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Technical Report
Project No. 0614E

Physical check and characteristic analyse of bonding behavior in application of tecRoad Premium

from
Professor .Dipl.Dr. Ronald Balb

And
Project Assostamce
Mr. Michael Wagner

Assigned by

Rubbertec GmbH
Werkstr. 5
A-8940 Liezen

Wien, Mai 2006

Dieser Projektbericht enthält 10 Seiten und einen Anhang mit Prüfberichten.

The report ncluded totally 10 pages and one attachment with laboratory technical report

Report 0614 E Date 15hth May 2006

Content

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1. Theme and methods

Rubbertec GmbH, Werkstr. 5, A-8940 Liezen, under representatives of Mr. Dr.FH Bernd Furche , assigned Research Institute of Highway construction and maintenance, a section of Technology University of Vienna, with an official letter dated on 19th April 2006, to have carried out a technical research and analyse of chateristicsapplication of collider test on rubber modified asphalt, trade mark named tecRoad Premium.

Under condition of technical research, rubber modified bitum . being mxed with standard bitum 70/100, in order to maintain rubber modified bitum in stage. tecRoad Premium,however, characteristic analyse ofadhesivity of low and high temperature application on tecRoad Premium being also carried out, moreover, both technical checks in applicable low and high temperature, following in laboratory of research institute, section of Highway construction and maintenance of Vienna technology University, with Dynamic Shear Rheometer DSR, as good as by mean of Bending Beam Rheometer, BBR.

2. Materials

A test being carried out under agreement of assigned Co.ltd. AG, that rubber modified bitum, together with standard bitum of 70/100 was mixed, in order to maintain same charactieristic as its usual way. (Table 1). Both components was mixed in a lab mixer for about 15 minutes at a temperature of 180degrees, then a volume of 12 M% of rubber modified granulate (S401), and 88 M% of bitum 70/100 (B001) to get an output of tecRoad Premium.

Table 1 : to applied l material and internal laboratory code set.

Material	Aricle	Lab Code
Adhesive additive	70/100	B001
Other Additive	Rubber modified granulate	S041

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3. Condition and method

The following method to be applied, to research its applicable characteristics :

Applicable bonding characteristics with its final result as follows :

- Aging bitumen by means of rolling thin film furnace testing (RTFOT) according to EN 12607-1 inclusive a mass shrinkage (163°C, 85 min., 15 RPM/min.)
- Aging bitumen by means of Pressure Aging vessel (PAV)according to prEN 14769 (100°C, 20h, 21bars)
- Measurement of dynamic viscosity by means of Rotational Viscosity Measuring method (RV) in a non-aging stage according to EN 13302. Trial is carried out all under a temperature between 120°C to 180°C , with a agglomeration of temperature of 15°C each time.
- Measurement of a complex driving module G* and of phase angel Beta to conclude output by means of Dynamic Cutting Heomoter (DSR) (Aging stage of A), moreover, also with RTFOT aging method (Aging stage of B) in a temperature level (46°C till 82°C) according to prEN 14770 Standard. The trials were fulfilled under a frequency of 1,59Hz.With double results each level of temperature add to agglomeration of each 6°C according to prEN14771 standard.

All carried out result with those detailed data was attached in research checking detail lists.

4. Experimental result

Here please find attached laboratory measuring result, as well as final testing knowledge .

4.1 RTFOT Result

By mean of Rolling Thin Film Furnace Test (RTFOT) can be carried out, besides simulation of aging bitumen as good as mass shrinkage through influence of distillation and oxidization on material . Tolerance according to SUPERPAVE standard, by method of RTFOT, with lost shrinkage of 1% being confirmed. Mass reduction of tecRoad Premium around 0,17%, moreover, tiny reduction as well., simultaneously , herewith mass shrinkage just in a same level of a polymer modified bitumen , that plastic was being almost reduced during aging process.

4.2 RV result

According to RV testing result, working process (such as mixing, transferring, integrating) of mixture was confirmed. Picture 1 shows about dynamic viscosity of tecRoad Premium over a level of temperature from 120°C to 180°C. Tolerance of SUPERPAVE for non-aging bitumen (Form A) is confirmed with 3000mPa.s around 135°C, however, with that tolerance is tecRoad Premium clearly clarified, nevertheless, according to picture 1, as tecRoad Premium with its processing viscosity comparable material to be applied as good as bitumen of 70/100. It is very clearly to say that viscosity of such special bonding

