Available online at www.sciencedirect.com
ScienceDirect
Fuel 86 (2007) 1446–1451
FUEL
www.fuelfirst.com

The influence of UV aging of a Styrene/Butadiene/Styrene modified bitumen: Comparison between laboratory and on site aging

Françoise Durrieu [a], Fabienne Farcas [a,*], Virginie Mouillet [b]

[a] Service Physico-chimie des matériaux, Laboratoire Central des Ponts et Chaussées, 58 Boulevard Lefebvre, 75732 Paris Cedex 15, France
[b] Laboratoire Régional des Ponts et Chaussées d'Aix-en-Provence, CETE Méditerranée, CS 70499, 13593 Aix-en-Provence Cedex 3, France

Received 3 July 2006; received in revised form 15 November 2006; accepted 16 November 2006
Available online 13 December 2006

Abstract

During the service life in a pavement, neat bitumen and modified bitumen age as the result of the mixing with aggregates, the process of laying, the climatic conditions and the traffic. Laboratory methods for simulating the short-term and long-term ageing (RTFOT and PAV, respectively) are standardized. None of them takes into account the influence of UV radiations. In the particular case of a pavement located in south France, a comparison is drawn through Fourier Transformed InfraRed (FTIR) analysis. Three types of ageing are compared: the standard simulated ageings, the actual on site ageing after 12 and 26 months of road service and the ageing when UV exposure in a weathering oven follows RTFOT simulation. According to carbonyle function evolution by FTIR spectroscopy, this work shows that for all tested binders, the same ageing level as the one simulated by PAV is reached in a few hours when a thin film of binder is submitted to UV exposure after RTFOT. It is also to be noted that the level of the on site ageing of a SBS Polymer modified Bitumen (PmB) reaches the simulated PAV ageing after 12 months of pavement life.
© 2006 Elsevier Ltd. All rights reserved.

Keywords: Modified bitumen; Simulations of aging; On site aging; FTIR characterization; UV radiation

1. Introduction

What is referred to the "ageing" of the bituminous road binders involves a set of complex physico-chemical processes which take place throughout the life of the road. It is generally divided into short-term aging (which occurs during manufacturing and laying) and long-term aging (which occurs over several years during service life). It is responsible for a deterioration of the physical and mechanical properties of the binders, so attempts have been made for many years to simulate in the laboratory this inevitable change in order to include it in standard specifications [1]. The influence of solar radiation on bituminous binders has been known for some considerable time, as in 1822 Niepce developed a photo-etching technique [2] based on the transformation of a thin layer of bitumen by the action of light. Notwithstanding, the influence of light on bitumen ageing is ignored in laboratory simulations of ageing as it is recognized that due to the high absorption coefficient of bitumens – particularly for ultraviolet (UV) radiation – solar radiation only affects the upper layers of the pavement surfacing [3,4]. In the 1950s, an "Exposure test" [5] was developed which showed that the effect of solar radiation depended on the nature of the bitumen [6], but this was not put to any subsequent use. This paper describes a study that investigates whether the omission of this factor might be able to explain some of the divergences noticed between the standardized laboratory simulations of ageing and observations in the field [7]. To this purpose, a device designed to investigate the ageing of paint [8] was used; the objective was not to propose a new simulation method, but to use a simple and relatively rapid technique to

* Corresponding author. Tel.: +33 1 40 43 54 14; fax: +33 1 40 43 65 14.
E-mail address: Fabienne.Farcas@lcpc.fr (F. Farcas).

0016-2361/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.fuel.2006.11.024

compare the ageing caused by exposure to UV radiation in an weathering oven with the ageing simulated by standardized methods in the laboratory and with the experience in the field.

2. Investigated materials and experimental methods

2.1. Bituminous binders

The following bitumens (B) and polymer-modified bitumens (PmB) were used in this study:

B1 a 35/50 penetration grade bitumen (NF EN 1 2591 standard) [9].

PmB1-3*l* a PmB with a penetration of 46 1/10 mm according the European standard NF EN 1426 and manufactured in the laboratory by adding 3% of linear SBS copolymer to B1.

