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Measuring and visualizing hot mix asphalt concrete paving operations

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ABSTRACT

This paper presents AsphaltOpen, a visualization tool for Hot Mix Asphalt (HMA) paving operations and a data collection process to collect the input data for AsphaltOpen from HMA paving operations. In detail, AsphaltOpen visualizes collected site-specific GIS data and GPS path tracing data of equipments' motions together with the HMA's temperature behavior. In this way, AsphaltOpen allows HMA paving professionals to understand and learn about the relation of machine operations and HMA temperature and its impact on the HMA compaction. To ensure the practical usability, we developed AsphaltOpen and the data collection process by conducting action research with HMA paving operators. Overall, AsphaltOpen offers an easy-to-use tool for HMA paving companies to visualize previous asphalting operations. In this way, it opens up new ways for HMA paving contractors to improve and professionalize their paving operations.

1. Introduction

Under lab conditions, the physical properties of Hot Mix Asphalt (HMA) in relation to its compaction grade are well understood. In particular, it is well known that an ideal compaction grade for HMA mats exists. If HMA mats are over-compacted it loses its plasticity because too little air voids exists in the mat, while under-compaction causes the mat to be not stable enough (Kari as cited in Chadboum [1]). During "real world" compaction efforts under site conditions, however, one of the main problems during the asphalt paving process is to decide when to start and stop compaction operations. Asphalt compaction roller operators have little information about actual compaction grades at hand during their rolling operations. Additionally, the decision of when to stop compaction operations is complicated because the HMA temperature has a direct effect on the rate of compaction that can be achieved with each pass of a compaction roller over a certain part of the HMA mat. The HMA temperature has a direct effect on the viscosity of the binder and viscosity directly influences the effect of compaction operations [1–3]. On the one hand, if the HMA is too hot roller loads will simply displace or "shove" the mat rather than compact it because the viscosity of the binder is too high. On the other hand, as the mix cools, the binder eventually becomes stiff enough to prevent any further reduction in air voids regardless of compaction efforts. Hence, if the mixture is too warm, it will be overstressed because the mat lacks the stability to support the weight of compaction rollers and the HMA spreads laterally from beneath the roller. If the mixture is too cool, it will be understressed. In this instance, the roller does not create shear forces sufficient to increase density (Kari as cited in Chadboum [1]). Below a certain HMA temperature, the cessation temperature, rollers operating on the HMA mat will only improve surface texture and further compaction will generally not occur [4,5]. In summary, it is hard for operators to decide when a sufficient compaction rate of the HMA mat has been achieved.

To support HMA paving operators with their paving efforts, the industry, mainly the vendors of asphalting machinery has developed sophisticated asphalt characteristic and process measurement technology [6]. Additionally, researchers have developed process monitoring and simulation tools. However, HMA practitioners, so far, did not adopt these tools. Despite the complexity of HMA paving operations and the close relation of the operations with the physical conditions of the HMA mix, HMA paving operations still heavily depend on craftsmanship. In practice, contractors select work methods largely based upon tradition and do, in general, not measure key process indicators, such as asphalt temperature, asphalt cooling rates, asphalt compaction grades, and asphalt machine operations [7]. One of the reasons for the slow uptake of measurement tools to support and understand HMA paving operations is the lack of an integrated process that allows the measurement of operations and the subsequent visualization of the measured data that enables HMA paving professionals to engage in meaningful cycles of learning and improvement [8].

To address this issue, this paper presents a data measurement process and a visualization environment, AsphaltOpen, that we developed in close collaboration with operators and project managers. Professionals can use the measurement process to collect asphalt temperature data and GPS path data of all asphalting machine motions. The accompanying software AsphaltOpen integrates this temperature and GPS data with site-specific GIS data and provides functionality to meaningfully overlay these different data. We developed the process and the tool in close collaboration with practitioners. This action research approach allowed us to contribute to knowledge in two areas.

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