CS10-5: The Stiffness Relation in the Rutting Prediction Module of the Shell Pavement Design Method

by J. Lijzenga

Shell International Oil Products BV, Amsterdam
Badhuisweg 3, 1031 CM Amsterdam/PO Box 38000, 1030 BN Amsterdam
Tel + 31 20 630 3935, fax 3085; e-mail: Jan.J.Lijzenga@opc.shell.com

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ABSTRACT

In the Shell Pavement Design Method (SPDM), the effect of the bituminous binder on permanent deformation is modelled via a relation between the stiffness of the asphaltic mix and its bituminous binder under long loading time conditions. Stiffness relationships obtained from accelerated testing in the Laboratory Test Track (LTT) are considered to be representative for rutting behaviour in practice, but these tests are laborious. Previously, such relations were determined by static creep experiments, which turned out not to be suitable for modified binders. The aim of the study is to identify other laboratory tests and conditions from which the stiffness relationships correlate or preferably match the LTT relationships.

Alternative tests investigated are the Strategic Highway Research Program (SHRP) repetitive simple shear test at constant height, unconfined dynamic creep test and triaxial tests. These tests were applied to dense-graded asphaltic concrete containing different type of bitumens: standard bitumens, multi-grade bitumens (MULTIPHALTE-type) and polymer modified bitumen of the CARIPHALTE-type.

Stiffness relationships derived from the SHRP shear test (Repetitive Simple Shear Test at Constant Height - RSCH) and the unconfined dynamic creep test practically coincide, indicating that essentially the same stiffness relationship is obtained from both tests. Moreover, the stiffness relations derived from these tests were found to be in line with the relations obtained from accelerated pavement deformation tests in the Laboratory Test Track (LTT). In other words these small scale laboratory tests are considered to be suitable to provide stiffness relationships required by the Shell Pavement Design rutting calculation method.

1. INTRODUCTION

Within the rutting model of the Shell Pavement Design Method (SPDM), the effect of the bituminous binder on permanent deformation is incorporated via a relationship between the stiffness of the asphaltic mix and its bituminous binder under long loading time (viscous) conditions.

SPDM stiffness relationships obtained with the large scale LTT (the circular Laboratory Test Track in the Shell Research and Technology Centre Amsterdam) are considered to be representative for rutting behaviour in practice. However, these tests are laborious and time-consuming and not suitable to provide results on day to day basis. In the past, these stiffness relationships were determined by static creep experiments, which turned out not to be suitable in demonstrating the effect of modified binders. The aim of the present study is to identify other laboratory tests and conditions from which the stiffness relationships correlate or preferably match the relationships from LTT tests.

This paper describes a series of tests carried out on dense asphaltic concrete mixes with different type of bitumens, namely standard bitumens, multi-grade bitumens (MULTIPHALTE-type) and polymer modified bitumen of the CARIPHALTE-type (MULTIPHALTE and CARIPHALTE are Shell Trade Marks). The permanent deformation was measured with aid of the SHRP repetitive simple shear test at constant height, unconfined dynamic creep test and triaxial testing. The stiffness relationships derived from these tests were compared with the LTT relationships. Ideally, such relations should be representative of rutting behaviour in the field.

2. KEY EQUATIONS OF THE SPDM RUTTING MODEL

In general, rutting of an asphalt pavement is caused by the combined result of deformation in the non-asphaltic base layers and permanent deformation within the asphalt layers. Within the Shell Pavement Design Method (SPDM) [1], subgrade deformation considerations are part of the thickness design module of the SPDM-method, in which the recommended asphalt layer is designed in such a way that both rutting by subgrade deformation and cracking by fatigue are avoided. The SPDM rutting method is applied to pavement structures built-up from three asphalt (sub)-layers; each layer consisting of its own mix composition. This paper deals with permanent deformation in the asphalt layers itself. For the sake of simplicity, the principles of the method are described for a one layer system.

The basic equation within the SPDM rutting model is the relationship between the stiffness of the asphaltic mix and the stiffness of its bituminous component. In formula:

$$\log S_{mix,v} = \log b + q \log S_{bit,v} \quad (1)$$

in which $S_{mix,v}$ = the stiffness of the mix under rutting conditions,
$S_{bit,v}$ = the viscous component of the stiffness of its bituminous binder, and
b and q are parameters specific for a certain asphaltic mix.

The philosophy of the method is to have a general relationship based on the fundamental stiffness concept aimed to estimate rut formation in practice from relations which can, in principle, be derived from laboratory deformation tests.

Within an SPDM rutting calculation on a pavement structure, accounting for climate and traffic loading, the parameter $S_{bit,v}$, is obtained from the following equation:

$$S_{bit,v} = \frac{3\,\eta_o}{W_{eq}\;t_w} \quad (2)$$

in which t_w = the wheel loading time as a measure for the traffic speed,
W_{eq} = the number of standard wheel passes, obtained from the traffic spectrum, and
η_o = the bitumen viscosity at the average paving temperature during service life of the road.

In other words, $S_{bit,v}$, is not just a bitumen property, but it should be considered as a rutting model parameter also reflecting the effect of pavement temperature (via the bitumen viscosity), the effect of traffic speed (via the wheel loading time) and of the type of traffic loading via W_{eq}.

