

Asphalt Pavement durability and lifespan depends mainly properly on chosen asphalt mixture, the quality of the installation site and the installation of quality. Current experience based on one the main cause of degradation of coatings lead out coatings insufficient density. Insufficient density means that the water and atmospheric oxygen escapeing through the pores in the coating easier to cover the interior of, weakening the chemical ties coating particles states. Estonian climate plus more wintry conditions forces generated by the freezing of water.

Following is summary from the research project "Comparison of Asphalt Pavement spreading technologies and quality control of thermography“ made by the Road Administration in Estonia 2014.

Summary from report

Temperature inhomogeneity of the asphalt mixture is found one of the major causes for poor compaction of new asphalt layers, so cooler spots in asphalt tend to remain porous compared to the other areas. Higher porosity of the upper asphalt layer favours the ingress of water into the layer and thus contributing the initiation and progress of defects, especially with the “aid” of freeze-thaw cycles.

Asphalt mixture starts cooling down already in asphalt plant and through the way until compacted and unfortunately, this happens unevenly. There are plenty of possible reasons - aggregate moisture content variation, aggregate segregation, temperature unevenness in the production, inadequate insulation of hot storage bins in the plant and time before loading, mix loading technology and truck bed shape and insulation, transport distance, cooling and the segregation of asphalt mixture in the paver hopper, uneven distribution of the mixture by paver, downtime/stops during paving etc. This list shows that the only contractor itself can effectively enough affect these aspects, so poss ibilities for motivating contractor to achieve good thermal mix homogeneity has received lot of attention in current study. In this study two innovative technologies were covered in more detail for better thermal homogeneity of the mix.

Asphalt feeder

One of these technologies investigated was asphalt feeder. We compared the road section paved with and without feeder. Also different asphalt plants were used, the transport distance and the other conditions were comparable. The study showed that the feeders **enable** significantly reduce segregation the asphalt. In this site no deductions were applied to contractor from air void measurements based on coresamples and we believe it is likely that there's no need for major repairs during the warranty period. Therefore, the only benefit from using feeders arise from reduction of downtime and hauling cycle speed - up, which alone obviously does not compensate for additional costs. Feeder, having roughly the price of paver, is worthwhile to be implemented only if the quality requirements from the customer are high enough and other, more effective options to ensure the quality are utilized. Unfortunately, so far these options have gained only very limited attention during the hauling and paving process-because the **motivation system is not effective enough.**

Figure - 1 and 2 Vögele "feeder" - asphalt spreader feeders workflow

Infrared thermal scanning

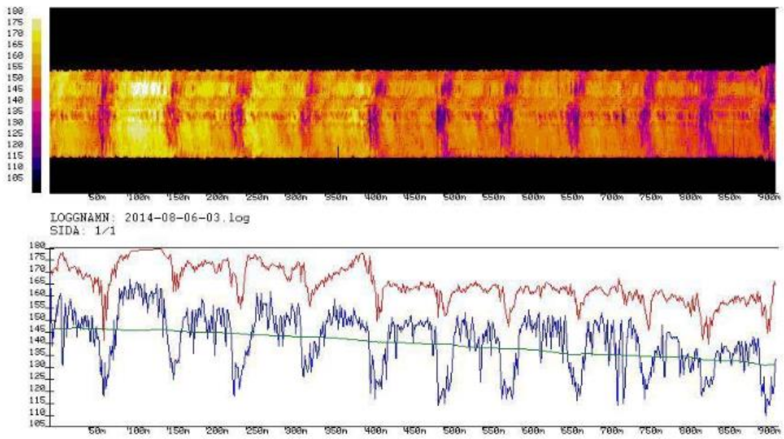
The other technology is infrared thermal scanning based motivation system, developed and successfully used in Sweden. The system scans the hot pavement temperature continuously during the installation and as a result, work quality (100% coverage of paved area) can be easily evaluated in real timeand respond to the problems immediately.

Figure – 2 Vögele "feeder"

The main value of the system however appears from integration to the **motivation system**. Simple enough to distinguisht hree major cases based on work quality–in case of substandard work quality the deductions are applied, in case of work quality just above the requirements - plain contract fee is paid out and in case of work quality significantly above the requirements - the bonuses apply.

Figure 3- Thermo scanners, type GPX 34

Figure 4 The thermo scanners covers the whole cross section of paved area



Picture from thermo scanner. Regular cool fields reflects the shift of asphalt trucks feeding the paver.

On the graph are shown the minimum and maximum teperature in each cross section of paved area.

Figure 5 - Thermo scanner results, paved without feeder.

The system highly **motivates contractor** not only to achieve requirements but continuously improve the quality of work towards maximum, by applying the most cost - effective measures. According to the Swedish experience up to 40% longer pavement life can be expected with such system. In Estonia, the benefits may be even higher.