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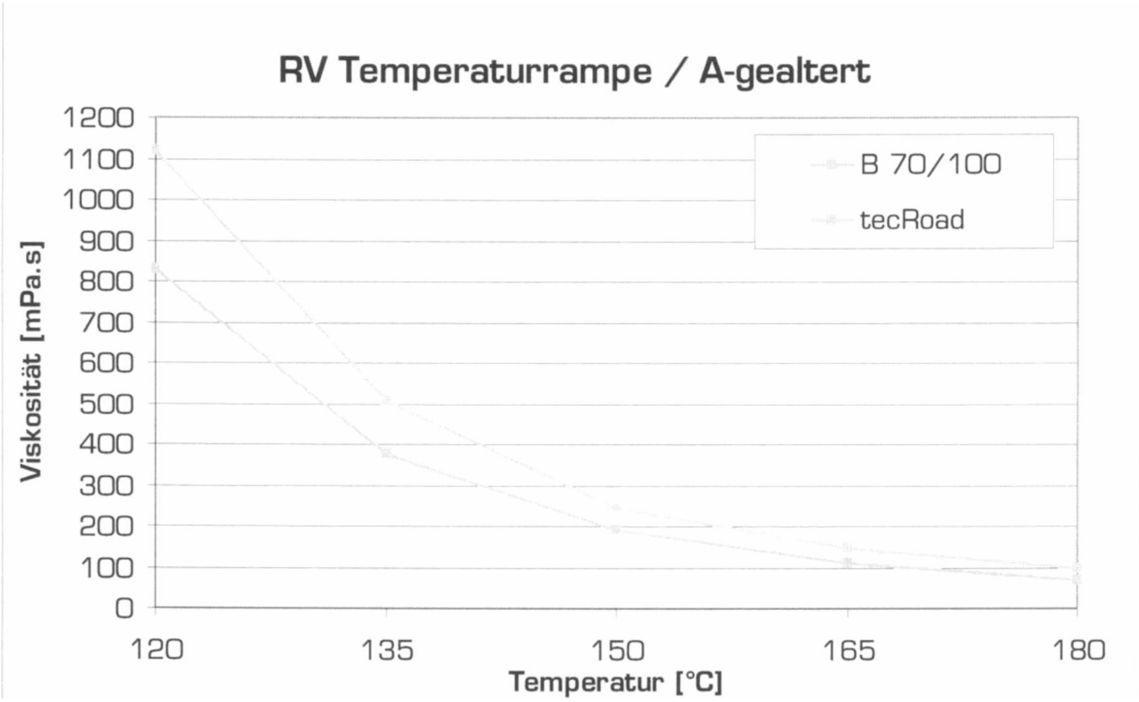
character of tecRoad Premium lowers at an agglomerative raising temperature, moreover, over the total stage of temperatures , confirms a high rate of viscosity as by bitumen 70/100 as well.
Comparing to unmodified bitumen, due to its disadvantage of production in working process, it means, as mixing, und integration.



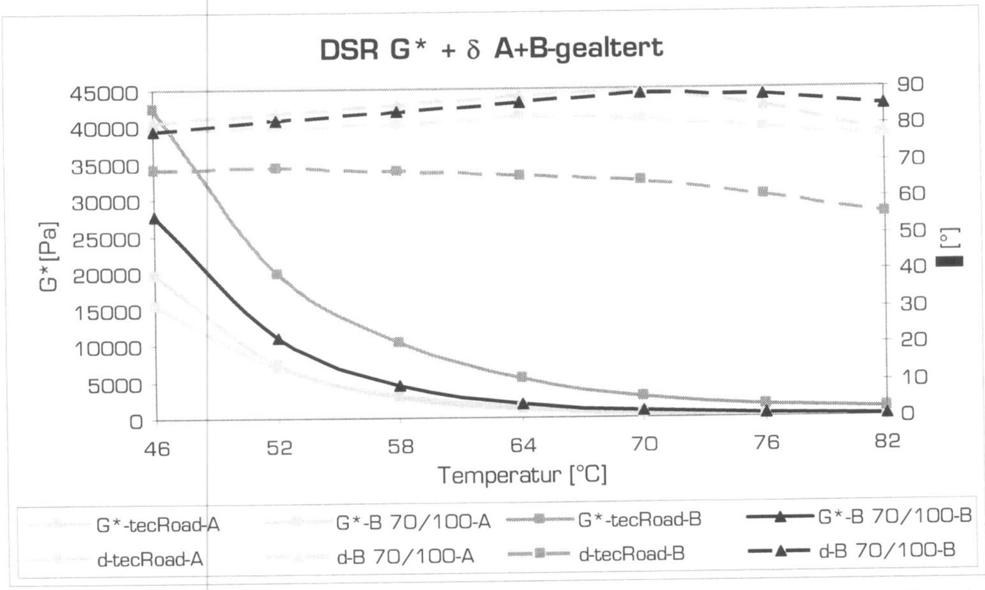
Sheet No. 1 RV Temperature level / A-aging. RV Measurement of RV viscosity value of tecRoad Premium, and 70/100 bitumen.

4.3 DSR result

By mean of DSR, a complex driving module G*, and phase angel Beta of tecRoad Premium with Output rate (A Stage) being confirmed, as well as RTFOT aging stage (B Stage). The measurements were carried out in higher temperature level (46°C to 82°C) with a minus agglomeration of around 6°C.
See the sheets of 2 and 3 are those clarified results- As result of measurements of DSR was granted a complex driving module G*, and also the phase angel o Beta. Through whole procedure of dependent temperatures.
The complex driving module G* is a mass of constancy of material with allowance of Beta phase angel , upon elastic, as well as , viscose part of bonding substance. The smaller the phase angel is, the bigger elastic proportion. The higher a complex driving module is, the smaller phase angel, however, the more efficient deforming characteristic on bonding substance.

Sheet No. 2 where DSR results for the higher temperature between 46°C to 82°C upon tecRoad Premium being clarified in an output stage (Stage A), and in RTFOT ageing stage B . From Sheet 2, is previously , that the complex driving module

G*from tecRoad Premium, in an output Stage A, as good as , in RTFOT ageing stage (Stage B) as per agglomerative temperature against clearly lower. As the same time, the phase angel of tecRoad Premium in output Stage A, nearing stayed unchanged, and reduced in mass lightly per ageing Stage B., it meant, with a agglomerative temperature, a weakening constancy of tecRaod Premium appeared., otherwise, while elastic proportion, nearing constantly stable, is reductive lightly in mass, however, it is to recognize, although in ageing stage B, but with a clearly higher value of driving module(Beta). The elastic proportion on material character is higher ageing process of the product. (Beta curve B stayed the lowest value.)



