ADVANCED DIRECT QUALITY CONTROL FOR ASPHALT COMPACTION

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Abstract. This presentation refers to modern asphalt compaction technology using a continuous compaction control system. It gives valuable information about the latest developments of measurement technology in conjunction with a Compaction Management System including Networking. The compaction control system combines several asphalt rollers in a wireless network. Each roller will be equipped with a tablet computer and a satellite receiver.

BCM net continuously provides every roller driver for example with an overview of passes being completed, the asphalt surface temperatures and also the progress of compaction. In practice, the operators can follow the development of a “compaction map” on the tablet-computer. All compaction data are not only visually displayed, but also saved for complete documentation. It gives an overview how quality control measures can be realized during the compaction process and the overall efficiency of the compaction task thereby can be improved. The aforementioned technology will be described by the example of two road construction projects in Lithuania and Germany in 2014.

Key words: Compaction of asphalt; Compaction Management System with Networking (WLAN); Continuous Compaction Control, (CCC); Indication of compaction progress; Automation.

1. Introduction

This report provides valued information about up-to-date compaction technologies at the example of a „networked job-site “. It shows how the inevitable control measures can be arranged area-wide and that also the efficiency of asphalt construction jobs thereby will be improved at the same time. Continuous Compaction Control on Asphalt (CCC-A) of today is becoming more and more a part of process engineering in the road construction business.

2. Efficient compaction for flexible asphalt pavement

Compaction efficiency has been always a key factor in the processing of rolled asphalt. However, the efficient operation and handling of vibratory rollers require some basic knowledge of flexible asphalt pavements. Vibration technology enables asphalt mixes to be compacted with fewer passes. But also the compactibility of the asphalt mix must be considered. For example, tender mixes comprising low viscosity bitumen together with natural sand require a special treatment which may result in static compaction. But the mix design of high classified roads has increased in stiffness e.g. with high viscosity bitumen over the last decade and must be compacted with higher intensity (see Fig.1) [4].

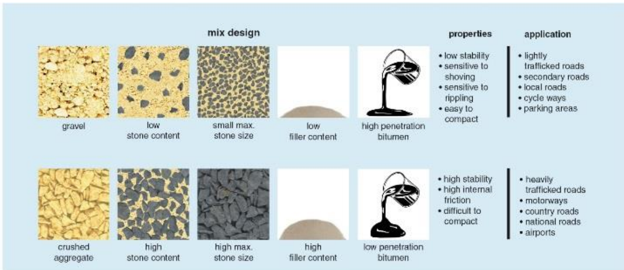

Fig. 1. Typical asphalt mix design – easy or hard-to-compact

However, the compaction task always comes last at the end of the process and it hardly depends on temperature.
Also, current mix design concepts are getting more and more complex in its structure and its workability. Even stone mastic asphalt which has been introduced many years ago, dedicated for highly trafficked roads will be very difficult to work with under unfavourable temperatures and not well adjusted compaction. When treated well, it features an average lifetime expectancy of 20 years [1]. This mixture also offers good noise reducing properties.

But compaction itself has always been a challenge due to the "gap-graded" mix design, composed of a coarse crushed aggregate skeleton bound with a mastic mortar. The sieve-curve (see Fig. 2) typically shows a higher percentage of the coarse grains [2].

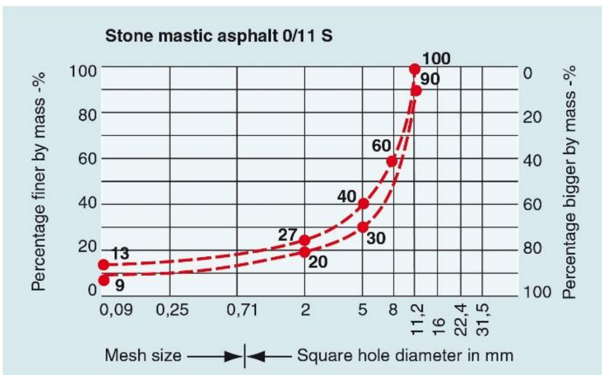

Fig. 2. Typical structure of SMA; sieve curve

When utilizing too many passes with dynamic compaction it may result in over-compaction with either aggregate cracking or fatting-up the surface with bitumen. This is basically due to the self-supporting stone structure with higher percentage of coarse grains, (see Fig. 3) [3].

