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Performance analysis of different type preventive maintenance materials for porous asphalt based on high viscosity modified asphalt

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HIGHLIGHTS

- Performance analysis of preventive maintenance materials is conducted.
- The preventive maintenance materials were used on a porous asphalt section.
- The properties of PQI, raveling resistance and so on are measured and analyzed.
- The relatively good type preventive maintenance materials is proposed.
- It provides support for preventive maintenance engineering on porous asphalt.

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ABSTRACT

Porous asphalt has been widely used all over the world. Nevertheless, as porous asphalt is a large-porosity and stone-on-stone interlocked structure, disasters in porous asphalt are typically presented in the form of raveling, cracking or a combination of them. Aiming to study and solve those problems, properties of four different types of preventive maintenance materials (reduced material RJ, the type of polymerizing GL1, CEM bonding enhanced material, emulsified asphalt EA) were analyzed. And then the four different types of preventive maintenance materials were used on a porous asphalt section which has been built for nine years. The performances of the porous asphalt before and after the curing were evaluated. It was found that CEM material increased the surface roughness, improving the skidding resistance of the pavement; GL1 and RJ can significantly improve the raveling resistance and the low-temperature cracking resistance of the mixture. Therefore, it is recommendable to take into account the apparent viscosity, cohesion and adhesion of the material when choosing a preventive maintenance material for porous asphalt pavement.

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1. Introduction

Porous asphalt pavement uses large-void asphalt mixtures as road surface so that water drained into the porous course on rainy days will flow laterally out of the pavement structure. This pavement features high skidding resistance, low noise, and the ability to inhibit driving mist on rainy days, prevent "water skiing" during fast driving and mitigate glares when driving in the nighttime [1]. First applied in Europe and America in the 1960, porous asphalt was designed to improve the driving safety on road and limit traffic noises in densely populated and frequently traveled areas. China began to study and apply porous asphalt in the 1980s, and currently uses high-viscosity modified asphalt as the binder. As of the present day, China has popularized and applied porous asphalt across a dozen provinces with total freeway application mileage of over 300 km.

However, because of its large-void, stone-to-stone interlocked construction, under repetitive traffic load and complex climate conditions, diseases of porous asphalt can include one or a combination of raveling, brittle cracking, and pitting [2]. In addition to raveling, another problem is associated with porous asphalt. Clogging is one of the main consequences of decreasing water infiltration on porous asphalt. Molenaar [3] and Hagos [4] deemed that the primary disease of porous asphalt is raveling (loss of aggregate

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in the top surface), which can greatly reduce the service life of the pavement. Huber G [5] discovered from a survey of OGFC application across the United States that aggregate stripping is among the greatest concerns for applying porous asphalt. Miradi [6] suggested that the raveling area of porous asphalt increases with the service time of the pavement, and that once raveling occurs, destruction will accelerate and the raveling will gradually intensify. Akihiro M. [7] believed that aggregate stripping is a very important constraint for the long life expectancy of porous asphalt, and that a longer service life cannot be expected unless aggregate stripping is resolved [8]. Zhang [9] investigated the preventive maintenance of porous asphalt on the LVO-ZOAB project in the Netherlands. The study tried to rejuvenate the healing capability of aged asphalt by spraying rejuvenators over porous asphalt to prevent aggregate raveling, extend the service life of the asphalt, and achieve the expected result of maintenance.

In our study, four different types of preventive maintenance materials are applied to four sections of a 9-year-old porous asphalt pavement of Yan-Tong Freeway, the first freeway built in a rainy area in South China, as the test road sections to evaluate their service performances before and after maintenance. Decrease rate of raveling loss of the porous asphalt mixture after treated with different preventive maintenance materials are compared to establish their raveling performances. Flexural stiffness modulus and flexural strain are used to measure the influences of different preventive maintenance materials on the pavement's low-temperature cracking resistance. The application performances of these materials for porous asphalt are examined.

