Wydział Inżynierii Lądowej

POLITECHNIKA WARSZAWSKA

Building materials

Laboratory excercises

Technical properties of bituminous binders and bituminous hydroinsulating materials

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1. The aim of the laboratory

The aim of the exercise is to test selected technical properties of bituminous binders and hydroinsulating materials according to the procedures described in this manual.

2. Basic information

2.1. Definitions

Product for anti-moisture insulation – a flexible product manufactured from asphalt or its composition, intended for use on or under floors or tiles in contact with the ground or in walls in order to protect against water not exerting hydrostatic pressure;

Product for waterproof insulation – a flexible product manufactured from asphalt or its composition, intended for use in wall constructions or on or under floors or tiles in order to protect against water which exerts hydrostatic pressure, passing from the ground to the internal environment or from one parts of a structure to another;

Underlayment – material introduced into a product or on a waterproofing product in order to ensure its stability and/or mechanical resistance;

Cover layer – material applied to a factory-made waterproofing product, without a permanent mechanical function;

Surface finishing – materials applied to the surfaces of waterproofing products, either as a permanent protection of the upper surface against weather conditions, or as an anti-adhesive spacer on one surface or on both surfaces of waterproofing products;

Manufacturer's limit value (MLV) – value established by the manufacturer which should be obtained during tests. The manufacturer's limit value can be a minimum or maximum value as defined for product properties;

Manufacturer's declared value (MDV) – the value declared by the manufacturer together with the declared tolerance;

Matrix asphalt product – a factory-made flexible layer of asphalt with one or more internal or external matrices incorporated, supplied in a rolled, ready-to-use form;

2.2. Introduction

The laboratory should be carried out according to the schedule given below:

PART I – BITUMEN

1. Using the standards and materials enclosed, get acquainted with the types and grades of bituminous binders and the requirements for the determination of properties considered for their assessment.
2. Using the standards and descriptions of tests included in Appendix No.2, find the ways (methods) of performing determination (measurements) of the following properties of bitumen: **penetration, softening point, ductility, flexibility in low temperature.**.
3. Make the determination of penetration and softening point of the bitumen indicated by the tutor.
4. On the basis of results obtained in particular determinations, identify the bitumen tested (grade and possibly additional classifying notations) together with the assessment of these results according to standard requirements.

PART II – BITUMINOUS MEMBRANES

1. Using the standards and materials enclosed, get acquainted with the types and grades of bituminous membranes and the requirements for the determination of technical properties considered for their assessment.
2. On the basis of standards, find the ways (methods) of performing determination (measurements) of the following properties of bituminous membranes: **flexibility, thermal resistance, permeability, rupturę force (tearing force), elongation at rupture.**
3. Make the determination of flexibility and heat resistance, determine the quantity of rupture force and elongation at rupture for the bituminous membranes indicated by the tutor.
4. On the grounds of results obtained in particular determinations, assess their compliance with standard requirements.

3. Tests to perform

3.1. Tests of technical properties of bitumen

3.1.1. Penetration test

The penetration depth of a 1 mm diameter needle plunged by 5 sec into the tested bitumen sample under 100 g load, at 25º C is measured. The penetration unit (pen) is an abstract number corresponding to 0.1 mm immersion of the penetration needle. The penetrometer (Fig.1) is used to measure the value of penetration. The result is based on the arithmetic mean of not less than 3 measurements with an accuracy of the integer.

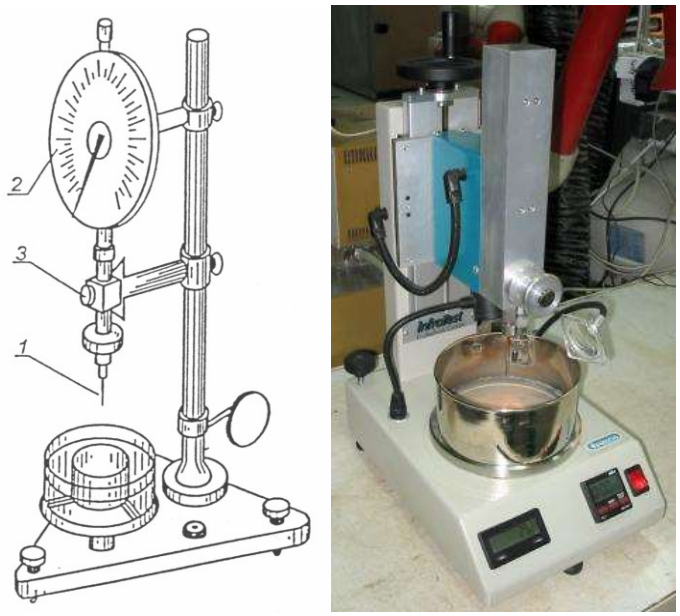


Figure 1. Penetrometer: 1: needle; 2 – plate/disk with 0-360 Pen scale; 3 – pneedle release button.

3.1.2. Ring and ball (R&B) softening point test (PN-EN 1427:2001)

It consists in heating the tested bitumen sample to a temperature that makes the softening bitumen move under the load of a steel ball and touch the apparatus bottom (Fig. 2). This temperature is acknowledged to be the softening point. The determination is made by filling the rings with the bitumen tested and placing standard steel balls on it and putting it into the vessel filled with water. Then the whole set is heated so that the speed of temperature increase is c. 5°C/min. The result is based on the arithmetic mean of at least 2 tests.

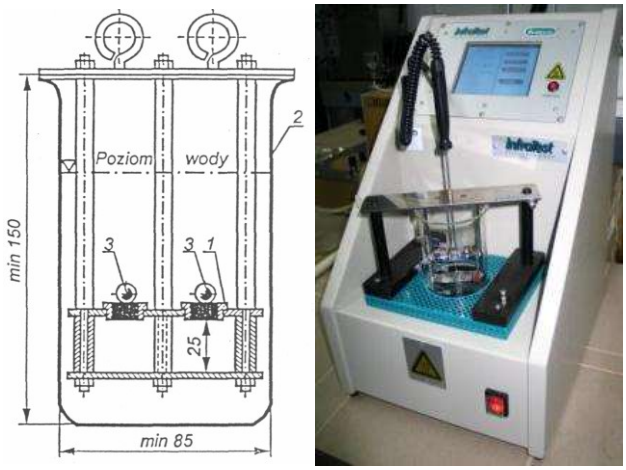


Figure 2. Ring-and-ball apparatus: 1-ring filled with bitumen, 2-glass beaker, 3-steel balls (dimensions in mm).

3.1.3. Ductility test (PN-EN 13587:2005 (U))

It consists in defining the maximum length, in cm, to which a sample may be stretched in ductilometer (Fig. 3) without rupture/breaking. A number-eight shaped bitumen sample (Fig.4) is stretched in water (in ductilometer) at the temperature of 25º C and at 5cm/min speed. The bath viscosity should be equal to the viscosity of bitumen. If the bitumen tested is more viscous than water, then sodium chloride or glycerine should be added to the ductilometer water. If bitumen viscosity is lower, then add ethanol to the water. When observing the bitumen sample, the location of ductilometer pointer at the moment of bitumen rupture should be noted. The result is the arithmetic mean of at least 3 tests.

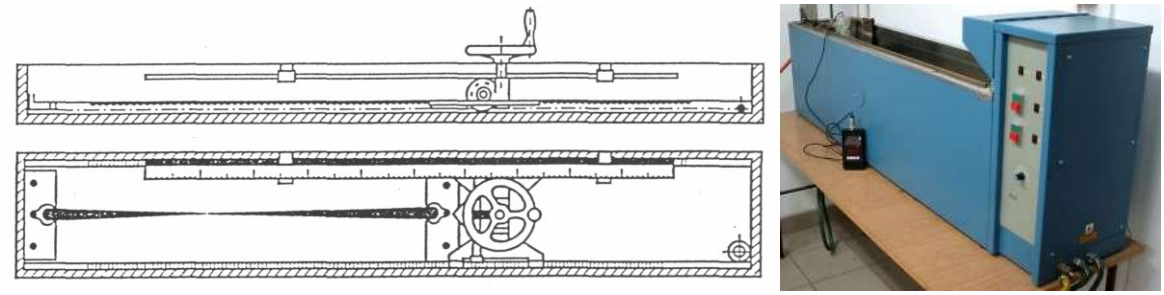


Figure 3. Ductilometer.

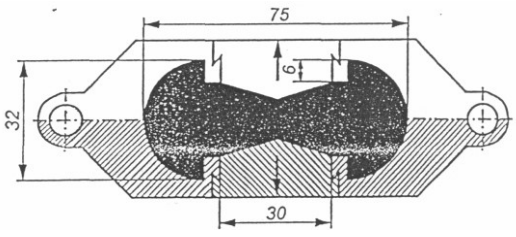


Figure 4. Bitumen sample prepared for bitumen ductility test (dimensions in mm).

3.1.4. Flexibility in low temperature test (PN-EN 12593:2004)

It consists in cooling a steel plate with a layer of bitumen tested in the Frass apparatus (Fig.5) and conducting a bending test. The initial temperature is of 10°C higher than brittle point. Then the temperature is reduced and the steel plate bent until reaching the temperature at which a first crack or fracture of the bitumen tested is visible. The result is based on the arithmetic mean of 3 tests at least. The results should be given with an accuracy of 1°C.

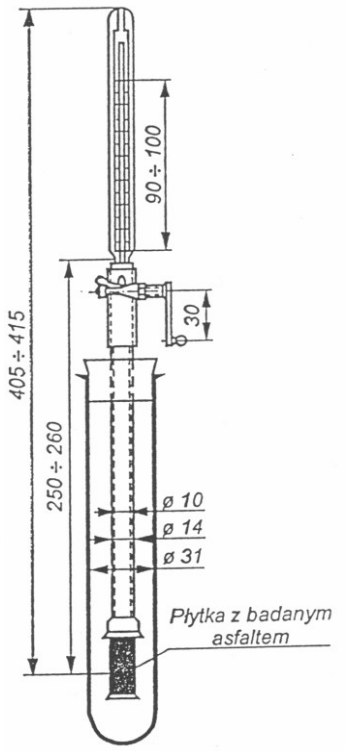


Figure 5. Frass apparatus (dimensions in mm).

3.2. Technical properties of bituminous membranes (PN-90/B-04615)

3.2.1. Membrance apperance

It is conducted by unrolling the bituminous membrane, checking the equality and condition of edges of the ribbon as well as uniformity of surface, with special consideration given to mechanical damage. Other elements to be checked:

- in case of isolation membranes - weatherproofing mass should not occur in excess to avoid membrane sticking in a roll.
- in case of both sides coated membranes - mineral shake-on should be evenly distributed.
- in membranes with metal or plastic foil – a foil making an outer layer should be precisely glued to the matrix covered with bitumen mass/mix, and the bitumen mass/mix on the underside of the foil should adhere well and be evenly distributed.

3.2.2. Size

It consists in measuring the width and length of membrane ribbon. The width should be taken with an accuracy of 1cm, the length – 5 cm.

3.2.3. Flexibility test

Test should be done on blocks (e.g. metal blocks of size given in Fig.1) or on a rod of equivalent diameter. Test temperature and block diameters - according to subject standards. Four pieces of unit samples intended for flexibility testing (for each temperature included in the subject standard) should be stored together with blocks or rods of diameters given, in the following way:

- in water of 20°C over 10 ± 15 minutes.
- in water of 4°C over c. 30 minutes.
- in iced water of 0°C over c. 30 minutes.

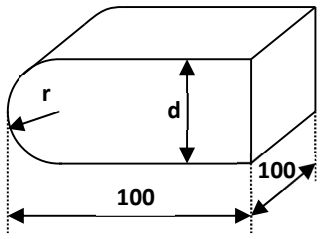


Figure 6. Master model for bituminous membrane flexibility testing (size in mm).

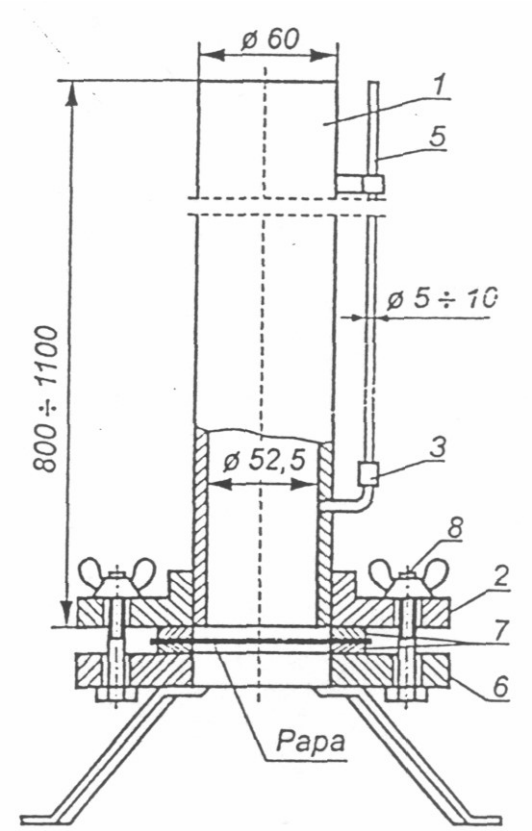
Measurement time from the moment of taking the samples out of water should not be longer than 15 s. After taking a sample out, it should be bent once around a rod or block through an arc of 180° and outer surface should be observed with the naked eye. If we test a bituminous membrane with outer foil covering, the sample underside should be watched. Test result is considered positive if at least three samples tested do not show any cracks or fractures.

3.2.4. Permeability test

It is conducted in an apparatus shown in Fig.2. A 6÷8 thick ring (2) of 165 mm outer diameter is tightly fixed to a 500÷2000 mm long pipe (1) of 52.5 mm inner diameter. The bottom surface of the ring is smoothly machined. C. 80 mm above the ring there is a curved (L-shaped) pipe (3) of 5÷10 mm diameter, with a tightly placed calibrated glass pipe (5) inside. The calibrated pipe is used to measure the fluid level in pipe (1). A ring (6) of outer and inner diameters equal to the upper ring diameters is fixed with 3 screws (8) to ring (2). The upper surface of the bottom

ring should be smoothly machined. Two 3÷5mm thick rubber gaskets (7) of inner diameter c. 35 mm are put between the two rings.

Figure 2. Apparatus for permeability test.



Three legs making the apparatus base are attached to the bottom ring. Testing should be performed in the following way:Three unit samples are placed separately between the rubber gaskets. Before fixing the gaskets, a circle of filter paper is placed on the bottom of the sample so that it adheres closely to the membrane. On putting the sample with the gaskets into the apparatus, the sample is clamped with 3 screws - tightly but carefully, not to cause damage. Water is carefully poured into the pipe, up to a depth defined in the relevant subject standard. After a standard-defined period of time, it should be observed if the bituminous membrane shows any sign of leaks, seen as spots on the filter paper. The result is considered positive if all samples tested meet the requirements.

3.2.5. Heat resistance test

Testing is done on six unit samples (three of lengthwise direction and three of crosswise direction), which should be loosely suspended in the direction of a longer edge in a dryer heated to a constant temperature given in the subject standard. After 2 hours, the samples should be removed from the dryer, cooled and possible changes in their appearance should be described

(curtaining of coat, blisters, shoulders, etc.). If five out of six samples tested do not show any negative changes defined in the subject standard, the test result should be considered positive.

3.2.6. Tensile strength test

Ten unit samples (five of lengthwise direction and five of crosswise direction) are exposed to four-hour air conditioning at the temperature of 20°C. When testing insulation bituminous membranes, relative humidity during the air conditioning should be app. 65%. When placing the samples at the tensile testing machine, a strip of bituminous membrane must be fixed between jaw chucks to keep a 200-mm distance between the jaws. The load of tested sample at rupture should rise at a uniform rate; tension speed should be 40 mm/min. If the sample is broken at a distance of less than or equal to 2 cm from the clamp, another measurement on a new sample is recommended. The tensile strength value should be calculated in kN, as the arithmetic mean separately for lengthwise and crosswise direction samples.

3.2.7. Elongation at break point test

It should be conducted during the check of breaking load at the moment of rupture or tear of the strip (dynamometer indicator withdrawal) when the increment of ΔL sample length is read. Unit elongation ε is calculated, separately as the arithmetic mean for lengthwise and crosswise direction of sample, according to the formula:

$$\varepsilon = \frac{\Delta L}{L} \cdot 100\ [\%]$$

where ΔL - increment of length at the moment of rupture or tear of the strip [mm], L - primary sample length between the machine clamps [mm].

4. Summary of test results

Table 1. Results obtained in bitumen properties tests:: ……..

(type, variety of bitumen)

No	Property		Test result	Requirements acc. to standard.....
1	Penetration at 25°C, 1/10 mm			
2	Softening point by R&B, °C			
3 *)	Brittleness temperature, °C			
4 *)	Ductility	at 25 °C, cm		
		at 15 °C, cm		
Conclusions:				
*) determination result is given by the tutor				

Table 2. Results obtained in bituminous membranes properties tests: ……

(type, variety of bituminous membrane)

No	Property		Test result	Requirements acc. to standard.....
1	Flexibility	at 20 ± 2°C		
		at 0 ± 2°C		
2	Heat resistance at 70 ± 2°C			
3	Permeability	Water test over 72 h		
		Water test over 100 h		
4	Tensile strength, N			
5	Elongation at brake, %			
Conclusions:				

5. Report

The report should include the following points:

I. Subject of research
(basic information about the tested materials)

II. Research results
(the results of tests performer during laboratory class, presented in a manner indicated in the 'summary of results' section)

III. Conclusions
(list of findings formulated on the basis of the conducted research)

IV. Literature
(list of references used to prepare the report)

6. Appendixes

6.1. Technical properties of road bitumious binders and industrial bitumious binders (PS)

Table 1. Technical properties of road bituminous binders acc. to PN-EN 12591:2002.

Property	Unit	Type of bitumen						
		20/30	35/50	50/70	70/100	100/150	160/220	250/330
Penetration at 25°C	Penetration degree (0,1 mm)	20-30	35-50	50-70	70-100	100-150	160-220	250-330
Softening temperature	°C	55-63	50-58	46-54	43-51	39-47	35-43	30-38
Combustion temperature	Not lower than, °C	240	240	230	230	230	220	220
Brittleness temperature,	Not higher than, °C	-	-5	-8	-10	-12	-15	-16
Dynamic viscosity at 60°C,	Not less than, Pa · s	440	225	145	90	55	30	18

Ductility test – only for polymer-modified bitumen.

Table 2. Technical properties of industrial bituminous binders (PS).

Property	Unit	Type of bitumen				
		40/175*)	75/30	85/25	85/40	105/15
Penetration at 25°C	Penetration degree (0,1 mm)	120÷200	10÷35	20÷30	35÷45	10÷25
Softening temperature	°C	38÷47	70÷80	80÷90	80÷90	100÷110
Ductility at 25°C	Not less than, cm	25	4	3	3	2
Brittleness temperature	Not more than, °C	-12	-12	-20	-20	-7
Dynamic viscosity at 60°C,	Not less than, Pa · s	18	30	55	90	145

*) the numerator of bitumen determination, e.g. 40/175, indicates the arithmetic mean of softening point in Celsius degrees – 40°C , while the denominator – the mean value of penetration in penetration degrees - 175.

6.2. Technical properties of bituminous membranes

Table 1. Technical properties of bituminous membranes

Property	Glass fleece											Polyester 'non-woven'under-layer		
	Under layer				Top layer									
	64/ 1200	100/ 1200	100/ 1400	100/ 1600	64/ 1200	64/ 2000	100/ 1200	100/ 1400	100/ 1600	100/ 2000	100/ 1600	P/ 1600	P/ 2000	P/ 2400
Tensile strength of a 50 mm strip, not less than [N]	200	280			200	320	280			320	300	250		
Elongation at break, not less than [%]	2											20		
No cracks on the top surface of bituminous membrane while bending around a mandrel/rod of diameter [cm], At the temperature: 20°C	4				6	4				6	4	2	4	
0°C	6	7	8	6	10	6	7	8	10	8		5	7	
No permeability over 100 hours under a column of water of height [cm]	50				-	50				-	50	50	100	
Heat resistance – no changes allowed at testing over 2 h at the temperature of [°C]	70											70		
Length of the roll [m]	10, 15 or 20											10	15	20
Width of the roll [cm]	100													

Tab.2. Technical properties of torch-on bituminous membranes.

Property	Reinforcement						
	Double needled, glass fabric and fleece			Polyester 'non-woven'			
	PZ/2500	PZ/3000	WZ/2500	PZ/2500	PZ/3000	WZ/2500	Polier-modified bitumen
Tensile strength, not less than [N]: - along - across	900 900			800 400			800 600
Elongation at rupture, not less than [%]: - along - across	3 3			30 40			40 40
Permeability - no water permeability	under pressure 0.5 MPa over 10 min						under pressure 0.2 MPa over 24h
Thermal resistance: no water flow	2 hours at 70°C						2 hours at -25°C
Flexibility – no cracks or fractures at bending through an arc of 180° at a diameter [mm] and temperature [°C]	50mm, 20°C 200mm, 0°C 250mm, -5°C						30mm at -25°C
Sizes: - length [m] - width [cm]	10 100						10 95, 100 lub 105

Tab.3. Technical properties of bituminous membranes (on building paperboard).

Property		Membrane type															
		Isolation			Underlayer							Top layer					
		Membrane variety															
		1400/1400	1400/1600	1420/1600	P/400/1100	P/400/1200	P/400/1400	P/400/1600	P/500/1300	P/500/1500	P/500/1700	W/400/1200	W/400/1400	W/440/1600	W/550/1300	W/500/1500	W/500/1700
Flexibility	at 20±2°C, when bent over a block of [mm] diameter, on half-perimeter]	15															
		cracks and fractures on the outer surface inadmissible															
	at 0 ± 2°C, when bent over a block of [mm] diameter, on half-perimeter	50	60		50	60						50	60				
		cracks and fractures on the outer surface inadmissible															
Heat resistance		70±2°C within 2h, shoulders and curtaining inadmissible															
Permeability	under a column of water of [cm] height over 72 hours	100			500												
		500	1000		inadmissible												
	under a column of water of [cm] height over 100 hours	500	1000		500		1000		500		1000	500		1000	500		1000
		inadmissible															
Tensile strength of 50 mm sample, the mean of both directions, not less than [N]		150	315		250	315			345			315			345		
Elongation at rupture, not less than [%]		2															
Roll sizes	length [m]	20; 40; 60			10; 15 or 20												
	width [cm]	90; 95; 100; 105 or 110															

7. Recommended supplementary literature

- Chojczak W., Materiały budowlane. Drewno, szkło, lepiszcza bitumiczne, tworzywa sztuczne. Ćwiczenia laboratoryjne. Część 2, OWPW, 2018
- Praca zbiorowa, Budownictwo ogólne. Tom I. Materiały i wyroby budowlane. Arkady, 2010