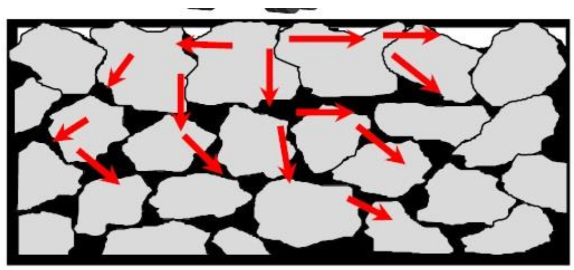

Fig. 3. Gap graded mix of SMA

That's why former guide lines recommended static compaction, only. So contractors were compromising either quality or efficiency of compaction.

Consequently, many Contractors wished to have a more sensitive or intelligent system, a tool that automatically optimises compaction – or allows for more flexible adaptation to different asphalt materials. This report will be referring to the latest development of compaction technology, already used on the road project E 262 in Lithuania, 2014 with an up-to-date system of Continuous Compaction Control on Asphalt (CCC-A) together with wireless LAN (WLAN)

3. Efficiency and quality control fit together

3.1 Road project E262, Lithuania

The European Route E 262 which connects Warsaw and St. Petersburg is a part of the International E-road network and begins in Kaunas, Lithuania and it ends in Ostrov, Russia. The specific asphalt construction project was started at Zarasai which is located in North East Lithuania, 3 km from the Latvian border.

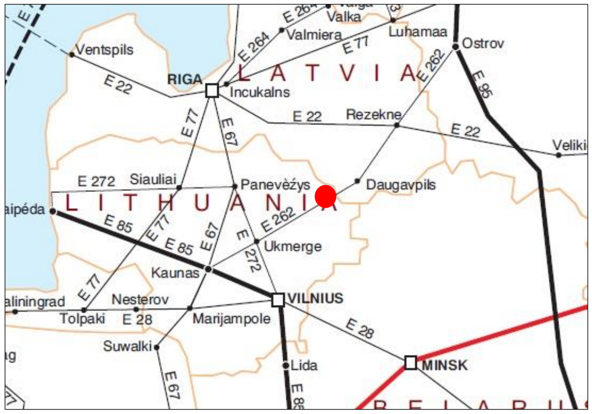

Fig. 4. Job-site, Lithuania on European Route E 262

The strain of heavy goods vehicle traffic on the road is accordingly intensive. In order to guarantee the high quality standards required, rollers with Intelligent Compaction (IC) were used together with BCM net for compaction control.

BCM net stands for BOMAG Compaction Management with Networking. The compaction control system links all machines involved in the construction process and integrates a tablet PC and a GPS receiver into every single roller.

In this way, BCM net provides every roller driver with a continuous overview of the

- number of completed passes,
- surface temperature and
- compaction progress

A coloured screen will be developed on the tablet-PC for every compaction task (with or w/o vibration), so that all operators get a clear overview as to how the job-site is proceeding [5].

Fig. 5. Tablet-PC showing a “compaction-map”

With the tablet PC in each cabin, all operators can see their own results at a glance enabling them to optimize their rolling pattern. But detailed information is also saved for complete documentation (see Fig. 5) with a simple colour display

- green = sufficient compaction,
- red = further passes are required,
- blue = target passes achieved

Thus, the driver knows immediately where there is still work to be done.

Scope of supply:

Basically, all rollers are working in a local wireless network. Lags caused by mobile telecommunications or servers are eliminated enabling real-time imaging and maximum availability. Even if the WLAN connection were to be interrupted, no data would be lost as it will be stored on an exchange server. The range of coverage is up to 400 m. All machines involved in the construction process are linked-in with a tablet PC and a GPS receiver. Only the server-machine is equipped with two tablet-PCs (see Fig.6).

