Technical Report 98/012 –PT4

October 1999

Fitness-for-Purpose Criteria for Bituminous Road Products: Proposed Test

FJ Jooste

E VAN ASSEN

S JOOSTE

Programme	:	Transport Infrastructure
Programme Manager	:	BMJA Verhaeghe
Technical Review	:	BMJA Verhaeghe

PREPARED BY: TRANSPORTEK, CSIR

P O Box 395

Pretoria 0001

Tel +27 12 841 2905

Fax +27 12 841 3232

DOCUMENT RETRIEVAL PAGE			**Report No:** CR–98/012-PTA4	
Title: FITNESS-FOR-PURPOSE CRITERIA FOR BITUMINOUS ROAD PRODUCTS: EVALUATION PROCEDURE AND TEST RESULTS				
Authors: FJ Jooste, E van Assen and S Jooste				
Client: Agrèment SA	**Client Reference No**:	**Date**: October 1999	**Distribution:**	
Project No: TRA83	**OE2: 9472**		**ISBN:**	

Abstract: In the first part of this document the proposed approach to the certification of non-conventional bituminous road products is discussed. An outline of the certification procedure is provided and discussed, and classes of bituminous road products are defined. Each class of materials is defined and tests arte proposed for assessing the fitness-for purpose for the product class.

Tests have been performed on standard materials to serve as a database for use as comparison in a relative performance evaluation scheme. The results of these tests are presented in the second part of this document.

Keywords: Fitness-for-purpose, asphalt performance, asphalt testing, surface seals, asphalt durability, asphalt fatigue, permanent deformation, skid resistance, pavement surface permeability

Proposals for implementation:

None

Related documents: (e.g. software, interim or other reports, working drawings etc):

None

Signatures:				
C M Mac Carron	BMJA Verhaeghe	BMJA Verhaeghe	A van der Merwe	Phil Hendricks
Language Editor	**Technical Reviewer**	**Programme Manager**	**Info Centre**	Division Director

DISCLAIMER

TABLE OF CONTENTS

PART 1: EVALUATION PROCEDURE AND PROPOSED TESTS

LIST OF TABLES

LIST OF FIGURES

PART 1

EVALUATION PROCEDURE AND PROPOSED TESTS

1. INTRODUCTION

Agrément has more than 25 years experience in the evaluation of non-standardized building and construction products. Agrément certification provides reassurance of the fitness-for-purpose of non-conventional products through an objective assessment by an independent organization. Certification has definite benefits for owners of a non-conventional products. Some of these benefits include:

- Agrément certificates facilitate acceptance and/or approval by designers and specifiers, authorities and financial institutions;
- Certification supports promotional drives initiated by the product owner and increases confidence in the technical merits of the product. Agrément certificates are high quality technical documents that contain an authoritative assessment of the product or system performance. Approved extracts from these certificates can be provided which highlight the uses and performance that may be expected;
- Certification saves selling time and can thus enhance sales
- Agrément certification assures customers that the product owner has implemented an approved quality management system;
- Valuable spin-offs can result from additional information that may be revealed during the assessment programme and which can benefit product development.

In 1997, Agrément South Africa (AGREMENT SA) requested CSIR Transportek to assist it with the establishment of performance criteria and with the identification or development of suitable test methods in support of the process of product certification for non-conventional bituminous road products.

The project was divided into four main phases: (i) Definition of fitness-for-purpose criteria; (ii) Identification and calibration of criteria; (iii) Recommendations and (iv) Future refinements. The first phase of the project was completed in March 1998. The project documentation for phase 1 outlined the philosophy and methodology to be implemented during phase 2 of the project. In this documentation, four performance aspects to be evaluated during certification were identified[1]. These were:

i) Durability (with respect to the environment and traffic);
ii) Stability (resistance to permanent deformation);
iii) Surface texture and
iv) Impermeability to air and water.

This set of performance aspects, or parts thereof, are deemed to represent the main characteristics required of asphalt mixes, surface seals and asphalt binders. In addition to these performance aspects, practical considerations such as workability and safety also need to be considered. It is the purpose of this document to outline the proposed tests, test methodology and test indicators to be used for the evaluation of the abovementioned performance aspects. Where possible, validation of the proposed tests will be provided through reference to relevant literature and past experience.

To keep the document concise, a detailed discussion of all performance aspects and distress mechanisms is not provided here. Details of the distress mechanisms as well as broad statements regarding observed field performance of conventional products can be found in the phase 1 documentation [1], as well as in some of the literature listed in the list of references of that document.

2. APPROACH TO EVALUATION AND TEST SELECTION

An important element of the development of performance acceptance criteria was the decision to adopt a relative rather than an absolute approach to performance evaluation. The essential difference between relative and absolute performance evaluations is that in a relative performance evaluation scheme the performance of a product is evaluated relative to the measured performance or specified performance of a range of standard products. In an absolute performance evaluation, on the other hand, the performance of a product is evaluated by reference to a prediction model which relates a parameter measured in the laboratory to field performance. Figures 2.1 and 2.2 use the example of skid resistance to illustrate the differences between absolute and relative performance evaluations.

Although there is a strong thrust in the international pavement industry to move toward an absolute prediction of performance, it should be recognized that for such a scheme to be reliable and statistically sound, a large number of controlled full scale tests, as well as long term pavement monitoring would be required. Although desirable as a part of a long term research effort, such tests and long term monitoring are not considered to be feasible within the constraints of this project. Furthermore, it is doubted whether a precise prediction of performance is economically feasible, given the high variability and uncertainty coupled with critical parameters such as support stiffness, temperature, loads, void content and many others. For these reasons a relative performance evaluation scheme was adopted. Although less ambitious, this scheme is considered to be more attainable and sound from a statistical viewpoint.

Having provided some justification for the selection of a relative performance evaluation scheme, some comments should be made regarding the outcome of a certification process based on a relative performance evaluation methodology. The proposed product certification scheme will be able to:

i) Provide potential clients as well as product owners with a measure of the performance of the submitted product relative to the performance of a range of conventional products as well as to the standard specifications of conventional products.
ii) Identify strengths and weaknesses of the submitted product, thereby better defining suitable fields of application (i.e the fitness-for-purpose of the product will be evaluated).
iii) Facilitate judgement regarding the engineering and economical advantages of using the submitted product in lieu of more conventional products.

Thus the product certificate is not intended to serve as a formal acceptance or rejection of a product based on an absolute performance evaluation. The primary reason for this, as explained above, is that the data needed to facilitate such a guarantee or prediction are not currently available. Absolute performance evaluation schemes that are based on a few data points that may be influenced by many unknown variables are not considered to offer a sound rational basis from which performance can be estimated.

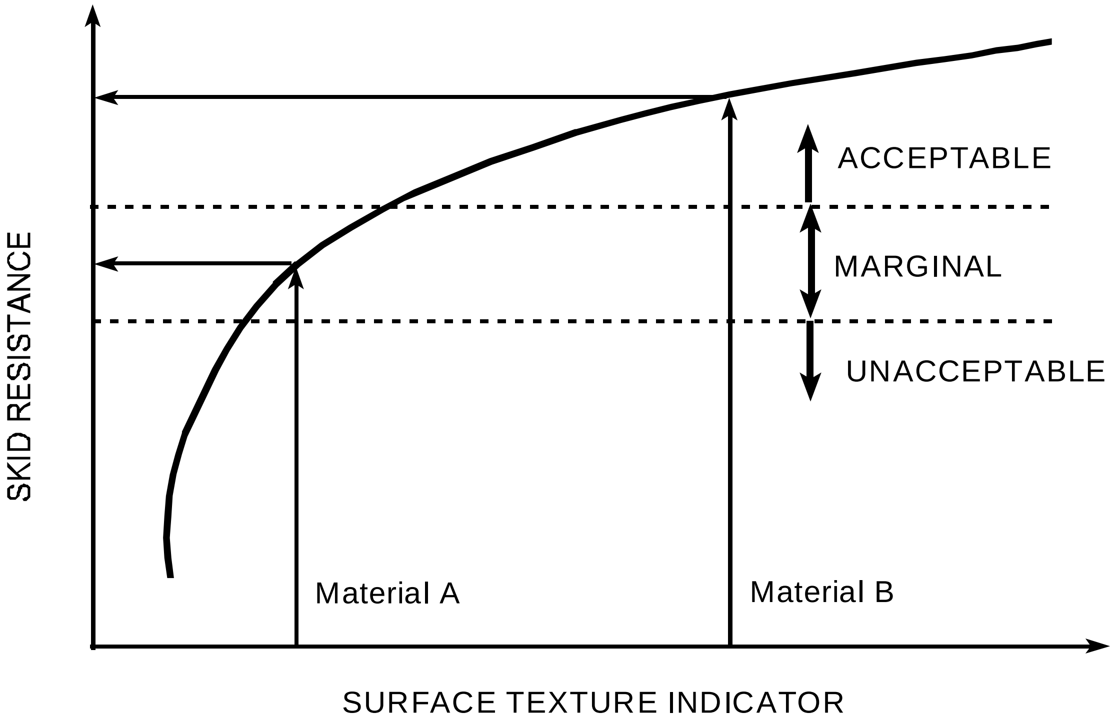


Figure 2.1 Example of an Absolute Performance Evaluation Scheme

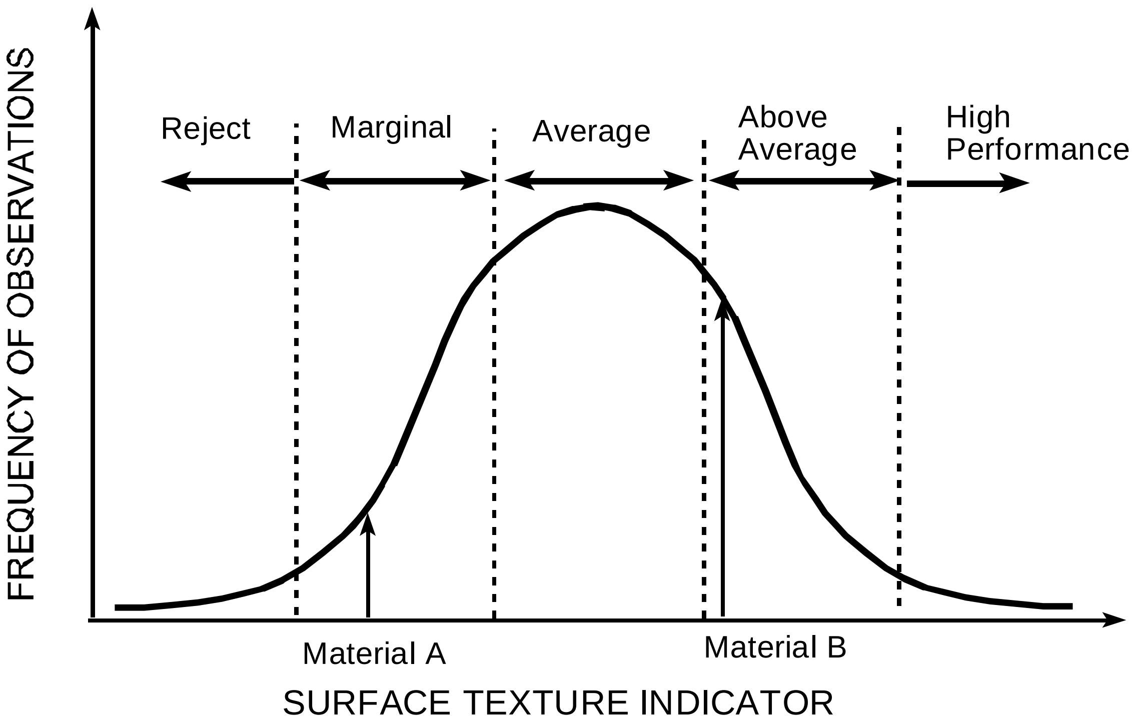


Figure 2.2 Example of a Relative Performance Evaluation Scheme

The steps needed to facilitate implementation of a relative performance evaluation scheme are (i) identification of suitable test methods and performance indicators (ii) testing a range of standard materials according to the stated test protocol, and (iii) refinement and statistical evaluation of distribution of standard material performance, with cognizance also being taken of existing standards or specifications for conventional products. These steps are considered to be attainable within the constraints of a project aimed at product certification.

Once the basis for relative performance has been finalized it becomes possible to move to the next phase, i.e. Agrément certification. In essence this would entail using the evaluation report as a basis for the drafting of a certificate. This certificate would be a published document containing a technical opinion of the suitability of the product for its specified purpose, including any limitations on its use, as established from the technical evaluation. An essential additional ingredient of certification would be an independent assessment of the adequacy of the applicant's quality management system for manufacture and application, where relevant, of the product.

3. OUTLINE OF FITNESS-FOR-PURPOSE EVALUATION PROCEDURE

3.1 General

The purpose of this section is to outline the methods and procedures that could be followed when a non-conventional bituminous road product is submitted for certification. It should be noted that the certification process will always be under development and the description of the procedure given here may therefore change to some extent to stay abreast of new research. The information given here should, however, provide a broad indication of the evaluation approach for different types of material. The evaluation process is likely to differ from one product to the next depending on the specific requirements identified by the evaluation committee.

Table 3.1 provides a detailed outline of the product submission, evaluation and certification procedures. Figure 3.1 illustrates the certification process in a very general manner. The process illustrated in Figure 3.1 is similar to those of other certification schemes that are currently implemented in the United States, Canada and New Zealand. Dotted lines in Figure 3.1 indicate formal or informal communications between Agrément SA and the product owner. The following paragraphs briefly describe the steps shown in Figure 3.1.

Product Submission: The first step of the certification process is the submission of the product to Agrément SA by the product owner. This step also involves documentation that contains a clear statement of the fitness-for-purpose of the product. This documentation should also state the intended use and the type of application of the product. If the client is unsure of the type of application of the product, an initial test phase may have to be performed to identify the most appropriate application. Table 3.1 provides an outline for the product submission procedure that would be followed.

Formation of an Evaluation Panel: A panel is formed to oversee the evaluation process. This panel will be appointed by the Agrément steering committee and would consist of members of the product certification steering committee, members of industry, client body representatives as well as researchers and evaluators from Agrément SA. Members of industry and researchers will be experts in the intended field of use of the submitted product. As indicated in Figure 3.1, the product owner will be notified of the selected panel members.

Planning the Evaluation Programme: This task consists of a detailed classification of the product class, as well as the defined fitness-of-purpose of the submitted product. Based on this classification an evaluation test plan would be developed. The following items should be considered and agreed upon during the planning of the evaluation programme:

- fitness-for-purpose;
- product or products to use as a reference during testing;
- product cost issues related to cost effectiveness and fitness-for-purpose;
- selected tests, validity of each test and the relative importance of the different tests;
- previous international or other evaluations and means of considering such evaluations in the certification process, and

- possible need for field evaluation or full scale test sections.

The test plan would include details of selected tests and test methodologies. The product owner would be notified of progress and might also be invited to attend a final meeting to ensure that all parties are in agreement as to the class of product, required performance aspects and appropriate sample preparation and testing procedures.

Laboratory Testing: This task forms the core of the certification process and consists of sample preparation, sample conditioning and/or ageing and performance testing. Where appropriate, a representative of the product owner might be invited to attend parts of the sample preparation and conditioning processes to ensure that all parties are in agreement that the product is prepared or applied as intended.

Reporting: In this task, the results of the performance testing are analyzed and discussed with the product owner. The product owner would be supplied with a detailed technical report which would include details of all relevant information from preceding tasks as well as test results. The product owner would also receive a two or three page technical summary which would list the product details (name, class, intended use), test results, a brief discussion of results and a overall evaluation of potential product performance based on laboratory test results.

Adjudication of Quality Management System (QMS): This task would be carried out by an independent body in terms of ISO 9000 series of norms. This could be done by the SABS or by another body with accreditation to carry out adjudication of such systems. A report on the adequacy of the QMS would be submitted to the applicant for discussion and possible amendment. Once finalized, the report, confirming the adequacy of the system, would be submitted to AGREMENT SA, as an input to the preparation of the certificate.

Preparation of the Certificate: AGREMENT SA's technical agency would draft a certificate bases on the evaluation certificate. The certificate would state what the product is regarded as being suitable for, how it should be used and what the expected behavior-in-use of the product would be, based on the known behaviors of traditional products against which it has been compared in the evaluation process (if possible this should include an indication of relative cost when compared with the base product against which the comparative evaluation has been made). The certificate would contain a technical specification with sufficient information to identify the product and its method of application, but would not reveal confidential information such as chemical composition etc. The certificate would confirm the adequacy of the certificate holder's quality management system and any conditions that needed to be complied with.

Approval and Issuing of the Certificate: The draft certificate would be referred back to the evaluation committee and the product owner for verification for technical accuracy and technical specification respectively. If satisfied the committee would then submit a formal recommendation to the Board of Agrément SA regarding the granting of the certificate. If accepted, the Board, acting in terms of its mandate as an agent of government, would approve the granting of the certificate and its publication. Notice to this effect would also be published in the Government Gazette.

Table 3.1 Agrément South Africa Product Submission, Evaluation and Certification Procedure

	CLIENT	AGREMENT SOUTH AFRICA	TECHNICAL ASSESSMENT COMMITTEE
APPLICATION	Client submits application together with information and documentation, as well as application fee, after discussion with Agrément South Africa. The application should define the use of the product being submitted for assessment and a relevant reference product should be selected. ÷		
		Agrément South Africa, after consultation with relevant experts, accepts or rejects the applicatio ≠	
PREPARATION OF ASSESSMENT PROGRAMME	Client is informed of the decision. ÷	Agrément South Africa determines assessment criteria and prepares an assessment programme after consultation with appropriate experts A formal contract offer for the assessment is presented to the client. ≠	
ASSESSMENT AND CERTIFICATION	Client considers the offer, if necessary discussing it with Agrément South Africa and accepts or rejects it.		
	If the offer is accepted: X client pays the contract price to Agrément South Africa X in the course of the assessment, client draws up a quality assurance plan, in accordance with Agrément South Africa's quality assurance guidelines. The SABS is available to assist in this activity or the client can use another consultant. The quality assurance manual is submitted to Agrément South Africa. ÷	Agrément South Africa carries out the assessment programme. (a) If the results are favourable: X a draft certificate is prepared in consultation with all parties (including the client) X the draft certificate is presented to the technical assessment committee ÷	Agrément South Africa, after consultation with relevant experts, assembles a technical assessment committee.
			The technical assessment committee reviews the draft certificate and:- X recommends approval to the Executive Committee of Agrément South Africa ≠ or X refers the draft certificate back to Agrément South Africa for revision.
		X if the Executive Committee approves the draft certificate a certified copy of the approved certificate is issued to the certificate holder X notice of the granting of the certificate is published in the Government Gazette and in the annual report of Agrément South Africa for that year X Agrément South Africa prints and issues the certificate. ≠ (b) If any result is not acceptable: X the client is informed and given the opportunity to make adjustments X the problematic item is reassessed, at the client's expense. If the results are favourable, then the procedure in (a) is followed.	
	Client receives the printed certificate.		
POST-CERTIFICATION ACTIONS		Agrément South Africa or its agents carry out six-monthly quality assurance inspections of the client's factory or site(s) as well as inspections of previous road construction projects X if the certificate holder has identified non-conformances its records of corrective action should be checked. If non-conformances are identified during the six-monthly quality assurance inspections, the certificate holder must demonstrate that it is able to implement and record effective corrective action X Agrément South Africa receives reports on the inspections. If the inspections are satisfactory, the validity of the certificate is confirmed. ≠	
	If there have been changes to the subject or to Agrément South Africa's criteria, then the certificate holder applies for reassessment.		