2. Materials and characterization

2.1. Preventive maintenance materials and characterization

Four types of preventive maintenance materials were used for our study [10]. Material 1 is a rejuvenating material, RJ, mainly composed of oily ingredients and designed to rejuvenate and recover the performance of the aged bitumen. Material 2 is a bonding-enhanced material, CEM, prepared from asphalt base and containing micrometer-sized kaolin used to increase the skidding resistance of the pavement. Material 3 is a polymerizing material, GL1, composed of α-cyanoacrylate adhesive. Material 4 is emulsified asphalt, EA, which is a popular preventive maintenance material.

Table 1 lists the characteristics of these four materials. The apparent viscosity was measured with a Bush viscometer. The cohesion was measured to *EN58, Bitumen and bituminous binders-Sampling bituminous binders* and *EN 12594, Bitumen and bituminous binders-Preparation of test samples.* The adhesion was yielded from UV spectrophotometry. Characterization of the four preventive maintenance materials indicates that GL1 has better cohesion and apparent viscosity than the other three materials. Its adhesion to stone is also satisfactory. Among the other three materials, CEM and EA are better than RJ. RJ does not appear to be very outstanding in any respect.

2.2. Porous asphalt mixture and characterization

The porous asphalt mixture used for our study was collected from the road pavement. Table 2 lists the key technical indicators (including Marshall Stability, Permeability and Friction Coefficient) of this mixture. Marshall Stability test shall be executed by reference to the test method of T 0709-2011 [11], Permeability and Friction Coefficient was measured according to T 0971-2008 and T 0964-2008 [12].

The Marshall Stability of all the lanes showed considerable increases. The increase of the heavy lane was the least. The Marshal strength increased because the asphalt in the mixture has been aging over a long period of time and its softening point has dropped, which causes the entire pavement to harden and the Marshal strength to increase. The heavy lane had the least increase because this lane has long been exposed to heavy weights such that, in addition to aged asphalt in the mixture, the strength of the aggregate itself has also reduced to some extent. The permeability has reduced modestly. Hence its functional indicator is reduced. The friction coefficient is close to the design value. Hence the skidding resistance is ideal.

To obtain a better understanding of the performances of cores of the porous asphalt mixture, we also extracted and sieved the cores collected from the site. Table 3 lists the performance indicators (including penetration, ductility, softening point and dynamic viscosity) of the asphalt, and the performance indicators were measured according to T0604-2011, T0605-2011, T0606-2011 and T0620-2000 of JTG E20-2011 [11]. From Table 3, all the three indicators (penetration, ductility, and softening point) of the asphalt were lower than their original values or the specified limits, especially penetration and ductility, which dropped by 68% and 99%, respectively, suggesting that the asphalt is seriously aged. What's more, the dynamic viscosity of the asphalt was 29181 Pa·s, which is more than 80% lower than its as-installed value of 182026 Pa·s. This indicates that aging has deteriorated the viscosity of the asphalt to well below the specified limit for porous asphalt pavement.

As the quality properties of a porous asphalt mixture, and the gradient composition of coarse aggregate, which contributes 80–

Table 1
Characterization of preventive maintenance materials' performance indicators.

Material	Apparent Viscosity (mPa·s)	Cohesion (J/cm^2)			Adhesion (%)
		5 °C	25 °C	40 °C	
RJ	83.55	0.0000	0.0000	0.0000	74.59
CEM	304.67	0.0562	0.0825	0.1127	21.45
GL1	1735.33	0.8309	0.1949	0.1983	28.73
EA	287.67	0.1063	0.1435	0.0825	34.67

Table 3
Performance of asphalt extracted from field cores.

Indicator	Unit	Extracted Asphalt	Design*
Penetration (25 °C, 100 g, 5 s)	0.1 mm	19.1	59.4
Softening Point (ring-and-ball)	°C	79	93
Ductility (5 °C, 5 cm/min)	cm	0.7	108
Dynamic Viscosity (60 °C)	Pas	29181.31	182,026

Note: "*" represents the design value of the pavement construction time.

Table 2
Key technical indicators of porous asphalt mixture.

Indicator	Overtaking lane	Middle lane	Heavy lane	Emergency lane	Design*
Marshall Stability (KN)	11.92	12.41	9.60	10.53	5.0
Permeability (ml/min)	3126	2185	629	213	5761
Friction Coefficient (BPN)	59	54	56	55	55

Note: "*" represents the design value of the pavement construction time.

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