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Studies on Ageing Effect in Bituminious Courses

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Abstract

Bitumen ageing is one of the principal factors causing the deterioration of bituminous pavement (Xiao and Isacsson, 2001). Important ageing related modes of failure are traffic, thermally induced cracking and ravelling Binder ageing which is considered as the main reason for durability in bituminous pavement. The ageing of binder has an influence on how long is in service a road coating. Based on hardening and stiffening of bitumen material ageing are of two types – (1) Short Term Ageing and (2) Long Term Ageing. The principal cause of bitumen ageing in service is the atmospheric oxidation of certain molecules with the formation of highly polar and strongly interacting functional groups containing oxygen. With the increasing demands of traffic on road building materials in recent years binders with improved performance relative to normal penetration grade bitumen are needed, that's why more and more modified bitumen is used in road pavement. In order to predict long term ageing successfully in the laboratory, ageing test should be done at temperature closer to that of the pavement because high temperature results in high volatile loss and will change the nature of oxygen reaction with the bitumen components. Field ageing can be accelerated in the laboratory by using increased temperature, decreased bitumen film thickness, increased oxygen pressure, or combinations of these factors.

Keywords: *Ageing Effect, Thin Film Oven Test, Bituminious Courses.*

1. Introduction

During the service life in a pavement, neat bitumen and modified bitumen age as the result of the mixing with aggregates, the process of lying, the climatic conditions and the traffic.

Bitumen ageing is one of the principal factors causing the deterioration of bituminous pavement (Xiao and Isacsson, 2001). Important ageing related modes of failure are traffic, thermally induced cracking and ravelling. Gradual loss of viscoelastic properties of bitumen is due to hardening of asphalt material, consequently an increasing traffic loading will hasten performance failure of the pavement. Binder ageing which is considered as the main reason for durability in bituminous pavement.

The ageing of binder has an influence on how long is in service a road coating. Thus, it is important to have reliable methods to predict pavement behaviour with time. During its service period, bitumen suffers a gradual loss of its desirable properties such as adhesion, cohesion, self-healing, waterproofing, and resistance to abrasion. This lessening of the effectiveness is caused by the continuous exposure of asphalt in the pavement to heat, light, air and moisture of the environment.

Based on hardening and stiffening of bitumen material ageing are of two types:

1. Short Term Ageing
2. Long Term Ageing

The short term oven ageing is in the vicinity to simulate earlier age hardening in pavement.
In bitumen ageing, two types of mechanisms are involved (Xiao and Isakson, 2002).

The main ageing mechanism is an irreversible characterised by chemical changes of the binder, which in turn has an impact on the rheological properties. The processes:

- Contributing to this type of ageing include oxidation, loss of volatile components and

exudation i.e. migration of oily components from the bitumen into the aggregate.

- The second mechanism is a reversible process called physical hardening. Physical hardening may be attributed to molecular structure the reorganisation of bitumen molecules or bitumen microstructures to approach an optimum thermodynamic state under a specific set of conditions.

The principal cause of bitumen ageing in service is the atmospheric oxidation of certain molecules with the formation of highly polar and strongly interacting functional groups containing oxygen.

2. Research Work

2.1 Thin Film Oven Test (TFOT) and Rolling Thin Film Oven Test (RTFOT)

The bituminous binders are aged using Thin Film Oven Test (TFOT, ASTM D 1754.) and Rolling Thin Film Oven Test (RTFOT, ASTM D 2872). In the tests Aluminium pans (TFOT) and glass containers (RTFOT) were heated to 160°C before loading the sample. The sample holders were kept in an oven at 160°C for about 15 min (RTFOT glass containers in a horizontal position) and then aged according to the standardized procedures: 163°C and 75 min for RTFOT and, 163°C and 5 h for TFOT. The aged binders were evaluated by measuring their rheological properties and chemical characteristics. Using chemical analyses or rheological measurements, a strong correlation is observed between TFOT and RTFOT, and the two methods show similar severity.

2.2 Rotating Cylinder Ageing Test (RCAT)

It was characterised by the test temperature between 70 and 95°C with cylinder rotating rate of 1rv/min, an oxygen inflow rate of 4.5 ± 0.5 l/h and various durations.

RTFOT is a standardized method to simulate ageing of binder during construction operation while RCAT rather simulated binder once the mixture has been laid on site. The long term ageing can be performed using the Rotating Cylinder Ageing Test (RCAT).

2.3 Pressure Aging Vessel (PAV)

Pressure aging vessel (PAV) aging of the binders was addressed according to ASTM D 6521. The residue from the thin film oven test (TFOT) was aged during 20 h at 100˚C under 2.1 MPa of air. The situ thermal aging was performed in oven. The residue from TFOT had been aged at 70˚C for a period from 0 to 60 days, the thickness of bitumen film was about 3.2 mm. Photo-oxidative aging was performed using ultraviolet (UV) radiation. The residue from the TFOT had been UV-aged for 12 days in draft oven (850 mm × 600 mm × 600 mm, together with fresh air) with an UV lamp of 500 W. The intensity of UV radiation was about 800 μw/cm2. The melted bitumen was placed on a U 150 ± 0.5 mm iron pan which was placed at the bottom of the chamber, and the thickness of bitumen film was about 2.0 mm. The vertical distance from the pan to the lamp was 500 mm. The working temperature was controlled at 70˚C. The aged binders were evaluated by measuring their mass change rate and physical properties. Aging susceptibility of the binders may be evaluated by means of an aging index, which is defined as the ratio of a chemical or physical parameter of the aged binder to that of the original binder. Aging indices obtained using mass and physical measurements were used to evaluate the aging properties of the binders (Henglong, et al. 2011).

RTFOT is a standardized method to simulate ageing of binder during construction operation while RCAT: Rotating Cylinder Ageing Test rather simulated binder once the mixture has been laid on site. There is actually no standard method to simulate ageing of bituminous mixture in a road pavement.

2.4 Tests for Physical Properties, Chemical Properties and Rheology affected by Ageing

The ageing properties of bitumen are normally characterized by measuring physical and rheological properties (e.g. penetration, softening point and viscosity) before and after artificial ageing in the laboratory. It was observed that ageing influence bitumen chemistry significantly. Thus the effect of ageing on bitumen chemistry and rheology was investigated using infrared spectroscopy, chromatography and dynamic mechanical analysis. Correlation between chemical and rheological

changes was examined. The following tests were used so far to study ageing properties:

2.4.1 Penetration and Softening Point Testing

The consistency of bitumen is measured by the penetration test. In this test, a needle of specified dimensions is allowed to penetrate into a sample of bitumen under known load. The distance, the needle penetrates in units of 1/10 millimetre (dmm) is termed penetration. Therefore the greater is the penetration, the softer is the bitumen. This test is the basis upon which penetration grade bitumen is classified into standard penetration ranges.

Bitumen can also be characterised by determining its softening point temperature (R&B method). In this test a steel ball is placed on a sample of bitumen contained in a brass ring which is suspended in a water or glycerol bath. The bath temperature is increasing linear with 5°C per minute, the bitumen softens and eventually deforms slowly with the ball through the ring and touch a base plate at 25.4 mm below the ring. The temperature of the water is recorded and designated the softening point of the bitumen (equi-viscous temperature). As the penetration and softening point tests are empirically derived, it is essential that they are always carried out under the same conditions. It is important to note that the above properties are used for quality control and grading the bitumen.

3. Conclusions

The following conclusions are drawn from the present literature review:-

1. The ageing of bituminous binder directly influences the service life of a pavement, thus it is very important to predict behaviour of binder with respect to time.
2. Ageing influences bitumen chemistry and rheology significantly and as a result of these changes aged bitumen become more solid. Thus by using chemical analysis and rheological measurement ageing can predicted and controlled accordingly.
3. With the increasing demands of traffic on road building materials in recent years binders with improved performance relative to normal penetration grade bitumen are needed, that's why more and more modified bitumen is used in road pavement.
4. In order to predict long term ageing successfully in the laboratory, ageing test should be done at temperature closer to that of the pavement because high temperature results in high volatile loss and will change the nature of oxygen reaction with the bitumen components.
5. Field ageing can be accelerated in the laboratory by using increased temperature, decreased bitumen film thickness, increased oxygen pressure, or combinations of these factors.

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