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THE INFLUENCE OF CHEMICAL COMPONENTS IN ASPHALT TO ITS PHYSICAL PROPERTIES

(PENGARUH UNSUR-UNSUR KIMIA DALAM ASPAL TERHADAP SIFAT-SIFAT FISIKNYA)

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ABSTRAK

Pada lapis penutup atau lapis aus perkerasan lentur jalan (flexible pavement), aspal dipergunakan sebagai bahan pengikat dalam campuran agregat. Ada beberapa syarat dari aspal yang harus dipenuhi pada perkerasan lentur jalan. Persyaratan tersebut adalah berupa spesifikasi untuk penggunaan-penggunaan yang tertentu. Spesifikasi pekerjaan umumnya memang diperlukan baik oleh pengguna jalan maupun oleh pelaksana pembangunan jalan. Sifat-sifat aspal akan berubah sehubungan dengan waktu, temperature dan kondisi pembebanan. Oleh karena itu perlu diketahui bagaimana dan di mana perubahan itu terjadi. Karena perubahan-perubahan sifat aspal disebabkan oleh adanya reaksi kimia dalam bitumen maka para peneliti telah meneliti komponen-komponen kimia yang menyebabkan terjadinya perubahan. Pengetahuan akan terjadinya perubahan tersebut juga diperlukan untuk memprediksi apakah aspal akan berubah banyak atau tidak setelah umur pelayanan jalan tertentu. Dalam tulisan ini bitumen murni (straight run bitumen) dan semi blown bitumen dikaji dan dianalisa secara fisik dan secara kim ia sebelum dan sesudah waktu atau umur pelayanan jalan tertentu. Hasil-hasilnya kemudian dibandingkan dan dihubungkan dengan kegagalan pelayanan perkerasan jalan.

Kata-kata kunci: Aspal, Kimia, Komposisi, Perkerasan Jalan

ABSTRACT

In wearing course of flexible pavement, bitumen is used as a binder of aggregate mixes and its properties affects the quality of the asphalt mixtures. There are several requirements of bitumen which has to fulfill to use in flexible pavement. These requirements are specified for certain uses. Usually the specified properties are needed by the road users or by the road engineer. The properties of bitumen will change with time, temperature and loading conditions, so it is necessary to find out its whereabouts. As the changes of the bitumen properties occur because of chemical reactions taking place within bitumen, researches has been made a research chemical components which are responsible for it. The knowledge on those changes of bitumen is also needed in predicting whether bitumen will change much or less after a certain of service. In this paper a straight run and semi blown bitumen are studied and analyzed physically and chemically before and after a certain time of service. The results are then compared and related to service failure.

Keywords: Bitumen, Chemical, Composition, Pavement

1. INTRODUCTION

The properties of bitumen changes related with time, temperature and loading conditions. So it's necessary to find out its whereabouts. All the changes occur because of chemical reactions taking place within the bitumen. Researches have to be conducted which group or groups of components are responsible for it. So measurement can be taken to present these changes to occur, for instance by adding some material to it. This knowledge is also needed in predicting whether bitumen will change much or less after a certain of service.

A straight run and semi blown bitumen has been studied in this paper by analyzing them physically before and after a certain time of service. These results are the compared and related to service failures.

In this paper a study has been made on the changes of certain chemical group of component in bitumen. The changes also occur in rheological properties when this bitumen has been subjected to traffic conditions after a certain period of service. These changes are then inter-correlated with theoretical considerations.

Purpose of the study

a. To know about the change of asphalt properties occur because of chemical reactions during service life of the pavement.
b. The result is then analyzed to know its influence on accelerating of pavement failure.

The Benefit of the Study

By analyzing and knowing the properties of bitumen which change with time, temperature and loading conditions, will be able to determine the type of bitumen which will be used, it penetration grade and penetration index as well as other properties of bitumen to accommodated with the regional conditions where the asphalt mix are taken place.

2. LITERATURE REVIEW

Design of flexible pavement should such that a safe, comfortable and fast public and commercial transportation is possible during large number of years. These demands, made by the road user, mean to the road engineer that he should provide a smooth driving surface with high skid resistance.

Premature failure of asphalt pavements are often observed is fast. Very high road surface temperature in summer, periodic heavy rainfall, large temperature gradients and wide traffic spectra are major causes of these failures.

Under hot climates, permanent deformation or rutting is the most important distress mode occurring within the surface asphalt layers. This is caused by the combined effect of

traffic and high temperatures. Also there are stripping problems caused by the poor adhesion of the asphalt cement to certain aggregate, especially in the presence of water.