Note: Within the SPDM rutting method, the actual traffic loading is translated into a number of standard wheel passes. The current traffic translation method [2] deviates from the original (1978) method, which was restricted to a traffic spectrum typical at that time.

The rut depth in the asphalt layer, Δh, is calculated with

$$\Delta h = k\,.\,h\,.\frac{\sigma_o}{S_{mix,v}} \tag{3}$$

with
- h = thickness of the asphalt layer,
- σ_o = the contact stress of the standard wheel, and
- k = a coefficient.

Within the original SPDM rutting model [1], the coefficient *k* was defined as

$$k = C_m\,.\,Z_o \tag{4}$$

in which
- C_m = a, so called, dynamic factor, and
- Z_o = a configuration factor.

The factor Z_o is a configuration factor introduced to account for the confinement pressure in actual pavements. Such a correction is needed when the laboratory deformation tests used to calculate the stiffness relation (Eq. 1) are carried out in a uni-axial mode. Z_o can be considered as a measure of the stress distribution in the asphalt layer when loaded with the SPDM standard wheel (contact pressure σ_o) and is defined as

$$Z_o = \frac{\sigma_{av,o}}{\sigma_o} \tag{5}$$

The average stress in the asphalt layer resulting from one standard wheel pass, $\sigma_{av,o}$, is calculated with the BISAR program [3] from the resulting deformation of the layer, thus taking the calculated confinement pressure into account.

C_m is the so called dynamic factor, introduced as a correction factor when the $S_{mix,v}$ value is obtained from a static creep test. The static creep test, however, appeared to be not suitable to adequately describe the rutting behaviour of modified bitumens like MULTIPHALTE and CARIPHALTE [4] as observed in large scale rutting tests with the LTT. The present SPDM method [5] assumes that the stiffness relation is obtained from dynamic tests and consequently C_m is set at a value of 1 by default.

3. STIFFNESS RELATIONSHIPS OBTAINED FROM RUTTING EXPERIMENTS IN THE LABORATORY TEST TRACK (LTT)

The LTT is a piece of equipment at the Shell Research and Technology Centre in Amsterdam. The circular track has an outer diameter of 3.25 m and a width of 0.7 m. Pavement sections can be tested on rut formation with wheel loadings of 20 kN and a wheel velocity of 16 km/h. The track is temperature controlled up to 60 °C.

The observed rut development in the test track can be translated into the creep characteristic by means of the following equations

$$S_{mix,v} = \frac{Z_{LTT}\,\sigma_{LTT}}{(\Delta h_{LTT} \,/\, H_{LTT})} \tag{6}$$

and

$$S_{bit,v} = \frac{3\,\eta_{o,fresh}}{N_{LTT}\;t_{LTT}} \tag{7}$$

in which
- σ_{LTT} = the contact pressure of the wheel in the LTT test (0.6 MPa),
- H_{LTT} = the thickness of the asphalt layer in the test (7 cm),
- Δh_{LTT} = the measured rut depth,
- Z_{LTT} = the configuration factor correcting for confinement in the test sections (Z_{LTT} = 0.6),

N_{LTT}	=	the number of wheel passes (up to 30000),
t_{LTT}	=	the loading time for one wheel pass (0.025 s),
$\eta_{o,fresh}$	=	the viscosity of the fresh bitumen (before asphalt mix preparation).

The measured rut depths include dilation at the edges of the wheel track due to lateral displacement of material within the layer. The $S_{bit,v}$ relation is based on the viscosity of the fresh bitumen, while the $S_{mix,v}$ value is obtained from measurements on the asphalt mix. In this way the properties of a component are related to the properties of a finished product. In the general application of the obtained creep characteristics, it is thus assumed that hardening of the different binders during mix preparation is similar.

An example of the results of an LTT rutting experiment on a dense-graded asphaltic concrete, containing 5.8 pha (parts per hundred parts of aggregate by weight) of a MULTIPHALTE binder is presented in Fig. 1.

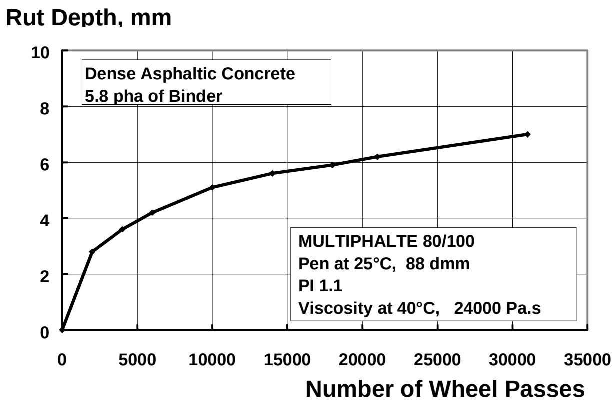

Figure 1. Example of Rut Development in the LTT at 40 °C

The calculated stiffness relationship corresponding to these measurements is presented in Fig. 2, confirming a linear relation on log-log basis.

