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How to save energy, CO_2 and costs with modern Transport Technology in Asphalt Construction and Installation

#ICA4point0

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How to save energy, CO_2 and costs with modern Transport Technology in Asphalt Construction and Installation

ABSTRACT

Using modern (transport) technology to avoid premature road damage already during the asphalt installation process - Protecting the environment through lower CO_2 emissions and saving the resources through lower power consumption.

This paper is about the problems associated with asphalt paving and an approach that enhances paving quality, protects the environment and resources.

Usually, three major problems occur in asphalt paving. These include mechanical, thermal and binder segregation. The push-off technology provides a solution to meet the requirements in asphalt paving. If the asphalt is pushed off, instead of dumped, there is a continuous mixing of the grain structure and temperature during the entire unloading process. The asphalt is unloaded "bit by bit" into the paver due to the push-off mechanism. Thus, both, cool and hot asphalt and coarser and finer grain sizes are evenly paved.

KEY WORDS

asphalt paving, lower power consumption, improvement in paving quality, thermal and mechanical segregation, uniform paving, push-off mechanism as a solution.

1. INTRODUCTION

A Using modern (transport) technology to avoid premature road damage already during the asphalt installation process - Protecting the environment through lower CO_2 emissions.

This paper is about the problems associated with asphalt paving and an approach that enhances paving quality, protects the environment and provides additional work safety.

Some special requirements apply for asphalt paving. The mix in the paver should be uniform in terms of temperature and also in terms of grain structure. These are the basic requirements for durable asphalt pavements. Usually, three major problems occur in asphalt paving. These include mechanical, thermal and binder segregation. The problems with mechanical segregation are coarse grain nests. These are caused by the fact that the coarse grain in the transport vehicle rests on top and on the sides, while the finer grain remains at the bottom. When tipping out a load, a lot of coarse grain flows out at the beginning, thus a uniform distribution of the mix is not given. Grain breakage and frost damage are the result. A second problem is thermal segregation. Even with thermally insulated dump bodies, the mixture is not evenly tempered. The coldest layer can be found on top. When the asphalt is tipped, the upper, colder layer flows into the paver first. As a result, non-uniform temperature distribution during asphalt paving is possible. The push-off technology provides a solution to meet the requirements in asphalt paving. If the asphalt is pushed off, instead of dumped, there is a continuous mixing of the grain structure and temperature during the entire unloading process. The asphalt is unloaded "bit by bit" into the paver due to the push-off mechanism. Thus, both, cool and hot asphalt and coarser and finer grain sizes are evenly paved. This has been confirmed by several studies, including those carried out by the Technical University of Darmstadt and the Vienna University of Technology. In addition, obstacles such as overhead lines, avenues or underpasses represent no problems for transport vehicles with push-off technology because there is no need for tipping the loads.

2. PROBLEMS AND SOLUTIONS

2.1 Requirements and rules in theory

On the one hand, the basic requirement for long-lasting asphalt surfaces is a uniform temperature of the mix in the finisher and, on the other hand, a uniformly distributed grain structure of the mix. Depending on the bitumen, the temperature of the mix must not fall below 140° to 160° Celsius on delivery to the construction site and must not exceed 180° to 190° Celsius when leaving the asphalt mixing plant. In order to ensure sufficient thermal insulation of the transport body, the wall/floor structure of a thermally insulated transport body must have a heat transfer resistance (R-value) of at least > 1.65 m² k/W (at 20° Celsius) and the temperature resistance of the insulating material must be 200° Celsius. Contractors in Germany have had to implement this regulation since 2019. The use of vehicles with push-off technology is recommended by the Federal Ministry of Transport. Thus, numerous building authorities such as the German capital Berlin, for example, request thermally insulated truck bodies with push-off technologies in public tenders.

2.2 Problems in asphalt road construction in practice

There are some problems in asphalt road construction with conventional transport technology. These include mechanical segregation, thermal segregation and bitumen / binder segregation.

2.2.1 Mechanical or granular segregation

Consequences of mechanical segregation with conventional transport technology.

Fig. 1: Coarse grains roll outward – coarse grains come out first → clusters of coarse grain usually occur at intervals.
Source: TU Darmstadt / FH Köln / Research project PAST (Prozesssicherer Automatisierter Straßenbau).

$$\text{Distance (m) between nests} = \frac{\text{Tonnage per truck load}}{\text{Installation width (m) x installation density (x) x 2,5 to/m}^2}$$

Consequential damage such as loss of material, grain break-outs, increased rutting, frost damage etc. are inevitable here.