Sheet No.2 Complex driving module G and phase angel of Beta for tecRoad Premium and bitums 70/100 in Stage A and Stage B.*

Sheet No. 2 , additional result indications of tecRoad Premium, in comparing with DSR results of an original constructive bitum 70/100. As good as in Stage A, and of the same but in RTFOT ageing Stage B. Through it, clearly that tecRoad Premium indicated in an output Stage A. same value of G*, as the same time, the driving module in RTFOT ageing Stage B is reachable as good as to Bitum 70/100. The phase angel from tecRoad Premium as per Stage A, indicated previously same high value, moreover, also high viscose material character as bitum 70/100 following ageing Stage B with a higher elastic material proportion.
Whole process of complex driving module, and of phase angels in high temperature level , indicated same deforming resistance ability from tecRoad Premium, as clearly better of those comparing to bitum 70/100 in ageing stage B.

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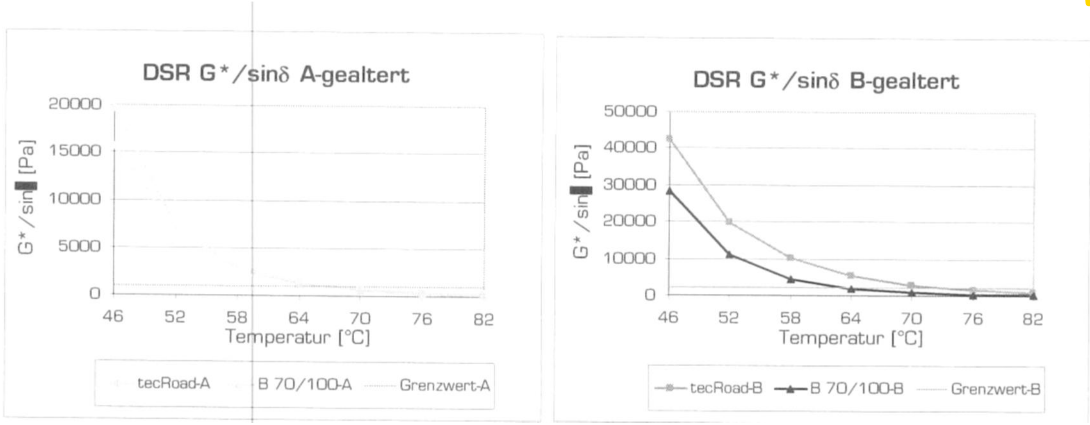

Sheet 3 G is Beta value for tecRoad Premium and Bitum 70/100 in Stage A and Stage B.*

A relative sheet of SUPERPAVE with its G* measuring values concerning to strength resistant and deforming values G*/ sinBeta can be calculated . The higher the driving module, and the smaller the phase angel , the higher resistant against forming furrows. Both values of G* and Beta of outputting bitum, as good as of RTFOT ageing bitum, are measured . Value of outputting bitum (Stage A) as minimized value of G*/sinBeta factor, 1,0kPa was also being measured within sheet SUPERPAVE, nevertheless , the indicated same minimized value for RTFOT ageing bitum is 2,2 kPa (Stage B). According to Sheet No.3, indicated IST-value of G*/sin Beta, in higher temperature level for output stage (Stage A) as well as for RTFOT ageing stage (Stage B). Apparently it showed G* under agglomerative temperature, tending reductive value. For those temperatures , that a tolerance almost exceeded, is high performance grade (high PG) a decisive one. (please see chapter 4.5)
A value of tolerance G*/sin Beta 1,0 kPa at 67°C was being granted, as good as B ageing material of 2,2 kPa at 80°C. In other words, an output stage around the level from bitum 70/100 at ar. 66°C. At Stage ageing B reached tecRoad Premium at 80°C previously same value as bitum 70/100. (63°C for 70/100 bitum .)

4.4. BBR result

A assessment of low temperature behavior is after measuring results of BBR due to its stiff value S and m Values, that are relative to relaxation and crawling ability of materials. A testing on RTFOT and a final PAV ageing tecRoad Premium under temperature level of -12°C to -30°C were being carried out.
According to table 2 , as well as to Sheet No.4 are those results of BBR testing trials are indicated. Such results of BBR measurement are bending resistant value S, and m Value, with the process in a dependent temperature to be indicated.
Value m is a mass for relaxation ability of bonding material . A higher m-value is also an indicator as well, and what a good material is, to reduce cryogenic strength in it.
The lower stiff value S, the higher m value, the better behavior of bonding material in low temperature section.

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Analyse report : Bitumen
Resistent test against hardening under heat and outdoors

F307-3
Page 1 of 1

Co.Name	Rubbertec
Date	25.04.2006
Project	0614E
Resp.Person	Wagner
Standard	Wagner
File Name	EN 12607-1:1999
	-

Maschinen- & Probedaten

Gerät: Rolling Thin Film Oven Cox and Sons CS-235 A

Probe: tecRoad Premium B70/100

Alterungsstufe: B

Analyse result

	RTFOT-Glas A	RTFOT-Glas B
Empty mass (g) -Mo	162,964	158,379
Before Ageing (g)-M1	197,627	195,303
After Ageing (g)-M2	197,676	195,377
Changing mass (g)	0,049	0,074
Changing mass (%)	0,14	0,20

Mid-value of changing mass (%)	0,17

Notice : During trials, all glasses are being shaked, whereas it would not affect directly the changing mass.