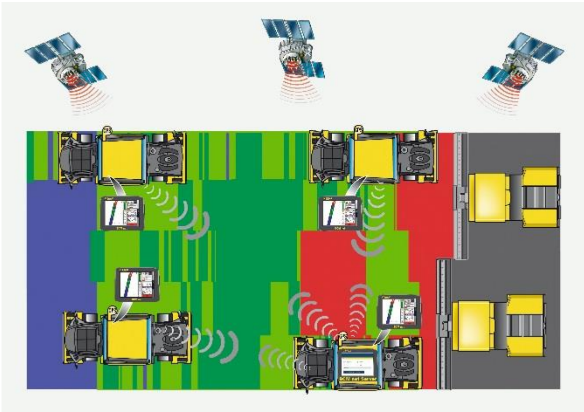

Fig. 6. WLAN-Equipment for a Server-machine

Job-site description:

As already mentioned, compaction tasks of asphalt are sometimes quite challenging in terms of material stability and / or resistance against shoving:

On the E262-route, the asphalt mix design was a commonly used binder AC 22 B with 0/22 grain size – and with a tendency to shoving! (see Fig. 7)

Fig. 7. BW 174 AP (10 t) equipped with BCM net

BCM net were installed in four rollers, comprising two new BW 174 AP-AM tandem rollers, equipped ex-factory. A further BOMAG BW 174 AP from stock and a roller from a different manufacturer were retrofitted.

Rolling pattern and density:

To avoid quality problems with a shoving asphalt mix, it was decided to operate the rollers in static mode, only. The required No. of passes to achieve the density of 98 % was determined by a Troxler gauge.

Finally, the experts at site opted for a 10 static passes and BCM net was an indispensable assistant for that purpose. It featured a color-coded mapping system, tied in with GPS location together with a temperature sensor. The colour mapping displayed the number of roller-passes, colour coded or it showed optionally the asphalt surface temperatures. This prevented the operators from driving too early onto hot material.

Optimized processes by simple handling:

The system was easy to handle and did not require a special training. The coordination of the construction processes and analysis of the resulting data for the site manager was also simplified. All the preparation and post processing was made on a PC in the office, before.

The advantages of networked machines were plain to see. BCM net enabled all operators to improve both the quality and efficiency of the asphalt construction job on E 262. The tremendous amount of data available was one of the crucial factors for the contractor in deciding on such a system. After 5 months of experience and with the help of the data the contractor now has the opportunity to further optimize the processes.

3.2 Road project highway A3, Germany 3.2 Road project federal highway B10, Germany

Another road construction project with Compaction Management System with Networking (BCM net) was done in the south of Germany during September 2014.

Fig. 8. Project BCM net on Highway A3; 6 km

The highway A 3 is one of the most important traffic routes in Europe at a length of 770 km. The traffic load measured in 2015 close to the city of Regensburg exceeded the level of 76.000 vehicles/ day. The number of heavy goods vehicles (HGV) reached a level of 11.000 units. The existing road structure was not strong enough anymore to cope with the high traffic load.

The project:

The particular project was comprising 6 km of a complete reconstruction of the highway with replacement of the existing concrete structure. In this case, three new layers of asphalt (totally 29 cm) were placed on the stress-relieved concrete layer or totally 34 cm asphalt in parts on a newly stabilised base. The project was finished after 5 months at a cost of 7,3 Mio. Euros.

The wearing course was made of stone mastic asphalt (SMA), particularly with a special surface texture for advanced noise reduction.

The German contractor is known as a trendsetter in the market. So it was clear for them to rely on advanced compaction technology with BCM net.

The compaction task here, is referring to an asphalt binder AC 16 B S with a high viscosity bitumen of 25/55-55. The target density was 98 % Marshall, together with a maximum of 5 % void content.

The asphalt binder was laid by two finishers (hot against hot) at a pave-width of 13 m and a thickness of 8,5 cm - totally 4.500 tons/day. In order to achieve best possible quality results in terms of compaction and evenness, area-wide it was indispensable to ensure a constant flow of material. Consequently, they were using a material transfer vehicle (MTV) for each finisher.