2.2.2 Thermal segregation

Even when transporting the mix with conventional thermally insulated (dumper) vehicles, the upper layer will cool off.

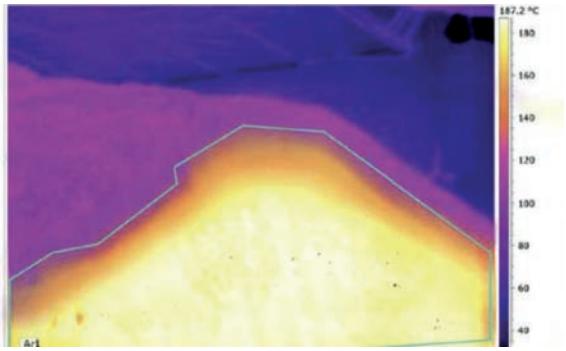

Fig. 2: Cold layer clearly visible on the top
Source: Fliegl Martin, Studies in asphalt building, Fliegl Bau- und Kommunaltechnik GmbH.

Fig. 3: Warmer layer in the lower part
Source: Fliegl Martin, Studies in asphalt building, Fliegl Bau- und Kommunaltechnik GmbH.

When dumping, first of all large quantities of the cooler mix slip into the finisher/feeder.

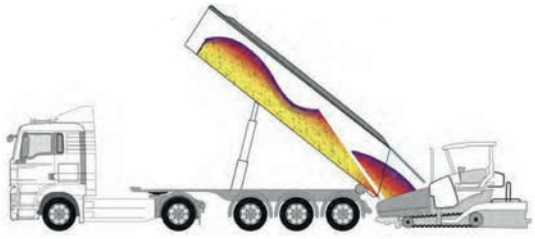

Fig. 4: Large quantities of the cooler mix slip into the finisher/feeder.
Source: Fliegl Martin, Studies in asphalt building, Fliegl Bau- und Kommunaltechnik GmbH.

With dump trucks, there are sometimes very large temperature differences behind the paving screed with every docking of a truck. The asphalt is here usually "stiffer", compaction unfriendly, rougher, has an increased void content, bumps, ... These are often "the potholes of tomorrow". Although the use of thermally insulated vehicles reduces the average temperature loss by around 3-5° Celsius compared to conventional, uninsulated vehicles, it does not solve the problem of segregation.

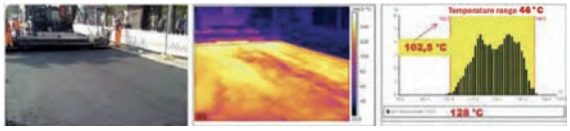

Fig. 5: The use of thermally insulated vehicles reduces the average loss of temperature, however does not solve the problem of segregation.
Source: Fliegl Martin, Studies in asphalt building, Fliegl Bau- und Kommunaltechnik GmbH.

2.2.3 Binder segregation

Dr.-Ing. Daniel Gogolin discovered during investigations that binder segregation during asphalt installation may occur since the binder accumulates at the surface after installation, resulting in a poor grip of the asphalt.

2.3 Accident prevention – Safety on the construction site

Vehicles with push-off technology offer maximum safety. The danger zones during unloading are minimal – a big plus in work safety. Power lines, avenues, bridges, inclined positions etc. may be deadly dangers. Risks that can be avoided by using push-off technology.

Fig. 6: Increased work safety with a push-off trailer compared to a dump truck
Source: Fliegl Martin, Studies in asphalt building, Fliegl Bau- und Kommunaltechnik GmbH.

2.4 Solutions in practice

In structural and civil engineering a lot of attention is paid to quality as well and therefore the certified concrete for civil engineering is delivered with concrete mixers not with dump trucks because quality has priority. The same should apply to asphalt paving with push-off vehicles. They provide a "bit-by-bit" mechanical and thermal mixing and have no problems with obstacles such as e.g. overhead lines, avenues, traffic lights, underpasses, etc. A continuous mixing of temperature as well as of bitumen and binder content is given during the entire unloading process. This results in an even grain size distribution in accordance with the grading curve and the body is emptied cleanly and completely, even without using a release agent such as diesel.

Fig: 7: Continuous mixing throughout the unloading process.
Source: Fliegl Martin, Studies in asphalt building, Fliegl Bau- und Kommunaltechnik GmbH.