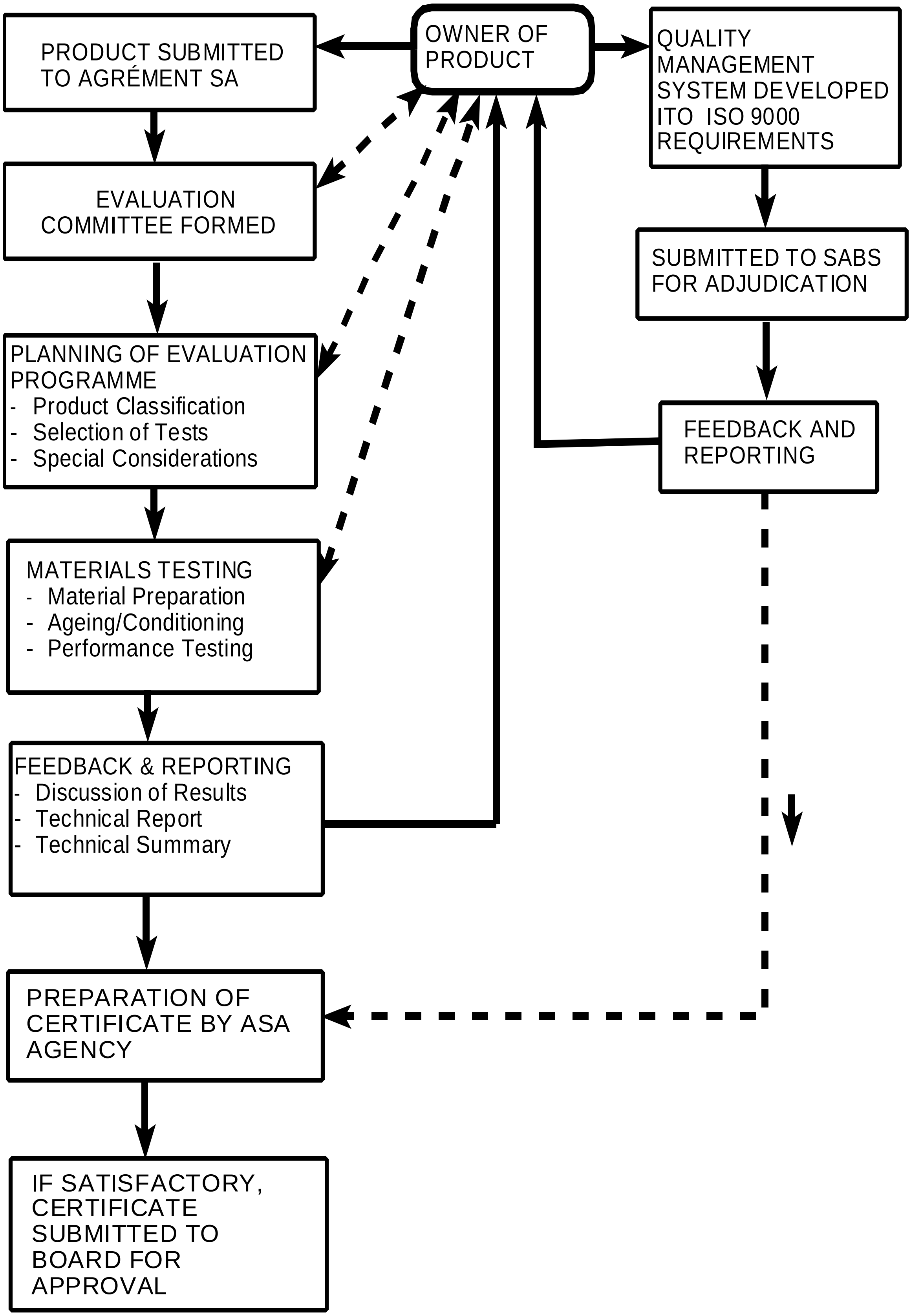


Figure 3.1 Schematic Representation of Certification Process

Post Certification Monitoring: This would be carried out on a regular basis by a qualified, independent inspection agency to be appointed by the evaluation panel. Non-compliance or problems would be reported back to the board for appropriate action.

3.2 Product Classification

During phase 1 of the project, several classes of bituminous road products were identified. A survey of some of the prominent manufacturers of bituminous road products was also performed to verify and expand this product classification so that most of the products that could conceivably be submitted for certification would be covered by the product classification scheme. Based on this scheme, the majority of products that are expected for certification can be grouped in one of the following classes:

i) Binders;
ii) Asphalt surfacings;
iii) Asphalt bases;
iv) Surface seals;
v) Cold-mix materials;
vi) Crack and Joint Sealants;
vii) Emulsions and Fog Sprays.

Based on the industry survey, it is expected that more than 90 per cent of submitted products would resort under classes (i) to (iv) noted above. The method of evaluation, together with the test methods that may potentially be used during the evaluation process, are summarized in the following sections for product classes (i) to (iv). At this stage, detailed planning for the tests to be used for cold-mix materials and for emulsions and fog-sprays has not been completed. Instead, focus has been placed on those materials which are most likely to be submitted for certification within the near future. A tentative outline for the evaluation of cold-mix materials such as patching materials is, however, discussed in section 9.

3.3 Evaluation of Pilot Product

To evaluate and test the materials testing procedure, a pilot product was tested according to the proposed testing program. The product is classified as a binder and for the purpose of this document will be referred to as the pilot binder. The results obtained from the tests performed on this binder were compared to results of similar products previously tested. The tabulated results are presented in Table 3.2 while graphical comparisons are shown in Appendix A.

Table 3.2: Results of Pilot Binder Compared to other Binders Previously Tested

Test	**Result of pilot binder**	**Average result of other binders**	**Range of results of other binders**
Viscosity at 60°C after RTFOT (Pa.s)	To high to be measured	336	181 - 833
Change in Softening point (°C)	4	4.08	0.2 – 11.1
Rutting Parameter at 58 °C (G*/Sin∗)	9.4	6.25	3.4 – 10
Rutting Parameter at 64 °C (G*/Sin∗)	4.6	3.04	1.4 – 4.8
Rutting Parameter at 70 °C (G*/Sin∗)	2.5	1.54	1.2 – 2.1

Table 3.2: Results of Pilot Binder Compared to other Binders Previously Tested

Test	Result of pilot binder	Average result of other binders	Range of results of other binders
Fatigue Parameter at 13 °C	-	7.14	5.5 – 10.9
Fatigue Parameter at 16 °C	6.0	5.51	3.9 – 8.3
Fatigue Parameter at 19 °C	4.4	3.62	2.6 – 6.2
Fatigue at 200 micro Strain (Reps to Failure)	2 030 000	1 705 600	140 000 - 6 930 000
Fatigue at 325 micro Strain (Reps to Failure)	163 000	263 000	21 000 - 1 210 000
Fatigue at 400 micro Strain (Reps to Failure)	40 600	70 632	7 500 - 460 000
Dynamic Creep Modulus (Mpa)	5.31	29.34	5 – 65.6
ITS (kPa)	502.8	1212.21	584 – 1806
% Strain at Maximum Stress	5.91	1.89	0.9 – 3.5
Modified Lottman Tensile Strength Ratio	0.92	-	-
Modified Lotman % Strain at Maximum Stress	7.6	-	-
Rutting (Actual Deformation in mm at 3000 repetitions)	4	7	2.5 - 19
Rutting (Actual Deformation in mm at 6000 repetitions)	4.5	9.5	4 - 22

Depending on the implementation and intended use of this product, the results will be analyzed and discussed by the members of the evaluation committee. Relative performance criteria will be provided based on the product classification. The different performance aspects of the product will be discussed and the committee will advise the issuing of a certificate based on the outcome of the test results, or recommendations for improving certain performance aspects of the product.

The tests performed on the pilot binder serves merely as an evaluation of the testing procedure and the performance of this product would not be discussed in this document.

4. BITUMINOUS BINDER EVALUATION

4.1 Definition of Product Class

Bituminous binders, in the present context, are defined as all bituminous materials which are used for the binding of aggregates (in the case of surface seals), and aggregates and fines (in the case of asphalt mixes). Products which are classified as binders are those that are submitted in a raw format as a binder, without any other components such as aggregates. It should, however, be noted that a standard aggregate type may be used by the certification body as part of the binder evaluation. Of those performance aspects noted in section 1, only durability and stability are viewed as important for binder evaluation.

4.2 Test Methodology

In this section, a general description is given of the testing procedure for bituminous binders. It should be noted that the tests mentioned, as well as the general procedure, may be modified for special applications or products, as deemed suitable by the product evaluation panel. The tests noted in the following sections are described in more detail in the appendices. Figure 4.1 illustrates the testing methodology for bituminous binders.

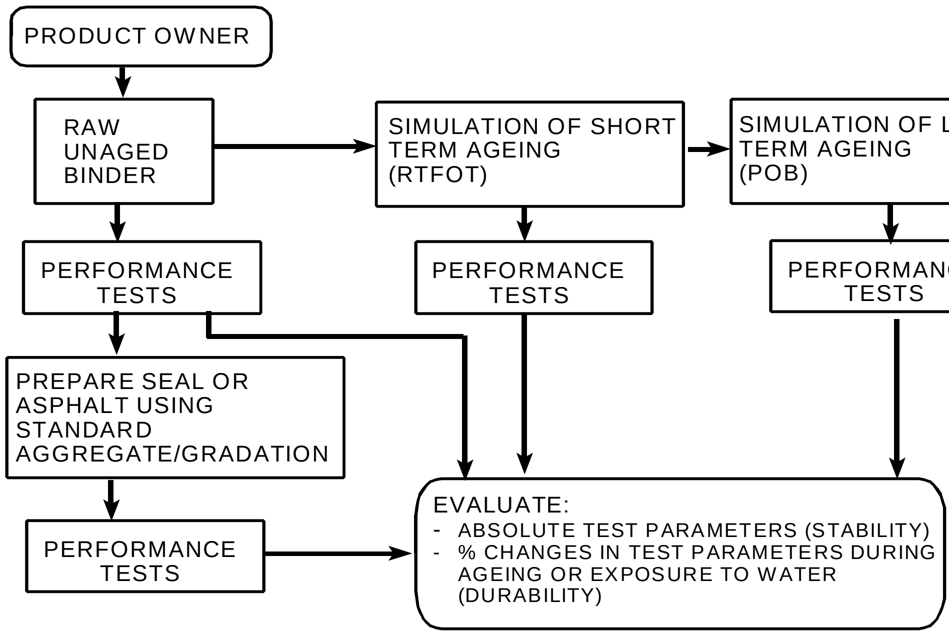


Figure 4.1 General Evaluation Methodology for Binders

4.3 Performance Tests

The tests that can potentially be used for binder evaluation are shown in Table 4.1. It should be noted that these tests are considered as candidates that are likely to be used during the certification process. The actual range of tests used during certification would be determined by the evaluation panel for the specific product in question.

Table 4.1 Tests for Bituminous Binders

Performance Aspect	Test Type	Test Parameter	Comments
Durability: Ageing	Viscosity at 60°C	% Change in Viscosity	Viscosity is measured before and after RTFOT and POB ageing.
	Softening Point	% Change in Softening Point	Softening point is measured before and after RTFOT ageing.
	Dynamic Shear Rheometer	G*θSinδ	Measured on POB aged specimens.
Loss of flexibility due to ageing	Four Point Bending Beam	N_{250}^{b} N_{250}^{a}	Applies to asphalt mix applications only. Number of repetitions to failure at a strain level of 250 microstrain, measured before and after simulated long term ageing.
		Slope change	Slope of the fatigue curve is measured before and after ageing.
Loss of binder adhesion due to ageing	Vialit Plate Test	% change in stone loss during ageing	Applies to surface seal applications only. Vialit plate test is performed before and after simulated long term ageing.
Moisture susceptibility	Modified Lottman Test	% Change in resilient modulus	Resilient modulus is measured before and after exposure to water. Test parameter is the % change in resilient modulus.
Retained Penetration	Penetration Test	Penetration Grade of Bitumen	Measured only on un-modified binders.
Stability	Viscosity at 60°C	Viscosity in Pa.s	Measured on RTFOT specimen.
	Softening Point	Softening point in °C	Measured on RTFOT specimen.
	Dynamic Shear Rheometer	G*/Sinδ	Measured on RTFOT specimen.
	Unconfined Dynamic Creep	Slope of creep curve	Repetitive loading test. The test parameter is the dynamic creep modulus.

Table 4.1 Tests for Bituminous Binders (continued)

Performance Aspect	Test Type	Test Parameter	Comments
Stability (continued)	Reduced Scale Wheel Track	Rut depth, Rut rate	For asphalt mix applications only
Heat Stability	Segregation or storage stability	The sample will be prepared and stored at the manufacturer's recommendation for storage of the product. Samples will be drawn from the top and bottom of the storage vessel and compared for softening point differences. Specific to Bitumen rubber, the flow test could be employed.	
	Tray Test	Viscosity (Pa.s)	The rate of change in viscosity at storage and application temperatures of the product

5. ASPHALT SURFACINGS

5.1 Definition of Product Class

Asphalt surfacings, in the present context, are defined as all asphalt mixes which are intended to serve as a wearing course for pavement structures.

5.2 Test Methodology

Figure 5.1 illustrates the general methodology for the testing of asphalt surfacings. It should be noted that deviations from this procedure may be warranted for specific products, as deemed necessary by the product evaluation panel.

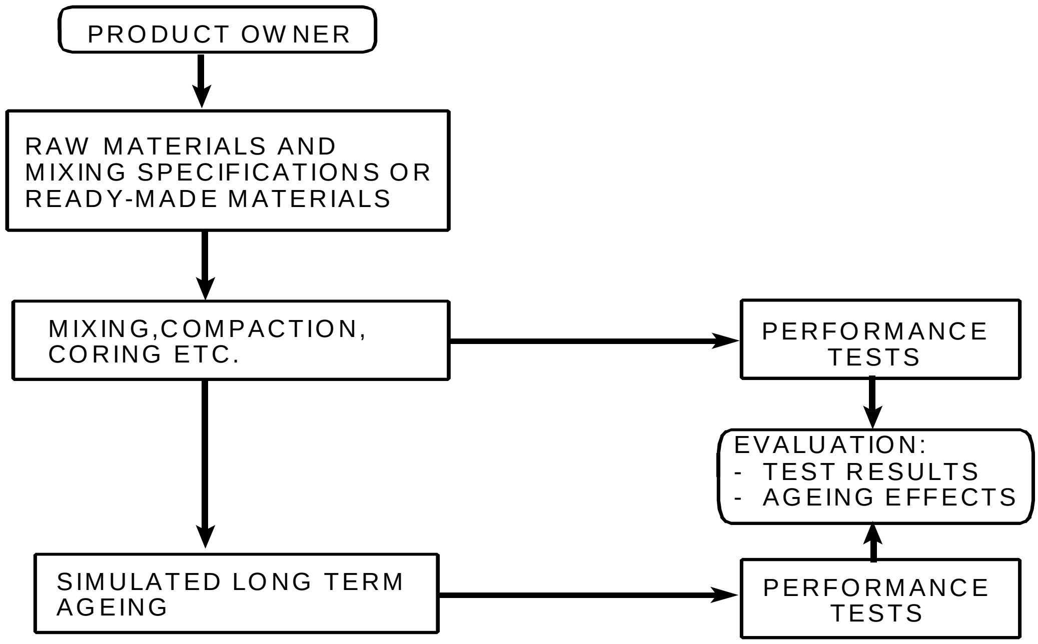


Figure 5.1 Evaluation Procedure for Asphalt Surfacings, Asphalt Bases and Surface Seals

5.3 Performance Tests

The tests that can potentially be used for asphalt surfacing evaluation are shown in Table 5.1. It should be noted that these tests are considered as candidates that are likely to be used during the certification process. The actual range of tests used during certification would be determined by the evaluation panel for the specific product in question. If the evaluation panel should decide that a laboratory skid resistance test should be necessary to evaluate the product, it is recommended that this test be repeated on a full scale test section of the completed product as part of the field evaluation of the proposed product.

Table 5.1 Tests for Asphalt Surfacings

Performance Aspect	Test Type	Test Parameter	Comments
Durability Loss of flexibility due to ageing	Four Point Bending Beam Test	N_{250} N_{350} N_{400}	Number of repetitions to failure at strain levels of 250, 350 and 400 microstrain, measured before and after simulated long term ageing.
		Slope change	Slope of the fatigue curve is measured before and after ageing.
Moisture susceptibility	Modified Lottman Test	% Change in resilient modulus	Resilient modulus is measured before and after exposure to water. Test parameter is the % change in resilient modulus.
Permeability	Air Permeability	Permeability coefficient	None
Stability	Reduced Scale Wheel Tracking Test	Rut depth and Rut Rate	Test is performed at a predetermined temperature under a moving wheel load. Rut depth and rut rate are measured at specified numbers of load applications.
Surface Texture	Laser Profilometer and Sand Patch Test	Macro-texture in mm	Texture depth is measured with a laser profilometer. Texture depth is measured by the volumetric sand patch method
	British Portable Pendulum Test and SCRIM Coefficient	Friction Coefficient (micro-texture)	Test is performed before and after reduced scale wheel tracking test. Once the section of road utilizing this product is completed, a skid resistance test must be repeated with the SCRIM. This will form part of the field evaluation procedure.

Table 5.1 Tests for Asphalt Surfacings (continued)

Performance Aspect	Test Type	Test Parameter	Comments
Structural Stiffness	Four Point Bending Beam Test	Flexural Stiffness in MPa	Stiffness is determined for a range of temperatures and loading frequencies. Test is performed at a standardized strain level.
	Indirect Tensile Strength	Resilient Stiffness in MPa	Stiffness is determined for a range of temperatures and loading frequencies.
Workability	Gyratory Compactor Test	Number of Gyrations to specified density	Test parameter is the number of gyrations to a specified density (e.g. 90 per cent of maximum theoretical relative density).

6. ASPHALT BASES

6.1 Definition of Product Class

Asphalt bases, in the present context, are defined as all asphalt mixes which are intended to serve as a base course for pavement structures. Of the performance aspects noted in section 1, only durability, permeability and stability apply to asphalt bases.

6.2 Test Methodology

Figure 5.1 illustrates the general methodology for the testing of asphalt surfacings and bases. It should be noted that deviations from this procedure may be warranted for specific products, as deemed necessary by the product evaluation panel.

6.3 Performance Tests

The tests that can potentially be used for asphalt base evaluation are shown in Table 6.1. It should be noted that these tests are considered as candidates that are likely to be used during the certification process. The actual range of tests used during certification would be determined by the evaluation panel for the specific product in question. Details of the tests shown in Table 6.1 can be found in the appendices.