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Analyse report : Bitumen
Viscosity check of bitumen with a rotation viscosiometer

F308-5
Seite 1 von 2

Co.Name	Rubbertec
Date	18.04.2006
Project	0614E
Resp.Person	Wagner
Standard	Riedmayer
File Name	EN 13302:2003
	-

Machine & Testing Datas

Gerät: Brookfield Model DV-III
Spindel: SC4-27

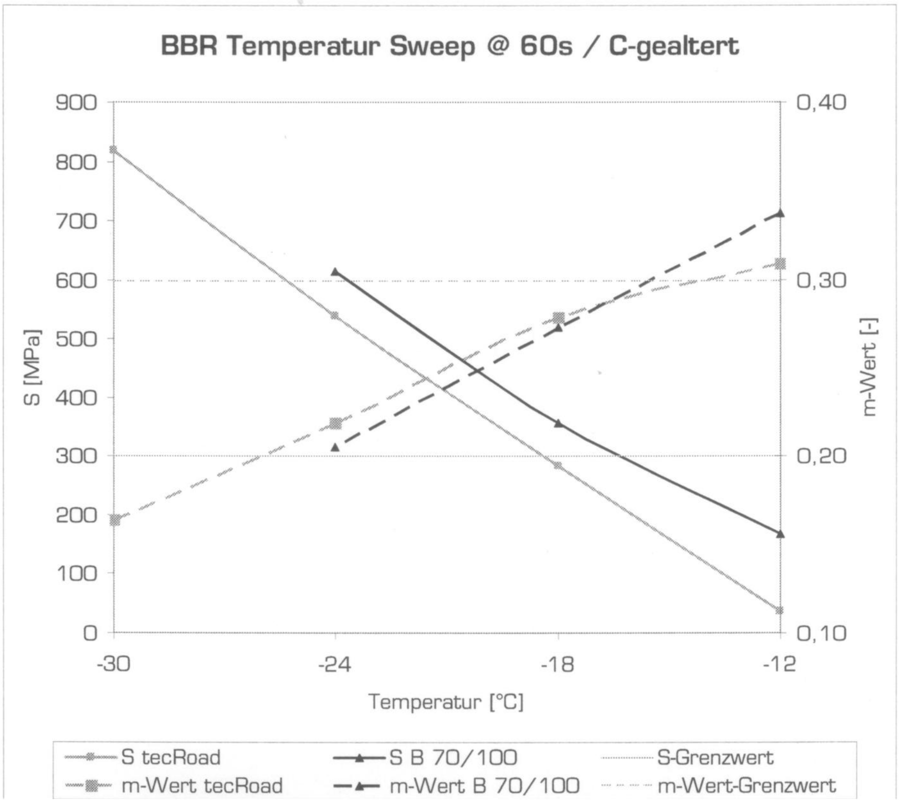
Probe: tecRoad Premium B 70/100

Alterungsstufe: A

Testing result

Messungen	Temperatur [°C]	Speed [U/min]	Torque [%]	Shear Rate [1/s]	Viskosität [mPas]
#1	120	20	8,99	6,8	1125
#2	120	20	8,94	6,8	1112,5
#3	120	20	8,87	6,8	1112,5
#1	135	20	4,07	6,8	512,5
#2	135	20	4,03	6,8	500
#3	135	20	3,99	6,8	500
#1	150	20	2,05	6,8	250
#2	150	20	1,94	6,8	237,5
#3	150	20	1,98	6,8	250
#1	165	20	1,2	6,8	150
#2	165	20	1,15	6,8	137,5
#3	165	20	1,21	6,8	150
#1	180	20	0,81	6,8	100
#2	180	20	0,82	6,8	100
#3	180	20	0,79	6,8	100

Viscosity in mPas at 135°C :
Mid value 504.17
Standard torelance 7.22



Sheet No. 4 : BBR testing trials (S, m-value) for tecRoad Premium and 70/100 bitumen

Apparently to get in sheet No. 4, that stiff ability lowered in higher temperature, and m value is higher, it means, with an agglomerative temperature reduced bending resistant of tecRoad Premium, and increased the relaxation value.

In order to categorize tecRoad Premium in better, according to sheet No.4 there is also grain number for bitumen 70/100 to be read out. Apparently tecRoad Premium clarified less stiff than bitumen 70/100, if it is compared to those with S stiff value and m-value during the whole process. In consideration with those stiff values to conclude a better characteristic performance of tecRoad Premium to bitumen 70/100 in low temperature behavior. The m-value of tecRoad Premium, as like as of bitumen 70/100 indicated the same effect, however, at -12°C lesser and unfavorable of m-value as 70/100. In a view of the processing of m-value, and with its relaxation ability of material m that tecRoad Premium is not advantageous as much as bitumen 70/100.

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Analyse report : Bitumen
Viscosity check of bitumen with a rotation viscosiometer

F308-5
Seite 2 von 2

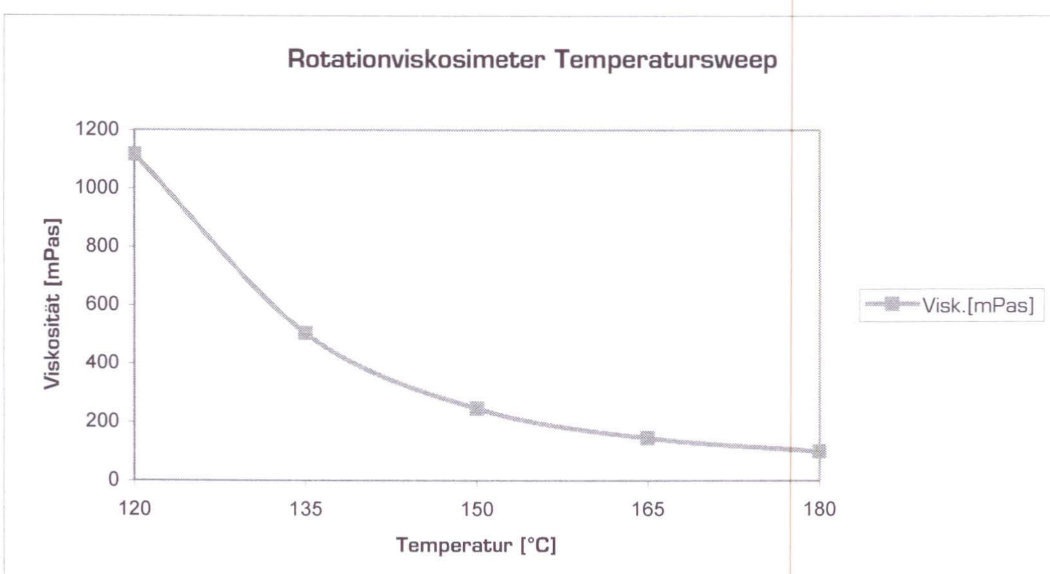
Co.Name	Rubbertec
Date	18.04.2006
Project	0614E
Resp.Person	Wagner
	Riedmayer
Standard	EN 13302:2003
File Name	-

Machine & Testing datas

Gerät:	Brookfield Model DV-III
Spindel:	SC4-21
Probe:	tecRoad Premium B 70/100

Testing result

Temp.[°C]	Visk.[mPas]
120	1117
135	504
150	246
165	146
180	100



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Analyse of complex cutting module & phase angel by mean of Dynamic cutting meter DSR

F304-3
Seite 1 von 2

Co.Name	Fa. Rubbertec
Date	18.04.2006
Project	0614E
Resp.Person	Wagner
Standard	Riedmayer
File Name	prEN 14770 : 2003
	-

Machine & Testing datas

Geräte: Haake RS 50, Julabo F3C
Sensor: Platte 25 mm Spalt 1 mm
A-Faktor: 325800 Pa/Nm M-Faktor: 12500 1/s
Probe: tecRoad Premium B70/100

Alterungsstufe: A

Testing results

	Temp. [°C]	Freq. [Hz]	G* [Pa]	δ [°]	G*/sin δ [Pa]
1_1	46,0	1,6	15400,0	78,9	15693,6
1_2	46,0	1,6	15300,0	78,9	15591,7
2_1	52,0	1,6	6690,0	79,8	6797,4
2_2	52,0	1,6	6690,0	79,9	6795,3
3_1	58,0	1,6	3080,0	80,0	3127,5
3_2	58,0	1,6	3070,0	80,1	3116,4
4_1	64,0	1,6	1410,0	82,6	1421,8
4_2	64,0	1,6	1400,0	82,5	1412,1
5_1	70,0	1,6	708,0	81,8	715,3
5_2	70,0	1,6	709,0	81,7	716,5
6_1	76,0	1,6	396,0	79,5	402,7
6_2	76,0	1,6	395,0	79,5	401,7
7_1	82,0	1,6	242,0	76,7	248,7
7_2	82,0	1,6	240,0	77,0	246,3

Mittelwert:	46,0	1,6	15350,0	78,9	15642,6
	52,0	1,6	6690,0	79,9	6796,4
	58,0	1,6	3075,0	80,1	3122,0
	64,0	1,6	1405,0	82,6	1417,0
	70,0	1,6	708,5	81,8	715,9
	76,0	1,6	395,5	79,5	402,2
	82,0	1,6	241,0	76,9	247,5

Anmerkungen:

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Analyse of complex cutting module & phase angel by mean of Dynamic cutting meter DSR

F304-3
Seite 2 von 2

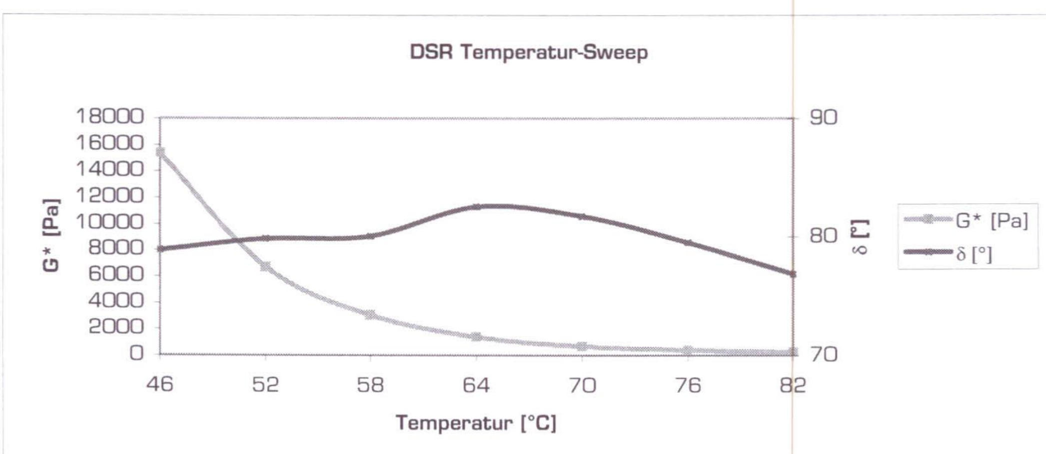
Auftraggeber	Fa. Rubbertec
Datum	18.04.2006
Projekt	0614E
Projektleiter	Wagner
Sachbearbeiter	Riedmayer
Norm	prEN 14770 : 2003
Datenfile Name	-