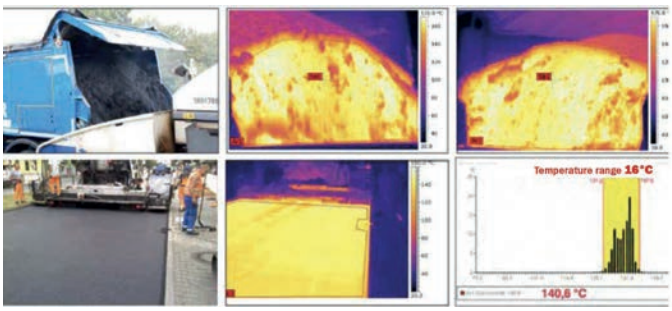

Fig. 8: Continuous mixing.
Source: Fliegl Martin, Studies in asphalt building, Fliegl Bau- und Kommunaltechnik GmbH.

2.5 Energy reduction

Due to the continuous mixing during the push-off process, the homogeneity of the asphalt can be kept at a constantly high level even at lower production temperatures. Lower temperatures

have the positive effect of saving energy. Raw materials such as gas or oil are only available in limited quantities, which is why asphalt paving using push-off technology has an advantage in terms of sustainability. Furthermore, lower energy requirements help save costs.

2.6 Environmental protection / CO_2 reduction

The environment is protected by lower CO_2 emissions from asphalt production, as the production temperature at the mixing plant can be slightly reduced. Nevertheless, one achieves a high and homogeneous quality of installation through the ongoing mixing, bit by bit. Resources can be saved as there is less CO_2, less oil and coal dust. Due to the low production temperature, the bitumen hardening or embrittlement is lower and the aging of the bitumen is reduced. The high paving quality increases the durability of asphalt surfaces.

3. STUDIES IN ASPHALT BUILDING

The advantages of push-off technology in road building have been confirmed in numerous studies.

3.1 Vienna University of Technology: Asphalt temperature from mixing unit to installation

On behalf of the Municipal Council of the City of Vienna, the Vienna University of Technology evaluated the asphalt temperature from the mixing plant to installation. The Municipal Department 28 installed a new road surface along a section of 465 meters on Pausingergasse in 1140 Vienna in March and April 2015. The differences between two types of delivery were compared, on the one hand delivery with conventional dumpers (KK truck) and on the other hand with push-off trailers (TA trucks) and the influence of both on the installation temperature was quantified. Employees of the Institute of Transport Economics used a thermal imaging camera to display the asphalt surface in order to be able to assess the homogeneity of the installation temperature. There were significant differences between KK truck and TA truck in surface temperature of the three asphalt layers (base layer, binder layer and top layer).

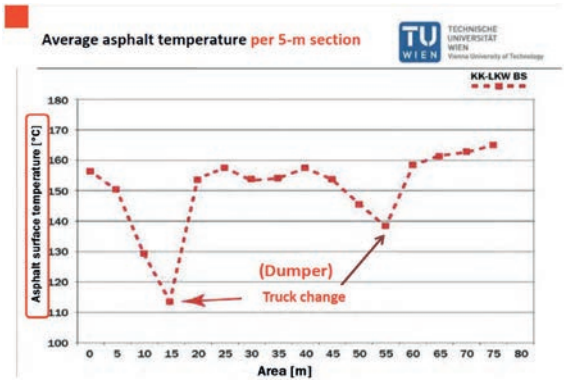

Fig. 9: Progression of the average asphalt temperature after installation with conventional dumpers for all layers (thermal image).
Source: Vienna University of Technology, Project number D230 0615 4003 / 15406.

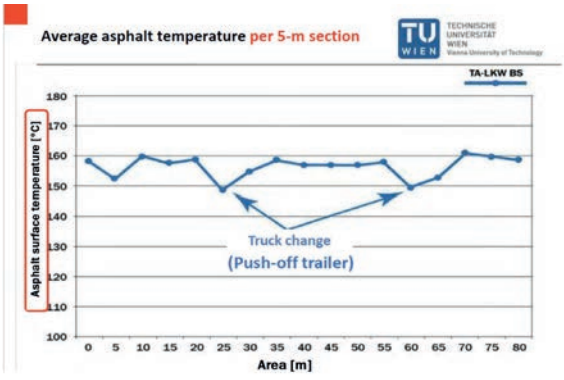

Fig. 10: Progression of the average asphalt temperature after installation with push-off trailer for all layers (thermal image).
Source: Vienna University of Technology, Project number D230 0615 4003 / 15406.