Well knowledge about the properties and characteristics of the bitumen is very important to road engineer in order to be able to know the reasons of those road deteriorations. Although bitumen is, in terms of its volume, a relative minor component of bituminous mix, it has a crucial role acting as durable binder and conferring visco-elastic properties to the mix.

Quality of the Bitumen

For many years Shell has been investigating the relationship between laboratory measured properties of penetration grade bitumen and their performance in asphalt mixes on the road. With increasing traffic loading ‘s’ and more demanding performance requirements the need to be able to predict long-term behavior is essential. Performance on the road depends on many factors, including the design, application and the quality of the individual components.

Essential satisfactory performance of bitumen on the road can be ensured if four properties are controlled: rheology, cohesion; adhesion; durability. Where, the rheology of the bitumen at service temperatures is adequately characterized by penetration and penetration index; the cohesive strength of penetration grade bitumen is characterized by low temperature ductility; the adhesion characteristics of bitumen are assessed by a retained Marshall test; and Durability can be defined as the ability to maintain satisfactory rheology, cohesion and adhesion in long-term service.

The influence of bitumen properties on performance of bituminous mixes in service

After the mixtures has been manufactured, laid and compacted, its behavior in service must be considered. The critical condition for the performance of bituminous mixes are generally associated with either high service temperature (30^0C to 60^0C) or low service temperature ($< 5^0$C). At high temperatures the problem are deformation and fatting-up and at low temperatures cracking and surface fretting.

2. ANALYSIS AND RESULT OF THE STUDY

2.1 Service failures caused by bitumen

In the characterization of bitumen there two essential factors:

a. The resistance to deformation (rheological)
b. The permissible deformation (fracture)

Resistance to deformation of a pavement is influenced by temperature and loading time or by a single parameter, namely it's stiffness. This stiffness of a pavement can be divided into the stiffness of asphalt cement and a mix factor which is dependent on the proportion of asphalt cement, grading of the aggregate and compaction of the mix. At the same time, the stiffness modulus of the asphalt cement is related to the rheological condition of the bitumen on which the fracture properties depend.

Fig. 3.1 below shows the relation between the stiffness modulus of asphalt cement and the elasticity modulus of asphalt concrete pavements with variations of asphalt content.