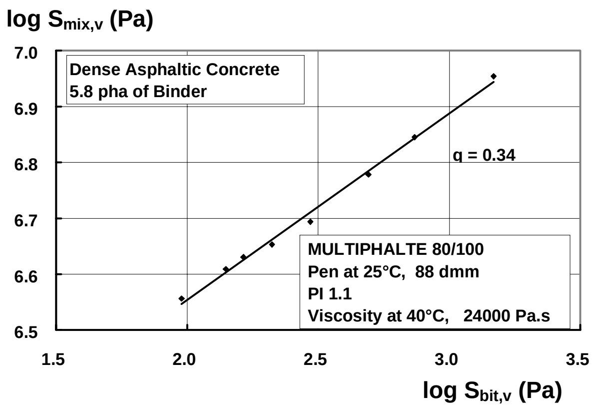

Figure 2. Example of an LTT Stiffness Characteristic

The LTT results [2] for a large number of test sections (at 40 and 50°C) with dense-graded asphaltic concrete mixes based on conventional-, Multiphalte- and Cariphalte-type of binders are illustrated in Fig. 3.

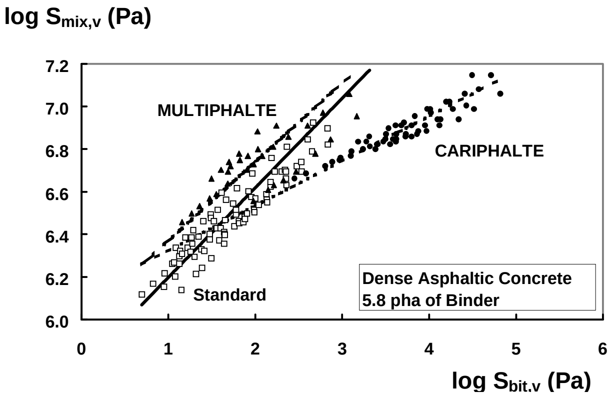

Figure 3. General Stiffness Characteristics from LTT

It is clear that two distinct clusters for the three types of binders are found. The average lines for MULTIPHALTE and conventional (standard) bitumens are positioned close to each other, while the slope and position of the stiffness correlation line for the CARIPHALTE cluster significantly deviates. The latter is striking because within the stiffness concept based on static creep measurements, it was assumed that the stiffness relationship was governed by the type of asphaltic mix, while the effect of the bituminous binder was taken into account by its position on that curve via its viscosity [6]. It should be realized, however, that the development of the stiffness concept was based on static creep measurements on mixes utilizing standard bitumens at that time.

The presented LTT results suggest that the rut depth formation for a certain type of mix is not only determined by the viscosity of the binder. The viscosities of the CARIPHALTE binders at the LTT test temperatures (40 and 50 °C) were measured according to the zero-shear- viscosity concept [7], so the deviating calculated stiffness relationship cannot be ascribed to non-Newtonian behaviour of the polymer modified bitumens (shear rate dependency). So, the difference in behaviour of this type polymer modified binders is not yet understood from a rheological point of view and it suggests effects of binder-aggregate interactions.

Some SPDM calculation results are illustrated in Fig.4 as examples. These examples clearly show the beneficial effect of the modified bitumens on rutting performance.

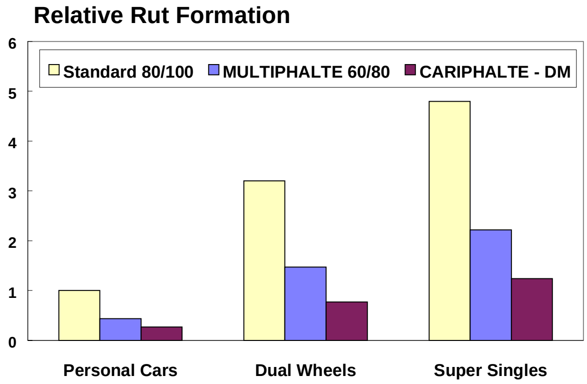

Figure 4. SPDM Calculations basis LTT Stiffness Relations

The LTT is believed to be representative for rutting in practice, so stiffness relationships obtained via the LTT are considered appropriate for SPDM rutting calculations [2] .Unfortunately these tests are laborious and time consuming and not suitable to provide results on a day to day basis. The aim of the experimental work described in this paper is to identify relatively simple laboratory test conditions from which the stiffness relationships correlate with (or preferably match) the relationships from LTT tests. Ideally, such relations should be representative for field rutting behaviour.

4. DEFORMATION IN SHEAR-, UNCONFINED DYNAMIC CREEP- AND TRIAXIAL TESTS

4.1. Set-up Deformation Tests

4.1.1 Repetitive Simple Shear Test at Constant Height

The Shear Tester as developed by Monismith and Sousa [8] within the SHRP programme is suited for testing 15 cm diameter specimens under shear in different modes of operation. An additional test, which was originally not included in the SHRP test protocol, is the Repetitive Simple Shear Test at Constant Height (RSST-CH). This test was selected as the test for comparison with an unconfined dynamic creep test and a triaxial test (Note: the SHRP level 3 mix design protocol is currently again under consideration [10] .

The shear tests were carried out at a temperature of 50 °C on cylindrical specimens (diameter 15 cm, height 5 cm) taken from a 8 cm thick asphalt slab. The shear strain at that temperature is usually sufficient to allow comparison of mixes with different binders.

4.1.2 Dynamic Creep Test

The unconfined dynamic creep test were carried out in the Nottingham Asphalt Tester (NAT) as in-house standard procedure to rank bituminous binders in a critical dense asphaltic formulation.

4.1.3 Triaxial Test

Triaxial testing of asphalt mixes is becoming increasingly popular because it allows direct comparison of the deformation performance of very different mix formulations like porous asphalt, SMA and dense-graded asphaltic concrete. The confinement pressure in this triaxial test set-up was applied around the cylindrical test specimen by means of a pneumatic pressure in a ring. It should be remarked that conditions for triaxial testing are still under discussion (e.g. in CEN committees).

4.1.4 Test Conditions

The various experimental conditions in the applied deformation tests are summarized in Table 1.

TABLE 1 Experimental Conditions in the Deformation Tests

	Shear Tester	Unconfined Dynamic (NAT)	Triaxial Test
Sample Diameter, mm	150	100	100
Sample Height, mm	50	60	60
Temperature, °C	50	50	50
Shear Stress, kPa	70	-	-
Normal Stress, kPa	-	100	750
Confinement Pressure, kPa	-	-	150
Pulse	Block	Block	Block
Effective Loading Time per Pulse, s	0.1	0.2	0.2
Rest Period, s	0.6	1.8	0.8
Total Pulse Time, s	0.7	2.0	1.0

4.2 Bitumen and Mix Characteristics

The standard characteristics of the bituminous binders are listed in Table 2.

TABLE 2 Properties of Bitumens

Bitumen	Pen_{25} (dmm)	$T_{R\&b}$(°C)	PI
Conventional 80/100	87	47	-0.6
MULTIPHALTE 60/80	65	56.5	1.0
CARIPHALTE DM	75	93.5	-

The bitumens were used in a standard dense-graded asphaltic concrete (see Table 3) with 5.8 pha . The asphalt cores (aimed at a void content of ca 4 % v/v) were taken from 8 cm thick specimens prepared with a slab-compactor produced by Matériels des Laboratoires des Ponts et Chaussées.

TABLE 3 Mix Properties (Dense Asphaltic Concrete 0/11)

Bitumen	Bitumen Content, pha	Void Content, %v/v
Conventional 80/100	5.8	4.4
MULTIPHALTE 60/80	5.8	4.4
CARIPHALTE DM	5.8	4.1

4.3 Deformation Test Results

This section deals with the direct results of the three tests in terms of deformation and number of load pulses. The results of the shear tests (average of four measurements) are given in Fig. 5. Fig. 6 shows the unconfined dynamic creep results, while Fig. 7 presents the deformation measured in the triaxial tests.

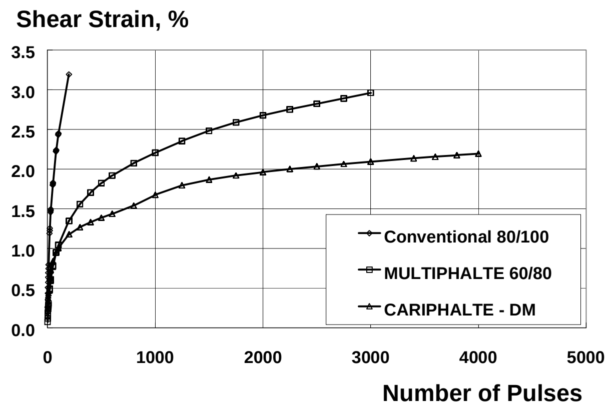

Figure 5. Deformation in Shear Tester

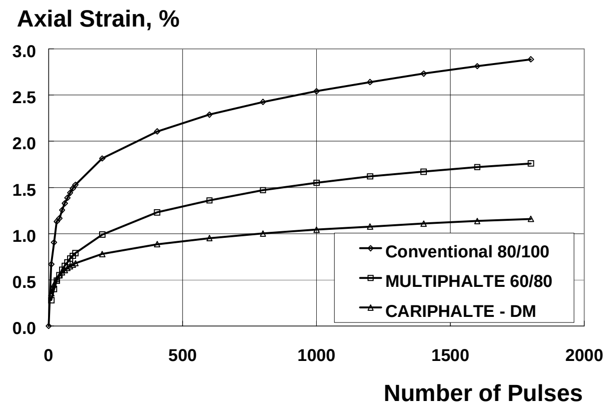

Figure 6. Deformation in Unconfined Dynamic Creep

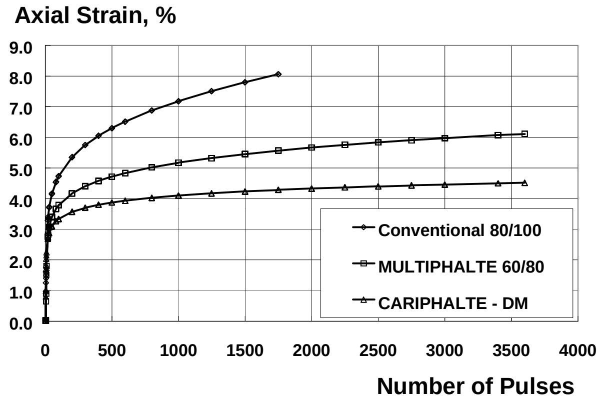

Figure 7. Deformation in Triaxial Test

Each of the deformation tests gives a similar qualitative ranking of the effect of the binder on stability in the same dense-graded asphaltic concrete with a bitumen content of 5.8 pha), showing increased stability in the order of conventional 80/100, MULTIPHALTE 60/80 and CARIPHALTE - DM.

