Construction and Building Materials 160 (2018) 233–239

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Exploratory study of porous asphalt mixtures with additions of reclaimed tetra pak material

Valerio C. Andrés-Valeri [a,*], Javier Rodriguez-Torres [a], Miguel A. Calzada-Perez [b], Jorge Rodriguez-Hernandez [a]

[a] University of Cantabria, Civil Engineering School, GITECO Research Group, Avda. De Los Castros s/n, Santander 39005, Spain
[b] University of Cantabria, Civil Engineering School, GCS Research Group, Avda. De Los Castros s/n, Santander 39005, Spain

HIGHLIGHTS

- TBA material is a suitable stabilizing addition for PA mixtures.
- TBA fiber size of 1-2 mm in a dosage of 0.25–0.50% by weight is recommended.
- TBA fibers produced similar improvement in PA mixtures than CF or even higher.

ARTICLE INFO

Article history:
Received 5 June 2016
Received in revised form 19 October 2017
Accepted 14 November 2017

Keywords:
Porous asphalt
Porous friction course
Open-graded friction course
Permeable pavement
Stabilizing additives
Cellulose fibers
Tetra brick

ABSTRACT

The use of cellulose fibers (CF) has become a common technique for reducing draindown problems in porous asphalt (PA) mixtures, helping to increase the bitumen content and providing thicker binder films. In this research, a laboratory study was conducted to assess the suitability of using recycled Tetra Brick Aseptic (TBA) containers as an environmentally friendly substitute for virgin cellulose fibers used in PA pavements. The results obtained showed that recycled TBA material was a suitable addition for PA mixtures, providing similar, or sometimes greater, improvements than commercial CF.

1. Introduction

Porous asphalt (PA) mixtures are special asphalt mixtures, characterized by a large air void (AV) content, generally higher than 18–20%, which allow water infiltration through their porous structure [1]. PA mixtures have been widely used all over the world as a surface layer in roads and pavements due to their safety and environmental benefits in relation to other types of asphalt mixtures. The main advantages provided by PA surfaces are the decrease in pavement noise and splash, the increase in safety by reducing the skidding risk and the hydroplaning effect in wet conditions, and the enhancement of visibility in wet weather conditions [2].

Although porous asphalt mixtures were developed more than 30 years ago, their first applications as a surface layer were unsatisfactory due to the premature aging of the mixtures and their raveling damage, limiting their application over time [1]. The continuous development of polymer modifications of bituminous mixtures and other additions led to the development of a new generation of PA mixtures with improved characteristics [3]. The addition of Styrene Butadiene Styrene (SBS) or Styrene Butadiene Rubber (SBR) polymers, crumb rubber, low density polyethylene and the addition of different kinds of fibers to PA mixtures have significantly increased their strength and durability [3,4], increasing their service life and allowing their continuous use for more than ten years [5].

The asphalt binder content is an important factor in the mechanical performance of PA mixtures. High binder contents increase the coating of the coarse aggregates, providing thicker binder films over the aggregates, increasing the strength and the

* Corresponding author.
E-mail addresses: andresv@unican.es (V.C. Andrés-Valeri), jrodriguez@innomerics.com (J. Rodriguez-Torres), Miguel.Calzada@unican.es (M.A. Calzada-Perez), rodrighj@unican.es (J. Rodriguez-Hernandez).

https://doi.org/10.1016/j.conbuildmat.2017.11.067
0950-0618/

durability of PA mixtures [3]. However, a binder excess may produce draindown and reduce the infiltration capacity of PA mixtures [1]. With the aim of reducing these problems, additives are normally incorporated to stabilize mixtures with high binder contents, preventing draindown problems [6] and increasing the resistance to raveling of PA mixtures. In the last decade some researchers have studied the influence of the addition of different types of natural and synthetic fibers as stabilizing additives in PA mixtures to obtain mixtures with high bitumen content without causing draindown problems [3,7,8]. The results of this research showed that Cellulose Fibers (CF) were more effective than polyester fibers for reducing draindown in PA mixtures [7], but can be more susceptible to the water effect than other types of fibers [9]. The addition of little amounts of CF, between 0.2 and 0.5% by weight of mixture, was recommended for reducing draindown problems [3], augmenting the long-term resistance to raveling and the Indirect Tensile Strength (ITS) of PA mixtures, but sacrificing part of their infiltration capacity [4,7,10–12].

Progressive social awareness about sustainability matters has increased the interest in reusing recycled materials for different purposes, including asphalt mixtures. Tetra Brick® Aseptic (TBA) packaging has been widely used worldwide to commercialize liquid foods such as milk or fruit juices, resulting in an annual production of nearly 30 billion containers, being one of the most common residues in recycling centers. This kind of containers is mainly composed of cellulose (63%), low-density polyethylene (30%) and aluminum (7%) [13], making it difficult to recycle due to the need to separate these different compounds.

The composition of TBA packages raises the possibility of reusing them as a stabilizing additive for asphalt mixtures. With the aim of studying the suitability of reclaimed TBA material for this purpose, a laboratory study was performed. The main aim of the research was to analyze the influence of the additions of reclaimed TBA packages on PA mixtures and compare their performance with commercial CF, normally used in PA pavements.

2. Materials and methods

2.1. Aggregates

A coarse basaltic aggregate was used for producing PA mixtures, with a particle density of 2921 kg/m^3, a flakiness index of 12 and a Los Angeles coefficient of 16. Limestone filler was added in a constant range of 4.5% by weight of mixture. The aggregates gradation can be seen in Fig. 1.

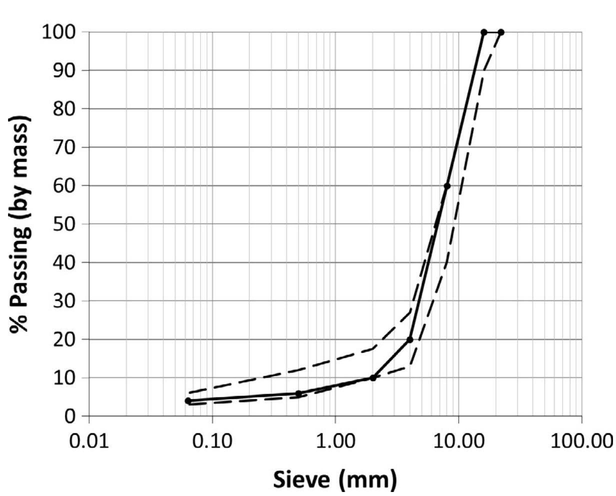

Fig. 1. Aggregate gradation used.

The gradation was selected according to the Spanish requirements for PA-16 mixtures [14], and designed for maximizing the air void content in mixture by using a specific methodology: the Bailey method [15]. This methodology is a systematic approach to blending aggregates that provides aggregate interlock as the backbone of the structure. The method provides a set of tools that provides a better understanding of the relationship between aggregate gradation and mixture voids [15]. After applying this method to the range of gradations that can be used for PA-16 mixtures according to the Spanish requirements [14], the best gradation in terms of air void content was selected. In this gradation the finer part of the aggregates was reduced and the dosages of the coarse aggregates were optimized according to the Bailey method, resulting in Voids in Mineral Aggregates (VMA) between 26 and 28% after compaction, measured according to the standard EN 1097-3 [16].

2.2. Bitumen

One conventional 50/70 penetration grade bitumen (50/70) was used for producing the tested PA mixtures. The main characteristics of the used bitumen are summarized in Table 1.

2.3. Fibers

Two different types of fibers were used as stabilizing additives for PA mixtures: commercial CF and recycled TBA material. Commercial CF, produced to be used in asphalt pavements, was selected for comparing the effects of recycled TBA material. These fibers were supplied by a local company in pellet form, with virgin cellulose fibers coated by a bituminous binder. The characteristics of the cellulose pellets used are shown in Table 2. Commercial CF were added to PA mixtures according to the manufacturer's recommendations. The process consists of shredding the cellulose pellets to separate the cellulose fibers and adding the material obtained to the aggregates before being heated in the oven to prepare the PA samples.

TBA material was obtained from recycling TBA packages. For recycling TBA containers, the packages were initially washed and air dried, and finally shredded. After that, the material obtained

Table 1
Characteristics of 50/70 conventional bituminous binder.

Characteristic	Standard	Value
Penetration at 25 °C, 100 g, 5 s (0.1 mm)	EN 1426 [17]	65
Softening Point (°C)	EN 1427 [18]	47.2
Penetration index	EN 12591 [19]	-1.3
Fraas Fragility point (°C)	EN 12593 [20]	-9

Table 2
Commercial cellulose fiber characteristics.

Pellet characteristics	
Cellulose fiber Content	87–93%
Pellet Length	2–8 mm
Pellet thickness	4 ± 1 mm
Bulk density	440–540 g/l
Cellulose fiber characteristics	
Cellulose content	80 ± 5%
Average fiber length	1100 µm
Average fiber thickness	45 µm
Bitumen characteristics	
Penetration at 25 °C	50/70 mm
Softening Point	46–54 °C