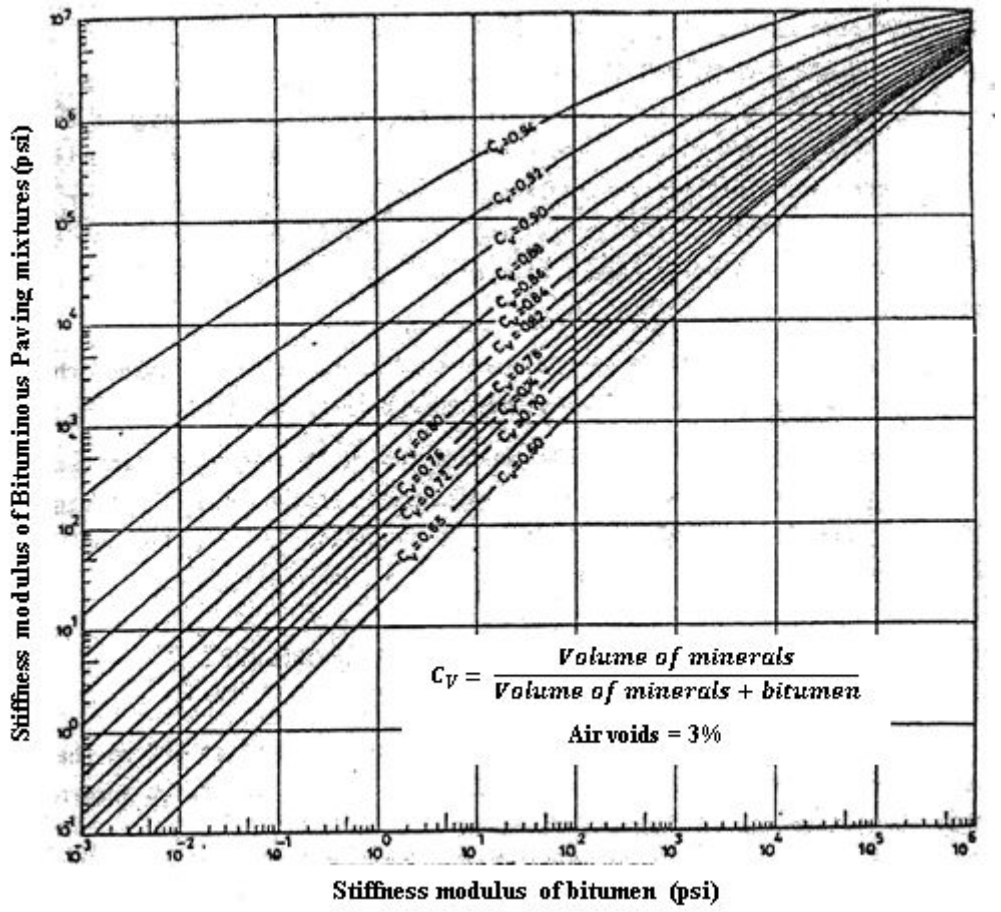

Figure 3.1. Stiffness modulus of Bitumen vs Stiffness modulus of Bituminous Paving Mixtures

Some failures data which are related to the stiffness of the bitumen are given as follows:

1. Cracking of pavement will take place after settlement with a long loading time. The stiffness of the bitumen was hereby 16 x 10^{-7} kg/cm at 25^0C.
2. Deformation of a pavement will occur by standing loads for at least one day. The stiffness of the bitumen was thereby 4,8 x 10^{-7} kg/cm at 25^0C.
3. Fatting up will occur by slow moving traffic with loading time of 10^{-1} second. Stiffness of the bitumen was thereby 13,2 kg/cm at 25^0C.
4. Fatting up will take place by fast moving raffic with loading time of 10^{-3} second. The stiffness of the bitumen was thereby 4 x 10^2 kg/cm at 25^0C.

2.2 The Relation Between Rheological Properties and Pavement Failures

As the failure of a pavement depends on mechanical properties of the asphalt mix and especially on the-stress strain conditions of the bitumen to solids, the stiffness modulus of bitumen plays an important role.

One of the Rheological tests on bitumen which has a close relation to this stiffness modulus is the penetration test. The result of this penetration test properly on several types of bitumen at 25^0C , were shown by Heukelom (1966).

This stiffness modulus can be measured directly with sliding rheometer or indirectly by using Heuklom's nomograph as shown in Fig. 3.2. When using the nomograph, the penetration, softening point and ductility values should be known of the bitumen under consideration. The loading time is taken from the elapes time in the ductility test where by an X shape bitumen specimen is elongated up till its breaking point. It is directly related to the stiffness modulus of bitumen.

Usually these properties are related as follows: the higher the penetration value whilst the two others remain constant, the lower will be the stiffness modulus. The same relation holds also for the penetration index value. If a pavement failure occurs because its stiffness modulus is too high or brittle, then another bitumen has to be used having rheological properties which decreases its stiffness modulus. According to the findings, the penetration of bitumen which is also inversely related to the stiffness modulus of bitumen. Another rheological property of bitumen which also inversely related to the stiffness modulus is ductility.

The penetration index, a property which related the penetration and the softening point instance a pavement failure occurs because the stiffness modulus is too low (distortion failures) then a bitumen has to be sought with a higher stiffness modulus.