Table 6.1 Tests for Asphalt Bases

Performance Aspect	Test Type	Test Parameter	Comments
Durability Loss of flexibility due to ageing	Four Point Bending Beam Test	N_{250}^{b} N_{250}^{a}	Tests parameters are the numbers of repetitions to failure at a strain level of 250 microstrain, measured before and after simulated long term ageing. The stress level needed to attain 250 microstrain is first determined.
		Slope change	Slope of the fatigue curve is measured before and after ageing.
Moisture susceptibility	Modified Lottman Test	% Change in resilient modulus	Resilient modulus is measured before and after exposure to water. Test parameter is the % change in resilient modulus.
Permeability	Air Permeability	Permeability coefficient	None
Stability	Reduced Scale Wheel Track	Rut depth and Rut Rate	Test is performed at a predetermined temperature under a moving wheel load. Rut depth and rut rate are measured at specified numbers of load applications.

Table 6.1 Tests for Asphalt Bases (continued)

Performance Aspect	Test Type	Test Parameter	Comments
Stability (continued)	Repetitive Simple Shear	Number of Repetitions to 2% Shear Strain	Repetitive loading test in simple shear. Test is performed at a predetermined temperature.
	Confined Dynamic Creep	Slope of creep curve	Repetitive loading test. Test is performed at a predetermined temperature.
Structural Stiffness	Four Point Bending Beam	Flexural Stiffness in MPa	Stiffness is determined for a range of temperatures and loading frequencies. Test is performed at a standardized strain level.
	Indirect Tensile Strength	Resilient Stiffness in MPa	Stiffness is determined for a range of temperatures and loading frequencies.
Workability	Gyratory Compactor Test	Number of Gyrations to specified density	Test parameter is the number of gyrations to a specified density (e.g. 90 per cent of maximum theoretical relative density)

7. SURFACE SEALS

7.1 Definition of Product Class

Surface seals, in the present context, are defined as thin binder-aggregate seal combinations, including multiple seals, seals involving modified binders and slurry seals. Of the performance aspects noted in section 1, only durability and surface texture applies to surface seals.

7.2 Test Methodology

Figure 5.1 illustrates the general methodology for the testing of surface seals. It should be noted that deviations from this procedure may be warranted for specific products, as deemed necessary by the product evaluation panel.

7.3 Performance Tests

The tests that can potentially be used for surface seal evaluation are shown in Table 7.1. It should be noted that these tests are considered as candidates that are likely to be used during the certification process. The actual range of tests used during certification would be determined by the evaluation panel for the specific product in question. Details of the tests shown in Table 7.1 can be found in the appendices.

Table 7.1 Tests for Surface Seals

Performance Aspect	Test Type	Test Parameter	Comments
Durability Loss of flexibility due to ageing	Crack Movement Simulator	M_{50}^{b} M_{50}^{a}	Magnitude of displacement amplitude to cause failure at 50000 load applications, measured before and after simulated long term ageing.
Loss of binder adhesion due to ageing	Vialit Plate Test	% change in stone loss during ageing	Vialit plate test is performed at low temperatures (-5°C to 5°C) before and after simulated long term ageing as explained in previous documentation[1].
	Reduced scale wheel tracking test	Aggregate loss and stripping	Test performed with a wetted surface, before and after simulated long term ageing.

Performance Aspect	Test Type	Test Parameter	Comments
Surface Texture	Reduced Scale Wheel Track	Bleeding Evaluation	Test is performed at a predetermined temperature under a moving wheel load. Bleeding is evaluated visually.
	British Portable Pendulum	Friction Coefficient	Test is performed before and after reduced scale wheel tracking test.
	Laser Profilometer and SCRIM	Macro-texture in mm and Friction in SFC	Texture depth is measured with a laser profilometer. Subsequent field test is performed by the SCRIM to obtain a value for friction of the surface
	Sandpatch	Mean Texture Depth (mm)	Texture is determined by the volumetric method.

8. CRACK AND JOINT SEALANTS

8.1 Definition of Product Class

Crack and joint sealants are defined as those materials which are used for the sealing of individual cracks or joints in flexible or rigid pavements. Of the performance aspects noted in section 1, only durability applies to crack and joint sealants. In addition to this, crack and joint sealants should also have enough consistency at high temperatures to prevent picking-up of the sealant by vehicle tires.

8.2 Test Methodology

Since crack and joint sealants generally consist only of a binder component, the methodology for testing of crack and joint sealants is likely to be the same as that for testing of binders, and is shown in Figure 4.1. It should be noted that deviations from this procedure may be warranted for specific products, as deemed necessary by the product evaluation panel.

8.3 Performance Tests

The tests that can potentially be used for crack and joint sealants are shown in Table 8.1. It should be noted that these tests are considered as candidates that are likely to be used during the certification process. The actual range of tests used during certification would be determined by the evaluation panel for the specific product in question. Details of the tests shown in Table 8.1 can be found in the appendices.

Table 8.1 Tests for Crack and Joint Sealants

Performance Aspect	Test Type	Test Parameter	Comments
Durability Flexibility, and loss of flexibility due to ageing	Crack Movement Simulator	M_{50}^{b} M_{50}^{a}	Magnitude of displacement amplitude to cause failure at 50,000 load applications, measured before and after simulated long term ageing.
	Reduced scale wheel tracking test	Time to crack reflection	Test is still under development. The gap between two asphalt slabs is sealed with the product and the time to crack reflection is monitored.
Consistency at high temperatures	Softening point	Softening Point in °C	Test is performed on un-aged sealant.
	Reduced scale wheel tracking test	Visual evaluation of pick-up and sealant behavior	Test is still under development. Test is performed at a predetermined temperature, under a loaded, slow moving wheel.
	Elasticity Test	Elastic Recovery	Test under development

Performance Aspect	Test Type	Test Parameter	Comments
Toughness	Cohesive Strength	Cohesion	Test under development

9. COLD-MIX MATERIALS

9.1 Definition of Product Class

Cold-mix materials, in the present context, include all cold and warm binder-aggregate mixes such as pre-mixed patching material and emulsion treated materials. Of the performance aspects noted in section 1, only durability, stability and permeability applies to cold-mix materials. In addition to these performance aspects, storage and workability are also regarded as important for cold-mix materials.

9.2 Test Methodology

Since cold-mix materials generally consist of the same components as asphalt surfacings and bases, the methodology for testing of cold-mix materials is likely to be the same as for asphalt surfacings and bases, and is shown in Figure 5.1. It should be noted that deviations from this procedure may be warranted for specific products, as deemed necessary by the product evaluation panel.

9.3 Performance Tests

The tests that can potentially be used for cold-mix materials Table 9.1. It should be noted that these tests are considered as candidates that are likely to be used during the certification process. The actual range of tests used during certification would be determined by the evaluation panel for the specific product in question. Details of the tests shown in Table 9.1 can be found in the appendices.

Table 9.1 Tests for Cold-mix materials

Performance Aspect	Test Type	Test Parameter	Comments
Durability Ravelling & Moisture Sensitivity	Reduced scale wheel tracking test	Material loss (gram) and visual evaluation	Test is still under development. A cold-mix 'patch' is compacted in a mould which has been prepared with a tack coat. The patch is subjected to repeated loading while being wetted at predetermined intervals. Test is performed at a predetermined temperature.
	Modified Lottman Test	% Change in resilient modulus	Resilient modulus is measured before and after exposure to water. Test parameter is the % change in resilient modulus
Stability	Reduced scale wheel tracking test	Rut depth and rut rate	Test is performed at a predetermined temperature, under a loaded, slowly moving wheel
Storage	The sample will be prepared and stored at the manufacturers		

Performance Aspect	Test Type	Test Parameter	Comments
	recommendation for storage of the product. Samples will be drawn from the top and bottom of the storage vessel and compared for softening point differences.		
Workability	Gyratory Compactor Test	No. of Gyrations to spec. density	Test parameter is the number of gyrations to a specified density
Permeability	Permeability Test	Water Permeability	Test parameter and test under development.

10. PROCESS CONTROL AND IN-SERVICE EVALUATION

10.1 General

The basket of laboratory tests that has been proposed for submitted products is an indication of both the short and long term performance of the product. However, the outcome of these tests is merely an indication of its relative performance compared to other standard products. Laboratory test cannot possibly capture all aspects of the performance of such a product in the field.

In some instances a process needs to be evaluated rather than a product, or the quality of the process whereby a certain product is implemented needs to be evaluated. In such a case specifications based on the ISO 9000 specification should be used to evaluate the process.

If a newly submitted product should perform satisfactory compared to a standard product being tested by the same method in the laboratory, a temporary certificate would be issued to state that the product successfully completed the laboratory part of the evaluation process. The product evaluation committee will thereafter decide upon a procedure for the subsequent in service evaluation of the product or process. Depending on the type and intended use of the product, one or more field evaluations will be performed at predetermined intervals and according to certain standards. Custom designed tests will also be performed to evaluate the performance of the product in the field. The committee will have the freedom to decide on a time limit in which the product should perform acceptably well before the final certificate will be issued. The observation period for certain products could be up to 10 years. The field evaluation will be based upon the standard visual assessment procedure as explained in TMH 9 [2] and other tests specified in this section. Should the applicant require accelerated field testing the use of the Heavy Vehicle Simulator could be considered.

10.2 Process and Quality Control

A requirement for certification by Agrément South Africa is that each certificate holder has an effective quality assurance system in place. This system must be based on the recommendations of the ISO 9000 series. This system is required to ensure that good quality materials and satisfactory standards of design and manufacture are maintained within defined parameters. The quality assurance system must be planned and drawn up in harmony with a company's existing administrative and technical programs. The quality assurance requirements for the certification of construction systems and products by Agrément South Africa are based on one of the following:

a) ISO 9001: Model for quality assurance in design, development, production, installation and servicing, or
b) ISO 9002: Model for quality assurance in production, installation and servicing or
c) ISO 9003: Model for quality assurance in final inspection and test.

Personnel who perform quality functions must have sufficient experience and well-defined authority, responsibility, and the freedom to identify, evaluate and rectify quality problems. If deemed necessary the committee will appoint a person with adequate authority and experience from a consultant to aid in the quality evaluation process.
To achieve consistent quality within defined parameters in any process, there will be

important operations and materials which should be identified as essential to the achievement of consistent quality. When these operations and materials have been identified, they should be listed to form part of a check list which is part of the quality scheme. For example, in the case of a bituminous binder the fingerprint of the product can be taken by means of photo chromatography and subsequent samples of the product can be compared to the sample used for initial evaluation. The quality scheme should contain instructions on the procedures to be taken in the case of any non-conformity.

The quality assurance policy and procedures instituted by the certificate holder must include and elaborate on the following headings for both the manufacturing and application process:

- Management responsibility
- Contract review
- Design control
- Document and data control
- Product identification, control and traceability (the client should assist in the identification of auditable flags)
- Process control
- Inspection and testing
- Control of inspection, measuring and test equipment
- Inspection and test status
- Control of non-conforming products
- Corrective and preventative action
- Handling, storage, packaging, preservation and delivery
- Control of quality records.

Notes on these points to be considered when drawing up a quality assurance policy are listed in the Agrément SA guidelines for a quality assurance system[3].

10.3 Criteria for In Service Evaluation of a Product

The criteria for evaluating the field performance of the product would be according to the performance aspects stipulated for the laboratory performance of each type of product in the preceding sections. E.g.: for an asphalt surfacing the durability, permeability, stability, surface texture, structural stiffness and workability would be assessed. The visual evaluation or field test recommended for use to assess the different performance aspects of the products are shown in Table 10.1:

Table 10.1 Field Tests Used to Assess Different Performance Aspects of the Product

Performance Aspect	Proposed Field Test or Visual Evaluation
Durability	Cracking, raveling and debonding/shoving
Stability	Rutting
Permeability	Field Permeability Test (Airflow) on cores
Surface Texture	Any macro texture determination and skid resistance test
Structural Stiffness	Cracking
Workability	Field Compaction

A definition and description of these visual assessments and field tests are provided in Table 10.2 [4]. The acceptance criteria stated in this table serve merely as general examples and can be altered by the evaluation committee according to the application and use of the specific product.

Table 10.2 Definition and Description of Field Tests

Functional Property	Definition	Equipment	Frequency of Measurement	Position of Measurement	Testing Interval	Acceptance Criteria
Road Roughness (Riding quality)	Deviations of a pavement surface from a true planar surface	Linear Displacement Integrator (LDI), or High Speed Profilometer (HSP)	After construction and annually thereafter	Slow Lane	Measurements cumulated and stored m/km roughness for every 100 m	Maximum length (%) of segment with roughness worse than the following limiting values: IRI of 2.5 : 10 % IRI of 3.4 : 5% IRI of 4.5 : 0%
Skid Resistance	Ration of the force to the normal loads on the wheel of a SCRIM or similar machine under wet road surface conditions	Sideway-Force Coefficient Routine Investigation Machine (SCRIM) of similar accepted machine	1 month, 3 months & 1 year after construction thereafter every 2 years	Slow and fast lanes outer wheel path	Record data over 10 m intervals	90% of all measurement shall be ∃0.40 SFC All measurements shall be ∃ 0.35 SFC
Rut Depth	Maximum vertical distance (mm) in the wheel paths measured between the road surface and the bottom of a 3 m straight edge	None specified, but so as to achieve an accuracy on the average rut depth within 3 mm of the true mean (over a 100 m section)	1 month & 1 year after construction thereafter every 2 years	Outside wheel paths in the slow lane	10 meters	Maximum length (%) of segment with rut depth worse than the following limiting value: 5mm rut: 10% 10 mm rut: 0%
Texture Depth	The area of the road surface covered by spreading a known volume of sand on the surface	Measurements will be done with a sand spreading box as defined in specs.	1 month & 1 year after construction thereafter every 2 years	Slow and fast lane wheel paths	Every 100m	Maximum length (%) of segment with texture depth less than 0.8 mm: 10%
Ravelling	-	Visual	1 month & 1 year after construction thereafter every 2 years	Overall	-	Less than 1% of total area (TMH9 Criteria)
Cracks	-	Visual	1 month & 1 year after construction thereafter every 2 years	Overall	-	Less than 5% of total area (TMH9 Criteria)
Debonding/ Shoving	-	Visual	1 month & 1 year after construction thereafter every 2 years	Overall	-	Nil

PART 2

TEST RESULTS

11. TEST RESULTS

11.1 General

A part of this study was to establish a database with test results for as many of the proposed tests as possible. The test results as well as an interpretation of the results are presented in this section.

The results presented in this section of this report will constantly be updated as the data base expands and as knowledge about the test procedures and parameters increases. Many of these tests are current and at the leading edge of technology and ongoing research might change test procedures and interpretation of results. To keep up with current developments, it is essential that the test procedures and results presented here, be upgraded and re-interpreted on a regular basis.

Some of the graphs in the next section contain information on the specified limits or requirement. These limits or requirements were added to these graphs to assist in the interpretation of the data and are as specified by the South African Bureau of Standards (SABS) [5], or the Strategic Highway and Research Program (SHARP)[6].

11.2 Viscosity at 60 °C

Outline

The test is performed on virgin binder as well as RTFOT aged binder and the reported test parameter is the viscosity in Pa.s as well as the percentage change in viscosity upon short-and long-term ageing.

Potential Applications

Durability of binders; Stability of binders.

Test Results:

60/70 penetration grade bitumen:

Table 11.1 Viscosity at 60°C after RTFOT: Statistical Summary

Parameter	Value
Minimum Value	181 pa.s
15th Percentile	221 pa.s
30th Percentile	268 pa.s
Average	336 pa.s
70th Percentile	356 pa.s
85th Percentile	408 pa.s
Maximum Value	833 pa.s
Range	652 pa.s
No of Observations	41

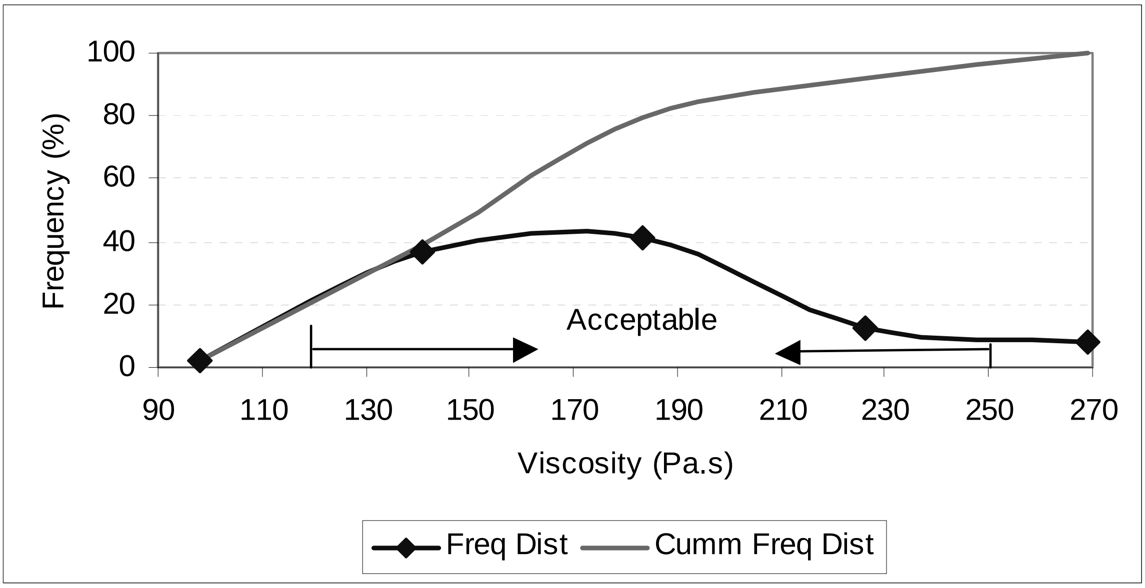


Figure 11.1 Frequency Distribution of Viscosity Results on Virgin 60/70 Pen Binder

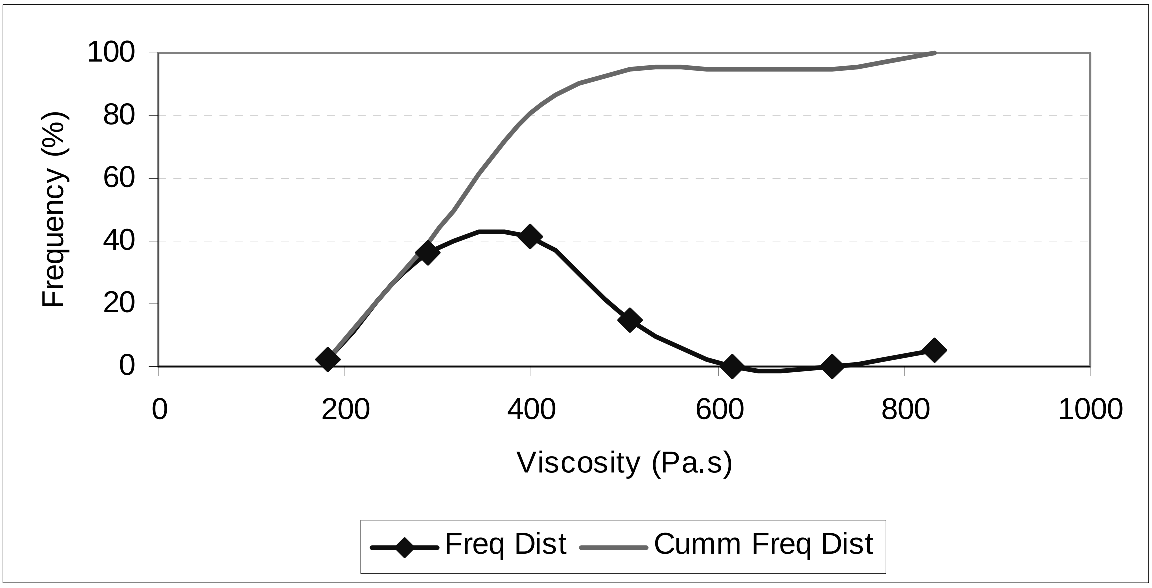


Figure 11.2 Frequency Distribution of Viscosity Results on 60/70 Pen Binder after RTFOT Ageing