Of course, job-site like this require many different rollers at a time - so it was indispensable to have a clear rolling pattern. But in practice, a concern is that most operators do not keep track of the number of passes completed during rolling [6].

As a result of a testing field, the No. of dynamic passes should be limited to eight (see Fig. 9).

Fig. 9. BCM net on highway A 3; Germany

However, it was clear that the operators needed a “smart assistant” to keep that target during the day and of course are-wide. That’s why the Compaction Management system with Networking (BCM net) has been a valuable tool on all 10 t - tandem rollers together with a precise navigation system (GPS) on all the four rollers.

All roller passes (static or dynamic) were clearly displayed on each tablet-PC. One specific roller was fitted with a Server-PC and it was responsible for a continuous data processing and updating of its own results and those of the client rollers.

The measured data are usually updated and transferred every 10 seconds. Even if the server machine quit the job-site (e.g. for refilling water) nothing gets lost, as all data of the client rollers will be buffered on each tablet-PC’s for final matching after their return.

The BCM net- System has been perfectly suitable for job-sites like this, where the rollers have produced a huge amount of online data. In fact, it worked like a data exchange system that kept all operators up-to-date with compaction data like asphalt surface temperature, number of roller passes and also the compaction progress.

Intelligent Compaction (IC) [7]. But how can the compaction progress be measured during compaction? In this case, all compactors were equipped with a directed exciter system, called “Asphalt Manager” (AM2). The system automatically optimises the compaction efficiency during vibration, based on an acceleration measuring and control system. Thus, the effective amplitude for compaction will be displayed as well as the asphalt surface temperature (see Fig. 10).

Fig. 10. AM2 provides valuable compaction data

The intense of compaction and also the depth effect of the exciter system will be adjusted according to the material stiffness or load bearing capacity of the ground. This also avoids the jumping effect of traditional vibrating rollers which often results in mix and / or aggregate cracking [5].

During vibration of the system it continuously measures the stability of the asphalt being compacted and calculates a so called EVIB-Value (MN/m²). It can be assumed that an increase of EVIB-Value after each pass of the roller, indicates an increase of compaction, which is true, provided there is a solid base underneath the asphalt layers. But this was not the case on this particular job-site. A certain stretch of asphalt was based on cracked concrete and another one was laid on a stabilized ground.

So, the EVIB-Values (MN/m²) could not be the right guideline for the operators to follow. That’s why the necessary No. of passes were determined by a testing field before the regular job has been started (see Fig. 11). Subsequently, the operators

Fig. 11. Tablet-PC displays the No. of dynamic passes

were instructed to follow a rolling pattern of eight dynamic passes. The No. of passes were corresponding to different colours, as follows:

- red colour ≥ 2 passes
- green colour ≥ 4 passes
- blue colour ≥ 8 passes

Those pre-adjustments were made by the site manager prior to the job-start, as a pre-installation for the server machine. Also here, the entire network (W-LAN) was consisting of one server-machine and three client-rollers. Fig. 10 shows the blue finished area and green ones which require additional passes.

<u>Efficient compaction and Quality control (QC)</u>

The Compaction Management System with Networking (BCM net) gave a clear picture of the whole area with key compaction data. All roller operators were participating in a job-site network with online data like No. of passes, surface temperatures and the relative compaction value EVIB (MN/m²).

Identical information was shown to each roller driver as part of the network, as well as a general overview enabling them to optimize their rolling schedule. Conclusion: All operators were able to achieve better results as they were shown a “compaction map”, thereby taking over more responsibility of quality management. But also site-managers could share the information from the job-site, even when they are not working on the roller.

It works via the Internet and using a so called IP-address like 192.168.178.xxx. (see Fig.11).

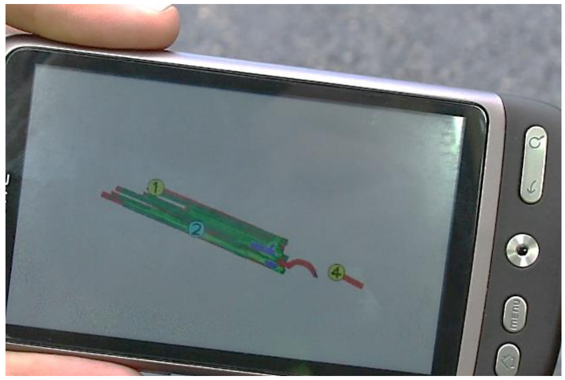

Fig. 12. Compaction progress shown by a smart phone

Of course, the compaction management system described herein comes along with an "Office Software Tool" which helps the site-manager to verify the "big data" of the whole job-site afterwards, as well (see Fig. 13). He will be able to make investigations or queries and to find out whether the No. of passes have been achieved and

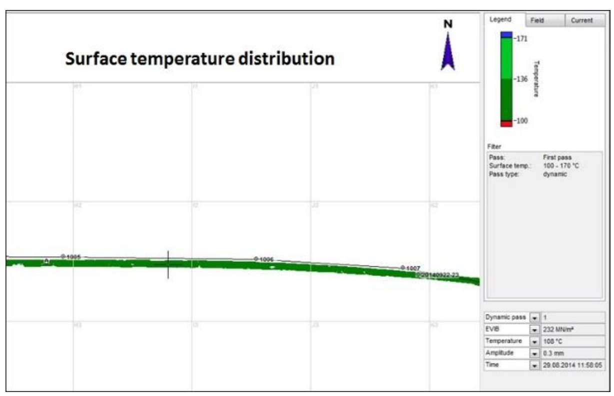

Fig. 13. BCM-office, Software for documentation and analysis

what have been the temperature levels for example during the final dynamic passes. This goes also along with a proper documentation for example with a pdf-file.

4. Conclusions and outlook

1. On the occasion of two individual road projects, one in Lithuania (5 months) and another one in Germany (3 months) it was shown that some innovative technologies used for construction machinery are technically matured and have been able to increase compaction efficiency and likewise the quality of asphalt paving. Description: In each case, the advanced system was combining a fleet of

four heavy tandem rollers in a WLAN-system (3 client-rollers and one server). Possible lags caused by mobile telecommunications or servers were eliminated enabling real-time imaging and maximum availability. The operators were provided a smart guideline in terms of a coloured road-map, in real time. All rollers were equipped with a positioning system (GPS) and a tablet-PC. The coordination of the construction processes and analysis of the resulting data was also greatly simplified for the site manager. All the preparation and post processing has been easily performed on a PC in the office. Another aspect: the tremendous amount of data available and easy processing was one of the key decision factors for the contractors in deciding on such a system. It also gives them the opportunity to further optimize their job-site processes. Regardless of the setting selected, everything is consistently documented: passes, temperatures, speeds, vibration, area output and also the compaction progress could be visualized.

2. Performance contracting and extended guarantee periods (e.g. Public Private Partnership) are forcing the contractors to further invest in product quality and control measures of the whole production process.

As authorities and agencies more and more looking at road construction measures in a more holistic manner, digitized operational strategies will become mandatory.

References

1. EAPA (European Asphalt Pavement Association). (06/2007). *Long-Life Asphalt Pavements; Technical version.* www.eapa.org
2. German Road and Transportation Research Association; FGSV. (n.d.). *TL Asphalt-StB 07/13.* www.fgsv.de
3. Gogolin, Dr.-Ing. D. 2015. Ingenieurgesellschaft PTM Dortmund mbH. www.ptm.net
4. Kloubert, H. J. 2009. Basics Principles of Asphalt Compaction. Boppard. www.bomag.com
5. Kloubert, H. J. Wallrath W. 2014. Intelligent Asphalt Compaction. Boppard www.bomag.com
6. Leech and Powell, 1., & NCAT, 1. 1974. *Levels of Compaction of dense coated macadam achieved during pavement construction.* Transport and Road Research Laboratory, UK.
7. Pedrosa, Maria Jose. 2017. Global Report. *Construction Equipment*.