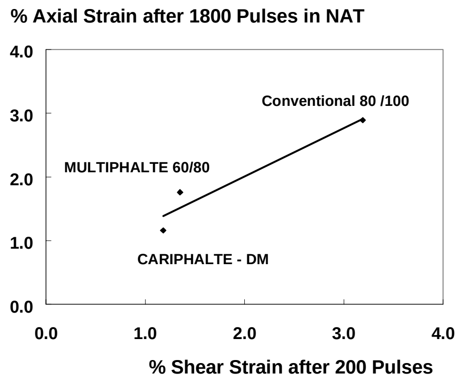

Figure 8. Ranking Results from Shear Tests and Unconfined Dynamic Creep (NAT)

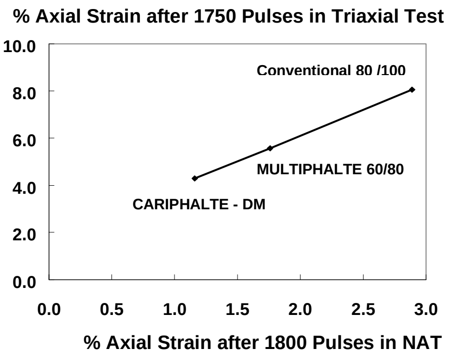

Figure 9. Ranking Results from Unconfined Dynamic Creep (NAT) and Triaxial Tests

Fig. 8 and 9 would superficially indicate that the results of one test can easily be translated into one of the other tests. It should be emphasized, however, that such correlations may be applicable to dense-graded asphaltic concrete (continuous aggregate grading), but in general not to porous asphalt and stone mastic asphalt. The nature of these gap-graded mixes requires creep testing with an application of a certain confinement pressure.

In addition, the relations depicted in Fig. 8 and 9 just correlate test results but give no information on the underlying effects of applied stresses and type of specimen. Such an analysis can be made by normalising the test results to stiffness relations as described in section 5.

5. STIFFNESS RELATIONS IN SHEAR-, UNCONFINED DYNAMIC CREEP- AND TRIAXIAL TESTS

The results of the three deformation tests, in terms of strain versus number of pulses, can be translated into the stiffness relations of the type used in the Shell Pavement Design Method (SPDM).

5.1 Calculation of Stiffness Relations from Deformation Tests

5.1.1 Calculation of $S_{bit,v}$

The viscous component of the bitumen stiffness, $S_{bit,v}$, is calculated with the formula

$$S_{bit,v} = \frac{3\,\eta_o}{N_p\ t_p} \tag{8}$$

in which

t_p = the effective loading time per pulse

N_p = the number of pulses applied, and

η_o = the (zero-shear) bitumen viscosity of the fresh bitumen at the test temperature

In this approach, the $S_{bit,v}$ relation is based on the viscosity of the fresh bitumen, which is related to the $S_{mix,v}$ value obtained from measurements on the asphalt mix. In this way properties of a mix component are related to the final properties of the finished product.

5.1.2 Calculation of $S_{mix,v}$

<u>5.1.2.1 Unconfined Dynamic Creep (NAT)</u>

The stiffness of the mix $S_{mix.v}$ is defined as

$$S_{mix,v} = \frac{\sigma}{\varepsilon_{res}} \tag{9}$$

in which

σ = the applied normal stress (see Table 3), and

ε_{res} = the measured axial strain (assumed to be permanent at high temperature test conditions).

<u>5.1.2.2 Triaxial Test</u>

Within this report, $S_{mix,v}$ from the triaxial tests is calculated with Eq. 9. It should be realized that the calculated value so obtained should be considered as an ‘apparent stiffness value’, which will be higher than the theoretical value (the observed deformation will be lower because a confinement pressure is applied).

<u>5.1.2.3 Shear Tester</u>

The stiffness modulus is estimated from the shear modulus, $G_{mix,v}$ which is calculated as

$$G_{mix,v} = \frac{\tau}{\gamma_{res}} \tag{10}$$

in which

τ = the applied shear stress (see Table 3), and

γ_{res} = the measured shear strain (assumed to be permanent at the high temperature test conditions).

The stiffness modulus $S_{mix.v}$, is estimated from the shear modulus $G_{mix.v}$ according to

$$S_{mix,v} = 2\,(1+\upsilon)\,G_{mix,v} \tag{11}$$

in which ν = the Poisson's Ratio of the asphaltic mix

In this study, Poisson's Ratio is set at a typical value of 0.35 (the default value within the Shell Pavement Design Method).

5.2 Use Of Stiffness Equations

The zero-shear viscosity [7] data, η_0, needed to calculate $S_{bit,v}$ in formula (8) are listed in Table 4.

