ARTICLE IN PRESS

JOURNAL OF TRAFFIC AND TRANSPORTATION ENGINEERING (ENGLISH EDITION) 2017; X (X): 1–12

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jtte

Original Research Paper

Thermal segregation of asphalt material in road repair

Juliana Byzyka[*], *Mujib Rahman*, *Denis Albert Chamberlain*

Institute of Energy Features, Department of Mechanical Aerospace and Civil Engineering, Brunel University London, Middlesex UB8 3PH, United Kingdom

HIGHLIGHTS

- Thermal segregation is developed in patching in both winter and summer seasons.
- Long haulage time of HMA progresses thermal segregation.
- Poor insulation measures of HMA during transportation raises thermal segregation.
- Poor compaction and low interface bonding adversely affect patching performance.
- Pothole repairs prematurely fail at cold spots and poorly bonded repair edges.

ARTICLE INFO

Article history:
Received 28 September 2016
Received in revised form
3 May 2017
Accepted 4 May 2017
Available online xxx

Keywords:
Hot mix asphalt
Pothole
Patch repair
Thermal segregation
Thermography method

ABSTRACT

This paper presents results from a field study of asphaltic pavement patching operations performed by three different contractors working in a total of ten sites. It forms part of an ongoing research programme towards improving the performance of pothole repairs. Thermal imaging technology was used to record temperatures of the patching material throughout the entire exercise, from the stage of material collection, through transportation to repair site, patch forming, and compaction. Practical complications occurring during patch repairs were also identified. It was found that depending on the weather conditions, duration of the travel and poor insulation of the transported hot asphalt mix, its temperature can drop as high as 116.6 °C over the period that the reinstatement team travel to the site and prepare the patch. This impacting is on the durability and performance of the executed repairs. Cold spots on the asphalt mat and temperature differentials between the new hot-fill asphalt mix and existing pavement were also identified as poorly compacted areas that were prone to premature failure. For example, over the five-minute period, the temperature at one point reduced by 33% whereas the temperatures of nearby areas decreased by 65% and 71%. A return visit to the repair sites, three months later, revealed that locations where thermal segregation was noted, during the patching operation, had failed prematurely.

* *Corresponding author*. Tel.: +44 7475 71 9051.
E-mail addresses: juliana.byzyka@brunel.ac.uk (J. Byzyka), mujib.rahman@brunel.ac.uk (M. Rahman), denis.chamberlain@brunel.ac.uk (D.A. Chamberlain).

Peer review under responsibility of Periodical Offices of Chang'an University.
http://dx.doi.org/10.1016/j.jtte.2017.05.008

1. Introduction

A road network constitutes an important asset of developed countries such as the UK. It contributes to the economic and social well-being at all levels. Among the three types of pavements, asphalt pavement is the most usual type of pavement in the UK commencing 95% of the road network. Even though the asphaltic surfacing of an asphalt pavement is designed to be a less permeable layer compared to other layers of a pavement structure (aggregate sub-base, capping, and subgrade), water does permeate into it. The ingress of water into the pavement deteriorates the mastic and the aggregate mastic-bond causing. In combination with traffic loading, initial stripping rapidly leads to very serious ravelling and then to the creation of potholes (Dawson, 2008; Thom, 2008; Adlinge and Gupta, 2013). Prolonged cold wet weather period with cyclic freeze-thaw conditions, such as occurring in the UK, accelerates pothole development and causes high maintenance costs.

Over recent years, the use of high-quality materials, that will protect the surface layer of the asphalt pavement from weather conditions and high traffic loading, has been tried (Texas Department of Transportation, 2011). However, increasing traffic volumes and heavier loads, allied with repeated adverse weather are causing significant deterioration of the UK road network, resulting in millions of potholes and failed areas (cracking, stripping, and ravelling). The Automobile Association (AA) survey, where more than 22,000 people participated, revealed that the 33% of participants have confronted damage to their vehicles due to potholes on roads. In 2012, the number of potholes, which has grown with the passage of the years, was found to have increased up to 30% (Knapman, 2013).