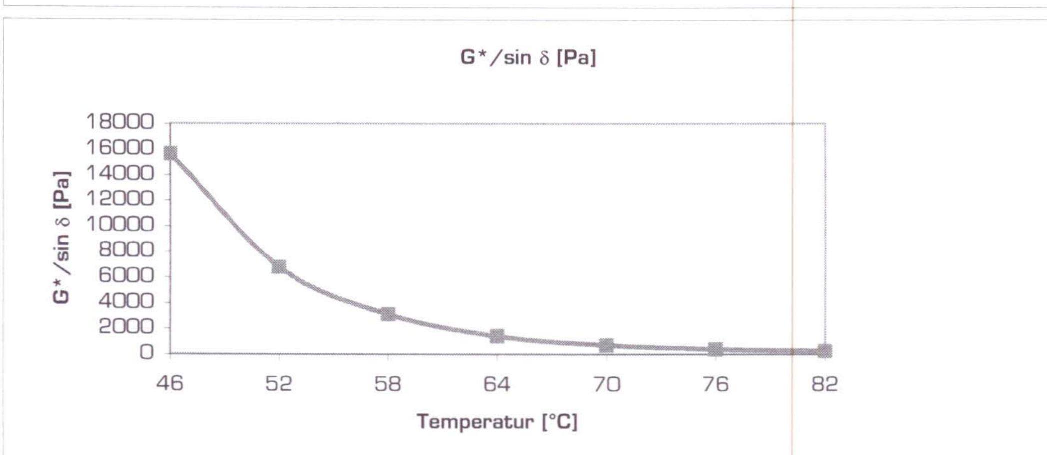
Machine & Testing datas

Geräte: Haake RS 50, Julabo F3C
Sensor: Platte 25 mm Spalt 1 mm
A-Faktor: 325800 Pa/Nm M-Faktor: 12500 1/s
Probe: tecRoad Premium B70/100

Alterungsstufe: A

Testing results





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Analyse of complex cutting module & phase angel by mean of Dynamic cutting meter DSR

F304-3
Seite 1 von 2

Auftraggeber	Fa. Rubbertec
Datum	25.04.2006
Projekt	0614E
Projektleiter	Wagner
Sachbearbeiter	Riedmayer
Norm	prEN 14770 : 2003
Datenfile Name	-

Machine & Datas

Geräte: Haake RS 50, Julabo F3C
Sensor: Platte 25 mm Spalt 1 mm
A-Faktor: 325800 Pa/Nm M-Faktor: 12500 1/s
Probe: tecRoad B70/100

Alterungsstufe: B

Testing results

	Temp. [°C]	Freq. [Hz]	G* [Pa]	δ [°]	G*/sin δ [Pa]
1_1	46,0	1,6	42600,0	67,8	46010,7
1_2	46,0	1,6	42300,0	67,9	45654,3
2_1	52,0	1,6	19800,0	68,5	21280,8
2_2	52,0	1,6	19900,0	68,5	21388,2
3_1	58,0	1,6	9770,0	68,6	10493,5
3_2	58,0	1,6	10800,0	66,7	11759,0
4_1	64,0	1,6	4940,0	67,4	5350,9
4_2	64,0	1,6	5790,0	65,0	6388,6
5_1	70,0	1,6	2720,0	64,9	3003,6
5_2	70,0	1,6	2710,0	65,0	2990,2
6_1	76,0	1,6	1630,0	60,7	1869,1
6_2	76,0	1,6	1620,0	60,6	1859,5
7_1	82,0	1,6	1060,0	55,4	1287,8
7_2	82,0	1,6	1060,0	55,3	1289,3

Mittelwert:	46,0	1,6	42450,0	67,9	45832,5
	52,0	1,6	19850,0	68,5	21334,5
	58,0	1,6	10285,0	67,7	11126,2
	64,0	1,6	5365,0	66,2	5869,7
	70,0	1,6	2715,0	65,0	2996,9
	76,0	1,6	1625,0	60,7	1864,3
	82,0	1,6	1060,0	55,4	1288,5

Anmerkungen:

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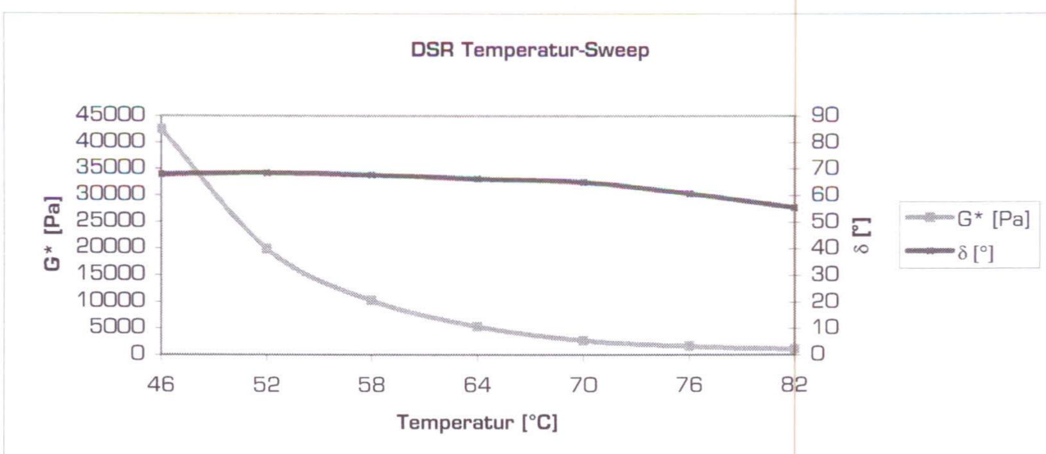
Analyse of complex cutting module & phase angel by mean of Dynamic cutting meter DSR	F304-3 Seite 2 von 2

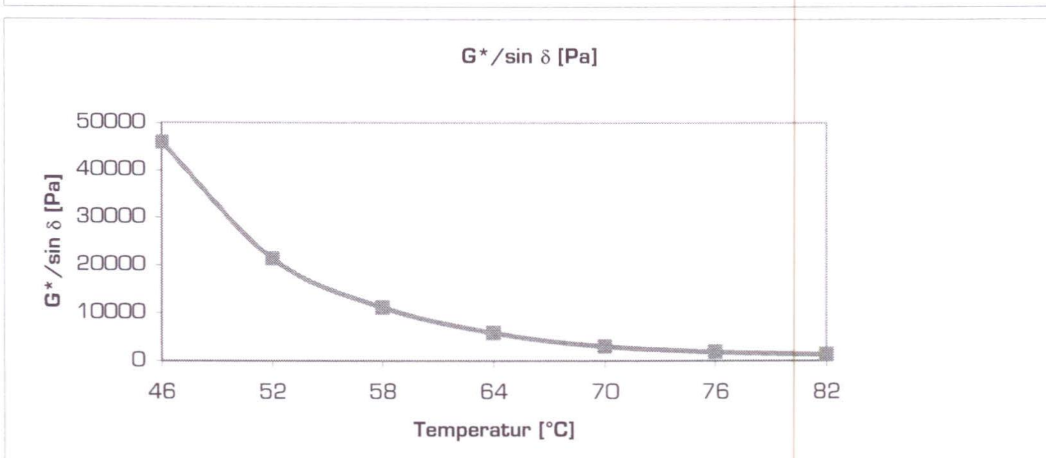
Auftraggeber	Fa. Rubbertec
Datum	25.04.2006
Projekt	0614E
Projektleiter	Wagner
Sachbearbeiter	Riedmayer
Norm	prEN 14770 : 2003
Datenfile Name	-

Machine & Testing datas

Geräte:	Haake RS 50, Julabo F3C		
Sensor:	Platte 25 mm	Spalt	1 mm
A-Faktor:	325800 Pa/Nm	M-Faktor:	12500 1/s
Probe:	tecRoad B70/100		
Alterungsstufe:	B		

Prüfergebnisse





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Analyse report : Bitum
BBR Testing process : Folding & stiff resistent test

F305-3
Seite 1 von 3

Auftraggeber	Fa. Rubbertec
Datum	27.04.2006
Projekt	0614E_Rubbertec
Projektleiter	Wagner
Sachbearbeiter	Wagner
Norm	prEN 14771:2003
Datenfile Name	-

Machine and testing datas

Geräte: BBR Cannon -Zematra; Model 1097
Julabo FP50 + Julabo MV

Probe: tecRoad Premium B 70/100

Alterungsstufe: C

Testing results

Temp. [°C]:	-6		-12		-18	
Zeit [s]	S [MPa]	m-Wert [-]	S [MPa]	m-Wert [-]	S [MPa]	m-Wert [-]
8			70,0	0,260	435,0	0,207
			58,1	0,237	485,0	0,201
15			60,8	0,277	379,0	0,230
			49,7	0,258	424,0	0,225
30			49,9	0,295	320,0	0,255
			41,2	0,282	360,0	0,251
60			40,7	0,313	266,0	0,281
			33,7	0,305	300,0	0,277
120			32,3	0,331	217,0	0,306
			27,0	0,328	245,0	0,304
240			25,5	0,350	174,0	0,331
			21,4	0,352	197,0	0,330

Mittelwerte:

Temp. [°C]:	-6		-12		-18	
Zeit [s]	S [MPa]	m-Wert [-]	S [MPa]	m-Wert [-]	S [MPa]	m-Wert [-]
8			64,1	0,249	460,0	0,204
15			55,3	0,268	401,5	0,228
30			45,6	0,289	340,0	0,253
60			37,2	0,309	283,0	0,279
120			29,7	0,330	231,0	0,305
240			23,5	0,351	185,5	0,331

Anmerkungen:

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Analyse report : Bitum
BBR Testing process : Folding & stiff resistent test

F305-3
Seite 2 von 3

Auftraggeber	Fa. Rubbertec
Datum	27.04.2006
Projekt	0614E_Rubbertec
Projektleiter	Wagner
Sachbearbeiter	Wagner
Norm	prEN 14771 : 2003
Datenfile Name	-