TABLE 4 Zero-shear Viscosities at 50 °C

Bitumen	η_0 (Pa.s)
Conventional 80/100	1030
MULTIPHALTE 60/80	7260
CARIPHALTE DM	12600

When assessing results from shear tests, unconfined dynamic creep and triaxial tests, it should be realized that $S_{mix.v}$ (see section 5.1.2) is obtained in different ways. $S_{mix.v}$ can be directly calculated in case of the uniaxial unconfined dynamic creep test (NAT). The value calculated for triaxial tests should be considered as 'apparent $S_{mix.v}$' values. In the case of shear tests, $S_{mix.v}$ is calculated via the shear modulus $G_{mix.v}$.

5.3 Comparison Of Tests For Each Binder

When comparing the stiffness relationships for each of the bituminous binders (see Fig. 10 - 12) it can be seen that the relationships obtained for the unconfined dynamic creep and the shear tests are in line and level. This was observed for all three types of bituminous binders: standard bitumen, MULTIPHALTE and CARIPHALTE. In other words, this strongly suggests that information obtained from the two unconfined deformation tests is essentially the same for the applied loading conditions and type of specimens.

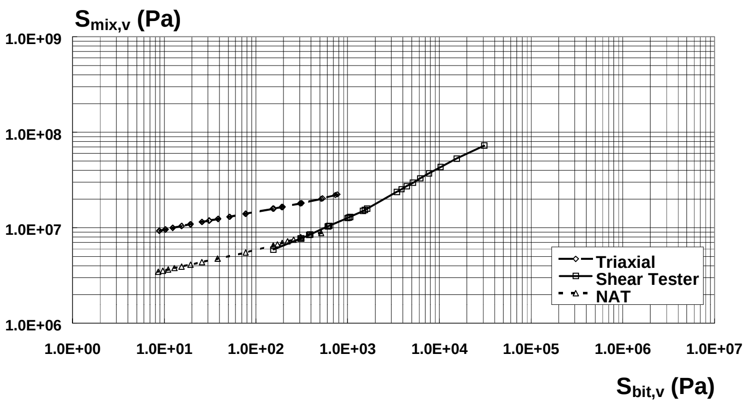

Figure 10. Stiffness Relationhips for Standard 80/100 bitumen

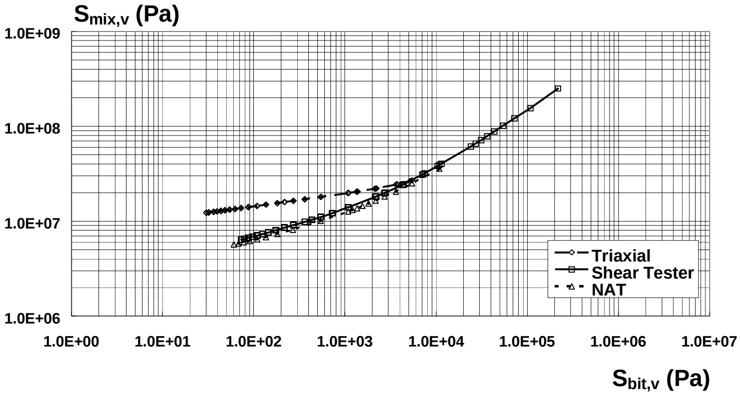

Figure 11. Stiffness Relationships for MULTIPHALTE 60/80

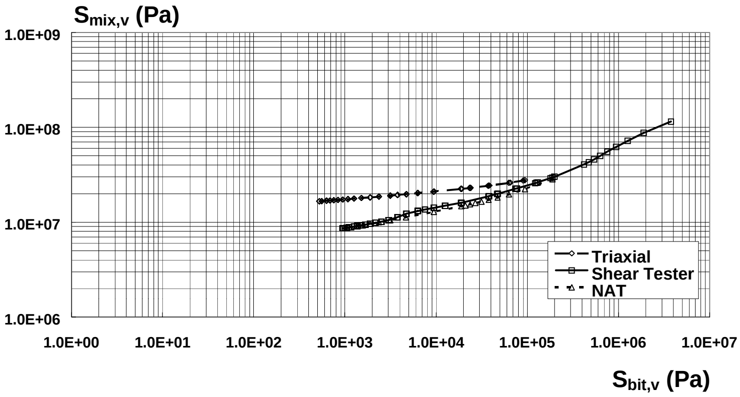

Figure 12. Stiffness Relationships for CARIPHALTE-DM

As expected, the calculated $S_{mix.v}$ values obtained with the triaxial tests are larger than the values found with both unconfined tests . In triaxial testing (see also section 5.1.2.2), the deformation is counteracted by the applied confinement pressure and consequently the calculated (apparent) values for $S_{mix,v}$ are larger. The ratio between the $S_{mix,v}$ in the confined and unconfined tests varies and decreases with increasing $S_{bit,v,}$ as demonstrated in Fig. 13.