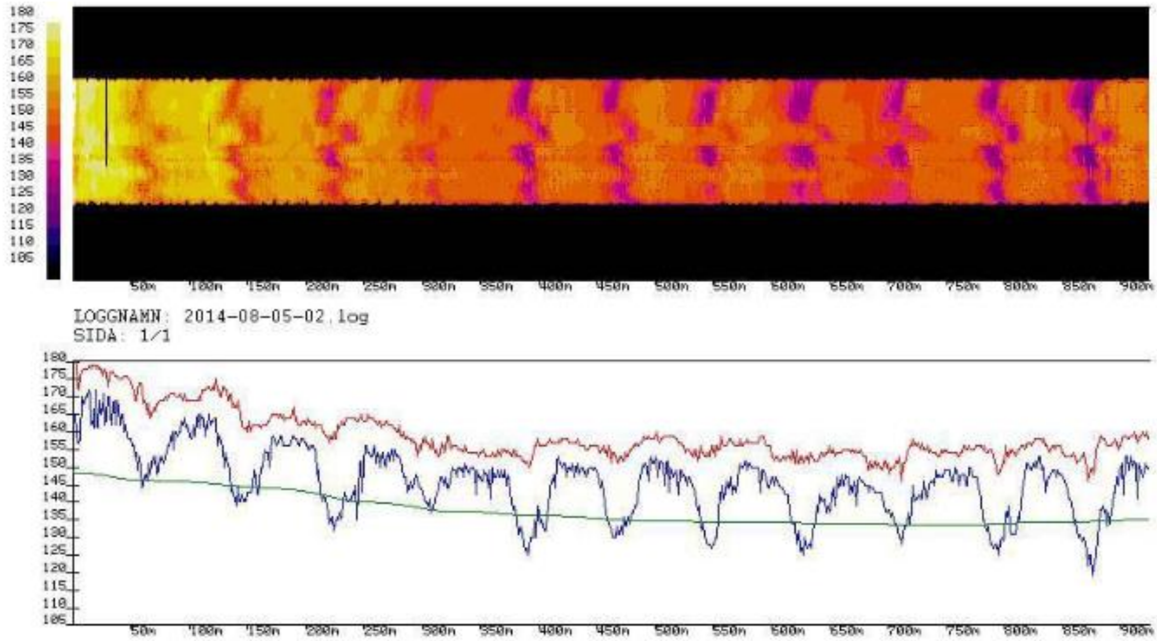


Figure 6 - Thermo scanner results, paved with feeder.

The idea of the green line (related to 30 min average) is to establish the basis for determining the risk area. This is local so-called cold spot which, due to significantly colder temperature has lower potential for compacting with the same effort. This is called „**risk area**". Performance of pavement can significantly be improve if the risk area can be reduced – which mean less porous pots. **It is extremely important in climates with many freeze-thaw cycles in upper part of pavement.**

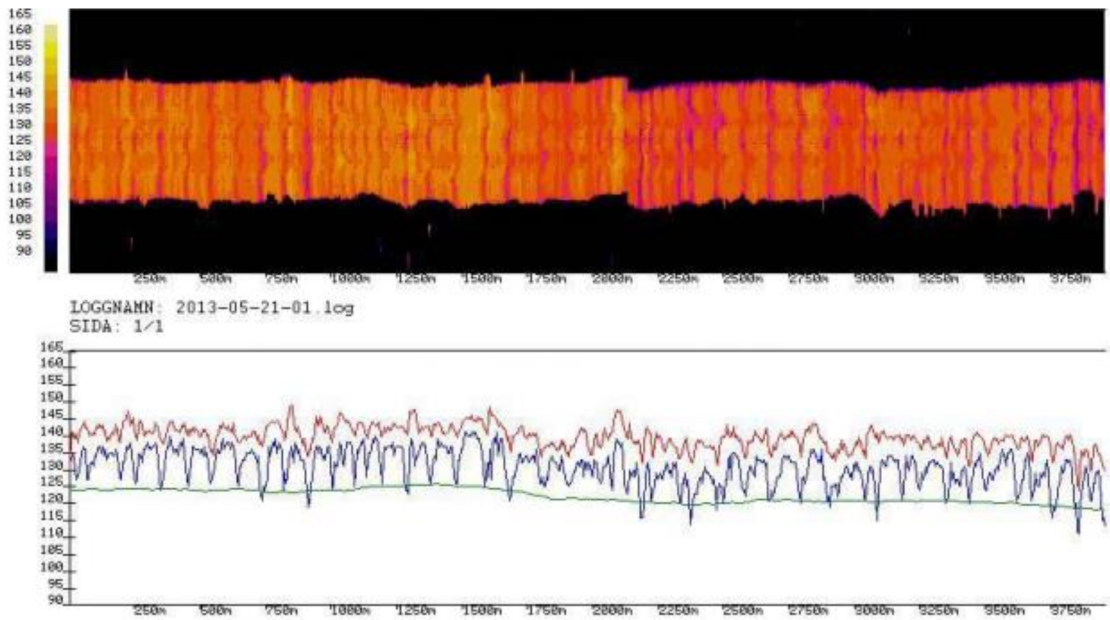


Figure 7 - Thermo scanner results from Sweden, asphalt loaded with trucks only and motivating bonus system.

Handheld infrared cameras

Feasibility of using handheld infrared cameras was also evaluated in the study. It was found that despite the relatively low cost of such devices(about €1,000... 8,000 depending on the model), its use in the road works supervision process is relatively **costly** if properly done and can be even harmful if deployed poorly.

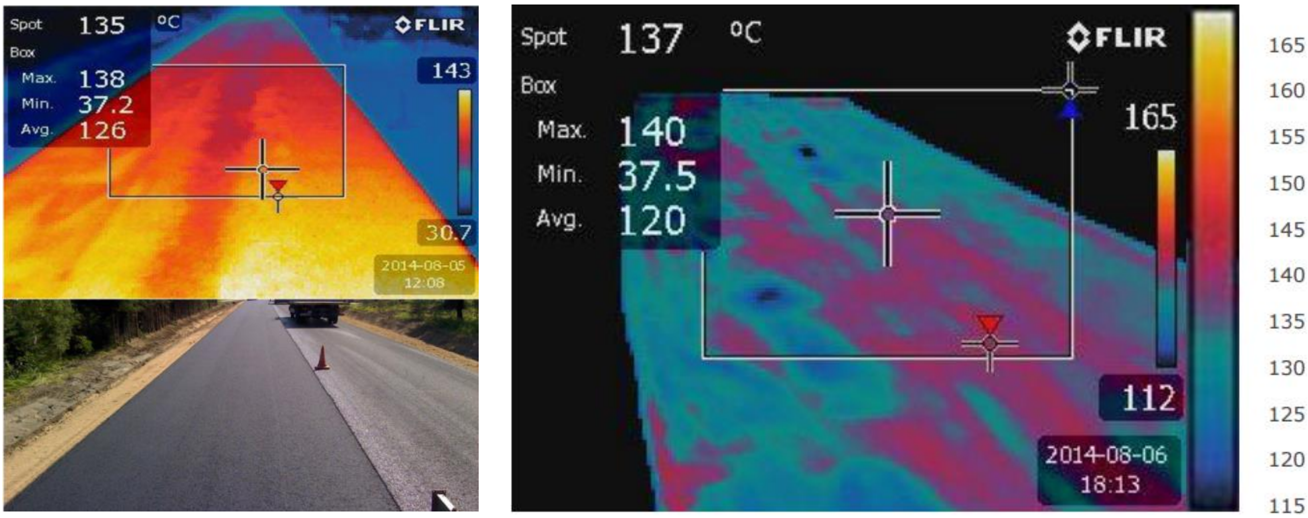


Figure 8 Examples showing temperature range using a handheld thermal camera.

However, we highly recommend handheld IR - cameras for paving contractor to be able to **quickly respond** to problems from temperatures and **prevent damages**.

Figure 9 - Thermal camera Flir E30 used in project.

Ground Penetrating Radar (GPR)

Rather positive results were obtained from Ground Penetrating Radar (GPR) studies as continuously measured air void contents of pavement very well correlated with those of infrared thermal scanning. Thus making it a mandatory component of the motivation system for upper pavement layers would be **very effective and highly recommended**.

Using GPR as an acceptance test method is discussed in more detail in the study "*Development of non - destructive acceptance system for asphalt pavements*".

Figure - 10 Residual porosity investigation were carried out with GPR GSSs (1.2 GHz antenna)

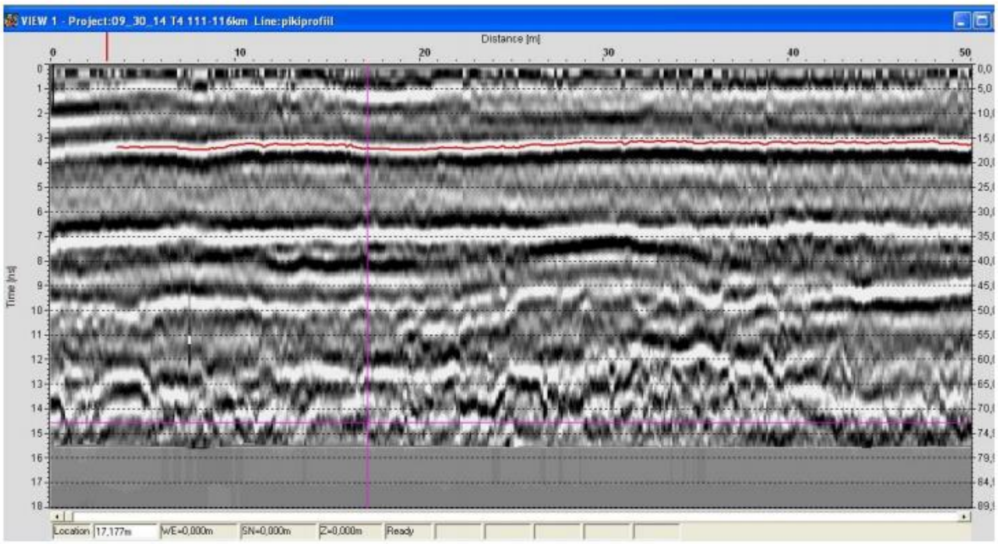


Figure 11- Layer thickness determination by GPR results.

The GPR is also used to measure air voids in upper layer of asphalt which is based on the knowledge, that asphalt layer components like aggregate and binder have similar *Er* (*dielectric value*) and the aggregate/binder ratio is quite constant while air voids have significantly lower *Er* value and affects the overall *Er* value as well. This *Er* value is calculated from measured signal travel times and calibrated with real samples. This makes possible to get air void values virtually continuously and as can be see from the report.

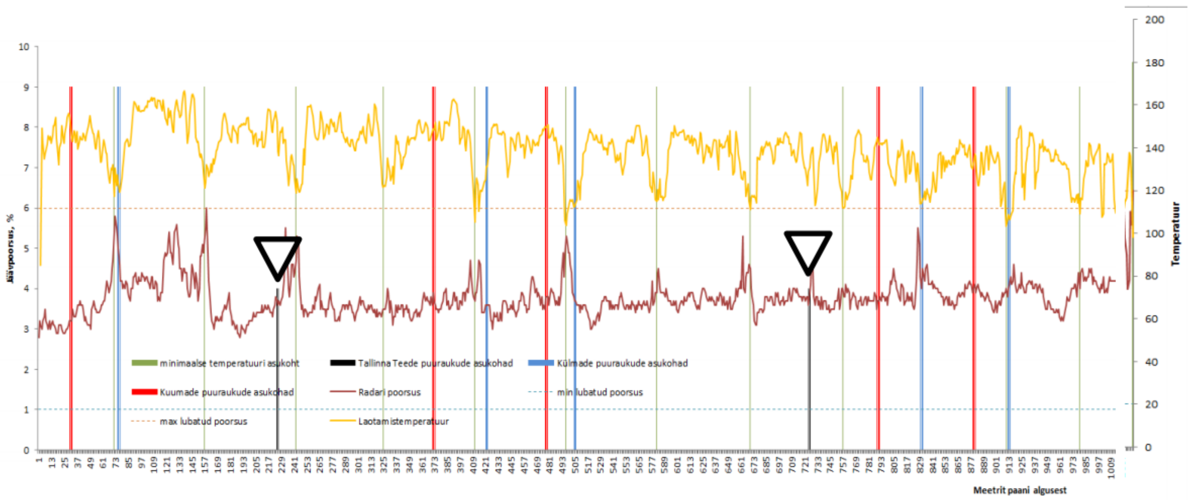


Figure 12 - Residual porosity and the installation of a temperature graph

As can be seen from the graph above, such air voids (red in graph) shows pretty good correlation with temperatures (in yellow) and the location of change in asphalt trucks. The State Highways in Estonia are working on both methods, thermal scanning primarily as a real-time tool for contractor and GPR primarily as a pavement quality control tool for client.

Cost - Benefit Analysis

Cost - Benefit Analysis showed that better motivation system that targets higher homogene ity of temperature and pavement density can effectively reduce paving costs in long term. Slightly higher pavement unit costs are fully paid off by longer pavement life with Net Present Value up to 109.9 m € and Benefit - Cost Ratio up to 3.54 (30 - year reference period), thus being highly feasible.

Closure

This summary is from the research report "Comparison of Asphalt Pavement spreading technologies and quality control of thermography the applicability of the study" done by the State Highways in Estonia and the authors are following:

- Marek Truu (AS Teede Tehnokeskus)
- Erko Puusaag (AS Teede Tehnokeskus)
- Veiko Tikas (AS Teede Tehnokeskus)
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- Heikki Pormeister (AS Tref)
- Märt Puust (Teedeklaster)
- Mati Ertsen (Wirtgen Eesti)

The report in Estonian can be found on the web from following link:

IR study for GPR Quality Control (as a must since 2016y in Estonia for topp layer)
http://www.mnt.ee/public/141130_IR_uuring.pdf

Other research reports from Estonia State Highways can be found on following link:

http://www.mnt.ee/index.php?id=12039