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Effect in the high modulus asphalt concrete with the temperature

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HIGHLIGHTS

- 25% of thickness reduction in the base layer with HMAC compared with conventional bitumen at 20 °C.
- 15% of thickness reduction in the base layer with HMAC compared with conventional bitumen at 0 °C.
- 0% of thickness reduction in the base layer with HMAC compared with conventional bitumen at −20 °C.
- This study shows a clear disadvantage of using HMAC compared with conventional bitumen in cold weathers and a clear advantage of using HMAC in warm weathers.

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ABSTRACT

The use of the high modulus asphalt concrete in the base course of airport pavements is not of recent utilization, but at present there is a considerable gap in the regulation for the use of this bitumen. The main objective of this paper is to present the results of the research that has been done using the experimental dynamic modulus of different mixtures of conventional bitumen with different penetration index B40/50, B60/70, B100/150, B150/200 and the high modulus bitumen B13/22 to calculate the percentage of reduction in thickness of the base course in airport pavements when is used High Modulus Asphalt Concrete (HMAC) compare with conventional bitumen mixtures and is also taken into account the temperature. In order to obtain the reduction in thickness depending on the temperature and the use of HMAC, the tests have been performed at the different temperatures −20 °C, −10 °C, 0 °C, 10 °C, 20 °C and all the results in this paper are presented for these temperatures.

To perform the calculations of this research the Airbus A380 has been taken as Aircraft Design.

1. Introduction

The design of roads is made taking into account the number and types of heavy vehicles circulating. The design of airport runways is made basically depending on four factors: Operational Capacity, Runway Length, Airport Classification/Design Standards and Wind Coverage. For the design of both runways and roads, it is very important the material selection. And this material selection depends on several factors, for example soil properties, water condition or traffic type.

In the eighties, a French company started to develop what today is known as high modulus asphalt concrete. The result was what today is known as Mixtures of High Modulus Asphalt Concrete (HMAC). Nowadays, the introduction of new materials for the construction of roads and runways has improved the quality of the pavement. HMAC has made an important contribution to the structural design of pavements due mainly to its good anti-rutting properties.

HMAC allow the construction of base layers of, most resistant pavements to be more rigid (higher modulus) and more resistance to fatigue. This bitumen allows the building of base layers of pavements which are longer-lasting, or to decrease the thickness of pavements manufactured with conventional bitumen, with the resulting savings. For instance, the use of HMAC in pavement reinforcement has the advantage of avoiding the complete removal of old bituminous layers, as HMAC make possible to reduce the thickness of the pavement [1].

At present despite all the advantages of the high modulus asphalt concrete there is a considerable gap for the use of this bitumen and the real reduction in thickness for the base layer depending on the temperature with the use of HMAC compare with conventional binders. This paper shows the results of the experimental research that has been done to calculate the reduction in thickness of the base layer with HMAC compare to a base layer with conventional bitumen for runway pavements at the different temperatures −20 °C, −10 °C, 0 °C, 10 °C, 20 °C. The program used

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in this research to calculate the thickness of the layers for a runway pavement has been LEDFAA 1.3. LEDFAA is a Federal Aviation Administration program and uses Layered Elastic Design (LED) methods for airport pavements design.

Apart that the thickness of the layer can vary depending on the temperature, viscous elastic properties of asphalt materials are significantly influenced by temperature. The temperature is a key factor for selecting the binder type for the asphalt mixture. The binder which is sufficiently stiff at high temperature often is not elastic enough at low temperatures [2].

2. High module mixtures

HMAC began to be used in France in the 1980's. Those mixtures were stiffer than traditional ones and had better mechanical behaviour relative to the fatigue cracking and permanent deformations. Since 1980's, HMAC have been used to reinforce old pavements or in the base layer to obtain economical benefits by reducing thickness. This last is the main objective of this research, calculate the real reduction in thickness of the base layer of HMAC compare with conventional bitumens.

In the 1990's the use of the HMAC for the base layer of roads and runways had increased. HMAC has made an important contribution to the mechanical performance of the pavements, mainly because of the good anti-rutting properties of the binders [3].

HMAC is a mixture of asphalt concrete designed for use in base and binder course of asphalt pavement. It has closed structure with comparatively large content of bitumen. Hard road bitumen grades are applied, mainly 10/20, 15/25, 20/30 and polymer modified bitumen. Hard bitumen assure the mixtures resistance to rutting. However large content of bitumen assure workability, fatigue durability and water resistance [4].

HMAC is a type of bituminous mixture that incorporates continuously graded aggregates, typically having 32–35% of material less than 2 mm and 7–8% less than 0.075 mm. The maximum aggregate size is 10, 14 or 20 mm for layers whose thickness' varies from 6 to 10 cm, 7 to 12 cm and 10 to 15 cm.

The high modulus asphalt concrete that has been used in this research is B13/22 and its main characteristics compare with a conventional bitumen can be seen in Table 1.

Table 1
Main properties of the bitumen used in this research.

	B13/22		B40/50		B60/70		B100/150		B150/200	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Penetration at 25 °C, 0.1 mm	13	22	40	50	60	70	100	150	150	200
Softening point °C	60	72	52	61	48	57	44	51	40	47
Ductility at 25 °C	10	–	70	–	90	–	130	–	180	–
Fraas temperature °C	–	+1	–	−4	–	−8	–	−12	–	−16

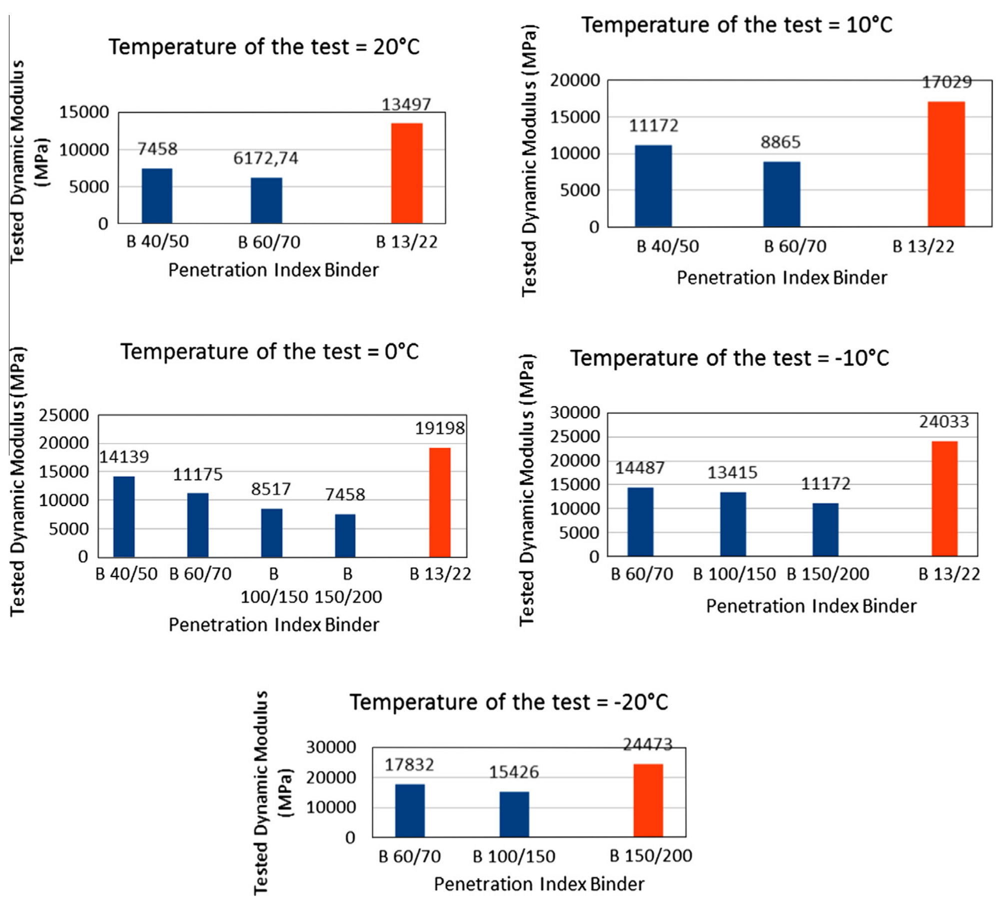

Fig. 1. Tested dynamic modulus at different temperatures.