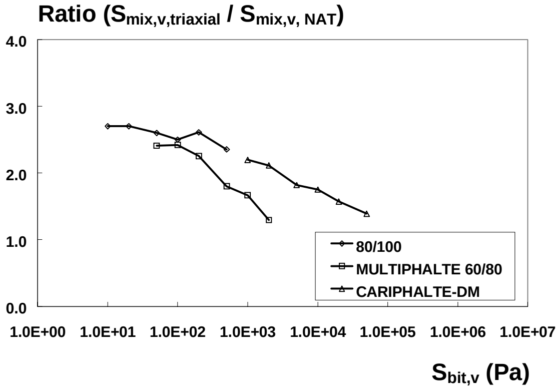

Figure 13. Ratio of $S_{mix,v}$ in Triaxial and NAT

In this approach, $S_{bit,v}$ is seen as the variable reflecting the cumulative effect of the loading time of the normal pressure while a constant confinement pressure is maintained. This would indicate that the effect of hampering the normal deformation increases with longer loading times. It is felt worthwhile to verify this approach (e.g. by carrying out tests at different confinement pressures).

5.4 Comparison Of Binders In Each Test

When comparing the stiffness relations for different bituminous binders in the shear test (Fig. 14) and the unconfined dynamic creep test (Fig. 15) it can be seen that the relations obtained for the conventional bitumen and the MULTIPHALTE coincide, while the relation CARIPHALTE - DM deviates in slope and position.

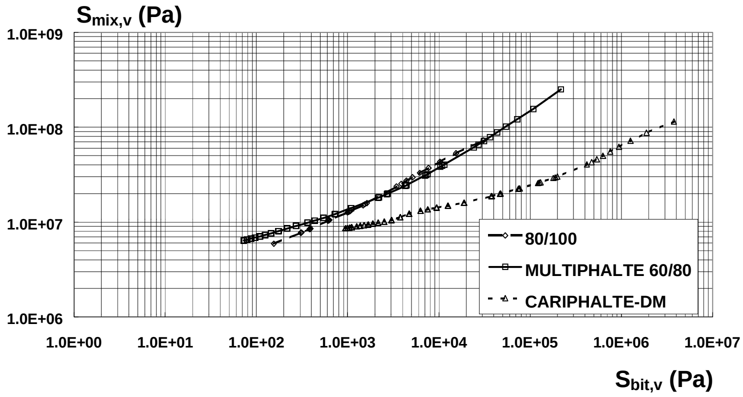

Figure 14. Stiffness Relationships in the Shear Tester

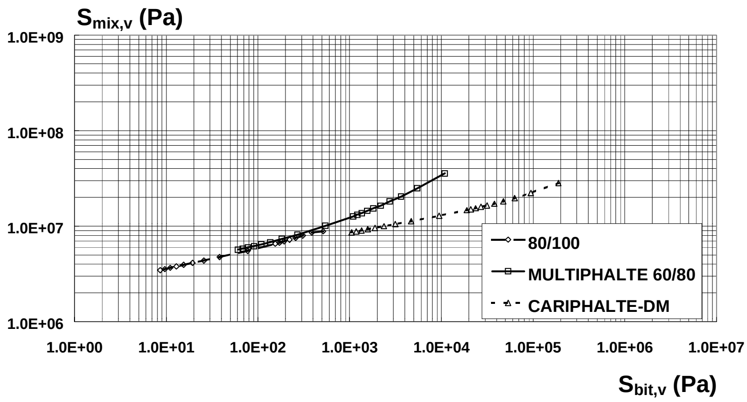

Figure 15. Stiffness Relationships in Dynamic Creep (NAT)

The mutual positions of these stiffness relationships is very similar to the average patterns observed in the Laboratory Test Track (see Fig. 3): same in position and slope for standard bitumen and MULTIPHALTE, while the relation for CARIPHALTE differs. Fig.16 shows a combined plot of the specific test results in shear test and (unconfined) dynamic creep with the general relationships for these types of binders in dense-graded asphaltic concrete.

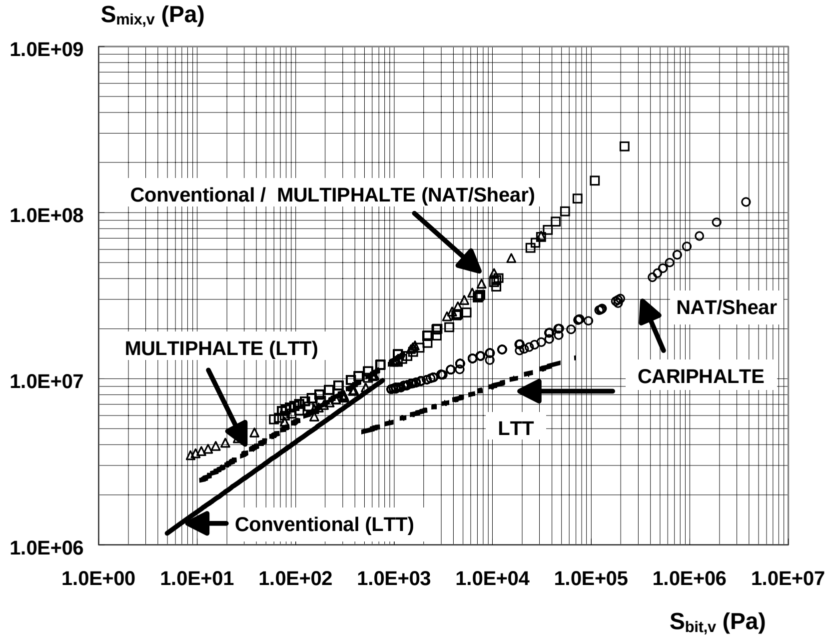

Figure 16. Stiffness Relationships from Shear Tester and NAT compared to typical LTT - Lines

The latter figure clearly demonstrates that the normalized stiffness relations obtained with the Shear Tester and the NAT (unconfined dynamic creep) are in good agreement with the typical relationships obtained from a large number of Laboratory Test Track tests. This finding supports the suitability of these small scale tests to provide stiffness relationships needed to carry out Shell Pavement Design rutting calculations. It should be mentioned that the present work is limited to dense-graded asphaltic concrete and the approach needs to be confirmed for other type of mixes. Nevertheless, the above results are promising to link deformation tests on asphalt cores to accelerated testing on laboratory prepared pavement sections.

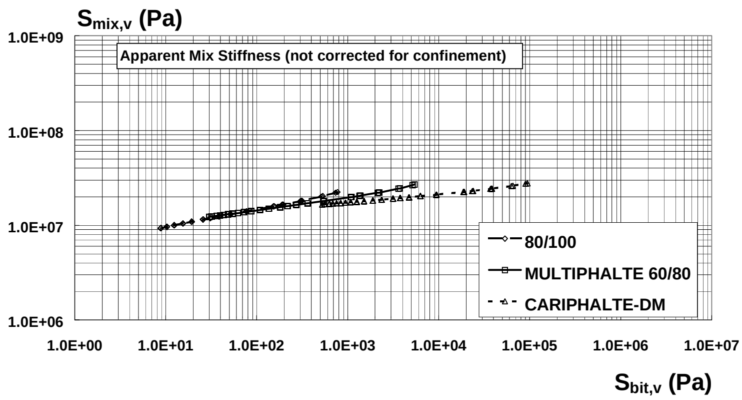

Figure 17. Stiffness Relationships in Triaxial Test

The stiffness relationships obtained with the triaxial tests are depicted in Fig. 17. As mentioned in section 5.1.2.2, the calculated stiffness of the mix should be considered as an apparent value, because the applied confinement pressure hampers the deformation. The apparent values of the mix stiffness ($S_{mix,v}$) obtained from the triaxial test are (as expected) larger than the $S_{mix.v}$ values calculated from the unconfined dynamic creep test. The slope of the curves is much lower than obtained with shear tester, NAT and LTT. The differences are very small, indicating that a confinement pressure of 150 kPa prevents deformation and does not allow a proper discrimination between the different mixes. Nevertheless, the difference in behaviour of CARIPHALTE based mixes (different slope and position) is still observable. More work needs to be done to define appropriate confinement stresses, which are needed to properly measure the deformation patterns of mixes like porous asphalt and stone mastic asphalt. Normalization of deformation patterns from triaxial tests into stiffness relationships may be a useful tool to find triaxial test conditions representative for confinement in accelerated pavement testing.

6. CONCLUSIONS

From the various deformation tests at 50 °C on dense-graded asphaltic concrete (5.8 pha of bitumen, 4 % voids) following conclusions can be drawn:

1. Stiffness relationships derived from the SHRP shear test (Repetitive Simple Shear Test at Constant Height) and the unconfined dynamic creep test practically coincide, indicating that essentially the same stiffness relationship is obtained from these tests (varying in way of loading, in applied stress level and in type of pulse). This applies to different type of bitumens: standard conventional 80/100 bitumen, a multi-grade bitumen (MULTIPHALTE 60/80) and a polymer modified bitumen (CARIPHALTE-DM).

2. The stiffness relationships for standard 80/100 and MULTIPHALTE 60/80 found with the shear test and the unconfined dynamic creep are in line with the SPDM concept that a specific stiffness relationship represents the type of mix while the effect of a binder on rutting is determined by its position via viscosity. The slope and position of the stiffness relationship found with CARIPHALTE-DM, however, deviates. This difference in behaviour of this class of polymer modified binder is not yet understood.

3. The stiffness relationships for standard 80/100, MULTIPHALTE 60/80 and CARIPHALTE - DM derived from the shear test and the unconfined dynamic creep test are in line with the stiffness relationships for accelerated pavement deformation tests in the Laboratory Test Track (LTT). In other words, these small-scale laboratory tests are considered to be suitable to provide stiffness relationships required by the Shell Pavement Design rutting calculation method. In addition, the different behaviour of these polymer modified binders in LTT and presumably in practice can be studied by means of small-scale deformation tests in the laboratory.

4. The apparent values of the mix stiffness ($S_{mix,v}$) obtained from the triaxial test are (as expected) larger than the $S_{mix.v}$ values calculated from the unconfined dynamic creep test. The difference in response for the different bituminous binders are very small, indicating that the applied confinement pressure of 150 kPa prevents deformation and does not allow a proper discrimination between different mixes.

It is stressed that the present work is limited to one type of dense-graded asphaltic concrete (same aggregate and gradation) and the approach need to be confirmed for other type of mixes. Nevertheless, the presented results are considered promising because of the ability to link deformation tests on small asphalt cores to accelerated testing on laboratory prepared pavement specimens.

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