BINDERS

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1. LIME

Generalities

The lime is a non-hydraulic binder compounds in principal from calcium hydroxide or oxide which is low hardened under carbon dioxide effect from the air (according to SR ENV 459-1/1997). It is obtained by calcinations of limestone (**$CaCO_3$**) and/or dolomite (**$CaCO_3 \cdot MgCO_3$**) like in relation:

$$CaCO_3 \xrightarrow{(1100\text{-}1200)\ ^oC} CaO + CO_2 - 42.5\ \text{kcal/mol} \quad (1)$$

The unslaked lime (**CaO**) has in composition especially calcium and dolomite oxides. It can have different graininess from the slumps until the fine powders.

By hydration of unslaked lime slake lime, will result, which is compound by calcium hydroxide **$Ca(OH)_2$** in principal and magnesium hydroxide **$Mg(OH)_2$** come time like in the following chemical reaction:

$$CaO + H_2O \Rightarrow Ca(OH)_2 + Q\uparrow \qquad (2)$$

The slake lime is presented in powder or paste.

Type of powder lime is presented in table 1.

Table 1 *Type of powder lime*

Lime type	**Symbol**	**% (CaO+MgO)**	**% MgO**
Calcium lime	CL90	≥ 90	≤ 5
	CL80	≥ 80	≤ 5
	CL70	≥ 70	≤ 5
Dolomite lime	DL85	≥ 85	≥ 30
	DL80	≥ 80	> 5

During the experimental determinations laboratory for powder slaked lime fineness and bulk density will be determined.

1.1. Fineness Determination

Determination of fineness is made by sifting of powder lime using the standard sieves of 0.09 mm and 0.20 mm eyes mesh diameters (according to SR EN 459-2/1997, SR EN 196-6/1994).

The steps to realise the experimental determination:

- a quantity of lime **m** =10 g is weighted;
- the sample is put over the sieve and the sifting begins;
- the start is with 0.20 mm sieve;
- the material which past through 0.20 mm sieve is sifted with 0.20 mm sieve;
- the material which remains on 0.20 mm sieve is noted $\mathbf{m_1}$ and the material which remains on 0.09 mm sieve is noted $\mathbf{m_2}$.

The rests remain on sieve are express like in relations:

$$\%R_{0.20} = \frac{m_1}{m} \times 100 \qquad (3)$$

$$\%R_{009} = \frac{m_1 + m_2}{m} \times 100 \qquad (4)$$

The final result is an average of 2 determinations.

The SR ENV 459-1/1997 standard regarding the quality lime characteristics request like: $\%R_{020} < 2\%$ and $\%R_{009} < 7\%$.

1.2. Bulk Density Determination

The powder lime is sifted through 2 mm eyes mesh diameter to prevent the agglomerated materials.

The device from figure 1 is used for this determination according to SR EN 459-2/1997.

The work technology:

- the funnel is unfilled until the powder lime exceeds beyond the borders;
- the gate is opened and after 2 minutes the tube is takes out;
- the powder lime which is in excess is cut out with a metal rule;
- by weighting, the mass **m** of the lime from the tank is established.

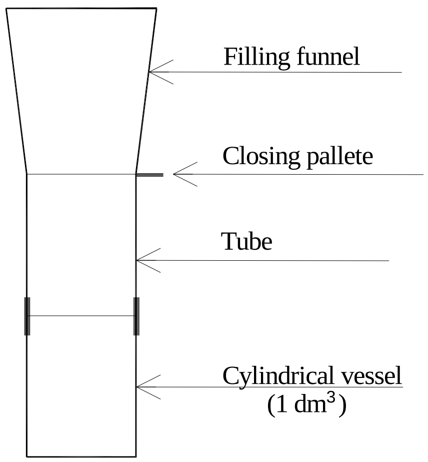

Fig. 1

The bulk density is calculated by:

$$\rho_g = \frac{m}{V} \qquad (kg/m^3) \qquad (5)$$

where: m – the lime mass from the tank, in kg;

V - the tank volume, in m^3.

The final result is an average of three determinations.