PmB2-4* a PmB with a penetration of 41 1/10 mm according the European standard NF EN 1426: the manufacturer's documentation gave the impression that this was a modified bitumen manufactured by adding a SBS; no information about the base bitumen (B2) was available.

PmB3-3* a PmB with a penetration of 60 1/10 mm according the European standard NF EN 1426 and manufactured in the laboratory by adding 3% of star SBS copolymer to a 70/100 penetration grade bitumen B3.

PmB4-3* a PmB with a penetration of 50 1/10 mm according the European standard NF EN 1426 and manufactured in the laboratory by adding 3% of star SBS copolymer to a B4 laboratory bitumen from the same penetration grade as B3 but more oxidizable.

Generic fractions of base bitumens, measured with the IATROSCAN by successive elution in heptane, toluène/*n*-heptane (80/20), dichlorométhane/méthanol (95/5), are listed in the Table 1. Details of the method are provided in the literature [10].

PmB2-4* was used for the wearing course of a pavement located in the south of France: with both a high level of traffic and a high level of sunlight. The structure of the surface layer is a porous asphalt with about 24% of void content. The SBS copolymer content was measured by FTIR spectrometry performed on a solution of bitumen in carbon disulphide (CS_2) with the linear SBS polymer, Kraton D-1184 as the reference polymer [11,12]. A sample from the mixing plant was found to have a polymer content of 3.4%.

In addition to the laboratory simulations of ageing, samplings from the pavement were carried out after 12 and 26 months of service. The binders which had undergone ageing in the pavement were extracted using perchlorethylene at 70 °C applying a technique used at the Aix-en-Provence Regional Public Works Laboratory [13].

As the composition of the base bitumen of PmB2-4* used on the road remained unknown, the attempt was made to relate our results to those obtained applying the same method of ageing simulation to similar PmBs, specially elaborated in the laboratory for this purpose: PmB3-3* and PmB4-3*.

2.2. Ageing methods

- *Short-term ageing* was addressed by the Rolling Thin Film Oven Test (RTFOT) as described in the European standard NF EN 12607-1. This technique has been validated for some time for unmodified bitumens for which it is considered to be more severe than actual jobsite conditions [14]; in the case of modified bitumens, its validity is still open to doubt. However, in the absence of anything better, it has been used with considerable success [13,15] to compare different PmBs during laboratory studies.
- *Long-term ageing* was addressed by the Pressure Aging Vessel (PAV). Binders were aged during 20 h at 100 °C under 2.1 MPa of air as described in the European standard NF EN 14769. In the case of unmodified bitumens, the simulated ageing provided is recognized to be equivalent to several years of service in a road, but how long this equivalence is depends on the bitumen [1,4,10]; recently, a study of several experimental pavements [7] found this simulated ageing to be equivalent to four years.
- *UV weathering oven*: according to Montepara [16,17], the binder film was aged by RTFOT test before UV exposure. Pieri's "dry slide" technique was used to prepare the binder film [18]: 25 μL of binder in a 170 g L^{-1} solution of dichloromethane were deposited on a slide suitable for transmission FTIR measurement (NaCl). The solvent was eliminated by natural evaporation and FTIR spectrometry was used to check its complete absence. From both the volume deposited and the area of the residual film, these films can be considered to be

Table 1
Generic fractions of base bitumens determined by IATROSCAN

PmB	Base bitumen	Saturates (%)[a]	Aromatics (%)[a]	Resins (%)[a]	Asphaltenes (%)[a]	Colloïdal Index (I_c)[b]
PMB1-3*l*	B1	9	43	31	17	0.35
PmB3-3*	B3	6	55	21	18	0.35
PmB4-3*	B4	7	53	22	18	0.33
PmB2-4*	Base bitumen unknown					

[a] Iatroscan thin film chromatography SARA analysis.
[b] Colloïdal index I_c = (asphaltenes + saturates)/(resins + aromatics).

Download English Version:

https://daneshyari.com/en/article/207794

Download Persian Version:

https://daneshyari.com/article/207794

Daneshyari.com