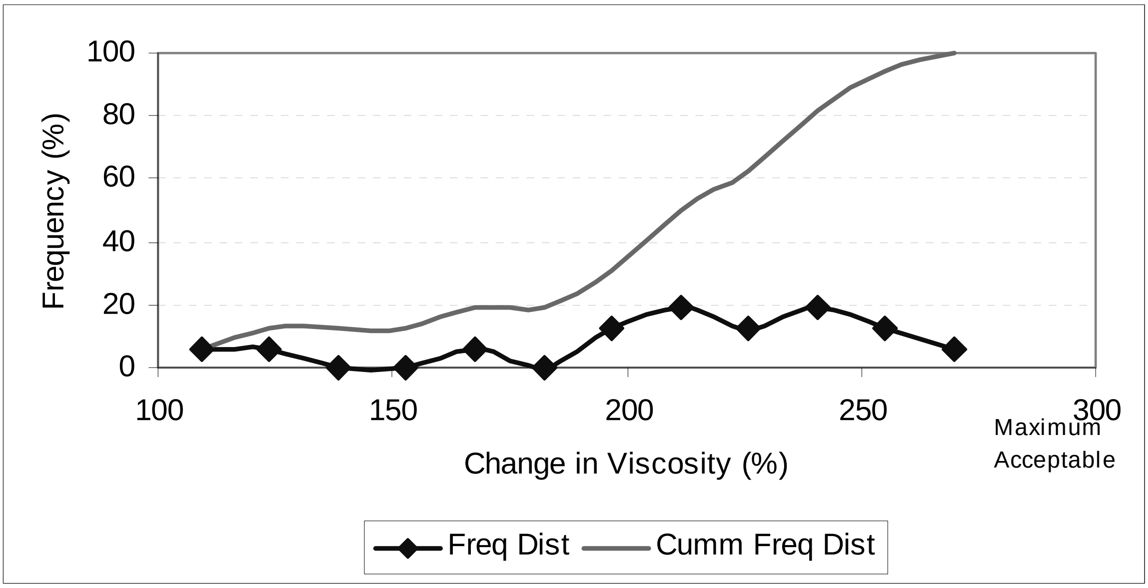


Figure 11.3 Change in Viscosity of a 60/70 Pen Bitumen

80/100 penetration grade bitumen:

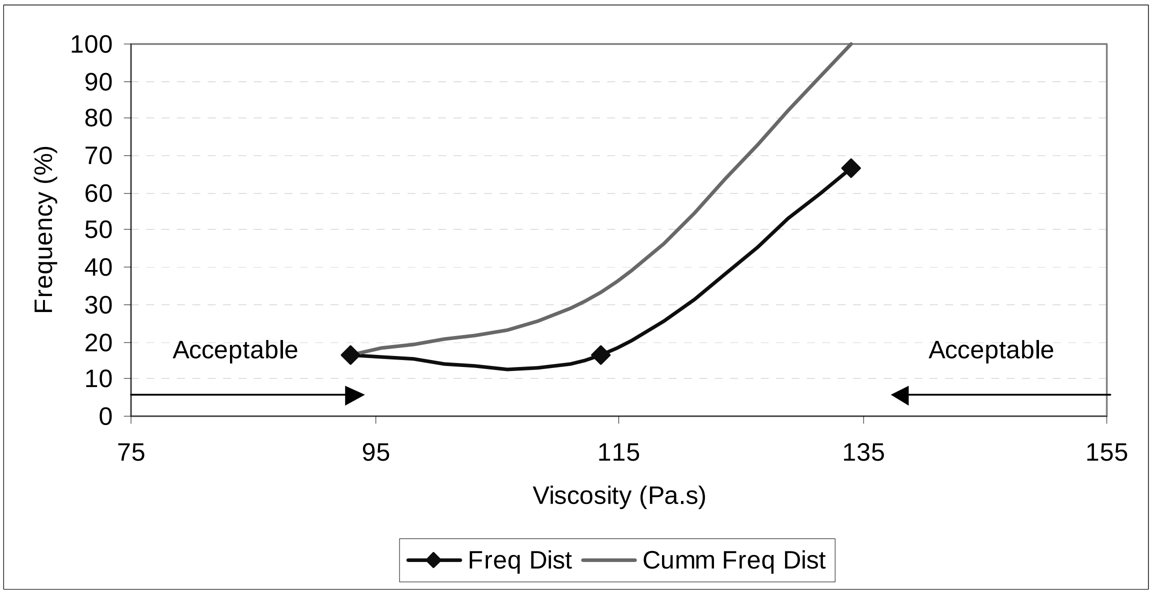


Figure 11.4 Frequency Distribution of Viscosity Results on Virgin 80/100 Pen Binder

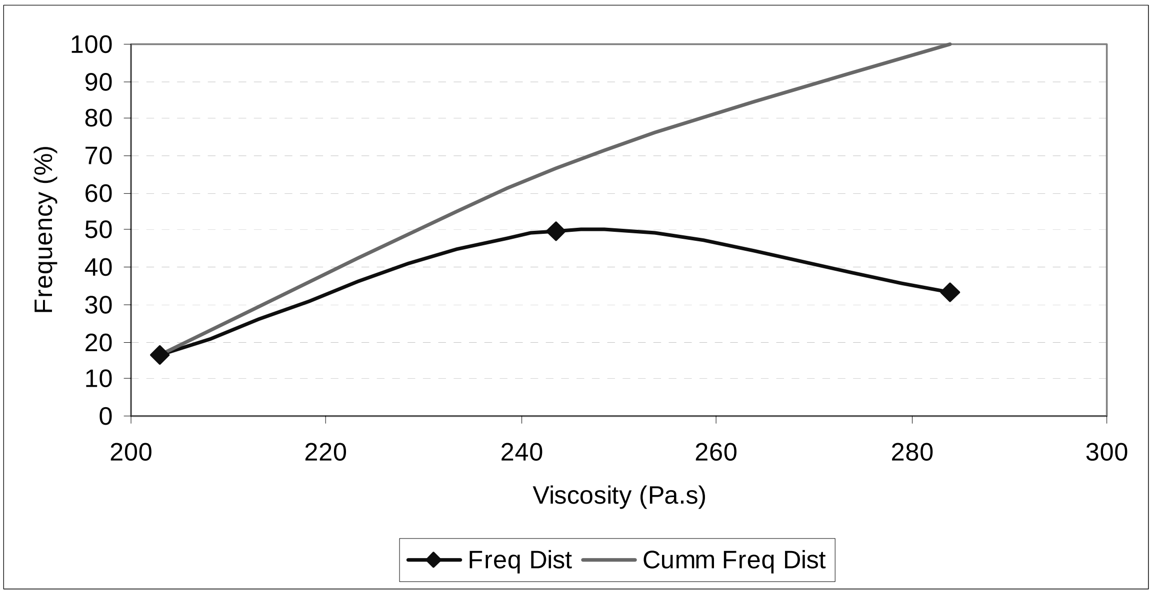


Figure 11.5 Frequency Distribution of Viscosity Results on 80/100 Pen Binder after RTFOT Ageing

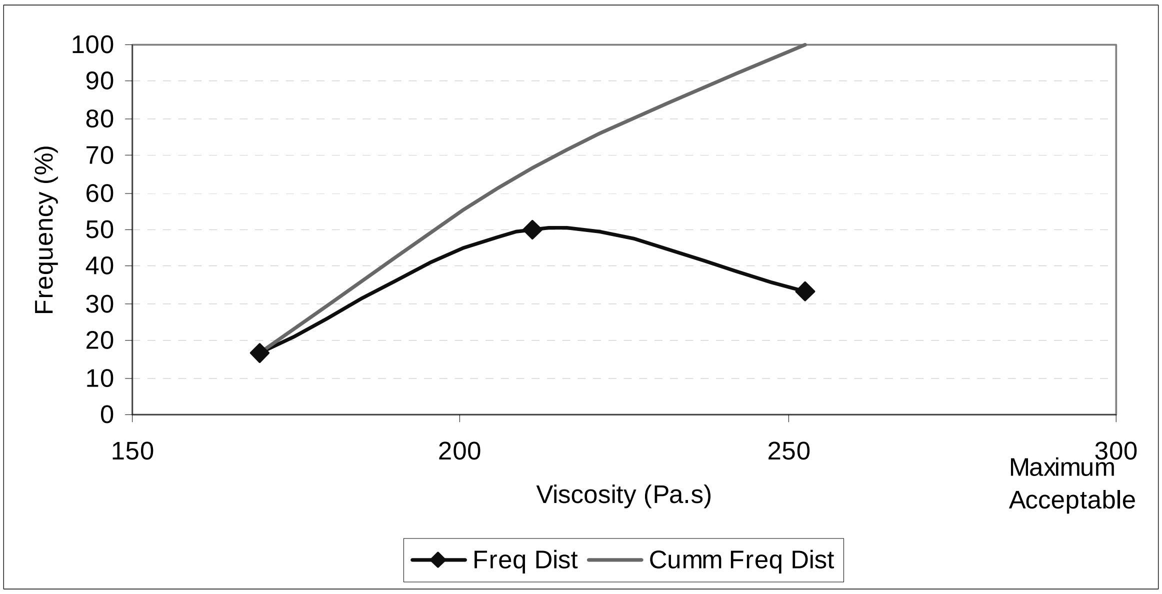


Figure 11.6 Change in Viscosity of a 60/70 Pen Bitumen

Discussion

The binders tested here all conformed to the standard specification which is indicated on some of the graphs. However, it is important to consider the distribution of results obtained from these binders. A new product should not only be evaluated according to the specification, but a relative performance indication should be obtained by means of expressing the result obtained from the new product as a percentile value of available results published here.

11.3 Ring and Ball Softening Point

Outline

Performed according to ASTM D36 [1]. The test parameter is the percentage increase in softening point temperature after RTFOT ageing.

Potential Applications

Durability of binders; Stability of binders.

Test Results:

Table 11.2 Change in Softening Point: Statistical Analysis

Parameter	Value
Minimum Value	0°C
15th Percentile	3°C
30th Percentile	3°C
Average	4°C
70th Percentile	4°C
85th Percentile	5°C
Maximum Value	11°C
Range	11°C
No of Observations	43

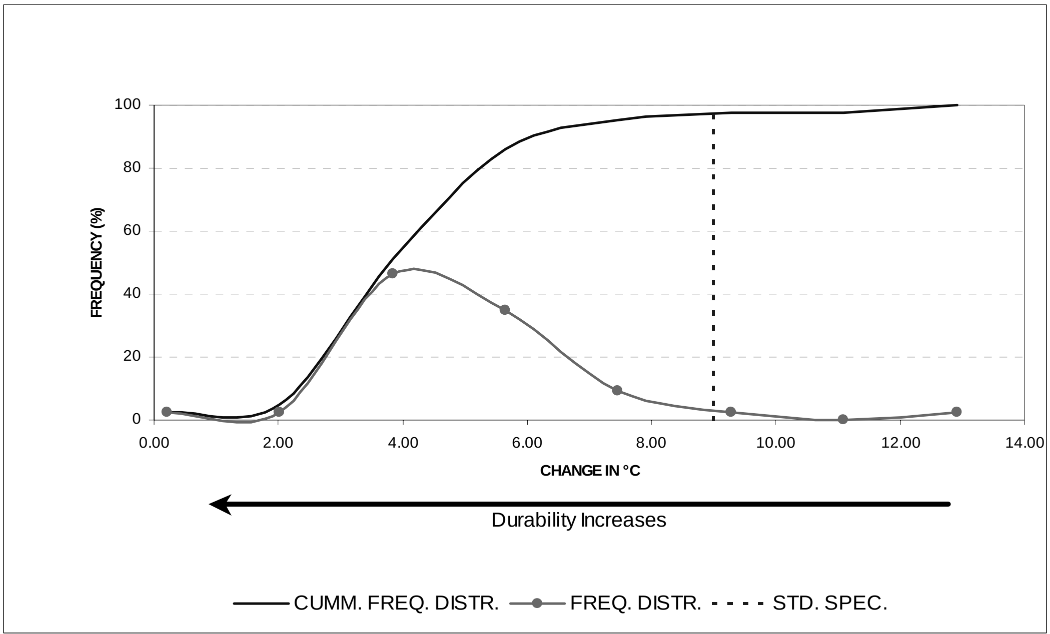


Figure 11.7 Change in Softening Point before and after RTFOT Ageing

Discussion

The majority of standard bitumen tested passed the standard specification of a change in softening point of lower than 9 degrees Celsius. From Figure 11.7 can be seen that almost 45% of all bitumen previously tested exhibited a increase in softening point less than 4 degrees Celsius. A new product should be judged according to these results.

11.4 Retained Penetration

Outline

Test is performed on RTFOT residue (test result is expressed as the percentage change during RTFO testing). Test is performed according to ASTM D5 [1].

Potential Applications

Durability of binders.

Results:

Table 11.3 % Retained Penetration: Statistical Summary

Parameter	Value
Minimum Value	53%
15th Percentile	61%
30th Percentile	63%
Average	67%
70th Percentile	70%
85th Percentile	73%
Maximum Value	81%
Range	28%
No of Observations	27

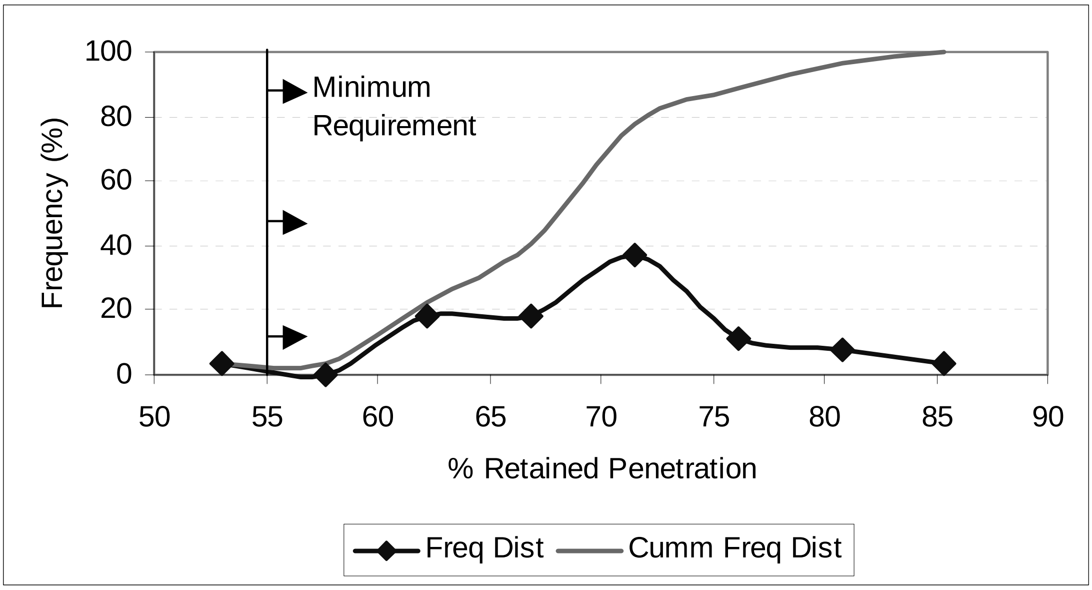


Figure 11.8 Percentage Change in Penetration After RTFOT

Discussion
The standard specification requires that the penetration after RTFOT should be more than 55% of the penetration determined on the original binder. Most of the binders tested had a retained penetration of between 60 and 75%.

11.5 Dynamic Shear Theometer (DSR)

Outline
Test is performed on RTFOT and PAV aged binders. The reported test parameters are G*•Sinδ and G*/Sinδ as defined in the Superpave system.

Potential Application
Durability and Stability of binders

Results:
The Dynamic Shear Rheometer (DSR) is used to assess the durability as well as the stability aspect of the binder. To assess durability of a binder, G*•Sinδ is reported at three temperatures, 13, 16 and 19 °C, on PAV aged specimens. The binder receives a classification according to the lowest corresponding temperature for which G*•Sinδ has a value lower than 5.

The stability aspect of the binder is assessed by reporting G*/Sinδ at temperatures varying from 52 to 70°C. Again the binder is classified according to the highest temperature for which G*/Sinδ has a minimum value of 2.2.

The binder receives a combined classification incorporating results of both G*/Sinδ and G*•Sinδ**.** The different results obtained for G*/Sinδ and G*•Sinδ at different temperatures are presented in the form of frequency plots in Figures 11.9 to 11.14.

