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STUDY OF THE EFFECT OF STORAGE TIME IN THE THERMAL BATH ON THE CHARACTERISTICS OF A 0/14 BITUMINOUS MIXTURE FORMULATED ACCORDING TO THE MARSHALL STANDARD

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ABSTRACT

Pavements asphaltic concrete surfacing is the most common in the world, mainly because of the ride comfort it offers. This surfacing, made up of a mixture of aggregates and hydrocarbon binder that is bitumen, is very exposed to traffic but also to the immediate effects of the climate, especially temperature. Asphaltic concrete is formulated by the Marshall method in Togo, which recommends a storage time of 30 minutes in a thermal bath set at a temperature of 60 ° C. However, the continuous exposure of the surfacing to temperature can last a few minutes to a few hours depending on the season and the thermal cycle. In this study, it is verified the effect of the storage time in a thermal bath on the characteristics of a bituminous mixture of class 50/70 with a serious 0/14. For this, asphaltic concrete samples are manufactured and stored in a thermal bath set at 60° for a time ranging from 30 to 420 minutes. On each sample are determined creep and Marshall stability. It emerges from the results obtained that the characteristics of the asphaltic concrete studied are influenced by the storage time: in fact, an increase in creep and a decrease in stability are noted.

KEYWORDS: storage time; thermal bath; asphaltic concrete; Marshall stability; creep.

1. INTRODUCTION

Asphaltic concrete is a mixture, produced by an asphalt plant, of gravel, fillers (sand and dust) and a hydrocarbon binder which is generally bitumen. It is mainly used as a coating layer for runways, roads, airports, aprons, etc. This layer is subject to the immediate effects of climate including temperature, rain and sunshine. Its durability depends on the viscoelastic character of the bitumen. In general, bitumen is a heat-sensitive material which results in the creation of stresses and deformations within the material due to thermal expansions and also by the creation in the roadway of tensile forces in the longitudinal direction leading to possible transverse cracks [1]. When formulating binder, it is therefore necessary to take into account the climatic conditions of use. In Togo, binder is formulated using the Marshall method developed by Bruce Marshall in 1939 [2]. This method makes it possible to determine a binder formula based on the mechanical resistance known as stability, subsidence called creep and the Marshall quotient [3-4]. The principle of the test is to determine the bitumen content of a bituminous mixture whose particle size composition is given and to assess its mechanical qualities. This then amounts to measuring the maximum resistance and the corresponding deformation of a mixture specimen previously immersed in a thermal bath at 60 ° C (± 1) for 30 minutes (± 1) then subjected to crushing between two cylindrical jaws. whose entire device is called the Marshall press [3-4]. In reality, the exposure time of bituminous pavements, either to temperature or to rain, varies from a few minutes to hours. The objective of this paper is to study the effect of varying the thermal bath storage time of bituminous mixture samples on Marshall stability and creep. It is thus envisaged to vary the storage time in a water bath of the samples of a semi-grained binder 0/14 formulated by the Marshall method and thus to assess the effect of the storage time on the stability and creep of binders.

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2. MATERIALS AND METHODS

The aggregates (sand and gravel) used during this study come from "Togo Carrière", one of the gravel crushing quarries in Togo located about fifty kilometers north of Lomé, the Togolese capital. The characteristics of the 0/14 aggregate split into three parts which are 0/5, 5/10 and 10/14 are shown in Table 1 and in Figure 1. The aggregates used have a continuous particle size and are of a common nature. The gravel is of good hardness.
The bitumen which was used for the mixture and whose characteristics are presented in Table 2 is of class 50/70.

Table 1. Aggregates used characteristics

Characteristics	Sand 0/5	Gravel 5/10	Gravel 10/14
Absolute density	2.78	2.70	2.70
Apparent density	1.69	1.46	1.44
Sand equivalent	51	-	-
Micro Deval coefficient	-	19	
Los Angeles coefficient	-	30	

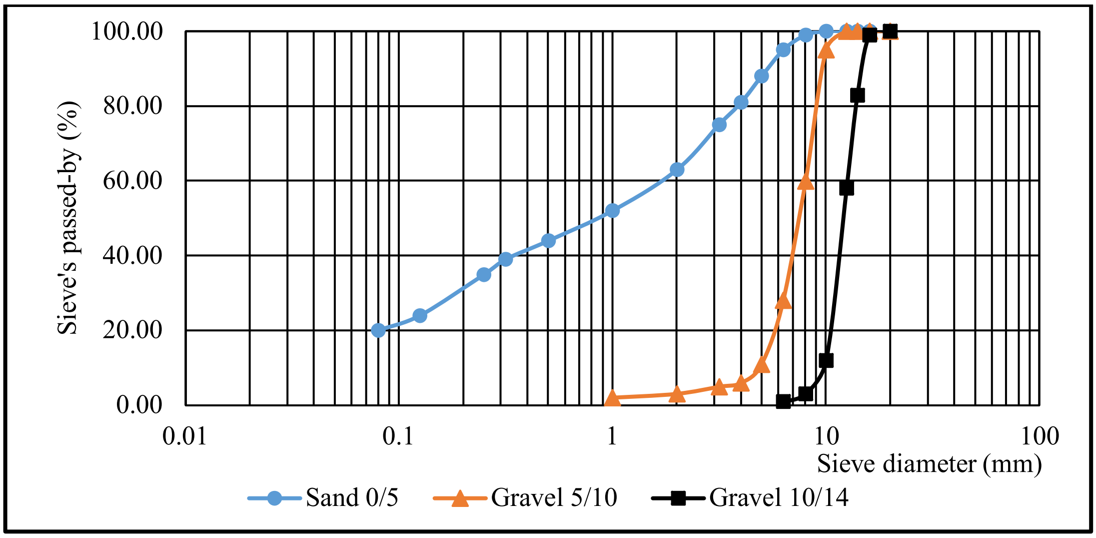

Figure 1. Aggregate used granulometric curve

Table 2. Bitumen characteristics

Characteristic		Bitumen 50/70
Relative density		1.03
Ball and rings temperature		47.9°C
Penetration in 1/10 mm		51

The approach adopted consisted in first determining the optimum binder content to ensure a certain threshold of stability, compactness and resistance to water by a formulation by the Marshall method according to standard NF EN 12697-34 [3]. The followed method consisted of:

• Choosing a granular mixture made up of three size fractions (0/6, 6/10 and 10/14) fitting perfectly into the reference spindle (Marshall zone for semi-grained asphalt concrete (BBSG) 0/14) given by,

• Determining the bitumen content by formula i [5]:

$$P_{bi} = \frac{TG+120}{100} \qquad \text{(i)}$$

With Pbi the bitumen content in percentage and TG the variation of the different fractions retained on various sieves;

• Then choosing contents that deviate by ± 0.5% from the average content thus calculated. The variation of 0.5% makes it possible to cover a range of contents of 2.5%;

• Making the asphalt concrete samples, keep them in the water bath for 30 min at a temperature of 60 °C and finally determine the stability and creep.

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The mixture with the best characteristics will be selected. On this asphalt, the influence of storage time in the thermal bath on stability and creep is studied, the storage temperature being maintained at 60 °C in accordance with the Marshall standard. The work consisted in varying the storage time of the samples in the thermal bath from 30 min to 420 min in steps of 30 min for the first 120 minutes and in steps of 60 minutes for the rest. At each moment, the stability and the creep are determined. Each result is the average of six values.

3. RESULTS AND DISCUSSION

Table 3 shows the granular composition of the mixture selected and figure 2 its granulometric curve. The grain size curve of the mixture fits perfectly into the specific spindle for semi-grained asphalt concrete 0/14 (Figure 2).

Table 3. Composition of the mixture

Fraction	Percentage (%)	Mass of each fraction (g)
Sand 0/5	47,40 %	1 896
Gravel 5/10	32,60%	1 304
Gravel 10/14	20,00%	800

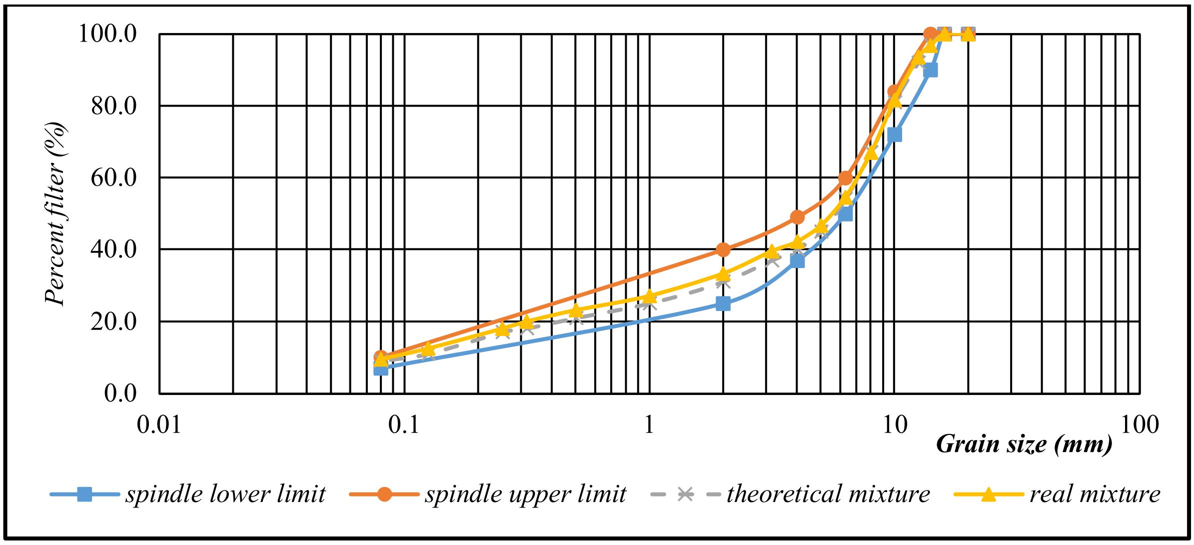

Figure 2. Particle size curve of the mixture and specification zone

The bitumen content determined by formula 1 is 5.4%. A variation in the bitumen content around this value was thus carried out in order to retain for the formulation the contents of 4.4; 4.9; 5.4; 5.9 and 6.4%. Figure 3 shows the Marshall samples prepared and stored in a thermal bath at 60 ° C for 30 minutes.

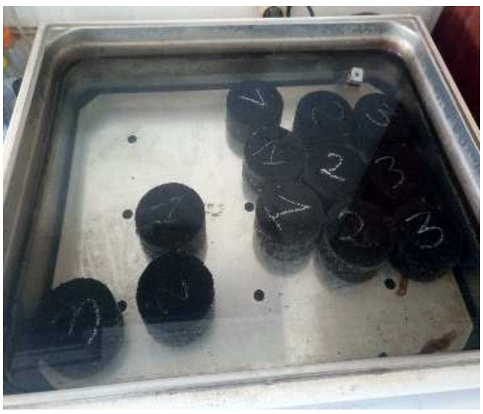

Figure 3: Sample in the thermal bath

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Table 4 shows the stability and creep results of the various samples

Table 4: Results of the Marshall formulation

Bitumen content (%)	Stability (KN)	Creep (mm)	Marshall quotient
4.4	10.50	3.55	2.96
4.9	11.89	2.93	4.06
5.4	12.60	2.65	4.76
5.9	12.01	2.83	4.24
6.4	11.02	3.34	3.30

From this table, it emerges that the mixture exhibiting better stability and low creep therefore a better Marshall quotient is that containing 5.4% bitumen. It is on this mixture that the variation in storage time in the water bath is studied. The results of this study are shown in Table 5.

Table 5: Results of storage time variations

Storage time (min)	Apparent density	Stability (KN)	Creep (mm)	Marshall quotient
30	2,401	12,50	2.62	4,77
60	2,415	12,48	2,62	4,76
90	2,423	11,23	2,75	4,08
120	2,419	10,68	2,86	3,73
180	2,421	10,46	2,86	3,66
240	2,429	10,22	2,88	3,55
300	2,439	9,82	2,89	3,46
360	2,449	9,82	2,94	3,34
420	2,453	9,77	3,04	3,21

From Table 5, we deduce the curves of variation of the apparent density, the stability, the creep and the Marshall quotient as a function of the storage time (figure 4).

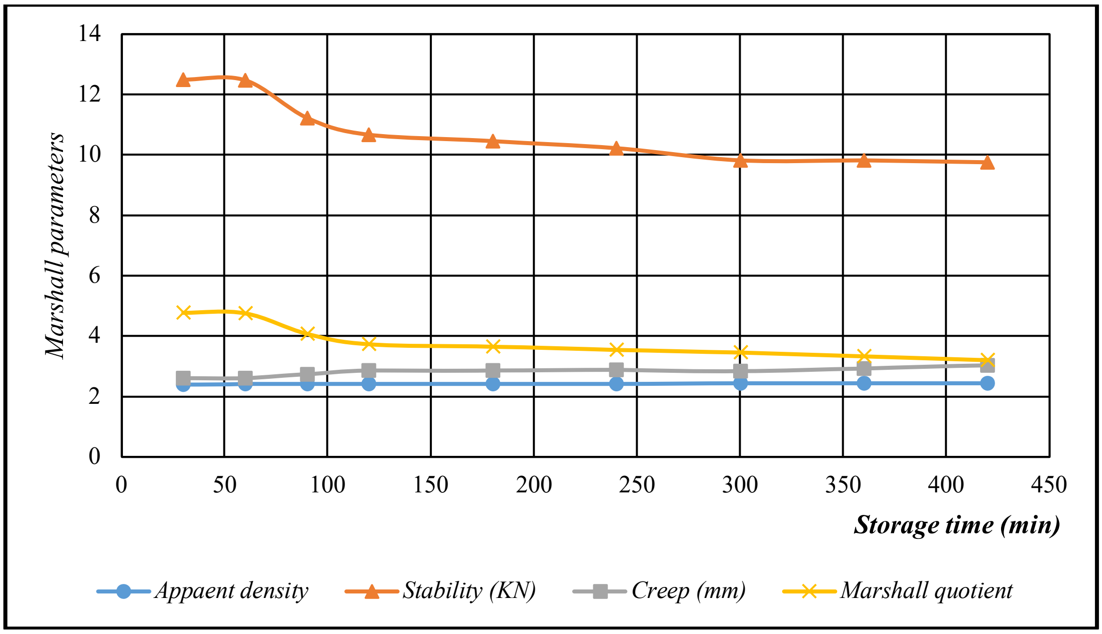

Figure 4: Variation of apparent density and Marshall parameters as a function of storage time in the thermal bath

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The apparent density increases with the variation of the storage time. This increase reflects a certain porosity in the material which absorbs the water in the thermal bath. Water absorption results in material weakness resulting in decreased stability with storage time. There is a rate of decrease of 15% on average compared to the stability after 30 min of storage. As the material is weakened by water, it deforms more, increasing creep. Since the material is stored in a water bath, it is difficult to know which, between water and temperature, has more effect on the variation in the properties of the material. But it is certain that the exposure time of the material to water and temperature has a considerable effect on the properties of asphalt. This finding may explain the early deformations encountered on asphalt roads in Togo where the rains can last for hours as well as exposure to the sun. It is therefore important to redefine, taking into account the climatic conditions of each country, the storage time in the thermal bath.

4. CONCLUSION

This work aims to study the influence of the storage time in the thermal bath of a 0/14 semi-grained mix formulated by the Marshall method on the stability and creep of this mix. For this, from 0/5 sand, 5/10 and 10/14 gravel, and 50/70 class bitumen, a semi-grained asphalt mix has been formulated using the Marshall method. The mix storage time in the thermal bath is then varied from 30min to 420min. It appears that the stability decreases with the storage time and the creep increases. It is therefore important to clearly define the storage time of asphalt in the thermal bath, taking into account climatic conditions in order to reduce the risk of premature deformation on asphalt roads.

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