The bulk density has the values between 300 and 600 kg/m^3 for calcium lime and between 4000 and 600 kg/m^3 for dolomite lime (according to SR ENV 459-1/1997)

2. BUILDING PLASTER

Generalities

The building plaster is a non-hydraulic binder. Main components of plaster is semi-hydrated (**$CaSO_4 \cdot 0{,}5H_2O$**) blended with variable quantities of soluble anhydrite (**$CaSO_4$**). It is obtaining by partial dehydration of gypsum (plaster stone) at a temperature between (200-300) ^oC proceeding with reaction:

$$CaSO_4 \cdot 2H_2O \xrightarrow{\qquad\qquad} CaSO_4 \cdot 0.5H_2O + 1.5H_2O \qquad (6)$$

To establish the plaster qualities the next physical and mechanical determinations are necessary: the milling fineness, bulk density in aeration stage, water for normal consistency paste, setting time, mechanical strengths etc.

2.1. Determination of the Milling Fineness

The milling fineness of plaster is established by sifting a mass of **m_0** = 100 g of plaster dried at 40 ^oC through 071 and 020 sieves. The sifting can be made manually or mechanically. For mechanically sifting, 125 oscillations/minutes are applied. After each 25 oscillations, the sieve is rotated with 90^o. To prevent the filling up, eyes mash is necessary to brush the exterior sieve side with a light brush.

The sifting is considered finished when the quantities of materials which pass through the sieve during 1 minute is not over 0.4 g for 071 sieve and 0.1 g for 020 sieve. It can be started with 071 sieve and the materials which past through this sieve will be sift on 020 sieve. The material which is remained on 071 sieves is noted **m_1** and the material which is remained on 020 sieves is noted **m_2**.

The remainders on the sieves can be expressed like these:

$$\%R_{071} = \frac{m_1}{m_0} \times 100 \qquad \%R_{020} = \frac{m_1 + m_2}{m_0} \times 100 \qquad (7\ a,\ b)$$

The final result is an average of two determinations.

The milling fineness has an influence of the water for normal consistency paste, setting time and mechanical strengths of plaster.

2.2. Determination of Bulk Density in Aerated Stage

The bulk density in aerated stage results by weighting the plaster volume obtained by touring of plaster from the certain height into the measurement tank (according to SR ISO 3049-1996).

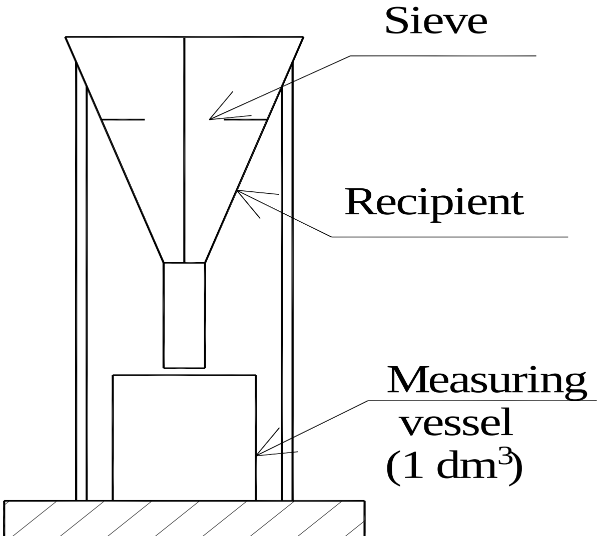

Fig. 2

The full plaster tank is weighted **(m_1)**.

The plaster is introduced into the tank by the help of the device from figure 4.2.

The empty tank is weighted **(m_0)**.

The plaster is toured over the sieve using a quantity equal with 100 g.

The timber spoon is used to mix the plaster to pass easily through the eyes mesh sieve.

When the tank is full, the excess is removed with a rule.

The bulk density in aerated stage is calculated by:

$$\rho_{ga} = \frac{m_1 - m_0}{V} \qquad [kg/m^3] \qquad (8)$$

where:

ρ_{ga} - the bulk density in aeration stage, in kg/m^3;

m_1 – the plaster tank mass, in kg;

m_0 – the empty tank mass, in kg;

V – the tank volume, in m^3.

The result is an average of 2 determinations.

2.3. Determination of Water for Normal Consistency Paste

This determination establishes the water quantity used to obtain some normal consistency paste utilised to prepare a pie with 78 – 80 mm diameter (in according to. SR 10275/1-1997).

The steps to obtain normal consistency paste are:

- into the fine ceramics tank cca 130 g of distilled water (**m_1**) are introduced and 0.2 g of sodium citrate is dissolved;
- a quantity **m_0** = 200 g of plaster is weighted and spread in 30 s time;
- the mixture has a break during a 30 s and after that the mixture is handle-made for a minute;
- the paste is introduced into steel ring with specific dimensions which is put down over a glass plate;
- the excess paste is removed;

- after max. 30 s over started time the ring is vertically elevated;

- in this moment the plaster paste will make a pie;

- if the medium diameter of pie is between 78 … 80 mm, the paste has a normal consistency; when a pie with another diameter is obtained, another determination will be made with variable quantities of water;

- the water quantity to obtain normal consistency paste is calculated with formula:

$$\%Water = \frac{m_1}{m_0} \times 100 \tag{9}$$

where:

A - the water for normal consistency paste, in %;
m_1- the water mass used, in g;
m_0- the plaster sample mass, in g.

2.4. Determination of Setting Time

Determination of setting time is realised on normal consistency paste using the Vicat device, which are showed in figure 3. Setting time is defined by beginning time and ending time. The paste is realized by means of 200 g plaster and the water used to obtain the normal consistency paste, without sodium citrate. The procedure to prepare the paste is the same like that presented before. The paste obtained this way is introduced into the Vicat device ring. The paste surface is levelled with a rule. The ring with paste is put in Vicat base plate. At intervals of 1 minute, the Vicat needle is taken down until at paste surface and permits to enter into paste.

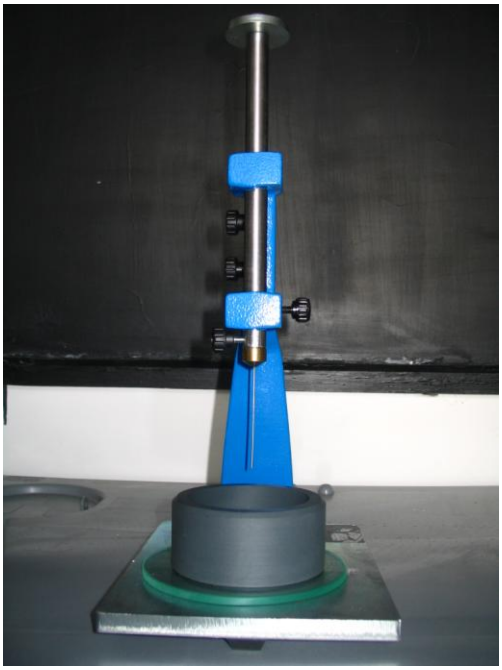

Fig. 3.a. Vicat apparatus

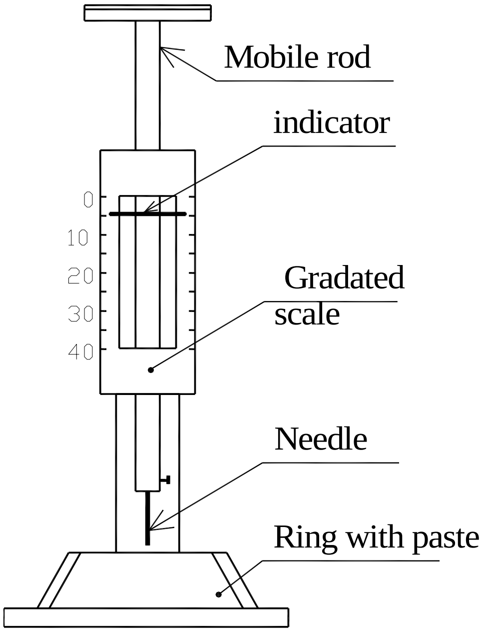

Fig. 3.b. Vicat apparatus

The beginning time is the time interval express on minutes from the moment the plaster was introduced into water until the needle enter in paste maximum 30 mm.

The ending time is the time interval expressed on minutes from the moment the plaster was introduced into water until the needle does not enter in paste.

The result is an average of 2 determinations.

2.5. Determinations of Mechanical Strengths

The mechanical strength are determined on prismatic samples of 40×40×160 mm (according to STAS 10275/4-1991) realised from normal consistency paste (without retarding admixtures).

The paste is prepared from 1200g plaster and water corresponding to normal consistency.

The samples are pulled out from the steel mould after 2 hours. The mechanical strengths are determined at 2 hours and 7 days.

The samples which are tested at 2 hours are kept in the laboratory clime until the test. The samples which are tested at 7 days are kept during the 6 days into the laboratory climate (the temperature in between 15…25 ^{o}C and 60…70% relative humidity of the air) and after this they are dried until constant mass into the oven at 40 ^{o}C. The samples are cooled to room temperature.

The tensile strength is determined by the test of the prismatic samples at bending using a hydraulic machine.

The test scheme is showed in figure 4.

The tensile strength (**f_{ct}**), in N/mm^2, is calculated by:

$$f_{ct} = \frac{3}{2}\frac{P \cdot l}{h^3} \qquad [N/mm^2] \qquad (10)$$

where:

P – the broken force to tensile test, in N;

l – the span between bearings, in mm;

h – the prism cross section depth, in mm.

The result is the average of the resistances obtained on 3 samples.

The compressive strength is established by testing on the prism half which results from the tensile testing. Hydraulic machine is used with a uniform increasing compression force. The samples must be broken during 20 … 40 s from the beginning test.

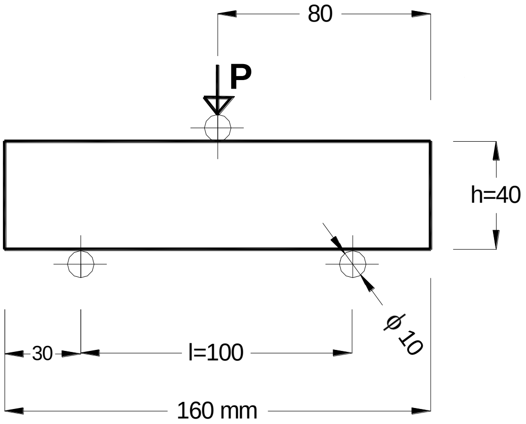

Fig. 4

For compressive testing 2 steel plates are used. These plates have o surface compression test of 1600 mm^2 (40 mm × 40 mm). It is necessary that the surface testing centre to be the same with surface centre of mechanical testing machine.

The compressive testing scheme is showed in figure 5.

The compressive strength (**f$_c$**) in N/mm^2 is calculated by:

$$f_c = \frac{P}{A} \qquad [\mathrm{N/mm^2}] \qquad (11)$$

where:

P – The force to broken to compressive test, in N;

A – the surface of compression test = 1600 mm^2.

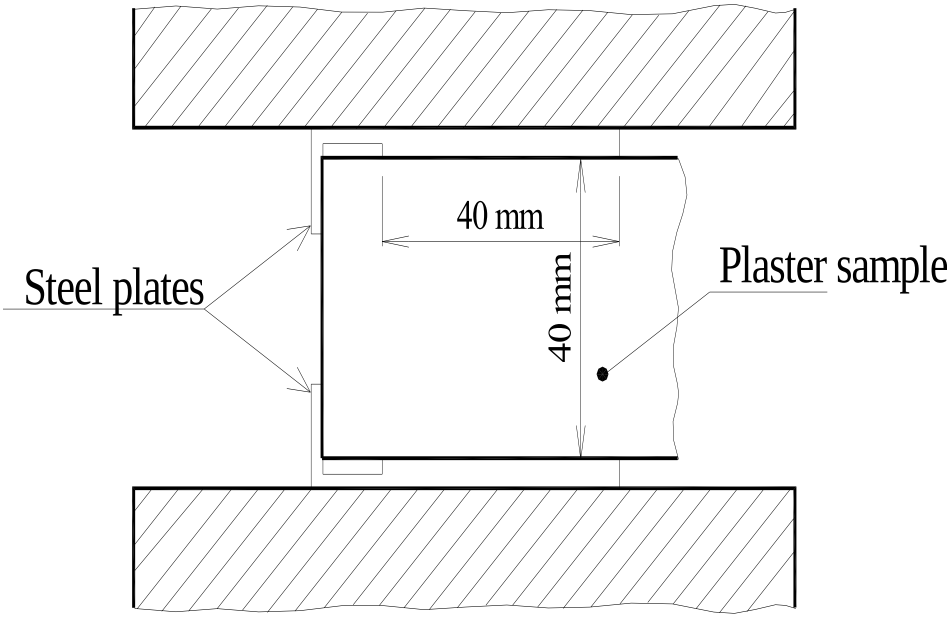

Fig. 5

The result of determination is the average of 6 partial determinations obtained on half of prisms which do not differ with more than ±5% comparative with the average.

According to STAS 545/1-1980 Standard, the building plaster is made in two types with the symbol **A Type** and **B Type,** and which have the technical conditions presented in table 2.

Table 2

Plaster type	Characteristics:					
	R_{071}, [%]	R_{020}, [%]	Setting time, [minute]		f_{ct}, [N/mm^2]	f_c, [N/mm^2]
			Beginning	Ending	at 7 days	at 7 days
A	≤ 2	≤ 15	≥ 5	10-30	≥ 3	≥ 8
B	≤ 4	≤ 17	≥ 4	6-30	≥ 2	≥ 7

3. PORTLAND CEMENT

Generalities

Portland cement is a hydraulic binder obtained by fine crushing of cement clinker with 3.5% of gypsum added for setting time regulation.

Cement clinker results by burning until clinkerization ($\cong$1450ºC) a natural or artificial mixture of calcite and clay.

Usually, for producing of portland cement, a mixture of 75…77% calcite, 23…25% clay and correction added materials (for setting time regulation, for acceleration of the clinkerization process etc.) are burned. The correction added materials can be: bauxite, dolomite, pyrite ash etc.

If mixed with water, a paste is obtained, which will harden both in water and in air and can be used for sticking together blocks or granular materials (mortars, concretes) for making construction elements.

The cement, water and apparatus used for making and testing the samples must be kept at a temperature of (20±2) ºC.

3.1. Determination of Water Quantity Needed For Obtaining a Paste with Standard Consistency

The necessary water quantity used for obtaining a standard consistence paste (SREN 196/3-1995) is determined for establishing setting time and volume constancy in identical conditions. The water depends on cement's composition and its fineness of crushing and has values between 23…33%.

The Vicat apparatus is used. The additional weight from apparatus is taken away and the needle is replaced by a well (rod). A mechanical mixing with a forced mixing pallet is used.

At the beginning of determination the Vicat apparatus is calibrated such as the moment the metallic rod reaches the support glass plate, the mark on the apparatus scale must be at zero.

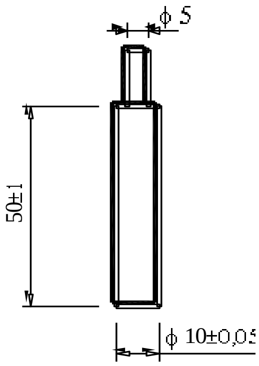

Fig. 6. The metallic rod

In the vessel of the mixing apparatus a measured water quantity is introduced — with the help of a graduated cylinder, for example 125 cm^3. A quantity of 500g of cement is poured then over the water. The end of this operation is denoted by "zero time". The mixing machine is started at slow velocity for 90 seconds. The functioning time of the machine must be total of 3 minutes.

The paste is introduced then in the ring of the Vicat apparatus, put over the glass plate (both the ring and the plate are lubricated by a mineral oil). The surplus of material is taken away and the upper face is levelled.

The glass plate and the ring are put on the Vicat apparatus base under the rod's axe. The rod is carefully released until it reaches the paste level, then it is freely released to penetrate the paste. This operation should take place at maximum 4 minutes from time zero.

At 30 seconds from the rod's release or if the penetration stopped, the depth of penetration is read on the apparatus scale. If the rod stopped at a distance of 5…7 mm to the glass plate, the cement paste has a standard consistency.

If the penetration is not between the upper mentioned limits, the paste is made again using different water quantity.

The rod from the Vicat apparatus should be clean out after each determination.

The used water for obtaining the normal consistency paste can be computed by:

$$\%water = \frac{V_{water} \cdot \rho_{water}}{m} \cdot 100 \tag{12}$$

where: V_{water}- water volume for making the paste, [cm³];

ρ_{water}=1g/cm³;

m – cement mass, [g].

3.2. Determination of Setting Time

For establishing the setting time the Vicat device is used (according to SR EN 196/3-1995).

Determination of setting time is realised on normal consistency paste using the Vicat device.

It is ready by the fixing of the check point to the “zero” position. That means the Vicat needle gets at the inferior glass plate when the ring sits down. Then check out if there is additional weight on the rod Vicat device.

To realize the determination, the Vicat device ring is filled with standard consistency paste; it is then covered with a glass plate and is put on the Vicat base. The ring and the glass plate which is under the ring are oiled up with mineral oil. At convenient interval time (15 minutes for example) the mobile part of Vicat is unlocked and it slow descends until the cement paste surface, after this is left to fall free under its weight. After 30 s, or if the fall is ended, it is read the depth of the Vicar needle into cement paste.

The testing is made in different points of the paste surface each time and at 10 mm distance to the rings edges.

The beginning time of the setting represents the time interval, expressed in hours and minutes, from the moment “zero”, when the cement was introduced into water, until the distance between the needle and the inferior glass plate is of 3-5 mm.

To determine the ending time of the setting, the test is made in the same way from 30 to 30 minutes, but on the side of cement paste which was initially in contact with inferior glass plate.

The ending time of the setting is the time interval, expressed on hours and minutes, from the moment “zero”, when the cement was introduced into water, until the Vicat needle did not enter in cement paste (enter in paste maximum 0.5 mm).

Between the penetration tests the samples (the Vicat ring with cement paste) are kept into wet box.

3.3. Determination of Crushing Fineness

The crushing fineness of cement influences, in a great measure, its characteristics. It is especially influenced the hydraion velocity and the hardening time, also the mechanical strengths.

The sieving method

The crushing fineness for cement is determined by passing it between the eyes of the sieve with 0.09mm we determine the percentage of the cement powder which has dimensions of its granules bigger than 0.09mm. The sifting can be done manually or mechanically.

For manual sifting, the sample of cement is introduced into a closed vessel and it is shacked well in order to avoid the agglomerations of material. Then the sample is left to rest for 2 minutes and a mass m_0=10g of cement is taken for determination with a weighting precision of 0.01g. This mass m_0 is put on the 0.09 mm sieve (under the sieve a collection tank is put), taking care to avoid any material loss. The material which is agglomerated is dispersed by gently pressing it. The sieve is stirred by planer moves until no more material passes through its eyes. The rest of the material (m_1), which remains on the sieve, is weighted.

$$\%R = \frac{m_1}{m_0} \times 100 \tag{13}$$

where:

m_0 - initial mass of cement, g
m_1 - the rest on the sieve, g

The result will be the arithmetical mean obtained by making determination on the cement two times.

3.4. Determination of Mechanical Strengths

The compressive strength is verified at cement. The samples used for determination are made from mortar and have the dimensions: 40x40x160mm.

For each test, three prismatic samples must be done, the compressive strength will be determined on the halves of the prisms obtained from tensile strength determination.

According to SR EN 19611-1995 for each three samples prepared we need: 450g cement,1350g of sand (of following sorts:150g very fine sand 0.08-0.16mm; 300g fine sand 0.16-0.5mm, 450g middle sand 0.5-10mm, 450g bulk sand 1-2mm) and 225 cm^3 of water (in the ratio cement/sand=1:3; water/cement=0.5).

The mortars are prepared into a mixing machine which has a palette (fig. 6).

Fig.6 The mixing machine for preparing the mortars

We introduce the water and cement into the vessel of the mixing machine and mix them with slow velocity for 30s. Then, leaving the machine working, in another 30s, we put all the sand in successive order: the bulk part, middle sand, fine and very fine sand.

Then the machine is passed on high velocity for another 30s. For the next 1 minute and 30s the machine is stopped. In the first 15s the mortar from the vessel’s walls is cleaned and put over the mortar from the vessel. Then the mixing is started at high velocity for another 1 minute.

From the obtained materials about 300g are put into the metallic moulds which are provided with a prolongation. The mortar is levelled by use of a spoon and then it is vibrated, by applying 60 shocks in 60s, by use of the vibration table. Then the metallic moulds are filled with the same quantities of mortar and a new vibration it is done. The prolongation is then taken away and the samples’ surfaces are levelled by the help of a metallic line. Each sample is then labelled and covered by a glass plate.

The samples are introduced into the box with humid air for 24 hours. Then the mortar is pulled out from the metallic moulds and it is introduced into a water basin which has 20°C. The water level must be at least 5mm over the samples’ level. The samples will be pulled out from water with 10-15 minutes before testing them. The test can be done at 2, 7 or 28 days.

The tests for strength determinations are the same like in the case of plaster.

The final results for compressive strength will be computed taking into account all 6 results obtained on the half prisms.

The mechanical strengths are compared with the ones given in table 3.

Table 3

Strength Class			**32.5N**	**32.5R**	**42.5N**	**42.5R**	**52.5N**	**52.5R**
Compression strength, N/mm^2	Initial strength	2 days	-	≥ 10.0	≥ 10.0	≥ 20.0	≥ 20.0	≥ 30.0
		7 days	≥ 16.0	-	-	-	-	-
	Standard strength	28 days	32.5...52.5		42.5...62.5		≥ 52.5	
Beginning of setting time, minutes			≥ 75		≥ 60		≥ 45	
Stability, mm			≤ 10					
Obs.: N = usual initial strength class; R = high initial strength class.								

4. BITUMINOUS BINDER

Generalities

Bitumen binders are natural or artificial products of fluid or semisolid consistency, having brown-black colour, composed of complex mixtures of organic substances.

Natural bitumen, when it is mixed with clay, calcareous stone and sand, is known to be called asphalt.

Natural bitumen is formed by rock, oil oxidation. The artificial bitumen is obtained at the processing of parafinous fuel oil or asphaltous fuel oil.

The following determinations should be done in order to establish the quality of bituminous materials: plasticity limits (defined by softening point and dropping point) and penetrations.

4.1. Softening Point

The softening point represents the temperature for which the bitumen sample, placed into a steal ring, in the same conditions, soften enough in order to allow the passing through of standard steal (STAS 60-1969).

For determination, the apparatus „ring and ball" is used (fig. 7). It is composed of glass (1) in which a metallic support is placed (2) and it has a superior plate (3) provided with holes on which the rings filled with bitumen will be put on (6) and thermometer (7).

The glass with water is slowly heated (with a speed of approximately 5 Celsius degrees per minute) and each temperature for each ball for which it reaches the inferior plate of the metallic support (4) is noted.

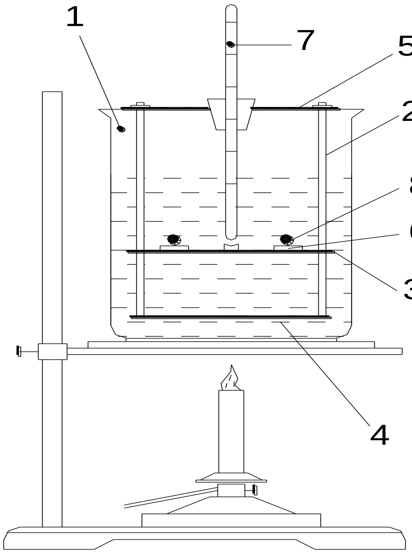

Fig. 7

The result is the arithmetical mean of the three temperatures of softening – between them it is not allowed to exist any difference bigger than 1 Celsius degree.

4.2. Dropping Point

The dropping point is the temperature for which the bitumen becomes so fluid that has deformations under its own weight and allows a drop to fall through a small (STAS 37 – 1967). The determination is done using Ubbelhode apparatus (fig 8).

This device is composed of a thermometer (1) having at its end a metallic ring (2) on which another one is screwed (3) and the bitumen is introduced in a small peak metallic shape (4).

The thermometer is fixed by means of a stopper, into a test tube (5) which assures the role of air bath. The test tube is introduced into a glass with distillate water (6) (for products having a dropping point less than 90 Celsius degrees) or glycerine (for bigger dropping points).

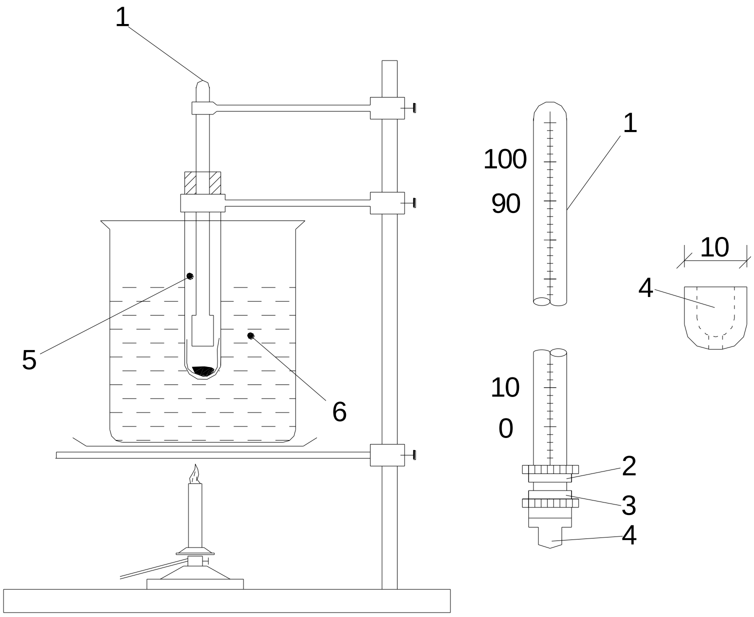

Fig. 8

The glass is slowly heated (with a speed of 1^{o}C/min) and the temperature at which bitumen drop falls on the filter paper placed into the test tube is noted.

4.3. Frass'Breaking Point

Frass breaking point represents the smallest temperature, at which a bitumen layer painted on a steel plate, resists to various number of bendings without presenting any cracks (STAS 113-1974).

For determination the Frass breaking point the apparatus from figure 9 should be used (Frass apparatus).This apparatus has a very thin plate made of steel (1) fixed between (2) and (2'). These are also fixed by metallically tubes (3); the interior tube goes up and down by use of the crank (4). A thermometer (7) it is introduced into the interior tube, in such a way that it reaches the plate (1).

This device it is attached by help of the stopper (9), into the test glass tube (8) putted into a glass vessel (5). The cooling solution made of carbonic snow and acetone is poured by use of the tube (6).

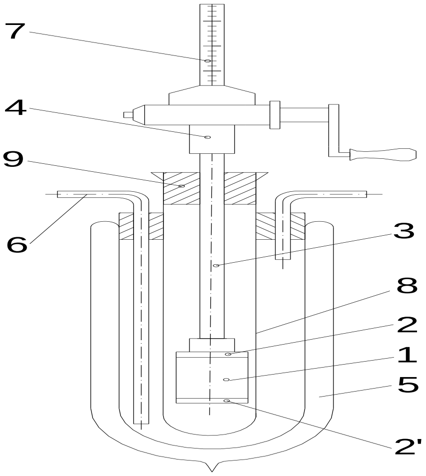

Fig. 9

The steel plate with is with a thin layer of bitumen is placed between the two bed plates (2) and (2’).

The cooling solution has to assure a 1 °C degree diminution in each minute, of the temperature. The bending of the plate starts at a supposed temperature with 10 °C bigger then the temperature for the breaking point. This is done by a uniform rotation of the crank (one rotation per second).

The temperature for which first crack appear on the bitumen layer it represents the Frass’breaking point.

4.4. Standard Penetration (consistency)

The consistency of bitumen is the resistance that they tend to have to the penetration of a needle of standard shape and dimensions, loaded by a certain weight (100 g), into a standard time period (5 seconds), at 25 °C (STAS 42-1986).

This determination is done using Richardson penetrometer and it represents the deep of needle penetration into the bitumen sample, measured in tens of millimetres.

The penetrometer (fig. 10) is composed of a base with column (1) on which the metallic support slides (2) and has at its superior end a micro comparator (5) and at inferior one the rod (3). At the inferior end of the rod the penetration needle is fixed.

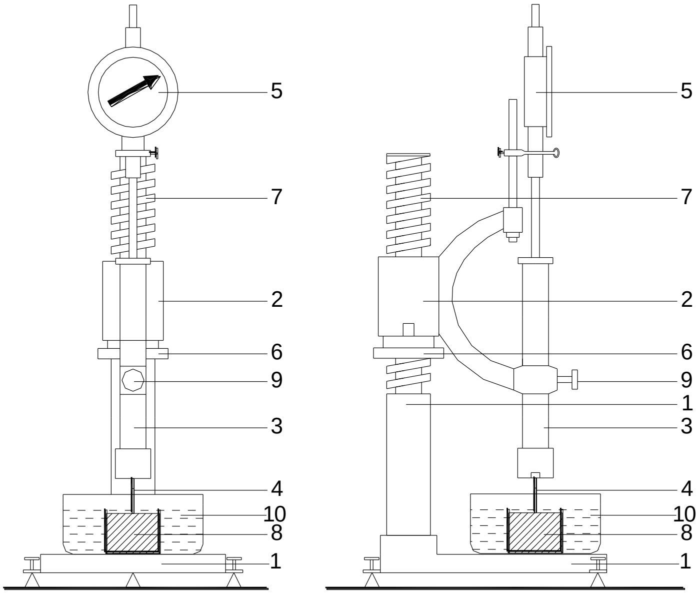

Fig. 10

The metallic vessel is introduced before the determination into a crystallising apparatus (10) with water at 25 ^{0}C – the water level should be 10 mm above bitumen level.

The needle is placed at the bitumen surface and the chronometer and the penetrometer are simultaneously started (9). After 5 seconds, the penetration is stopped releasing the button (9) and the micro comparator which represents the penetration depth is read.

Three determinations are made, at a distance of 10 mm one to each other. The final result will be the arithmetical mean between the three.

Technical conditions for hydro insulating bitumen (H) used for making insulating materials and for roads (D) are presented into table 4.

Table 4

Bitumen type	**Softening point (^oC)**	**Frass'breaking point (^oC)**	**Standard penetration at 25^oC (1/10 mm)**
H 38/42	38-42	-17	180-220
H 45/55	45-55	-10	40-60
H 68/75	68-75	-12	33-50
H 80/90	80-90	-10	20-30
H 100/105	100-105	-8	15-25
D 25/40	57-67	-10	25-40
D 40/50	55-60	-12	41-50
D 50/80	48-55	-12	51-80
D 80/120	43-49	-15	81-120
D 120/180	39-45	-17	121-180
D 180/200	38-42	-17	181-200

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