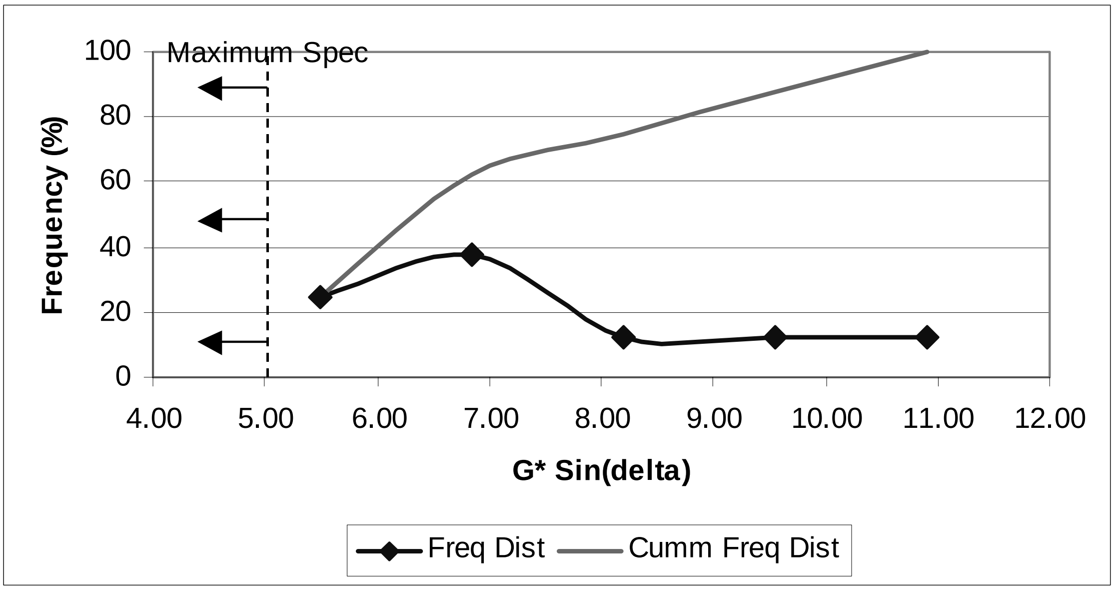


Figure 11.9 DSR Results to assess Durability at 13 °C (Fatigue parameter

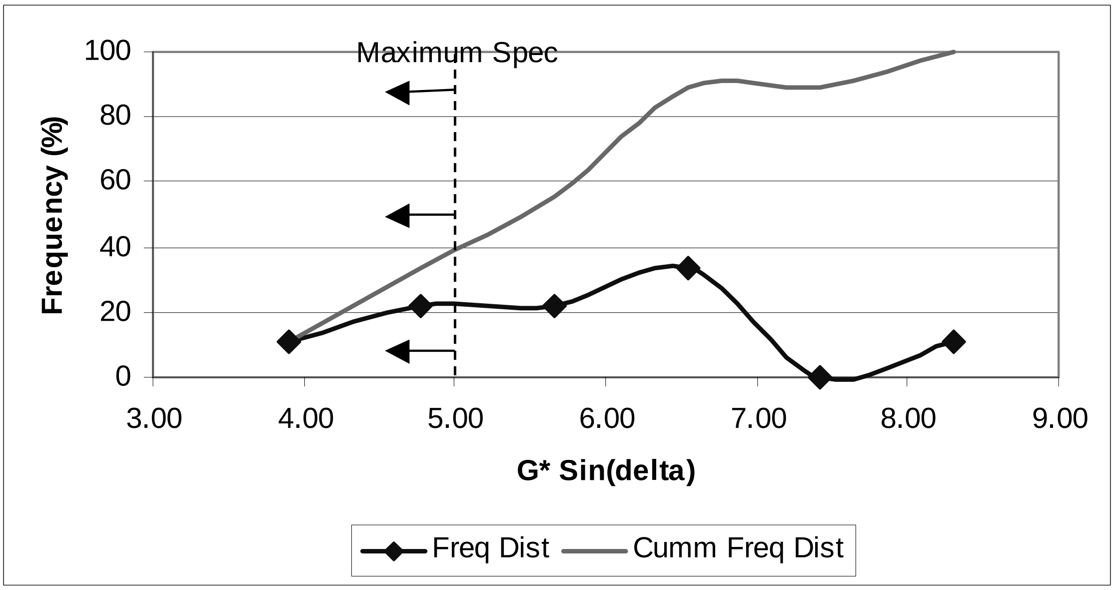


Figure 11.10 DSR Results to assess Durability at 16 °C (Fatigue Parameter)

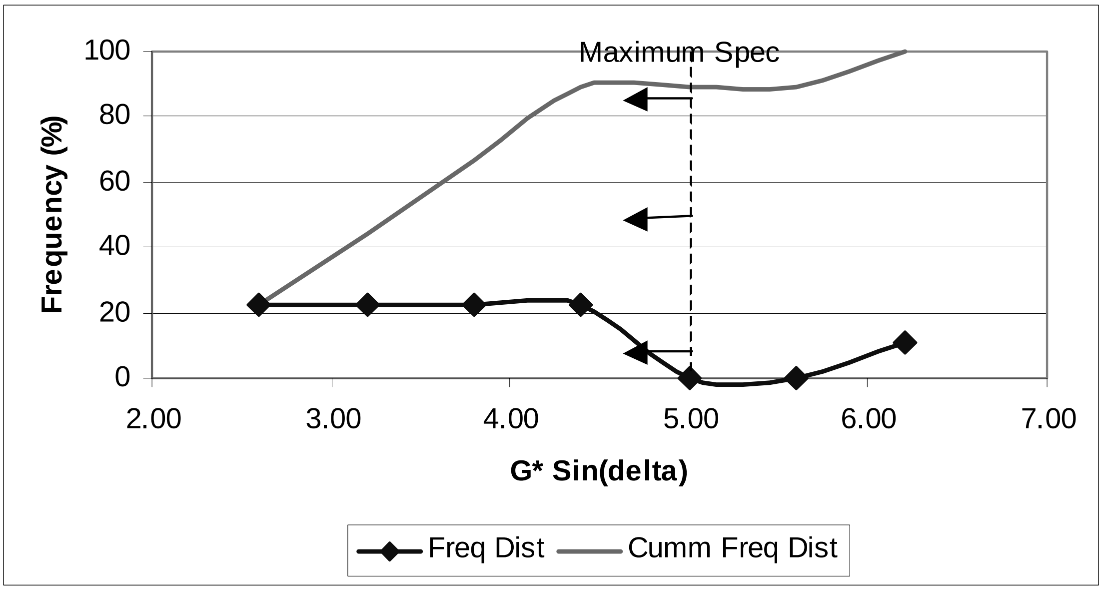


Figure 11.11 DSR Results to assess Durability at 19 °C (Fatigue Parameter)

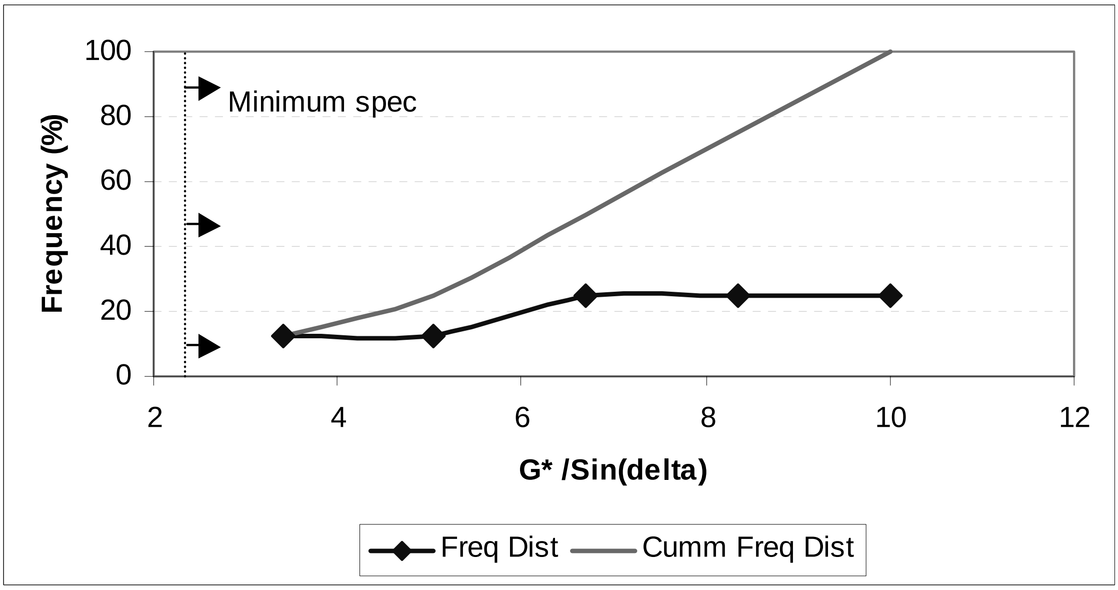


Figure 11.12 DSR Results to assess Stability at 58 °C (Rutting Parameter)

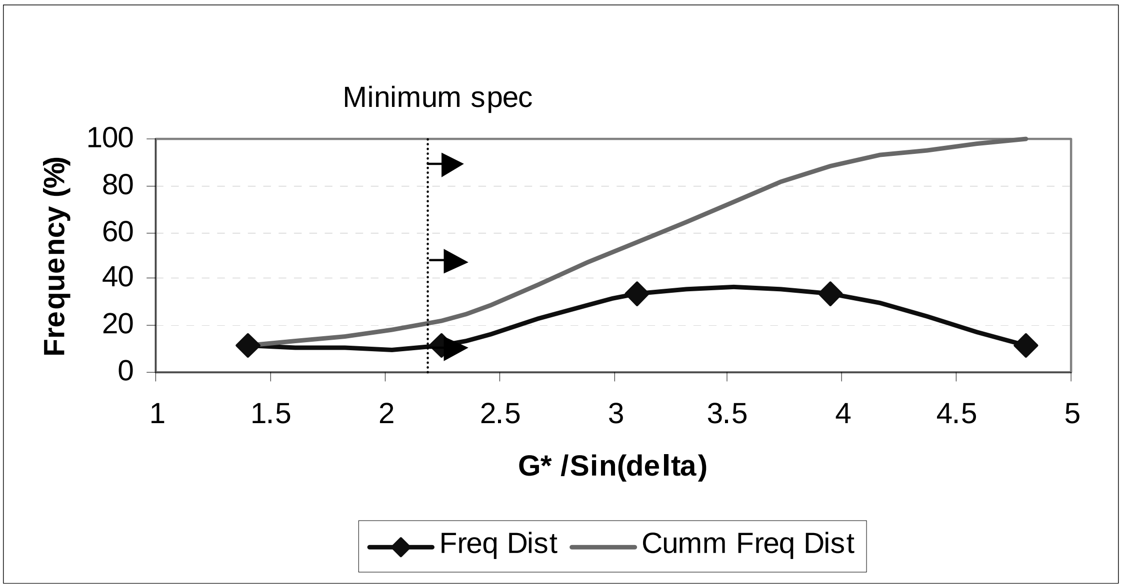


Figure 11.13 DSR Results to assess Stability at 64 °C

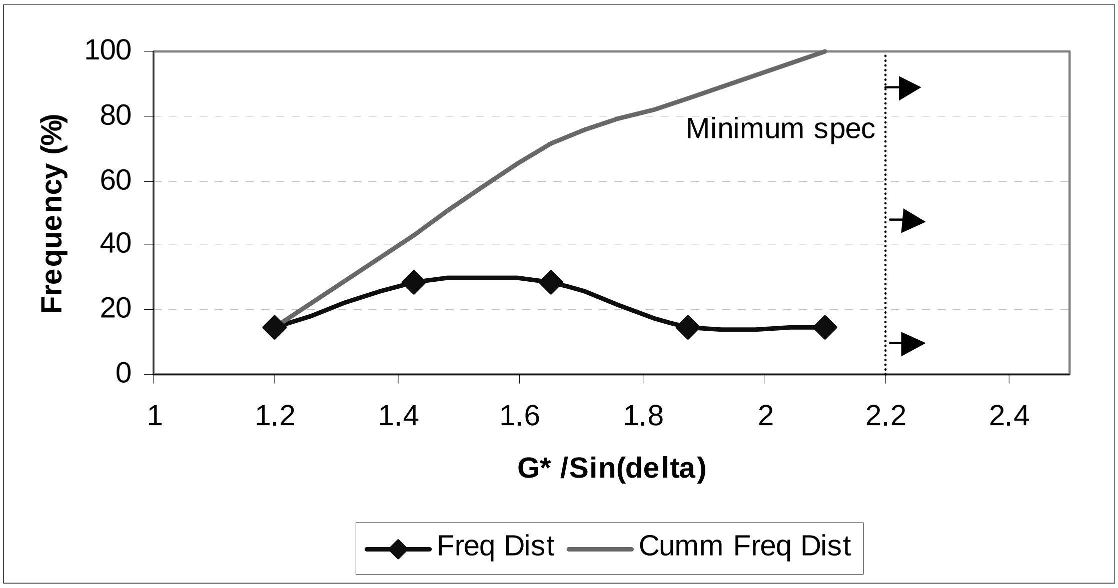


Figure 11.14 DSR Results to assess Stability at 70 °C

Discussion

At 13 °C none of the binders tested had a G*.Sinδ value of less than 5. Most of the binders conform to this specification only at temperatures in excess of 19°C. The lower the temperature at which the maximum specification is reached, the better the durability of the mix. It does not have much meaning to express the G*.Sinδ result of a binder at a single temperature, however, when a relative comparison is made between the binders at specific temperatures, the new product can be rated in terms of the performance of conventional binders by obtaining a result at only one temperature.

The stability parameter G*/Sinδ which essentially assesses the rutting potential of the mix, conformed to the minimum specification at 58 °C for most binders tested. The higher the temperature at which the minimum specification is reached, the better the stability of the mix. Again, relative assessments of new products can be made by testing the product at one temperature only and comparing results to that of commonly used binders.

It is, however, important to realize that stability and durability are conflicting performance aspects. It would thus not be fair towards a new product not to perform the whole specified range of tests at different temperatures. The evaluation of the new product should also be based on what the product is to be used for to assess which of stability or durability should exhibit superior qualities.

11.6 Unconfined Dynamic Creep Test

Outline
Test is performed on cylindrical samples, prepared using a standard aggregate and mix formulation.

Potential Applications
Stability of binders.

Results:

Table 11.4 Dynamic Creep Results: Statistical Analysis

Parameter	Value
Minimum Value	5
15th Percentile	14
30th Percentile	17
Average	29
70th Percentile	39
85th Percentile	45
Maximum Value	66
Range	61
No of Observations	40

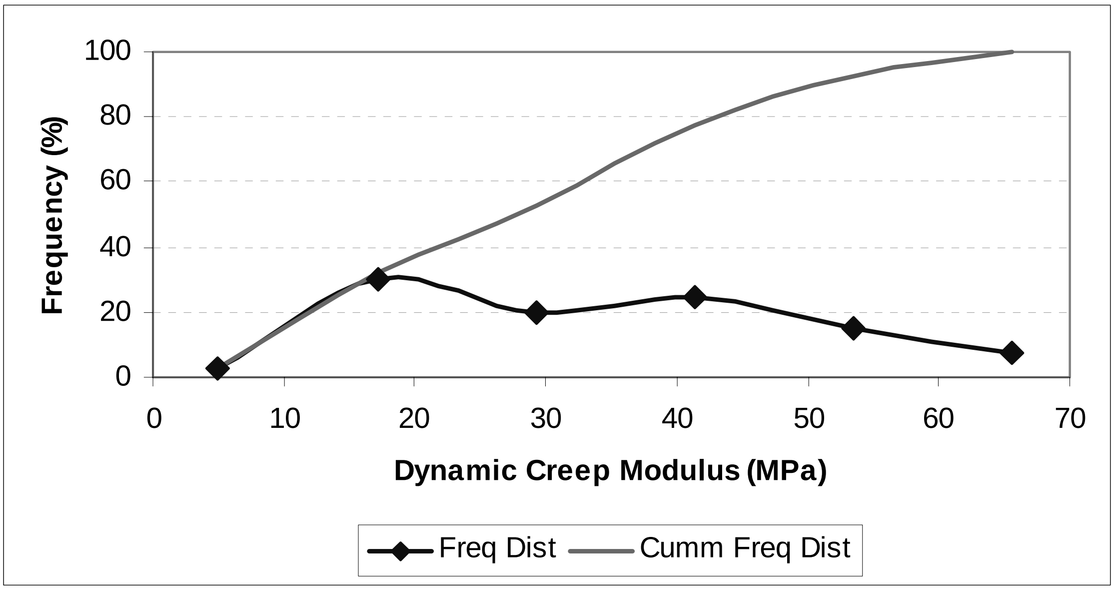


Figure 11.15 Frequency Distribution of Dynamic Creep Modulus

Discussion

The creep modulus of the samples tested varies from 5 to 65 MPa. There are no specified limits for the creep modulus, however, a value of less than 10 MPa is generally regarded as unacceptable.

11.7 Four Point Bending Beam Test

Outline

The test is performed on asphalt mixes. Samples are cut from a larger slab which is prepared using a rolling wheel compactor. Testing is performed before and after simulated long-term ageing.

Potential Applications

Traffic-related durability (flexibility) of binders, asphalt surfacings and asphalt bases; Flexural stiffness of asphalt surfacings and bases.

Results:

Table 11.5 Slopes of the Fatigue Curve

Sample Name	**Slope of Fatigue Curve**		
	Unaged	**Aged**	**Change in Slope (%)**
SMA	-0.1099	-0.1569	42
Continuous	-0.1437	-0.1363	-5
Semi-Gap	-0.1323	-0.1337	1
SBS modified	-0.1727	-0.1801	4

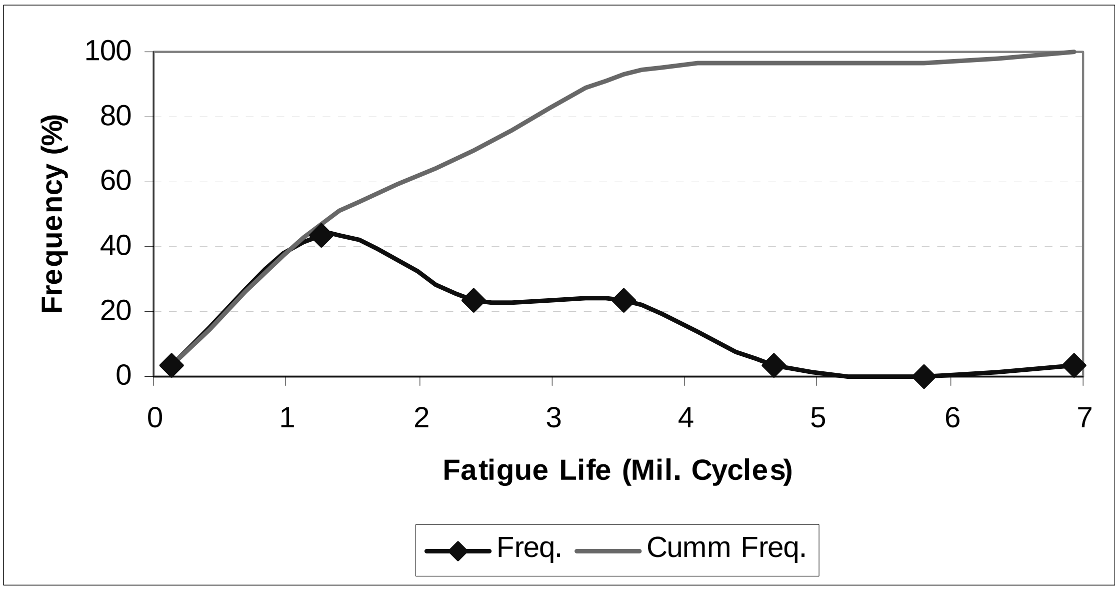


Figure 11.16 Frequency Distribution of Fatigue Life at an Average of 200 Micro Strain