The situation is not improving. According to the AA report in 2014, road deterioration in the UK had risen to 40% by March 2014 in comparison with October 2013 figures (The Automobile Association (AA), 2016). The annual local authority road maintenance (ALARM) report in 2015 (Asphalt Industry Alliance, 2015) confirms also an increase in potholes. The poor riding condition of UK roads has generated significant public dissatisfaction as road distress does not only create dangerous driving conditions but also high repair bills for their vehicles.

Even when road distresses are repaired a number of them fail within few years (Rahman and Thom, 2012). Usually, the reasons for this failure are because (a) the patching material is laid on failed areas and it is likely that the underlying materials are in poor condition, (b) the quality of the repairs offered by the contractor differs with the skill levels of the teams responsible for the repairs varies, and (c) the variable quality of patch repairs. Other reasons that confirm the failure of road maintenance are the lack of technical quality due to not established guidelines or test methods, inadequate compaction, poor surface preparation and overall inferior workmanship, as well as the lack of appropriate guidelines for maintenance engineers on materials suitability in every patch repair situation.

Potholes are repaired by two main methods named as pothole filling and pothole patching. The former is mainly considered as a temporary repair whilst pothole patching is a more permanent repair operation (Lavin, 2003). Pothole patching usually includes marking of the area around the pothole which indicates the material to be removed from the existing pavement, cutting off the old asphalt and removal, cleaning of the pothole excavation from debris and water, tack coat application for bonding of the existing pavement with new fill material and compaction (Anderson and Thomas, 1984; Lavin, 2003; Thom, 2008). The fill material, in the case of pothole patching, is usually hot mix asphalt (HMA). Thus, inappropriate levels of mix temperature will affect patching performance. If the temperature of HMA falls below the cessation temperature, no further compaction can occur (Hartman et al., 2001; Delgadillo and Bahia, 2008; Kloubert, 2009; Watson et al., 2010). Insufficient compaction leads to reduced density of HMA surface resulting in possible future premature failure (Thom, 2008).

Main causes of pothole patching failures are the mode of transportation of HMA between production plant and paving site, segregation, inappropriate compaction, low interface bonding between pothole excavation and hot-fill material, and pothole geometry preparation. Among the referred patching causes, segregation is of most concern in this study. Segregation is usually categorised into aggregate segregation and thermal segregation. The former is defined as the non-uniform distribution of course and fine aggregates in the asphalt matrix whilst thermal segregation is described as cold spots in the HMA mat (Stroup-Gardiner and Brown, 2000).

In comparison with aggregate segregation, thermal segregation cannot be visually identified by the human eye. However, a suitable, well-defined method is infrared thermography (Davis, 2012). This is able to recognize and measure the thermal energy emitted from an object that is not possible with the human eye (FLIR Systems AB, 2011).

2. Research objectives

The key objective of this research is to evaluate the extent of thermal segregation in HMA road patch repairs executed by three independent teams of workers (designated contractors A, B and C) operating in different weather conditions, methods of transportation and repair processes, and observe the outcomes after three months. It is also intended to identify possible shortcomings in current heated patch repair practices, which are failing to deliver durable outcomes.

The research involves (a) temperature monitoring during material transportation, (b) temperature monitoring during material placement and after compaction, and (c) the collection of temperature differences from several locations over the repair mat. Infrared thermography and a contactless handheld thermometer were used to gather temperature data. Observations were made for five sites in the case of Contractor A and one and four sites in the case of Contractors B and C, respectively. A return visit was made to each of these sites three months after the patching operations.

Through examining the activity of the three road repair contractors, the research is intended as a contribution towards understanding the realities of patch repair work, especially repair material heat loss and the possible

Please cite this article in press as: Byzyka, J., et al., Thermal segregation of asphalt material in road repair, Journal of Traffic and Transportation Engineering (English Edition) (2017), http://dx.doi.org/10.1016/j.jtte.2017.05.008