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Influence of truck load channelization on stripping in asphalt mixtures

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Abstract

The influence of load channelization on stripping was investigated using cores and block samples from a heavily loaded highway. The original 80/100 asphalt (virgin and RTFOT aged) was characterized using conventional methods. Stripping of mixtures was measured using ASTM D1664 and that of cores using visual diametral plane rating and loss in indirect tensile strength due to soaking. The pore saturation and air voids were found to be influenced by ground water level and wheel track location across traffic lanes. Stripping was rated higher in the wheel paths than between wheel paths, especially in shallow water table areas where it was observed to be 82% higher, implying possible dependency of stripping on channelization. To enhance resistance to moisture damage, it is recommended that Hot Mix Asphalt surfaces in areas with shallow water tables be designed to a more favorable refusal density.

Keywords: Stripping; Wheel paths; Air voids; Saturation; Channelization

1. Introduction

Moisture damage in hot mix asphalt surfaced pavements is a serious problem especially in zones of high precipitation. Many least developed countries in sub-Saharan Africa and southern Asia are spending large sums of donor funds on road construction materials, yet the return on investment is overwhelmed by short service lives due to moisture damage. Stripping, amongst other moisture damage distresses, is commonly believed to be caused by water induced loss of adhesion between asphalt and aggregate [1]. Kandhal et al. [2] and Stuart [3] reported that water or its vapour can enter the air voids by infiltration from above or seepage/capillarity from the underlying water table/local aquifers. However, it is still not fully clear how the water or vapour in the pores enters the asphalt/aggregate interface assuming the aggregate is well coated. One of the proposed mechanisms is a macro-level means involving high pore water pressure build up due to external cyclic stress, which then acts on the asphalt/mastic film that is coating the aggregate, especially under undrained conditions (mainly the pessimum voids). Efforts to test pore water pressure have been ongoing for the last 50 years. For example, literature documents work by Hallberg (Water pressure measurement by assessing the pore size effects in the 1950s), Johnson (measurement of thermally induced pore pressure in the 1960s), Jimenez (measurement of pore pressure using the Double punch method in the 1970s), and Mallick et al. (determined cyclic pressure through suction in the 2000s). A comprehensive review of more basic fundamentals behind this and other related mechanisms can be found in [4,5]. An attempt was made, in the investigation reported in this paper, to study this mechanism using field cores from a heavily trafficked road north of Lake Victoria. The study approach was based on evaluating the influence of truck load channelization on stripping in asphalt mixtures since it causes excessive stresses in the wheel paths of wearing surfaces.

A previous survey of heavy trucks by the Ministry of Public Works and Housing of Kenya gave mean and

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maximum tire pressures of 0.70 and 1.03 MPa, respectively, on the main road from Mombasa to the boarder with Uganda [6]. Another study in Uganda indicated that the 95% confidence interval of typical tire pressures on the road joining Kenya and Uganda is 0.82–0.96 MPa [7]. These road sections are located on the Northern regional corridor of East Africa. For such high pressures that are most of the time found in the wheel paths, the pore water pressure is increased possibly followed by separation of asphalt from the aggregate if water is present in the pores. Consequently, if it can be shown that heavily truck loaded wheel paths in the carriageway exhibit high loss of asphalt/mastic films from the aggregate by stripping, it is then most likely that cyclic traffic loading relates to transport of water into the asphalt/aggregate interface.

A 65.6 km stretch of the Northern regional corridor of East Africa was selected for this study. This stretch is situated between Malaba (a border town with Kenya) and Bugiri town located north of Lake Victoria in Uganda. The stretch has two lanes with a carriageway width of 7000 mm and two shoulders each 1000 mm. It received a major rehabilitation that was completed in September 2002, with funding from Government of Uganda and Kreditanstalt für Wiederaufbau of Germany. The new rehabilitated road consisted of a 150 mm lime stabilised gravel sub-base, 125 mm crushed stone base and 100 mm dense asphalt mixture. Within two years of service, the road surface showed serious moisture damage related failures in several areas and hence its selection for this study. The method employed involved a technique that is inexpensive, easy to perform, safe and requires no expensive capital equipment, and would be ideal for poor countries.