Machine & testing datas

Geräte: BBR Cannon -Zematra; Model 1097
Julabo FP50 + Julabo MV

Probe: tecRoad Premium B 70/100

Alterungsstufe: C

Testing results

Temp. [°C]:	-24		-30		-36	
Zeit [s]	S [MPa]	m-Wert [-]	S [MPa]	m-Wert [-]	S [MPa]	m-Wert [-]
8	789,0	0,149	1070,0	0,108		
	776,0	0,157	1090,0	0,110		
15	714,0	0,169	993,0	0,124		
	699,0	0,177	1010,0	0,128		
30	630,0	0,192	906,0	0,142		
	614,0	0,199	918,0	0,148		
60	547,0	0,215	816,0	0,160		
	530,0	0,222	822,0	0,168		
120	468,0	0,238	726,0	0,177		
	451,0	0,244	727,0	0,188		
240	393,0	0,261	638,0	0,195		
	378,0	0,266	633,0	0,209		

Mittelwerte:

Temp. [°C]:	-24		-30		-36	
Zeit [s]	S [MPa]	m-Wert [-]	S [MPa]	m-Wert [-]	S [MPa]	m-Wert [-]
8	782,5	0,153	1080,0	0,109		
15	706,5	0,173	1001,5	0,126		
30	622,0	0,196	912,0	0,145		
60	538,5	0,219	819,0	0,164		
120	459,5	0,241	726,5	0,183		
240	385,5	0,264	635,5	0,202		

Anmerkungen:

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Analyse report : Bitumen
BBR Testing process : Folding & stiff resistant test

F305-3
Seite 3 von 3

Auftraggeber	Fa. Rubbertec
Datum	27.04.2006
Projekt	0614E_Rubbertec
Projektleiter	Wagner
Sachbearbeiter	Wagner
Norm	prEN 14771 : 2003
Datenfile Name	-

Machine & testing datas

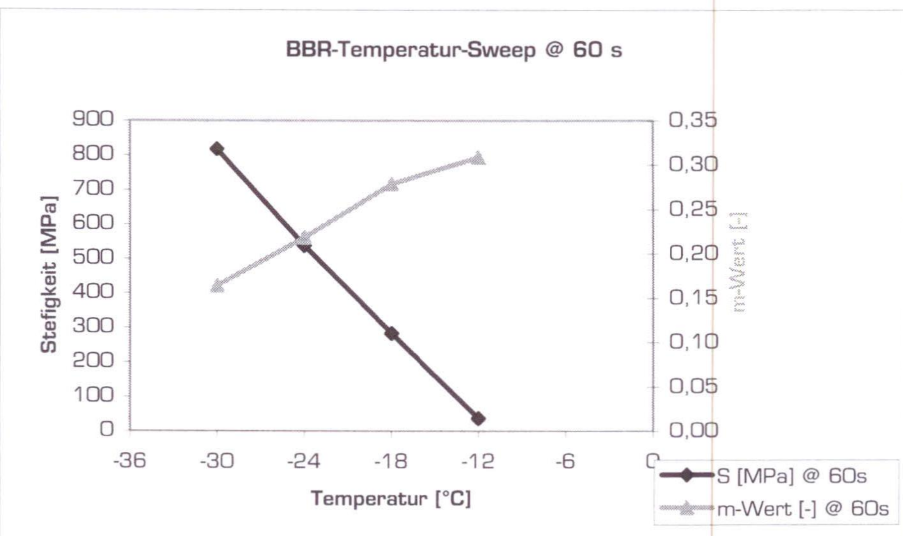
Geräte: BBR Cannon -Zematra; Model 1097
Julabo FP50 + Julabo MV

Probe: tecRoad Premium B 70/100

Alterungsstufe: C

Testing results

Temp.[°C]	S [MPa] @ 60s	m-Wert [-] @ 60s
-6	0,0	0,000
-12	37,2	0,309
-18	283,0	0,279
-24	538,5	0,219
-30	819,0	0,164
-36	0,0	0,000



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Analyse report : Bitumen Performance Grade Testing

F309-3
Seite 1 von 1

Auftraggeber	Rubbertec
Datum	25.04.2006
Projekt	0614E_Rubbertec
Projektleiter	Wagner
Sachbearbeiter	Wagner
Norm	prEN 14770:2003; prEN 14771:2003
Datenfile Name	-

Machine & Testing datas

Probe: tecRoad Premium B70/100

Testing Results

High Temperature Performance Grade

Anforderung:	DSR (Originalbitumen, A)	$G^*/\sin\delta$ > 1 kPa	67	°C
	DSR (RTFOT-gealtert, B)	$G^*/\sin\delta$ > 2,2 kPa	80	°C
High Temperature Performance Grade exakt			67	°C

Low Temperature Performance Grade

Anforderung:	BBR (RTFOT+PAV-gealtert, C)	S (60s) < 300 MPa	-18,4	°C
		m-Wert (60s) > 0,3 [-]	-13,8	°C
Zeit-Temperatur-Superpositionsprinzip:	δ (2h, T_{min}) = δ (60s, T_{min} + 10°C)			
		S < 300 MPa	-28,4	°C
		m-Wert > 0,3 [-]	-23,8	°C
Low Temperature Performance Grade exakt			-23	°C

PERFORMANCE GRADE **PG 67-23** °C

Anmerkungen: