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Application News

No. SCA_300_065

Material Testing System Servopulser

Asphalt Testing Package 4PB – Stiffness Test according to EN 12697-26:2004 Annex B

▪ Introduction

Figure 1: Shimadzu dedicated asphalt testing systems

EN 12697-26:2004 specifies the methods for characterizing the stiffness of bituminous mixtures by alternative tests, including bending tests and direct and indirect tensile tests. The tests are performed on compacted bituminous material under a sinusoidal loading or other controlled loading, using different types of specimens and supports. The procedure is used to rank bituminous mixtures on the basis of stiffness, as a guide to relative performance in the pavement, to obtain data for estimating the structural behavior in the road and to judge test data according to specifications for bituminous mixtures

For this purpose, dedicated testing system was developed based on hydraulic Servopulser system combined with specific tools and sensors. For method development, test control and data collection, upgraded 4830 Software was used, which supplies data for specialized calculation files, developed for 4PB Stiffness calculations.

▪ 4PB Testing Setup

Figure 2: Assembly for 4PB Stiffnes test

- 50 KN EHF-U Servopulser system
- 4PB testing tool (Figure 2)
- QF-40 Hydraulic power supply
- 4830 Controller
- Windows software for 4830 controller
- 4PB Stiffness calculation macro

▪ Testing method

1. based on principle of 4-point bending test,
2. test sample: beams of 450 mm length, 50 mm x 50 mm or 70 mm x 70 mm,
3. LVDT controlled deflection sine wave, mean value = 0, maximum bending strain 50 µm/mm, various frequencies (0.1 Hz to 30 Hz),
4. maximum 3000 cycles should be done to avoid premature fatigue damage.

According to the EN 12697-24:2004 Annex D, this test is applied before fatigue test.

- **Test conditions**

1. Maximum amplitude for the bending strain 50 micro strain (µm/m) (which implies 37.57 µm of deflection in the middle of the setup for 50 mm x 50 mm samples). Deflection is controlled by LVDT sensor integrated into 4PB tool.
2. Various frequencies of sinusoidal loading wave are applied, as shown in Table 1,
3. Tests are performed at room temperature as and 40 ºC,
4. Force, Stroke and 4PB deflection are sampled in last 5 cycles as illustrated in Table 1,
5. Dynamic characteristic values are automatically calculated by 4830 software,

Step No.	Frequency (Hz)	Number of repeats	Sampling Cycle
1	0,1	36	31-35
2	0,2	36	31-35
3	0,5	56	51-55
4	1	106	101-105
5	2	106	101-105
6	5	106	101-105
7	8	306	301-305
8	10	306	301-305
9	20	406	401-405
10	30	506	501-505
11	0,1	26	21-25

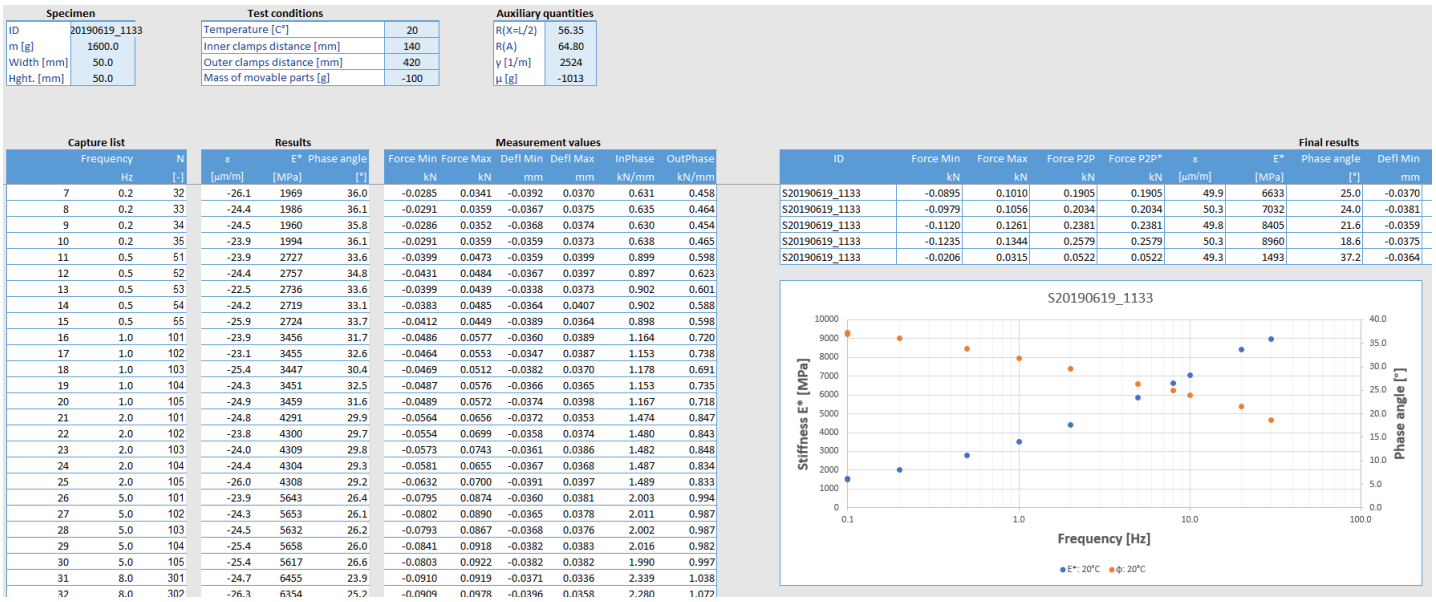
Table 1: Test frequency and number of repeats

Figure 4 shows Result window with results for 5 samples measured at room temperature. Their calculated stiffness and phase angle are shown in regard to the loading frequency.
Mean results table calculates mean value for 5 measured samples and corresponding graph is drawn.

All the asphalt samples show increasing Stiffness with the decrease of the cycle repetition period.
Response of different asphalt mixtures and different porosity can be evaluated in this way at different temperatures.

- **Results and postprocessing**

1. When the test is finished, measurement data and calculated characteristic values are automatically exported to CSV format. Each sample test with its measurement data is represented with one CSV file.
2. Exported measurement data is loaded to calculation file. Relevant sample data as well as test conditions (temperature, 4PB tool geometry, correction factors) are entered.
3. Calculation file calculates actual deflection, resolved stiffness and phase angle. For each sample separate sheet with the results as well as Stiffness and phase angle graphs over test frequency (Figure 3).
4. Results sheet summarizes at one place and shows data for all samples, mean results and graph for mean results (Figure 4).



Specimen

ID	20190619_1133
m [g]	1600.0
Width [mm]	50.0
Hght. [mm]	50.0

Test conditions

Temperature [C°]	20
Inner clamps distance [mm]	140
Outer clamps distance [mm]	420
Mass of movable parts [g]	-100

Auxiliary quantities

R(X=L/2)	56.35
R(A)	64.80
γ [1/m]	2524
µ [g]	-1013

Capture list

	Frequency	N
	Hz	[-]
7	0.2	32
8	0.2	33
9	0.2	34
10	0.2	35
11	0.5	51
12	0.5	52
13	0.5	53
14	0.5	54
15	0.5	55
16	1.0	101
17	1.0	102
18	1.0	103
19	1.0	104
20	1.0	105
21	2.0	101
22	2.0	102
23	2.0	103
24	2.0	104
25	2.0	105
26	5.0	101
27	5.0	102
28	5.0	103
29	5.0	104
30	5.0	105
31	8.0	301
32	8.0	302

Results

	ε	E*	Phase angle
	[µm/m]	[MPa]	[°]
7	-26.1	1969	36.0
8	-24.4	1986	36.1
9	-24.5	1960	35.8
10	-23.9	1994	36.1
11	-23.9	2727	33.6
12	-24.4	2757	34.8
13	-22.5	2736	33.6
14	-24.2	2719	33.1
15	-25.9	2724	33.7
16	-23.9	3456	31.7
17	-23.1	3455	32.6
18	-25.4	3447	30.4
19	-24.3	3451	32.5
20	-24.9	3459	31.6
21	-24.8	4291	29.9
22	-23.8	4300	29.7
23	-24.0	4309	29.8
24	-24.4	4304	29.3
25	-26.0	4308	29.2
26	-23.9	5643	26.4
27	-24.3	5653	26.1
28	-24.5	5632	26.2
29	-25.4	5658	26.0
30	-25.4	5617	26.6
31	-24.7	6455	23.9
32	-26.3	6354	25.2

Measurement values

Force Min	Force Max	Defl Min	Defl Max	InPhase	OutPhase
kN	kN	mm	mm	kN/mm	kN/mm
-0.0285	0.0341	-0.0392	0.0370	0.631	0.458
-0.0291	0.0359	-0.0367	0.0375	0.635	0.464
-0.0286	0.0352	-0.0368	0.0374	0.630	0.454
-0.0291	0.0359	-0.0359	0.0373	0.638	0.465
-0.0399	0.0473	-0.0359	0.0399	0.899	0.598
-0.0431	0.0484	-0.0367	0.0397	0.897	0.623
-0.0399	0.0439	-0.0338	0.0373	0.902	0.601
-0.0383	0.0485	-0.0364	0.0407	0.902	0.588
-0.0412	0.0449	-0.0389	0.0364	0.898	0.598
-0.0486	0.0577	-0.0360	0.0389	1.164	0.720
-0.0464	0.0553	-0.0347	0.0387	1.153	0.738
-0.0469	0.0512	-0.0382	0.0370	1.178	0.691
-0.0487	0.0576	-0.0366	0.0365	1.153	0.735
-0.0489	0.0572	-0.0374	0.0398	1.167	0.718
-0.0564	0.0656	-0.0372	0.0353	1.474	0.847
-0.0554	0.0699	-0.0358	0.0374	1.480	0.843
-0.0573	0.0743	-0.0361	0.0386	1.482	0.848
-0.0581	0.0655	-0.0367	0.0368	1.487	0.834
-0.0632	0.0700	-0.0391	0.0397	1.489	0.833
-0.0795	0.0874	-0.0360	0.0381	2.003	0.994
-0.0802	0.0890	-0.0365	0.0378	2.011	0.987
-0.0793	0.0867	-0.0368	0.0376	2.002	0.987
-0.0841	0.0918	-0.0382	0.0383	2.016	0.982
-0.0803	0.0922	-0.0382	0.0382	1.990	0.997
-0.0910	0.0919	-0.0371	0.0336	2.339	1.038
-0.0909	0.0978	-0.0396	0.0358	2.280	1.072

Final results

ID	Force Min	Force Max	Force P2P	Force P2P*	ε	E*	Phase angle	Defl Min
	kN	kN	kN	kN	[µm/m]	[MPa]	[°]	mm
S20190619_1133	-0.0895	0.1010	0.1905	0.1905	49.9	6633	25.0	-0.0370
S20190619_1133	-0.0979	0.1056	0.2034	0.2034	50.3	7032	24.0	-0.0381
S20190619_1133	-0.1120	0.1261	0.2381	0.2381	49.8	8405	21.6	-0.0359
S20190619_1133	-0.1235	0.1344	0.2579	0.2579	50.3	8960	18.6	-0.0375
S20190619_1133	-0.0206	0.0315	0.0522	0.0522	49.3	1493	37.2	-0.0364

Figure 3: Sample result window

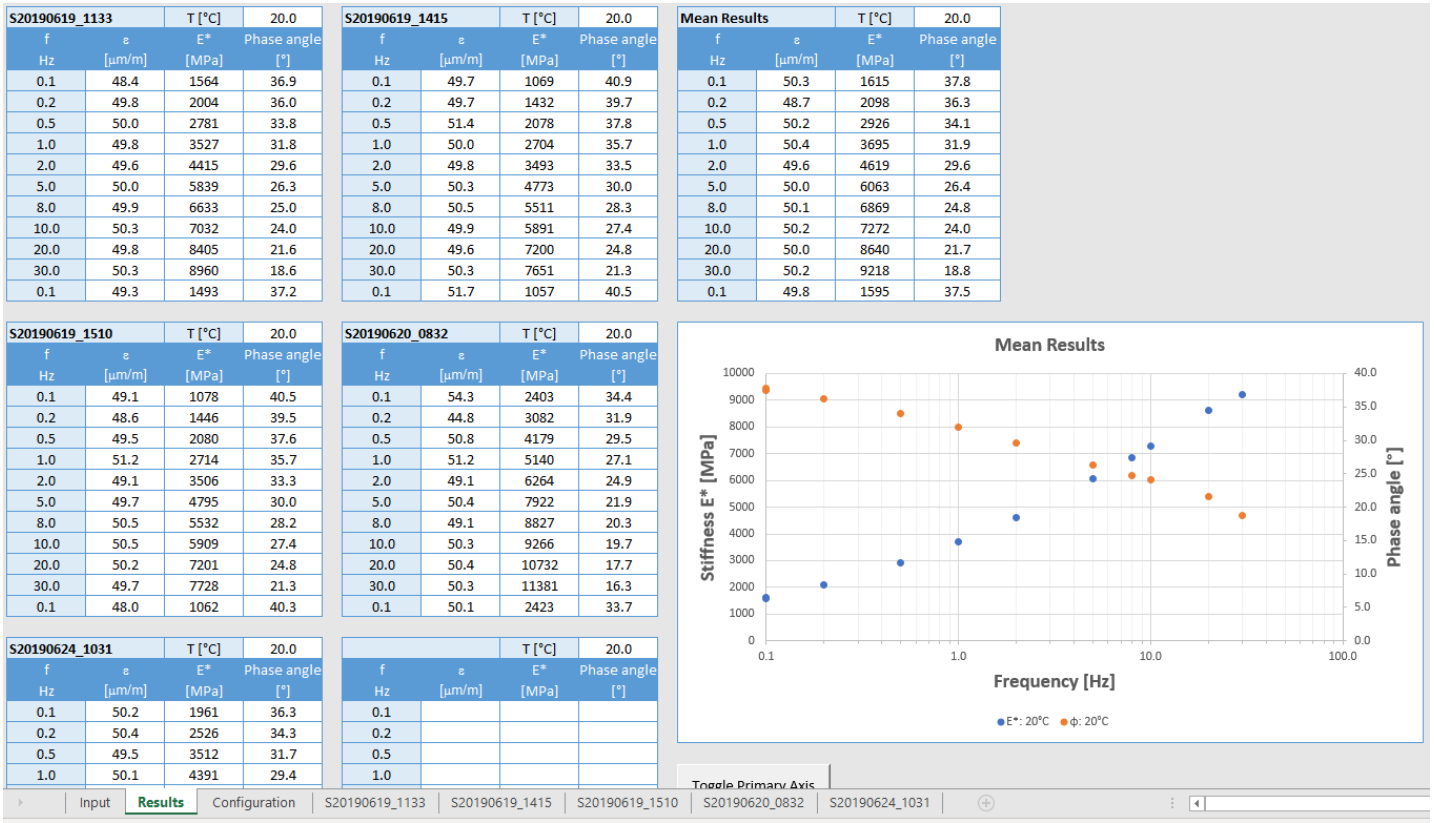


Figure 4: Results window

▪ Summary

EN 12697-26 standard and describe a cyclic bending and indirect tension test protocols for determination of the Stiffness, which the results of the measurements conducted have confirmed as being flexible procedures that can efficiently characterize the mechanical response of both porous and dense bituminous mixtures, over a wide range of temperatures and frequencies.

Shimadzu Asphalt Testing Package provides accuracy and flexibility for such an application.
System is designed to be used for other tests described in EN 12697 standard (such as EN 12697 -26 Annex C IT-CY, EN 12697 -24 Annex E IT-CY, EN 12697 -25 Method B), only by changing the testing support.

▪ Reference

1. Indirect Tensile Test for the Determination of the Stiffness and the Resilient Modulus of Asphalt Concretes: Experimental Analysis of the EN 12697 -26 and the ASTM D 4123 Standards, N. Baldo, M. Dal Ben, M. Pasetto, M. van de Ven & A.A.A. Molenaar
2. Asphalt testing package v 1.1, Shimadzu Europa GmbH, 2019

Shimadzu Europa GmbH

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