It can be clearly seen that the temperature differences in the vehicle with push-off technology

are much smaller than the ones in the KK truck. This is a result of the continuous mixing in the push-off trailer. The analysis showed that the use of push-off vehicles significantly reduces the risk of the occurrence of cold nests and that a more homogeneous temperature distribution results from the bit-by-bit transfer of the mix to the paver. Using transport vehicles with push-off technology in urban areas also reduces the risk of overhead cable damages during unloading. Unlike dump trucks, these vehicles can also be used in tunnels, under bridges or on avenues without any problems.

3.2 Building Authority of Berlin: Asphalt installation with thermal insulated dumper bodies and push-off vehicles

The Building Authority of Berlin analyzed the temperature progression during asphalt installation on B96 Residenzstraße. The binder layer was delivered in thermally insulated dumper bodies, the surface layer with thermally insulated push-off vehicles.

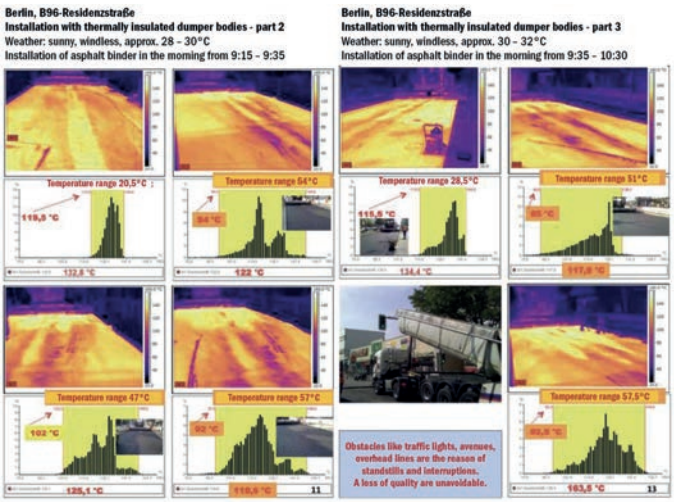

Fig. 11: Temperature progression with thermally insulated dumper bodies – dumpers.
Source: Construction site-report / Berlin Reinickendorf Building Authority.

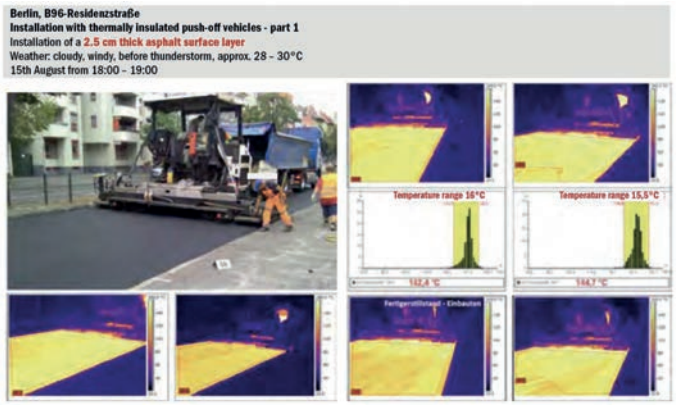

Fig. 12: Temperature progression with thermally insulated bodies – push-off vehicles.
Source: Construction site-report / Berlin Reinickendorf Building Authority.

It was clearly recognizable that compared to the push-off vehicle, the temperature range was much higher (at times over 50°C) with the dumper.

3.3 Documentation of the Technical University of Darmstadt: Temperature progression in the asphalt paving process

The TU Darmstadt also examined the temperature curve in the asphalt installation process and came to the same conclusion as other studies. In vehicles with push-off technology, there are fewer temperature differences of the asphalt mix due to the continuous mixing during the entire unloading. The choice of transport vehicle has a decisive impact on the quality and durability of the asphalt.

4. SUMMARY

Using push-off vehicles for asphalt installation offers important advantages. There is a lot less thermal and mechanical segregation which leads to a better asphalt quality and more durable asphalt pavements. Especially in times of too little budget for road maintenance and new construction, it is all the more important that the activities that can be tendered, will be as long-lasting as possible. Asphalt installation with push-off vehicles reduces the required rehabilitation cycles. In addition, with push-off technology, less CO_2 is produced and

work safety is increased because, for example, tunnel or overhead lines pose no problem. Vehicles with push-off technology have become global standard and are often already anchored in regulations.

Fig. 13: The necessary rehabilitation cycles are reduced by using push-off technology
Source: Fliegl Martin, Studies in asphalt building, Fliegl Bau- und Kommunaltechnik GmbH.

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