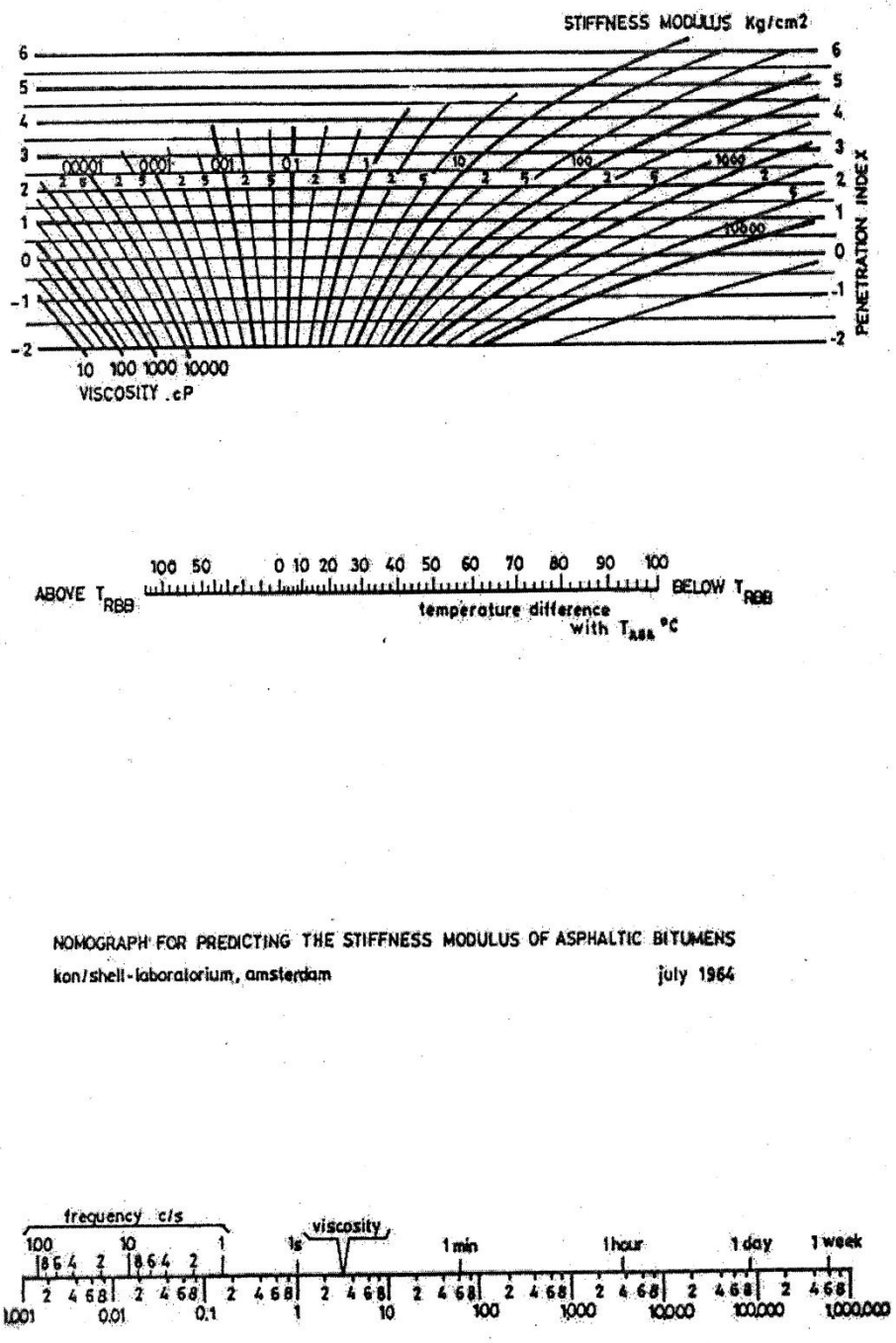

Figure 3.2. Nomograph W. Heukelom

2.3 The Chemical Components Of Bitumen Which Influence The Rheological Properties

Certain chemical component which has a detrimental effect on the quality of bitumen as a road construction material can be classified according their sensitiveness to chemical reactions.
This subsequently as follows: resins, unsaturated hydrocarbons, alucyclic hydrocarbons, aromatics and paraffin. The influence of these components on the rheological properties of bitumen is as follows.

2.3.1 Influence on Penetration

a. With fixed asphaltene content of 25% and constant ratio of saturates to aromatics, increasing the resin content increases hardness (Fig. 3.3).
b. Increasing saturates at a constant resins to aromatics ratio decreases hardness (Fig. 3.4).
c. At constant saturates to resins ratio the aromatics constant has no influence on hardness.

Figure 3.3. Graph the relation between Penetration and Resin content

Figure 3.4. Graph the relation between Penetration and Saturates

2.3.2 Influence on Softening Point

a. Increasing resins at constant saturates to aromatic ratio increases softening point (Fig 3.5).
b. Increasing saturates at constant aromatics to resins ratio lowers softening point.
c. Increasing aromatic at constant saturates to resins has no influence.

Figure 3.5. Graph relation of Softening Point and Resin content

Figure 3.6. Graph relation of Penetration Index and Resin content

2.3.3 Influence on Penetration Index

a. Increasing resins at constant saturates to aromatics ratio decreases penetration index (Fig 3.6).
b. Increasing saturates at constant aromatics to resins no influence on penetration index until very high concentration is reached.

2.3.4 Influence on Ductility

a. Increasing resins at constant saturates to aromatics ratio decreases ductility (Fig. 3.7).
b. Increasing saturates at constant resins to aromatics ratio decreases ductility (Fig. 3.8).

Figure 3.7. Graph relation of Ductility and

Figure 3.8. Graph relation of Ductility and

Resin content Saturates

2.4 Changes In Rheological Properties And Chemical Composition Due To Ageing

The rheological properties and chemical composition of two types of bitumen has been studied before and after ageing with the following result shown in Table 3.1 and Table 3.2 The names acidify 1, 2 and 3 are successively given to resins, unsaturated + alicyclic hydrocarbons and aromatics respectively. In this order the reactivity of these components decreases for sulfuric acid and many other oxidizing agents.

2.4.1 Rheological Analysis

The result have been obtained from two types of bitumen a straight run (imported) and a semi blown bitumen (local). Cores have been taken after 5 years of service and the layer containing the bitumen under investigation taken by cutting the cores into slices. The slice containing the bitumen were complied and extracted with benzene solution was then distilled according a modified Abson's procedure and its residue tested for their rheological properties. To obtain the rheological properties of the bitumen before ageing a fresh bitumen sample was analyzed as usual. The results are shown in Table 3.1.

Table 3.1 Rheological Properties Of Bitumen Before And After Ageing

Properties	Before Ageing		After Ageing (5 years)	
	Local Pen 60	Imported Pen 80	Local Pen 60	Imported Pen 80
Penetration at 25^0C, (0,01 mm)	63	84	20	34
Softening Point (^{0} C)	52	46	63	53
Penetration Index	-0.16	-1.04	-0.3	1.3
Ductility at 25^0C (cm)	136	>40	20	>140

Table 3.2Chemical Composition Of Bitumen And After Ageing

Properties	Before Ageing		After Ageing (5 years)	
	Local Pen 60	Imported Pen 80	Local Pen 60	Imported Pen 80
Asphaltene %	36.2	31.5	44.2	52.2
A1	15.9	12.4	9.1	11.6
A2	18.9	19.1	28.3	22.1
A3	20.9	17.7	4.6	0.8
Paraffin	8.1	19.3	13.8	13.4

Remarks: A = acidafit; A1 = resins; A2 = unsaturated + alicyclic; A3 = aromatics.

2.4.2 Chemical Analysis

In order to analyze the aged bitumen, the residue obtained from modified Abson's test was treated with normal Pentane solution. The asphaltene was separated by filtration and the pentane solution containing the other was then treated with sulfuric acid of 85% concentration. The sludge formed (A1) was separated and the clear solution containing the remaining components treated with a 98% sulfuric acid. The sludge formed (A2) was again separated and the clear solution was finally treated with oleum. The sludge formed (A3) was separated and the clear solution containing paraffin was then evaporated to obtain the paraffin as agel. To obtain the chemical components of bitumen sample was analyzed according above procedure. The results are as shown in Table 3.2.

2.4.3 Comparing The Results

At this stage of ageing only physically hardening has been obtained. Component A3 which contains low molecular weight aromatics has been evaporated so its value has been decreased.

Chemical hardening has just been started which increases the asphaltene content at the expense of resin content A1. As ageing continuous A2 will also decrease forming asphaltenes but this stage has not yet been reached.

It can be shown that the parameter is an indication for durability. The parameter for local bitumen is 1.2, while to some researchers; the durability of bitumen can be classified according their parameters as shown in Table 3.3.

Table 3.3 Durability classification of Paving Asphalt

Durability Group	(A1 + A2)/(A3 + P)	Durability Rating
I	0.4	Decreasing durability with decreasing parameter value, because of cheesy consistency
II	0.4 – 1.0	Superior
III	1.0 – 1.2	Good
IV	1.2 – 1.5	Satisfactory
V	1.5 – 1.7	Fair
VI	1.7	Inferior

Evaluating the quantitative data presented, it appears that the straight run bitumen above has better durability properties than the semi blown one.

Visually the sliced cores containing the imported bitumen darker in the color than the cores containing the local bitumen, which means that the imported bitumen has a lower stiffness modulus.

3. CONCLUSION

From some test and analysis as mentioned above, some conclusions can be drawn as follows:

1. Changing in the chemical components of bitumen will also change in rheological properties.
2. Ageing is a physical and chemical process will change the bitumen and its components both physically as well as chemically according to their differences in the reactivity with time and temperature.
3. Chemical analysis of bitumen into these reactive component can be used evaluate both its durability and the rate of ageing.
4. The reactive components in native bitumen can be used to determine the mix formula with other materials.
5. As the chemical composition of bitumen depends on the source and manufacturing procedures, all durability values of the bitumen can be used for mix asphalt.

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