2. Materials and methods

2.1. Asphalt cement

Samples of the asphalt cement that was used in the actual surfacing of the road project in 2002 were obtained from the project consultants (H.P. Gauff Ingeniuere Gmbh. Co. KG-IBG). The asphalt was of Arabian origin and as part of the study, it was aged using the RTFOT in accordance with ASTM D 2872. Ageing was done to simulate loss of lighter asphalt components during mixing, laying and rolling leading to increased viscosity and stiffness. The engineering properties of original and aged asphalts are listed in Table 1. The unaged asphalt was previously analyzed using FTIR spectroscopy in the frequency range 4000–700 cm^{-1} [8]. No sharp absorbance peaks were apparent near 1700 cm^{-1} (the carbonyl region) (cf. Fig. 1). However, the small broad band on the right of the carbonyl region results from 2-quinolone types [9,10]. This observation, coupled with a low acid number (0.25 mg/g), possibly indicates that the original asphalt has low acidity.

2.2. Road section sampling and coring

Two *randomly* selected sections of the road were required for investigation namely, one located in an area with a shallow water table and another in an area with a deep water table. The road studied had seven sections with shallow water table and 16 sections with deep water table levels. All these sections had truck traffic that on average moves at 80 km/h and with a maximum single axle load not exceeding 10 tons (according to weigh bridge records) in the more heavily loaded Bugiri bound lane. Traffic in Malaba bound lane was lighter and faster. The other areas were situated in trading centers where the speed of the trucks was very low. Stratified sampling was therefore used to select the two road sections studied. Bugiri town was arbitrarily taken as the origin with a 0 + 00 chainage. The two randomly selected sections were found out to be between chainages 49 + 332 to 51 + 160 for the one with shallow water table and 52 + 206 to 54 + 134 for the one with deep water table, and were arbitrarily designated as Section A and Section B, respectively. Cores of diameter 100 mm were taken from both lanes of Section A and Sec-

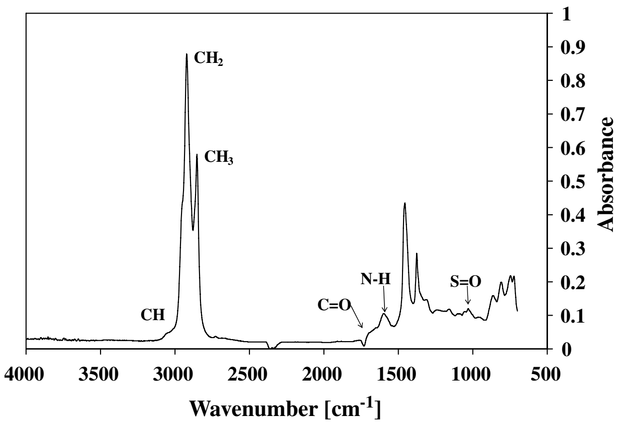

Fig. 1. FTIR-spectra for the unaged asphalt [7].

Table 1
Conventional properties of the asphalt cement used in this study

Test	Standard	Unaged	RTFOT residue	Limits[a]
Penetration at 100 g, 5 s, 25 °C (0.1 mm)	ASTM D5	86	72	70–100
Softening point (°C)	ASTM D36	47.4	53.2	41–51
Ductility at 25 °C (cm)	ASTM D113	115	94	100+
Brookfield viscosity at 135 °C mPa · s	ASTM D4402	346	nd	350–450
Acid number (mg/g)[b]	ASTM D664	0.25	nd	–

[a] Adopted from Ministry of Works Specifications for Uganda, 2004.

[b] Mean of two data values and nd = not determined.