GUBKIN E&TC

1. **Method of determining the water absorption of short-term and partial immersion of samples.**

2. **Methods of determining the frost resistance of waterproofing covering.**

3. **Results of tests on building materials.**

Генеральный директор
Бусыгин И.Г.

1. Method of determining the water absorption of short-term and partial immersion of samples

The essence of the method

The sample to be tested, partly immersed in water for 1 hour (or 24 hours), and determine the change in its weight.

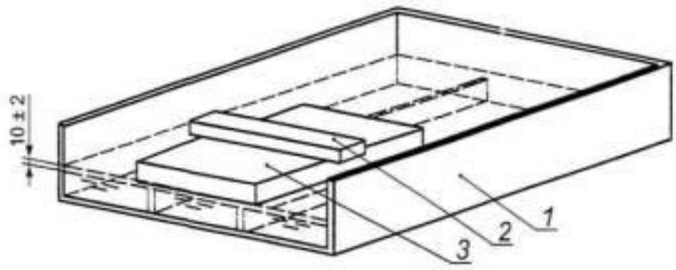
Excess water retained on the sample surface, but it is not absorbed is removed, allowing it to drain.

Means testing

1. Scales for weighing the samples with an accuracy of 0.1 g

2. Container of water, fitted with a device to maintain the water level within ± 2 mm prigruzami holding the sample in a partly submerged.

Sample holder, which must not cover more than 15% of the area of the sample was immersed in water (see Figure 1).



1 - container of water, 2 - prigruzami holding the sample in a partly submerged, 3 - sample

Figure 1 - Device for testing of samples by partial immersion

3. Tap water temperature (23 ± 5) ° C.

4. Accessories for water run-off. Examples of devices are shown in Figure 2.

Methodology of testing

1. Testing

The samples were weighed with an accuracy of 0.1 g to determine the initial mass m_0.

The sample is placed in an empty container on the base and load applied by the load is sufficient to hold the sample in a state partially immersed in the water. Carefully add water to the container until the bottom face of the sample will not be at (10 ± 2) mm below the water surface (see Figure 1). During the test, the water level should remain constant.

After 1 hour (or 24 hours) the sample is removed from the water and removes excess water and putting the (10,0 ± 0,5) minutes in a vertical position on the grid set at an angle of 45 °, as shown in Figure 2. The sample is then re-weighed to determine the mass m_1 (or m_{24}).

2. Processing and presentation of test results

The result should be the arithmetic mean of the results of individual tests. For products with different facial faces calculate the arithmetic mean of the two values.

Water absorption of short-term and partial immersion of samples for 1 h (or 24h) W_p *kg/m²* (*g/cm²*) was calculated by the following formulas:

$$W_p = \frac{m_1 - m_0}{A_p}$$

$$W_p = \frac{m_{24} - m_0}{A_p}$$

where m_0 - initial weight of the sample was measured at test, kg (g);

m_1 - sample weight after partial immersion in water for 1 hour, kg (g);

m_{24} - sample weight after partial immersion in water for 24 hours, kg (g);

A_p - the lower area of the sample in m^2 (cm^2).

W_p value shall be rounded off to 0.01 kg/m^2.

Water absorption of short-term and partial immersion of samples for 1 h (or 24h) W_p % wt., calculated by the formulas:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\%$$

$$W_p = \frac{m_{24} - m_0}{m_0} * 100\%$$

W_p % wt. value shall be rounded off to 0,01 % wt.

The results of the initial testing of samples of brick and brick with a waterproofing coating on the basis of the thin coating of polymeric sulfur.

Water absorption of short-term and partial immersion of samples of brick without waterproof covering for 1 h (and 24 h) W_p kg/m^2 (g/cm^2):

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{216{,}77 - 209{,}15}{12{,}6} = 6{,}047$$

$$W_p = \frac{m_{24} - m_0}{A_p} = \frac{229{,}20 - 209{,}15}{12{,}6} = 15{,}91$$

Water absorption of short-term and partial immersion of samples of brick with a waterproofing coating for 1 h (and 24 h) W_p kg/m^2 (g/cm^2):

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{219{,}98 - 219{,}96}{11{,}375} = 0{,}00176$$

$$W_p = \frac{m_{24} - m_0}{A_p} = \frac{221{,}08 - 219{,}96}{11{,}375} = 0{,}0985$$

Water absorption of short-term and partial immersion of samples of brick without waterproof covering for 1 h (and 24 h) W_p % wt.:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{216{,}77 - 209{,}15}{209{,}15} * 100\% = 3{,}64\%$$

$$W_p = \frac{m_{24} - m_0}{m_0} * 100\% = \frac{229{,}20 - 209{,}15}{209{,}15} * 100\% = 9{,}59\%$$

Water absorption of short-term and partial immersion of samples of brick with a waterproofing coating for 1 h (and 24 h) W_p % wt.:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{219{,}98 - 219{,}96}{219{,}96} * 100\% = 0{,}009\%$$

$$W_p = \frac{m_{24} - m_0}{m_0} * 100\% = \frac{221{,}08 - 219{,}96}{219{,}96} * 100\% = 0{,}509\%$$

The results of the initial testing of samples of concrete and concrete with a waterproofing coating on the basis of the thin coating of polymeric sulfur.

Water absorption of short-term and partial immersion of samples of concrete without waterproof covering for 1 h (and 24 h) W_p kg/m^2 (g/cm^2):

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{275,48 - 272,82}{25,00} = 1,064$$

$$W_p = \frac{m_{24} - m_0}{A_p} = \frac{277,13 - 272,82}{25,00} = 1,724$$

Water absorption of short-term and partial immersion of samples of concrete with a waterproofing coating for 1 h (and 24 h) W_p kg/m^2 (g/cm^2):

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{264,94 - 264,59}{24,01} = 0,0146$$

$$W_p = \frac{m_{24} - m_0}{A_p} = \frac{265,35 - 264,59}{24,01} = 0,0317$$

Water absorption of short-term and partial immersion of samples of concrete without waterproof covering for 1 h (and 24 h) W_p % wt.:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{275,48 - 272,82}{272,82} * 100\% = 0,975\%$$

$$W_p = \frac{m_{24} - m_0}{m_0} * 100\% = \frac{277,13 - 272,82}{272,82} * 100\% = 1,58\%$$

Water absorption of short-term and partial immersion of samples of concrete with a waterproofing coating for 1 h (and 24 h) W_p % wt.:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{264,94 - 264,59}{264,59} * 100\% = 0,13\%$$

$$W_p = \frac{m_{24} - m_0}{m_0} * 100\% = \frac{265,35 - 264,59}{264,59} * 100\% = 0,287\%$$

The comparative results are presented in Table 1:

Table 1. The calculation results of water absorption of building materials with waterproofing coating and without.

Sample	W_p (water absorption)		Sample	W_p (water absorption)	
Brick	kg/m^2	% wt.	Brick with a waterproofing coating	kg/m^2	% wt.
after 1 h	6,047	3,64	after 1 h	0,00176	0,009
after 24 h	15,91	9,59	after 24 h	0,0985	0,509
Concrete M500	kg/m^2	% wt.	Concrete M500 with a waterproofing coating	kg/m^2	% wt.
after 1 h	1,064	0,975	after 1 h	0,0146	0,13
after 24 h	1,724	1,58	after 24 h	0,0317	0,287

2. The frost resistance of waterproofing covering.

The essence of the method

Samples building materials with a waterproofing coating is subjected to moisture saturation for 1 h by partial immersion method for determination of water absorption as described above. Determine the index of water absorption. After 1h water saturation the samples of brick and concrete with waterproofing coating was placed in the freezer t = - 18°C and maintained there for 5 hours. After this time, the samples were subjected to a visual inspection for cracks and delamination of the waterproofing coating from the building materials. The samples were allowed to thaw for 1 h (to room temperature) and then again tested for water absorption index (as described earlier).

The quality of waterproofing material is judged on appearance of the samples after cycles of freezing (in waterproofing coating should be no cracks, and there shall be no delamination of the waterproofing coating from the building materials), as well as the change of water absorption index of the samples before and after a number of cycles of freezing.

<u>Estimation of water absorption at 24 h cycle of freezing.</u>

Water absorption of short-term and partial immersion of brick samples with a waterproofing coating (after 24 hours freezing) for 1 h (and 24 h) W_p kg/m^2 (g/cm^2)

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{221{,}27 - 221{,}01}{11{,}375} = 0{,}0229$$

$$W_p = \frac{m_{24} - m_0}{A_p} = \frac{222{,}17 - 221{,}01}{11{,}375} = 0{,}102$$

Water absorption of short-term and partial immersion of brick samples with a waterproofing coating (after 24 hours freezing) for 1 h (and 24 h) W_p % wt.:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{221{,}27 - 221{,}01}{221{,}01} * 100\% = 0{,}118\%$$

$$W_p = \frac{m_{24} - m_0}{m_0} * 100\% = \frac{222,17 - 221,01}{221,01} * 100\% = 0,5249\%$$

Water absorption of short-term and partial immersion of concrete samples with a waterproofing coating (after 24 hours freezing) for 1 h (and 24 h) W_p kg/m^2 (g/cm^2):

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{266,01 - 265,40}{24,01} = 0,0254$$

$$W_p = \frac{m_{24} - m_0}{A_p} = \frac{267,04 - 265,40}{24,01} = 0,0683$$

Water absorption of short-term and partial immersion of concrete samples with a waterproofing coating (after 24 hours freezing) for 1 h (and 24 h) W_p % wt.:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{266,01 - 265,40}{265,40} * 100\% = 0,23\%$$

$$W_p = \frac{m_{24} - m_0}{m_0} * 100\% = \frac{267,04 - 265,40}{265,40} * 100\% = 0,6179\%$$

Comparative results of indices of water absorption for 1 h and 24 h before and after the 24h freezing cycle are shown in Table 2.

Table 2. Comparative results of indices of water absorption for 1 h and 24 h before and after the 24h freezing cycle.

Sample	W_p (water absorption)		Sample	W_p (water absorption)	
Brick with a waterproofing coating	kg/m^2	% wt.	Brick with a waterproofing coating (after the 24h freezing cycle)	kg/m^2	% wt.
after 1 h	0,00176	0,009	after 1 h	0,0229	0,118
after 24 h	0,0985	0,509	after 24 h	0,102	0,525
Concrete M500 with a waterproofing coating	kg/m^2	% wt.	Concrete M500 with a waterproofing coating (after the 24h freezing cycle)	kg/m^2	% wt.
after 1 h	0,0146	0,13	after 1 h	0,0254	0,23
after 24 h	0,0317	0,287	after 24 h	0,0683	0,618

<u>Estimation of change water absorption of building materials with a waterproofing coating before and after a number of cycles of freezing of samples.</u>

Conditions: Water absorption was measured within 1h, the freezing cycle is continued for 5 hours, thawing samples is 17 hours, 30 cycles.

The cycle (24 h) comprises steps of:

1) Weigh the samples to water saturation;
2) Saturation moisture in the sample for 1 hour;
3) Weigh the samples after saturation with moisture and definition of water absorption index;
4) Withstanding of samples in a freezer at a temperature of minus 18 ° C for 5 hours;
5) Thawing for 17 hours

The cycle (24 h) is repeated:

1) Weighing images before re-saturation with water
2) Saturation moisture in the sample for 1 hour;
3) Weigh the samples after saturation with moisture and definition of water absorption index;
4) Withstanding of samples in a freezer at a temperature of minus 18 ° C for 5 hours;
5) Thawing for 17 hours

Water absorption of short-term and partial immersion of brick samples with a waterproofing coating (before and after a series of 5-hour cycles of freezing) for 1 h, W_p kg/m^2 (g/cm^2):

Before the freeze:

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{219{,}98 - 219{,}96}{11{,}375} = 0{,}00176$$

After the 10th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{221{,}27 - 221{,}01}{11{,}375} = 0{,}0229$$

After the 20th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{221{,}36 - 221{,}3}{11{,}375} = 0{,}0053$$

After the 30th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{221{,}39 - 221{,}14}{11{,}375} = 0{,}022$$

Water absorption of short-term and partial immersion of brick samples with a waterproofing coating (before and after a series of 5-hour cycles of freezing) for 1 h, W_p % wt.:

Before the freeze:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{219{,}98 - 219{,}96}{219{,}96} * 100\% = 0{,}009\%$$

After the 10th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{221{,}27 - 221{,}01}{221{,}01} * 100\% = 0{,}118\%$$

After the 20th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{221{,}36 - 221{,}3}{221{,}3} * 100\% = 0{,}027\%$$

After the 30th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{221{,}39 - 221{,}14}{221{,}14} * 100\% = 0{,}113\%$$

Water absorption of short-term and partial immersion of brick samples with a waterproofing coating (before and after a series of 5-hour cycles of freezing) for 1 h, W_p kg/m^2 (g/cm^2):

Before the freeze:

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{264{,}94 - 264{,}59}{24{,}01} = 0{,}0146$$

After the 10th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{266{,}01 - 265{,}40}{24{,}01} = 0{,}0254$$

After the 20th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{266{,}22 - 265{,}93}{24{,}01} = 0{,}012$$

After the 30th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{A_p} = \frac{266{,}45 - 265{,}95}{24{,}01} = 0{,}0208$$

Water absorption of short-term and partial immersion of brick samples with a waterproofing coating (before and after a series of 5-hour cycles of freezing) for 1 h, W_p % wt.:

Before the freeze:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{264{,}94 - 264{,}59}{264{,}59} * 100\% = 0{,}13\%$$

After the 10th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{266{,}01 - 265{,}40}{265{,}40} * 100\% = 0{,}23\%$$

After the 20th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{266{,}22 - 265{,}93}{265{,}93} * 100\% = 0{,}109\%$$

After the 30th cycle of freezing:

$$W_p = \frac{m_1 - m_0}{m_0} * 100\% = \frac{266{,}45 - 265{,}95}{265{,}95} * 100\% = 0{,}188\%$$

Comparative results of changes of water absorption after cycles freeze are shown in Table 3:

Table 3.

Sample	W_p (water absorption) Before the freeze		W_p (water absorption) after the 10th cycle of freezing		W_p (water absorption) after the 20th cycle of freezing		W_p (water absorption) after the 30th cycle of freezing	
	kg/m^2	% wt.	kg/m^2	% wt.	kg/m^2	% wt.	kg/m^2	% wt.
Brick with a waterproofing coating								
Через 1ч	0,00176	0,009	0,0229	0,118	0,0053	0,027	0,022	0,113
Concrete M500 with a waterproofing coating								
Через 1ч	0,0146	0,13	0,0254	0,23	0,012	0,109	0,0208	0,188

CONCLUSION

1. Water absorption of building materials is significantly reduced after treating by waterproofing coating based on a polymer thin layer of sulfur. According to the study the water absorption (1 h) of building materials with waterproofing coating is reduced from 6,05 kg/m^2 to 0,0018 kg/m^2 or from 3,64% wt. to 0,009% wt. (for products from bricks) and from 1,064 kg/m^2 to 0,0146 kg/m^2 or from 0,98% wt. to 0,13% wt. (for concrete products).

2. Frost resistance of waterproof covering is characterized by an increase in water absorption of samples of building materials after a number of cycles of freezing and thawing. This is due to occurrence of cracks and peeling of the coating of building material, which in turn reduces the protective function of the material and provides access water. The data obtained show that after several freeze-thaw cycles (number of cycles - 30) in process of visual inspection of samples the cracks and peeling of coating on the surface of construction material is not detected.

3. High frost waterproofing covering on the basis of thin-film polymeric sulfur is confirmed by the obtained data of water absorption before and after a number of cycles of freezing and thawing, according to which the water absorption remains practically unchanged within 0,0018-0,022 kg/m^2 or 0,009-0,12% wt. for brick product and 0,015-0,025 kg/m^2 or 0,11-0,23% wt. for concrete product.