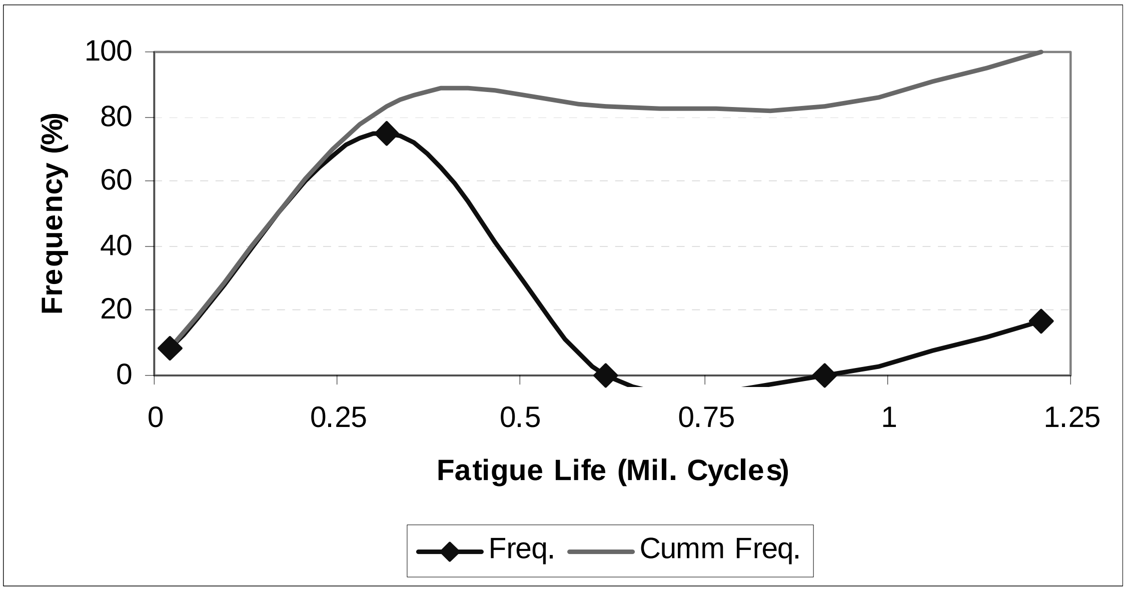


Figure 11.17 Frequency Distribution of Fatigue Life at an Average of 325 Micro Strain

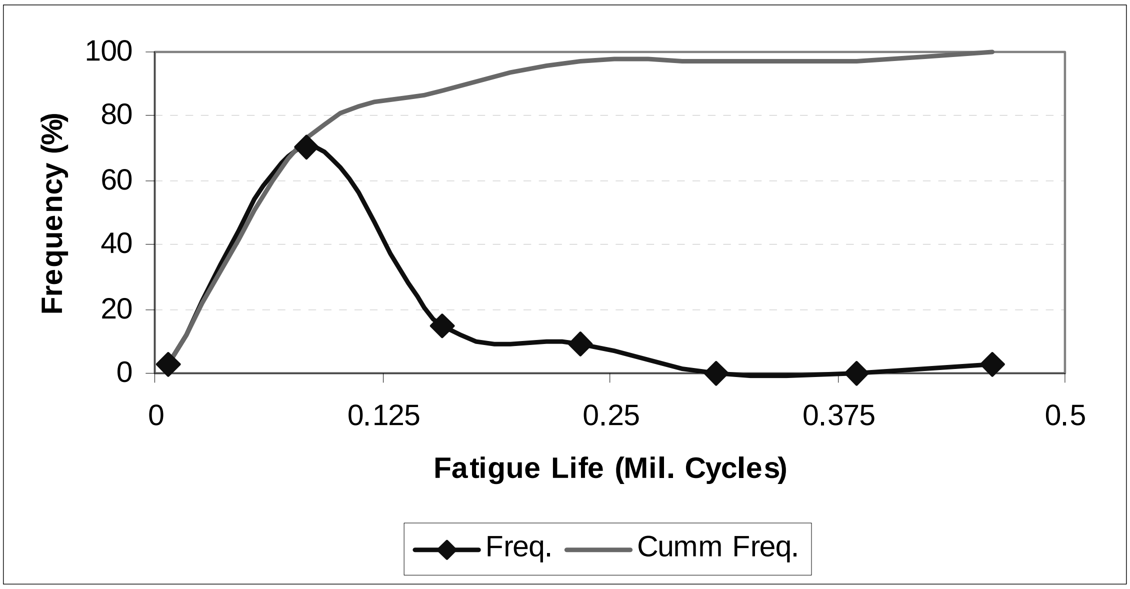


Figure 11.18 **Frequency Distribution of Fatigue Life at an Average of 400 Micro Strain**

Discussion
In Table 11.1 a greater negative value for the slope of the fatigue curve indicates a sharper decline in fatigue life. It is thus anticipated that the slopes of curves of aged samples should have greater negative values compared to unaged samples. However, with the current ageing procedure, only one of the aged samples showed a substantial decline in fatigue life compared to the unaged samples. A more strenuous ageing process should thus be considered.

Figure 11.16 to 11.18 show the frequency distributions for fatigue lives of samples tested at an average of 200, 325 and 400 micro strain respectively.

11.8 Reduced Scale Wheel Tracking Test

Outline
The apparatus consists of a 400 mm diameter wheel with a width of 100 mm which is loaded but held static while a slab of asphalt, confined in a steel mould, moves underneath it. The support of the asphalt slab can be changed to induce mainly compression (rutting test) or mainly flexure (durability test).This test has only recently been introduced and certain facets of the test are still under development.

Potential Applications
i) Stability of asphalt surfacings, asphalt bases and cold-mix materials (high temperature rutting test);
ii) Durability of asphalt surfacings, asphalt bases and cold mix materials (test is performed at 20°C, and a predetermined amount of water is periodically applied to the asphalt slab);
iv) Durability of surface seals (test is performed on a surface seal which is

constructed on an asphalt slab consisting of a standard mix type. The slab with the seal is cut to size, and subjected to testing at 20°C and with periodical wetting of the surface seal. Ageing of the slab and seal can also be performed before testing starts. Ravelling and bleeding is assessed. Skid resistance measurements using the British Portable Pendulum test can be made before and after testing.

Results:

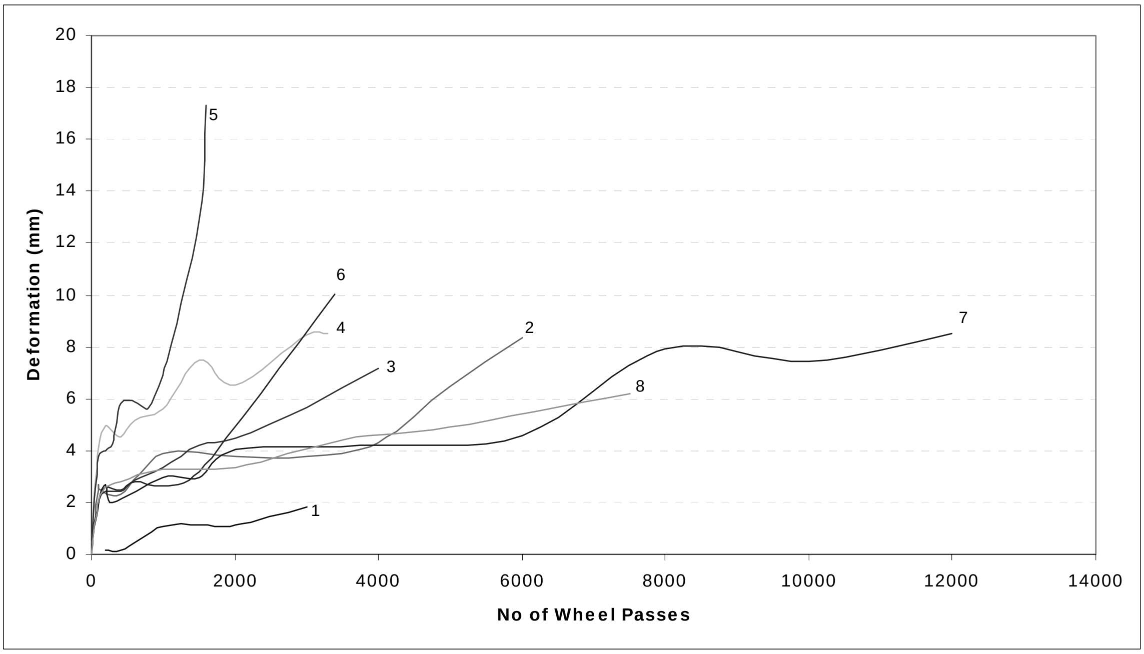


Figure 11.19 Rutting Progression of Different Asphalt Mixes

Table 11.6 Volume Change Potential at 800 Repetitions(%)

Reference Mix	Volume Change Potential (%)
1	1.29
2	5.57
3	5.16
4	8.99
5	9.44
6	4.52
7	23.93
8	5.75
9	22.39

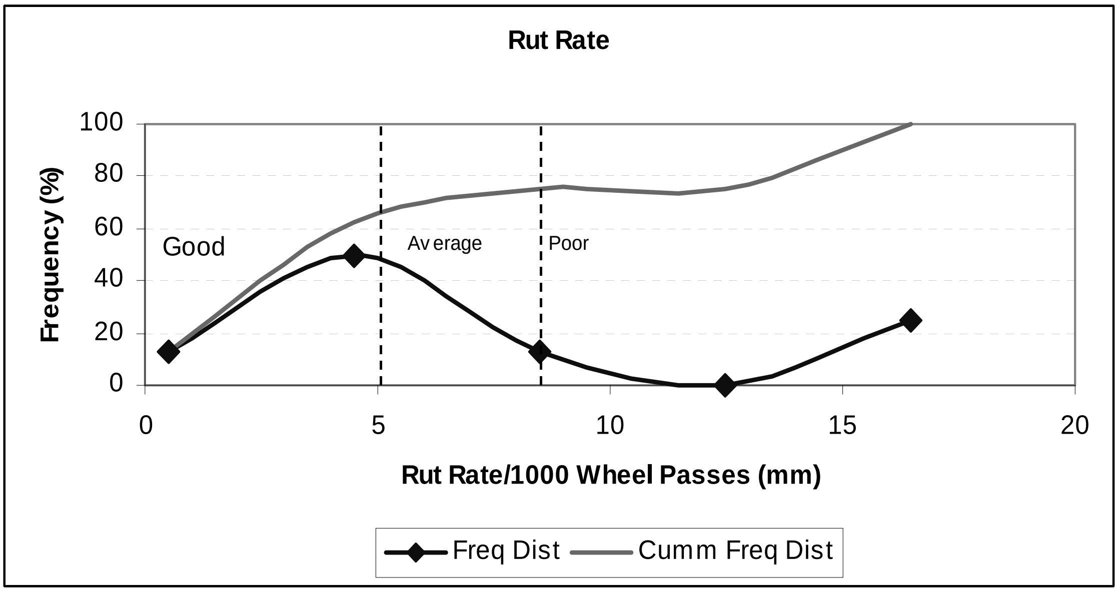


Figure 11.20 Frequency Distribution of Average Rut Rate over 1000 Wheel Passes

Discussion

The allowable amount of rutting depends on what the mix is designed and to be used for. In some instances it might be worth investigating the temperature susceptibility of the rut rate or the influence of a varying load. The volume change potential of a mix was calculated by obtaining the actual deformation at 800 repetitions and dividing it by the depth of the slab tested. The percentage change for each mix is reported in Table 11.6.

The rut rate for each mix was obtained by calculating an average rut rate from the rut rates at different repetition intervals. However, comparison of rut rates should be very carefully interpreted since results were not obtained at the same repetition intervals and this could influence the rut rate drastically. The most accurate evaluation method would probably be to plot the deformation against the number of repetitions and then compare it to the deformation of other mixes.

11.9 British Portable Pendulum Test

Outline

The test is performed on a small section of a prepared mix or seal. The test measures a friction coefficient by means of a rubber slider.

Potential Applications

Micro-texture assessment of asphalt surfacings and surface seals;
Assessment of the durability of micro-texture (when used in conjunction with the polished stone value test).

Results:

Table 11.7 British Pendulum Results on Different Surfaces

Average BPN	Surface
0.667	coarse slurry
0.528	13/6 ds
0.756	asphalt cont
0.658	13 s
0.745	9.5 s
0.662	19/9 ds
0.600	19/6 ds
0.459	cape seal
0.496	asphalt cont + rolled in chips
0.700	smooth concrete
0.760	coarse concrete

Discussion

The British Pendulum Number (BPN) is not only a measure of skid resistance but also a measure of the microtexture of the surface. The skid resistance of a surface that was constructed with a new product should be compared to that of an appropriately similar surface. A proper evaluation of skid resistance should also take a measure of macro texture into account. Skid resistance should also be assessed on a full scale section constructed with the submitted product (where applicable) with an instrument such as the SCRIM or the GripTester. A measure of macrotexture should be obtained by means of the sand patch method or a laser macrotexture measurement device.

11.10 Crack Movement Simulator (CMS) Test

Outline

The test is performed on a thin film of the seal or binder. The test can be performed before and after simulated long term ageing.

Potential Applications

Traffic related durability (flexibility) of surface seals, crack sealants and joint sealants.

Results:

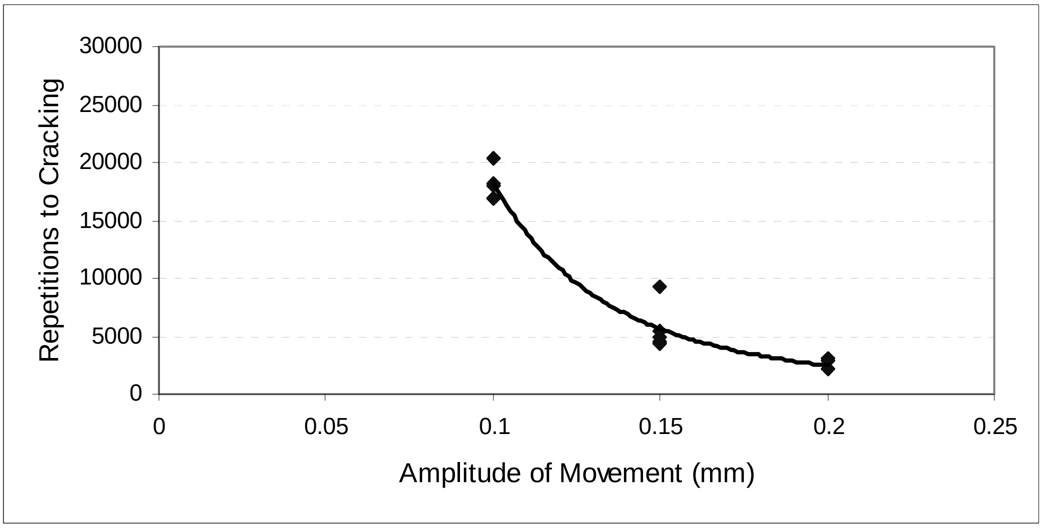


Figure 11.21 Repetitions to the Formation of the Third Crack at Different Amplitudes of Movement

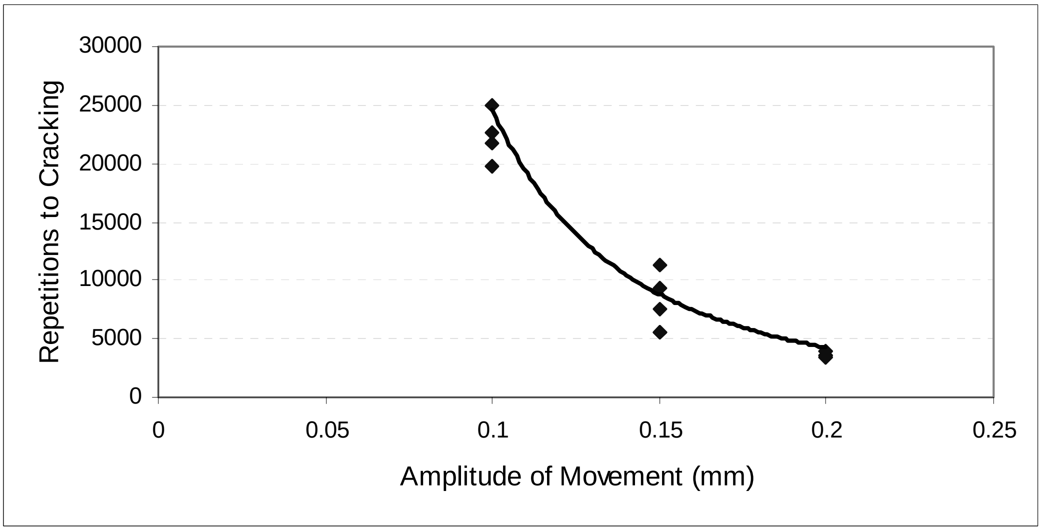


Figure 11.22 Repetitions to 90% Cracking at Different Amplitudes of Movement

Discussion

The CMS results were obtained from 6 different unmodified binders. According to the specification the reported value should be the amplitude of movement at 50 000 repetitions to cracking. However, in the case of these binders, the extreme extrapolation necessary to obtain this value would inaccurately represent the test results. Also, the accuracy of the LVDT that controls the vertical displacement does not accurately allow for movements smaller than 0.1 mm.

It was therefore decided to compare the results of a new product to the curves in Figures 11.21 and 11.22 which show the average number of repetitions to the occurrence of the third crack and the average number of repetitions until the sample was 90% cracked, respectively.

11.11 Indirect Tensile Strength Test (ITS)

Outline

The test is performed according to ASTM 4132. The test provides an indication of the resilient modulus (stiffness) of asphalt mixes.

Potential Applications

Structural stiffness and cohesive strength of asphalt surfacings and asphalt bases.

Results:

Table 11.8 Indirect Tensile Strength and %Strain at Failure: Statistical Analysis

Parameter	Value (ITS)	Value (% Strain)
Minimum Value	584 kPa	0.90 %
15th Percentile	836 kPa	1.30 %
30th Percentile	1103 kPa	1.50 %
Average	1212 kPa	1.89 %
70th Percentile	1357 kPa	2.20 %
85th Percentile	1510 kPa	2.60 %
Maximum Value	1806 kPa	3.50 %
Range	1222 kPa	2.60 %
No of Observations	23	21

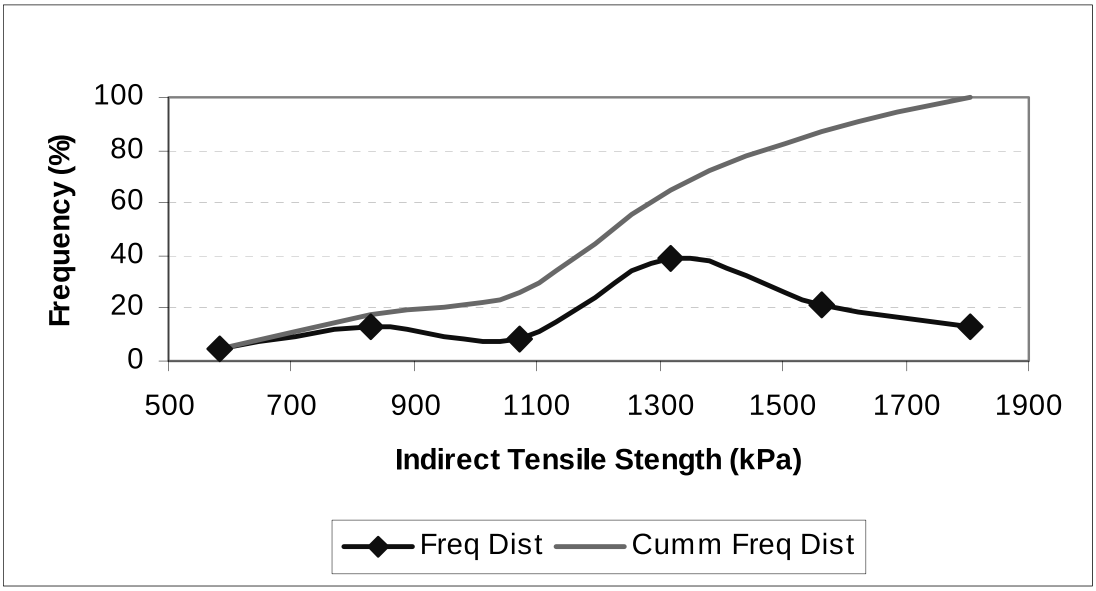


Figure 11.23 Frequency Distribution of Indirect Tensile Strength

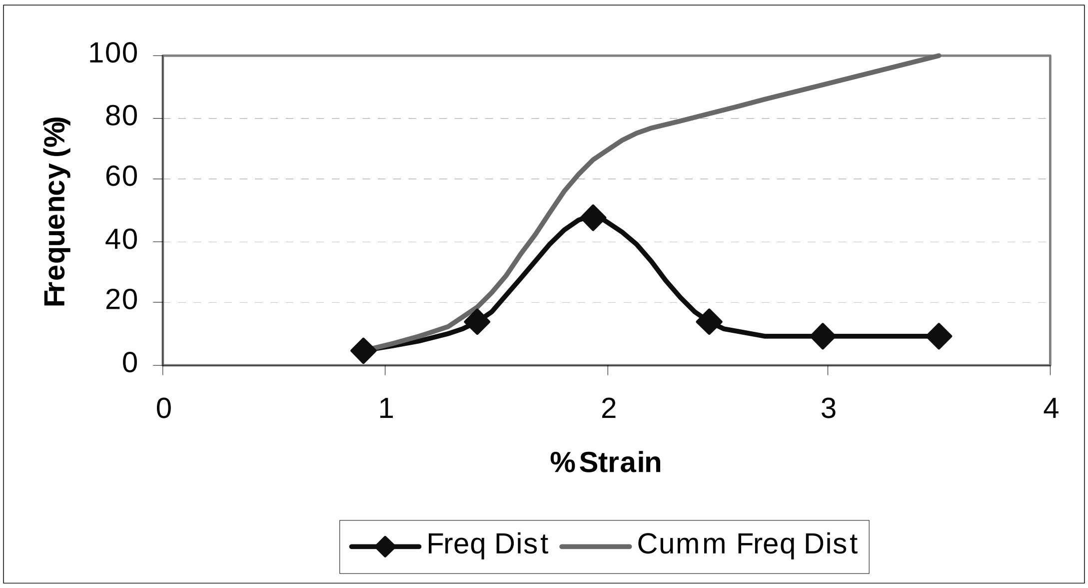


Figure 11.24 Frequency Distribution of % Strain Measured at Maximum Stress

Discussion

The ITS is a conventional test that is used to evaluate the tensile strength of asphalt mixes. The ITS has also been linked to mix stability and durability. A minimum ITS value of 800 kPa is typically enforced during asphalt construction projects. However, results obtained on some of the mixes tested as part of this project, and correlation thereof with wheel track test results, suggest that a more appropriate limit is between 900 and 1000 kPa. An ideal range for ITS values is between 1100 and 1400 kPa. ITS values in excess of 1700 kPa may be indicative of brittleness and low durability.

The ITS is performed at 25°C and does not provide a good absolute indication of stability at high temperatures. The ITS value may be inappropriate as an indicator of mix stability for some mix types and mixes with modified binders. Anomalies between ITS and wheel tracking test results should indicate when this is the case.

12. REFERENCES

1. JOOSTE, FJ and Verhaeghe, BMJA. 1998. Development of Fitness-for-Purpose criteria for bituminous road products: Phase 1. Pretoria: Division of Roads and Transportation Technology, CSIR (Contract Report; CR-98/012).

2. Committee of State Road Authorities (CSRA). 1992. Pavement Management Systems: Standard Visual Assessment Manual for Flexible Pavements. Technical Methods for Highways (TMH) 9, CSRA, Pretoria.

3. Agrément South Africa. 1999. Guidelines for the preparation of a quality assurance system for Agrement South Africa certification. Pretoria: Agrement South Africa, CSIR.

4. VERHAEGHE, BMJA, Rutland, GP, Maree, JH and Vos, RM. 1997. Framework for the Development of a South African Product Performance Guarantee System for the Asphalt Industry. Eight International Conference on Asphalt Pavements, Seattle, Washington.

5. South African Bureau of Standards. SABS 307-1972, Penetration Grade Bitumens. Amendment No. 5

6. **Fatigue Response of Asphalt-aggregate Mixes**. 1992. California, Berkeley: Institute of Transportation Studies, University of California, Berkeley. (SHARP Project A-003A. Asphalt Research program).

APPENDIX A

RESULTS AND COMPARISON OF A PILOT BINDER

A1. RESULTS OF TESTING A PILOT BINDER

Background

As part of the development of an evaluation procedure for bituminous road materials, a modified binder was evaluated using the recommended test methods for bituminous binders (section 4). The results shown below form part of an evaluation performed for a Transportek client, and details of the material and background to the testing can therefore not be disclosed here.

The evaluation of test results cannot be discussed in detail, since a fitness-for-purpose statement was not agreed on before testing commenced, nor was an evaluation committee formed to agree on the test procedure and evaluation criteria. However, the results do show some interesting trends and a brief discussion of the results is therefore included below. It should be noted that this discussion is necessarily limited in scope and detail and should therefore not be regarded as a formal evaluation, nor does it approximate a typical Agrément evaluation.

Results of Pilot Binder

Table C1 contains the results of tests performed on the pilot binder. In the second and third column of this table is the average result and range of results obtained from similar products previously tested.

Table C1: Results of Pilot Binder Compared to other Binders Previously Tested

Test	Result of pilot binder	Average result of other binders	Range of results of other binders
Viscosity at 60°C after RTFOT (Pa.s)	To high to be measured	336	181 - 833
Change in Softening point (°C)	4	4.08	0.2 – 11.1
Rutting Parameter at 58 °C (G*/Sin*)	9.4	6.25	3.4 – 10
Rutting Parameter at 64 °C (G*/Sin*)	4.6	3.04	1.4 – 4.8
Rutting Parameter at 70 °C (G*/Sin*)	2.5	1.54	1.2 – 2.1
Fatigue Parameter at 13 °C		7.14	5.5 – 10.9
Fatigue Parameter at 16 °C	6.0	5.51	3.9 – 8.3
Fatigue Parameter at 19 °C	4.4	3.62	2.6 – 6.2
Fatigue at 200 micro Strain (Reps to Failure)	2 030 000	1 705 600	140 000 - 6 930 000
Fatigue at 325 micro Strain (Reps to Failure)	163 000	263 000	21 000 - 1 210 000
Fatigue at 400 micro Strain (Reps to Failure)	40 600	70 632	7 500 - 460 000
Dynamic Creep Modulus (MPa)	5.31	29.34	5 – 65.6
ITS (kPa)	502.8	1212.21	584 – 1806
% Strain at Maximum Stress	5.91	1.89	0.9 – 3.5
Modified Lottman	0.92	-	-

Test	Result of pilot binder	Average result of other binders	Range of results of other binders
Tensile Strength Ratio			
Modified Lotman % Strain at Maximum Stress	7.6	-	-
Rutting (Actual Deformation in mm at 3000 repetitions)	4	7	2.5 - 19
Rutting (Actual Deformation in mm at 6000 repetitions)	4.5	9.5	4 - 22

Discussion of Results

Durability and Fatigue Resistance
In the low strain regime (average 200 microstrain) the fatigue resistance of the binder is above average, as compared to conventional, unmodified binders. However, the fatigue performance is not regarded as excellent. In the low strain regime, and for the type of asphalt mix that was evaluated, the binder can be expected to endure between 10 and 20 million load applications before the onset of fatigue cracking.

In the medium to high strain regime, the fatigue performance is rated as poor to medium, with and expected fatigue life of less than 1 million load applications at an average strain level of 325 microstrain. The binder is not regarded as a high flexibility binder and the product will typically not be recommended for thin surfacings on poor support systems (support stiffness below 300 Mpa) . The bending beam fatigue results in the high strain regime are supported by the dynamic shear rheometer results, which show below average performance for fatigue resistance.

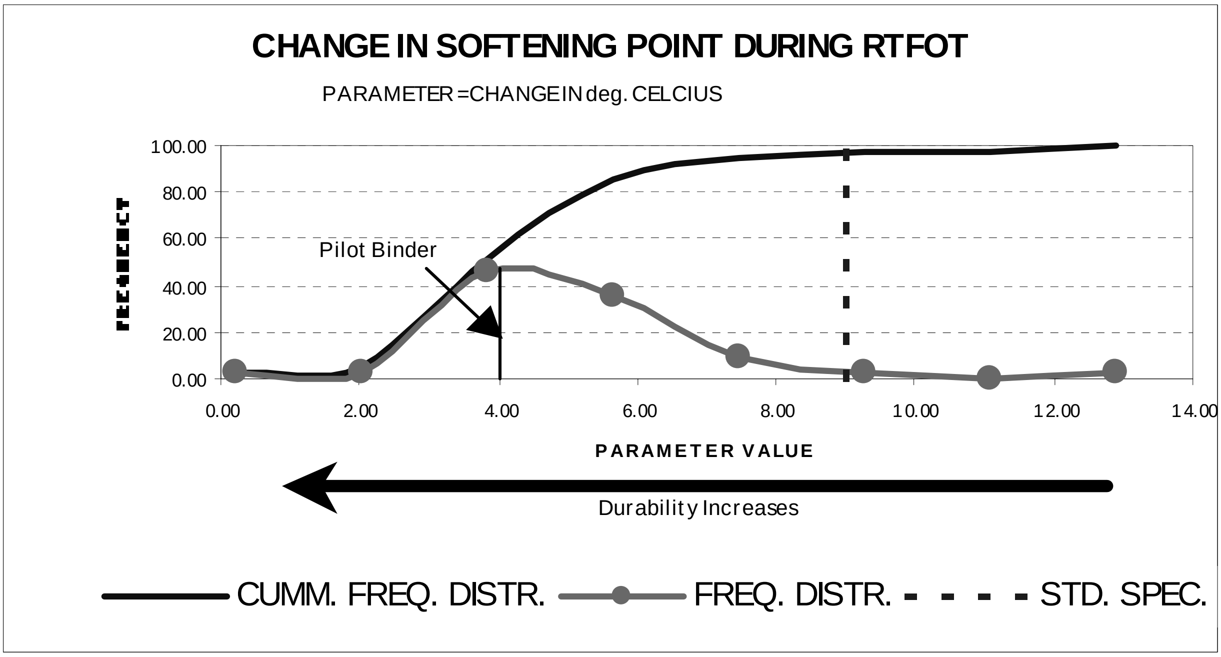
The binder did not exhibit any extreme behavior as far as durability is concerned. Based on the change in softening point during RTFOT ageing, the durability of the binder is rated as medium. If the binder is used as a surfacing, a service life of between 8 and 12 years can be expected, providing that the support conditions are such that the layer will work in the low strain regime.

Stability and Rut Resistance
The primary advantage of the pilot binder is its high stability. The DSR and wheel tracking results show that binder has excellent stability at high temperatures and can be expected to have good rutting performance if used in thick asphalt layers on good support systems (support stiffness of 400 MPa and higher).

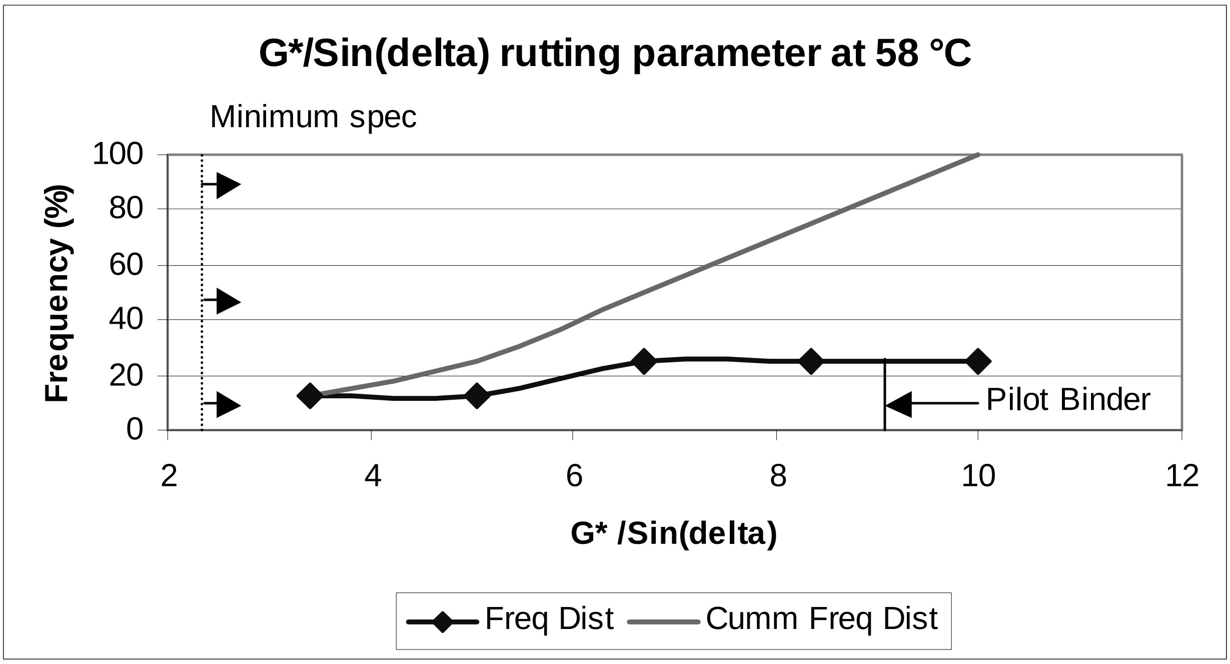
An anomaly noted in the test results is the low dynamic creep stiffness and low ITS values. These tests are not performed at high temperatures and therefore may give an erroneous impression of the binder performance as far as stability is concerned. The results suggest that a more detailed evaluation of the binder performance at medium temperatures is needed. In a certification process, these results may prompt further wheel tracking tests at lower temperatures, as well as a temperature sweep test using the DSR.

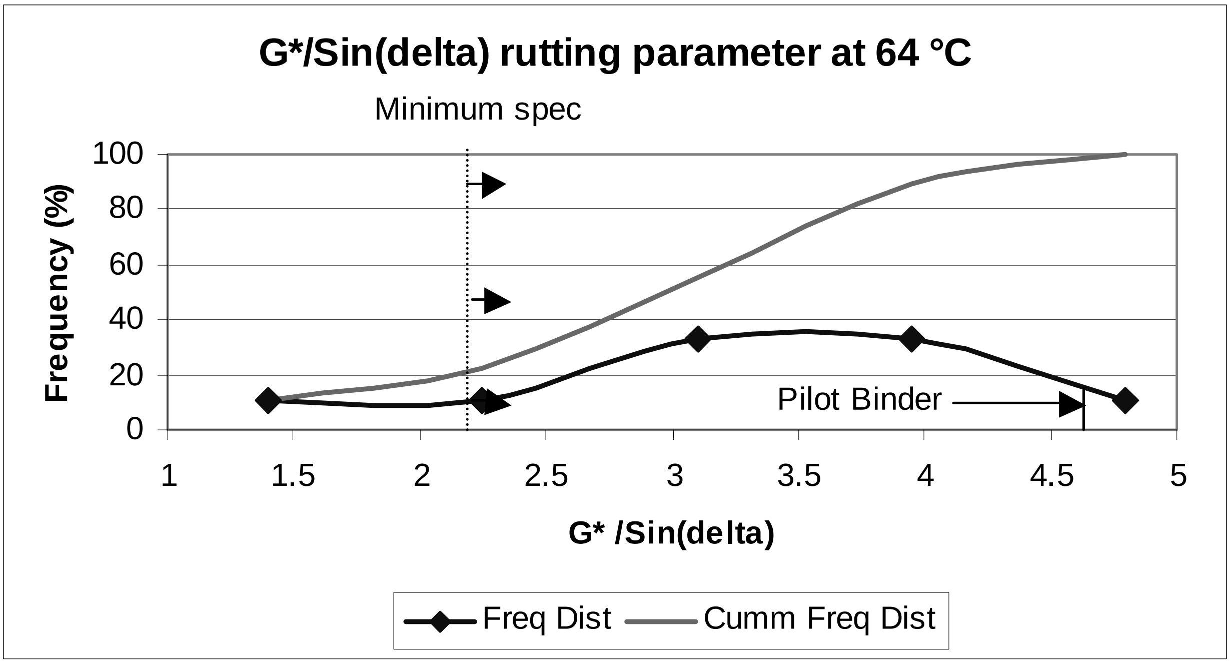
GRAPHICAL COMPARISON OF THE RESULTS

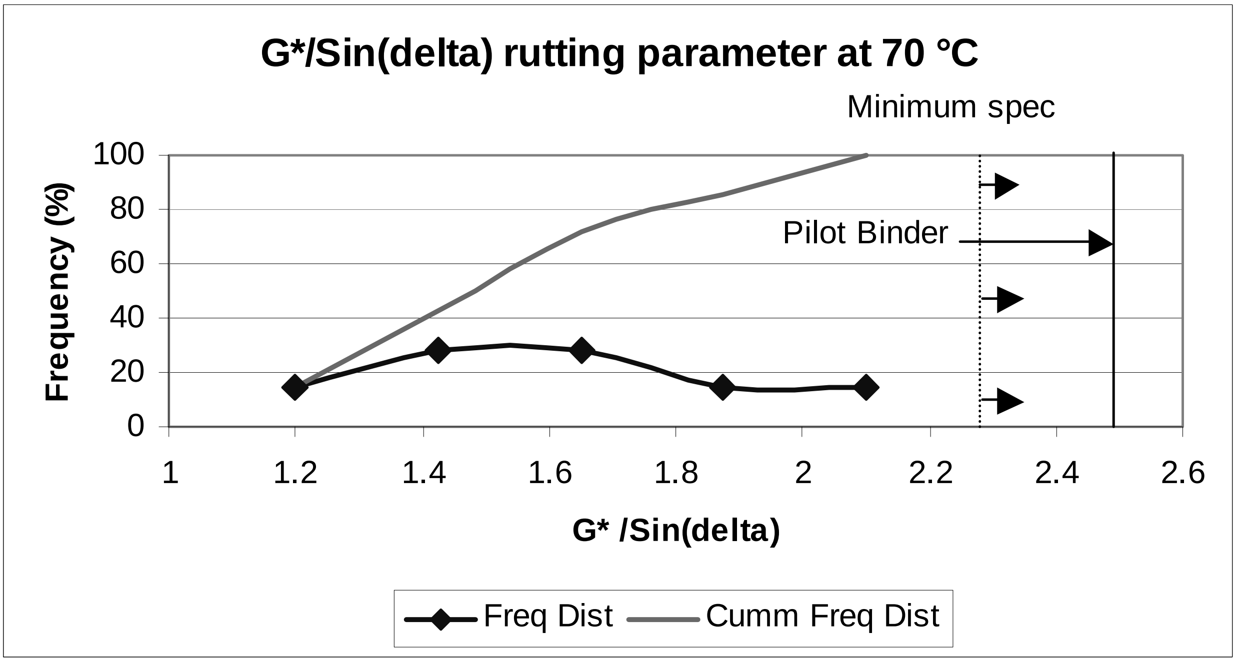
Change in Softening Point:



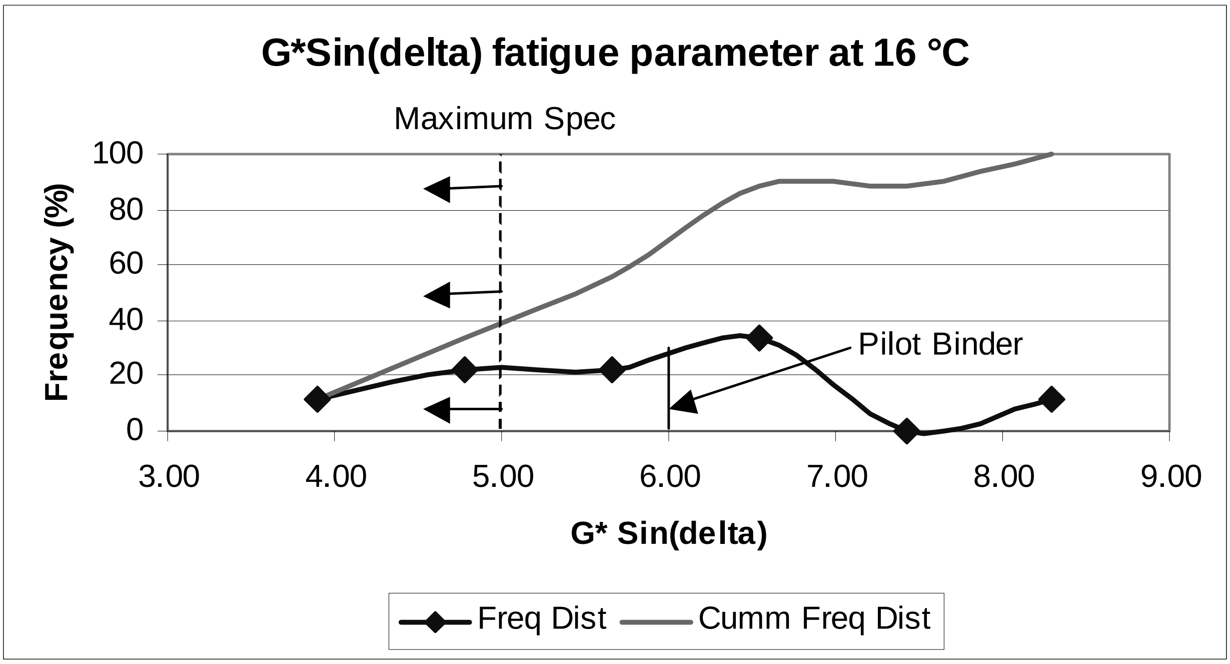
Dynamic Shear Rheometer - Rutting Parameter:

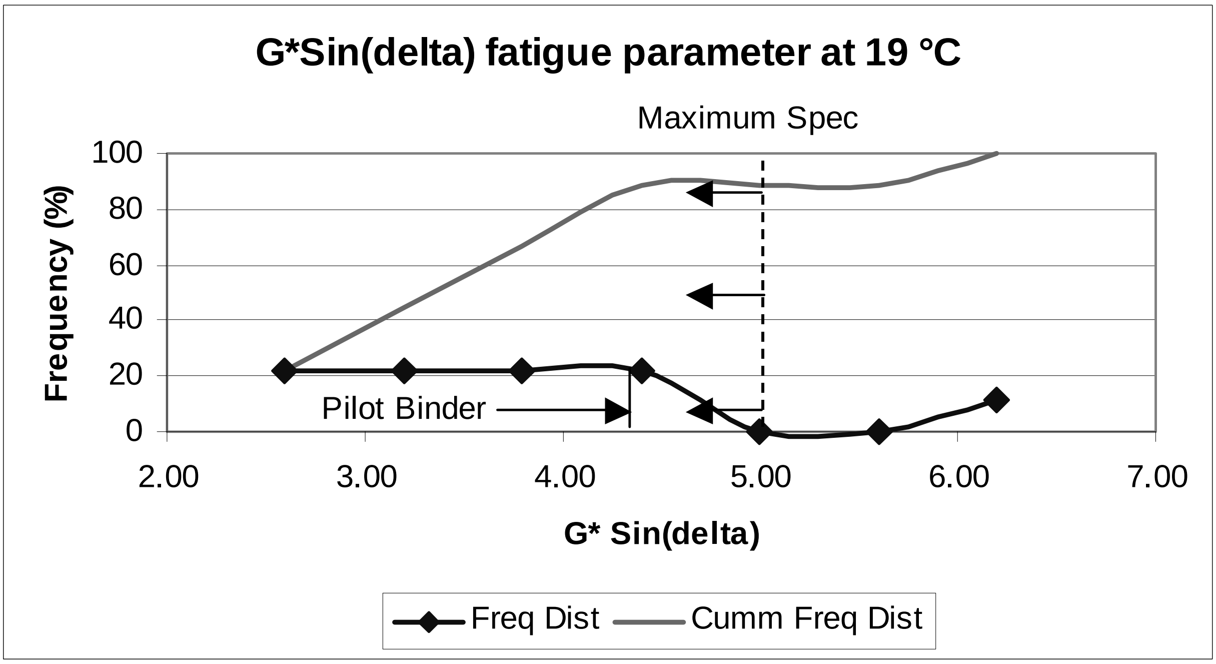




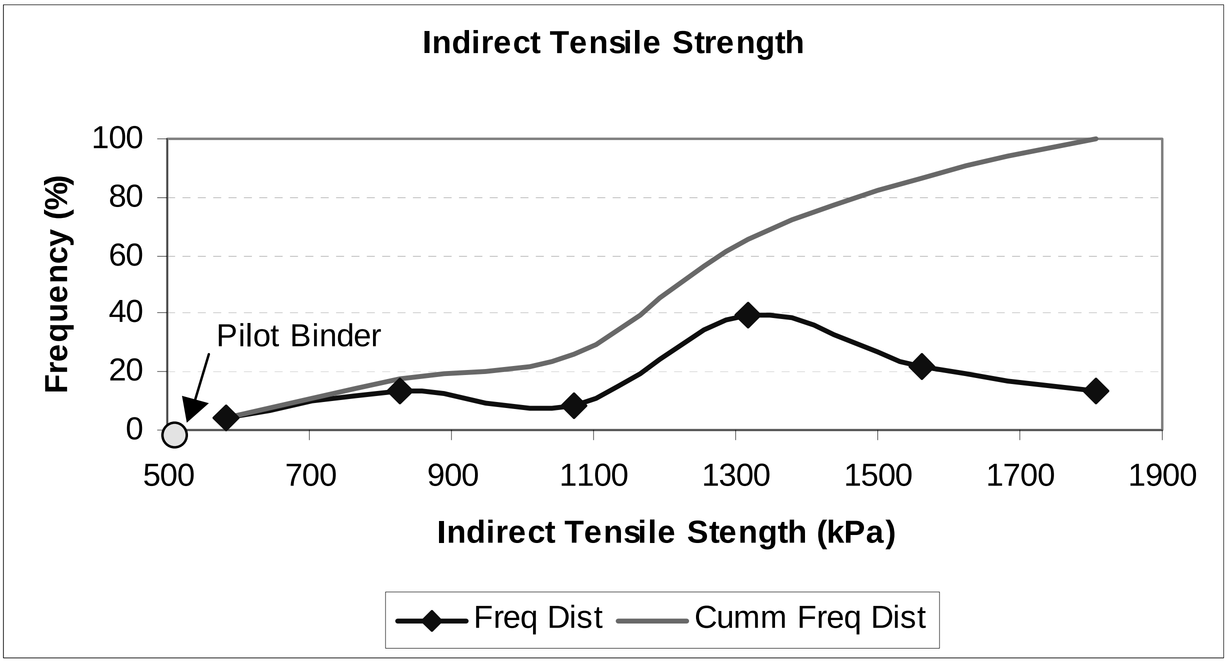


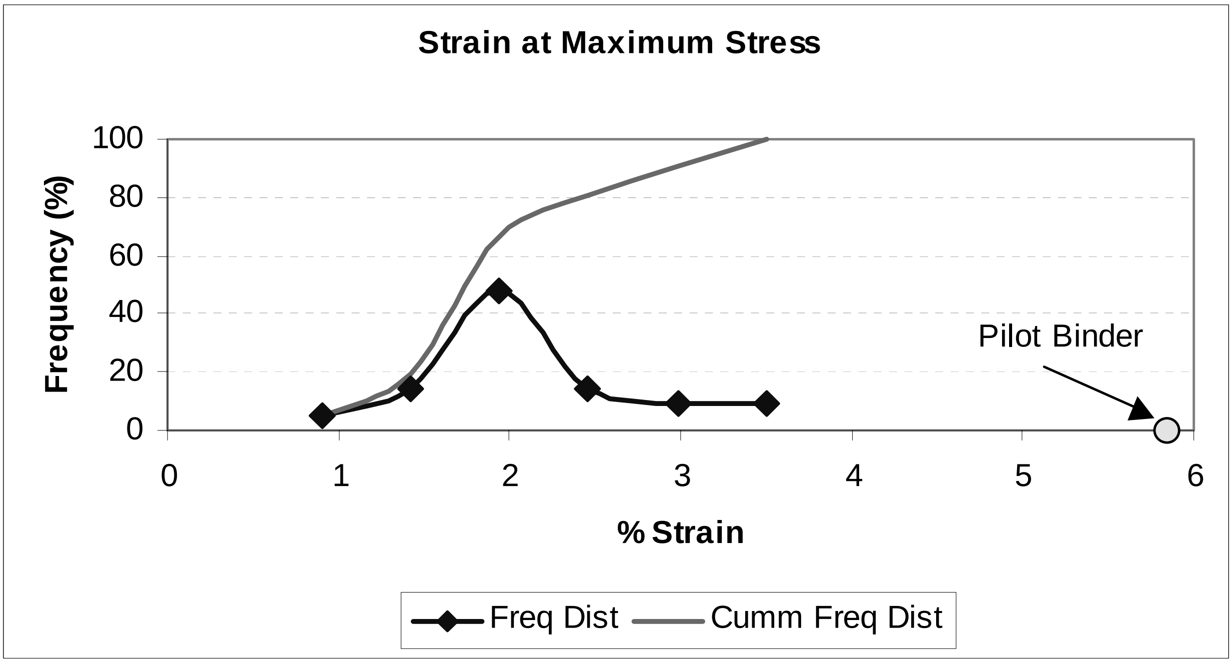
Dynamic Shear Rheometer - Fatigue Parameter:



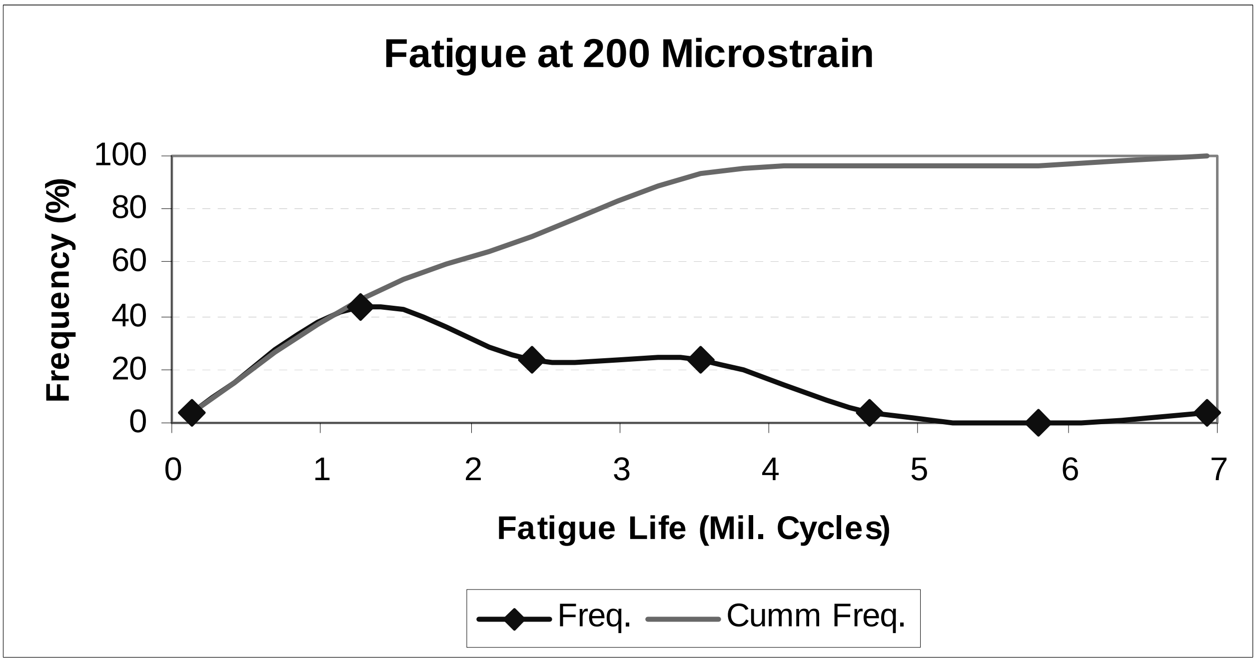


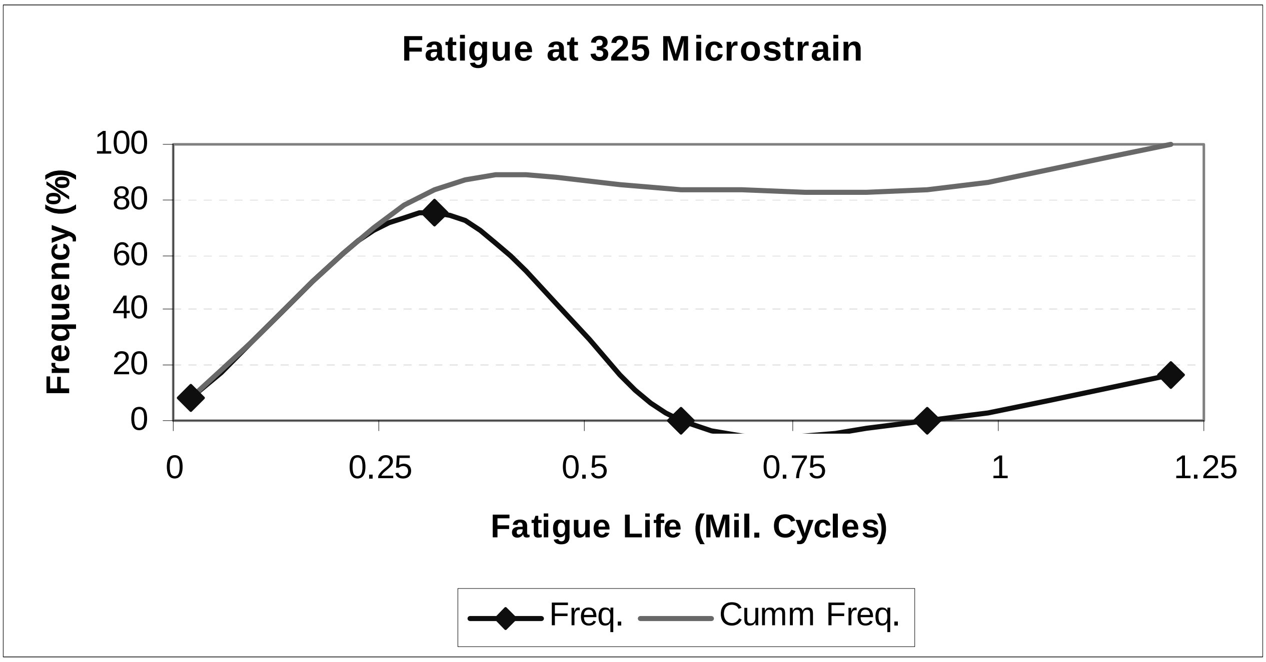
Indirect Tensile Strength and % Strain at Maximum Stress

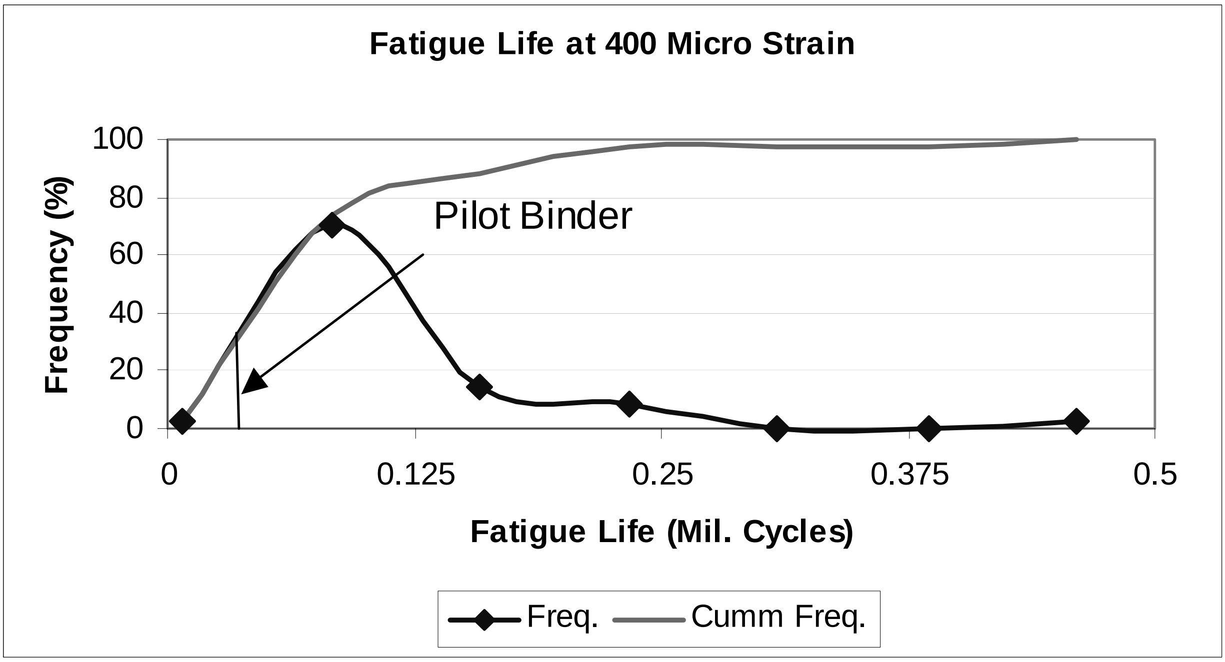




Fatigue Results:


Fatigue at 200 Microstrain
Frequency (%)
100
80
60
40
20
0
0
1
2
3
4
5
6
7
Fatigue Life (Mil. Cycles)
Freq.
Cumm Freq.


Fatigue at 325 Microstrain
Frequency (%)
100
80
60
40
20
0
0
0.25
0.5
0.75
1
1.25
Fatigue Life (Mil. Cycles)
Freq.
Cumm Freq.



Rutting Results: