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International Journal of Pavement Research and Technology 9 (2016) 313–320

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Field investigation of skid resistance degradation of asphalt pavement during early service

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Received 6 April 2016; received in revised form 9 August 2016; accepted 9 August 2016
Available online 13 August 2016

Abstract

This paper documents a field investigation into the skid resistance degradation of asphalt pavement during early service. Field tests were conducted 7 times during more than 2 years. There are 2 highway sections included in the field tests, which cover 4 asphalt surface types, i.e., dense asphalt concrete (DAC), rubber asphalt concrete (RAC), stone matrix asphalt (SMA), and ultra-thin wearing course (UTWC). Macrotexture and friction data were collected using the sand patch method and the dynamic friction tester respectively. The degradation of the mean texture depth (MTD) and the friction coefficient at slip speed of 60 km/h (DFT60) were analyzed. The international friction index (IFI) was also calculated using the friction coefficient at slip speed of 20 km/h (DFT20) with MTD to evaluate the skid resistance degradation. The UTWC has relatively good skid resistance even after 7.4×10^6 standard vehicle passes. The SMA has very stable friction performance which maintains almost the same friction level after 4.61×10^6 standard vehicle passes. The DAC and RAC have relatively poor friction performance while the RAC has better macrotexture. The changing trends of skid resistance with traffic wear can be fitted by a logarithmic model for all surface types. The SMA and UTWC have relatively clear relationship between DFT20 and MTD, while the RAC and the DAC show more complex.

Keywords: Asphalt pavement; Skid resistance; Degradation; International friction index

1. Introduction

Skid resistance is an important surface function of pavement, which is involved in driving safety [1,2]. It is usually evaluated using a friction coefficient accompanied by a texture measurement, usually a macrotexture measurement [3–5]. During service life, pavement skid resistance could degrade due to traffic wear. Good and durable skid resistance is pursued by researchers and practitioners. There were many researches performed to understand pavement skid resistance and its evolution during service.

Ech et al. [6] captured the evolution of pavement macrotexture by the Abbott curve through simulating traffic wear in laboratory. Ahammed and Tighe [7] analyzed the early-life, long-term, and seasonal variations of pavement skid resistance using the data collected in the long term pavement performance (LTPP) program. They also discussed the potential impacting factors of pavement skid resistance. Kane et al. [8] investigated the polish of pavement surface using an indoor simulating test and established a model describing the polishing phenomenon observed in the tests. Kane et al. [9] proposed a skid resistance evolution model with consideration of the effects of aging, polishing, and

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Peer review under responsibility of Chinese Society of Pavement Engineering.

http://dx.doi.org/10.1016/j.ijprt.2016.08.005
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binder removing in accordance with laboratory simulation. Zhang et al. [10] investigated the impact of traffic load on pavement macrotexture and friction performance using a kneading machine to simulate traffic wear in the laboratory. It is shown that kneading can lower the macrotexture indices and friction coefficient. Villani et al. [11] employed the fractal approach to describe the texture and its polishing levels of asphalt mixes and investigated the variation of friction properties due to polishing in the laboratory.

There are also some researchers trying to establish relationships between texture and friction performance. Rado and Kane [12] constructed a series of texture parameters using a decomposition method called Huang-Hilbert transform. According to laboratory data, friction performance is correlated with some of the decomposition based BIMFs (base intrinsic mode functions) parameters. Kane et al. [13] employed the same method in correlating friction performance with texture according to data collected in field. Good result was also obtained. Kanafi et al. [14] evaluated the evolution of macro- and micro- texture of 3 asphalt pavement surfaces using data collected in field during 9 months and investigated the relationship between friction and texture.

There were many new methods employed to investigate pavement skid resistance and its degradation. Some researches also improved the understanding of them. However, they are also challenging problems. This paper focuses on (1) the degradation of macrotexture and friction performance of asphalt pavement in actual road during early service; (2) the investigation of the skid resistance degradation in the international friction index (IFI) context. Firstly, the field data collection is elaborated, which covers 4 types of asphalt surfaces. Secondly, the degradations of macrotexture and friction performance are evaluated using the mean texture depth (MTD) and the friction coefficient at slip speed of 60 km/h (DFT60) respectively for each surface type. The early changing trends of them are also discussed. Thirdly, the values of IFI are calculated using the friction coefficient at slip speed of 20 km/h (DFT20) with MTD. The relationship between DFT20 and MTD is investigated for each surface type. And the degrading trend of the friction coefficient at slip speed of 60 km/h in IFI context (F_{60}) is also investigated.

2. Field data collection

A continual field test plan was implemented from Nov. 2010 to Nov. 2012 for investigating the degradation of asphalt pavement skid resistance. Two test sections were selected from highways in Huairou District, Beijing, China. One is about 18 km at national highway 111 (G111), including surfaces of dense asphalt concrete (DAC), and rubber asphalt concrete (RAC). The other is about 7 km at national highway 101 (G101), which includes 2 types of surfaces, stone matrix asphalt (SMA), and ultra-thin wearing course (UTWC). Table 1 lists the basic information of the test sections, where NMPS is the abbreviation for nominal maximum particle size. The SMA and UTWC are made with basalt aggregates, and the DAC and RAC are made with limestone aggregates. Fig. 1 depicts the gradations of the 4 surface types.

There are total 10 DAC and 9 RAC test sites at G111, and 5 SMA and 8 UTWC test sites at G101. Among the 8 UTWC test sites, 4 opened in 2009 and the other 4 opened in 2010. All test sites are kept away from the sections with bridge, sharp curve or steep slope. During the 2 years, data collections were conducted 7 times in total. Table 2 lists the date of each collection. MTD, DFT20, and DFT60 were collected for each time using the sand patch method (ASTM E 965) [15] and the dynamic friction tester (ASTM E 1911) [16] respectively. The corresponding traffic data were also collected, which are based on the standard vehicle defined in the "technical standard of highway engineering (JTG B01-2014)" of china [17]. All vehicles are converted to the standard vehicle, whose size is 6 m, 1.8 m, and 2 m in length, width, and height respectively. All tests were performed on the wheel path area at the test sites. For the DAC and RAC, not each data collection covers all test sites because of some restrictions. For the UTWC opened in 2009, a test site was dropped for maintenance after the 2nd data collection. The number of

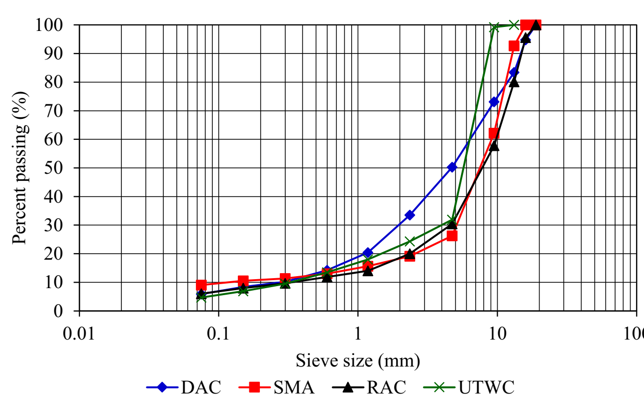

Fig. 1. Gradations of the pavement surfaces.

Table 1
Basic information of the test sections.

Route	Highway classification	Surface type	Asphalt content	NMPS/mm	Opening date
G111	Class 2	DAC	4.4%	16	Jul. 2010
G111	Class 2	RAC	5.4%	16	Sept. 2010
G101	Class 1	SMA	5.7%	13.2	Aug. 2010
G101	Class 1	UTWC	5.0%	9.5	Sept. 2009
G101	Class 1	UTWC	5.0%	9.5	Sept. 2010