Ministry of Education and Science of Ukraine

Ternopil Ivan Puluj National Technical University

Department of Structural Mechanics

Study guide on

“Building Materials Science”

Part 2“Building Materials”

for students of Bachelor's Degree Program 192 “Building and civil engineering”

Ternopil, 2020

Study guide on “Building Materials Science” Part 2“Building Materials” for students of Bachelor's Degree Program 192 “Building and civil engineering” comp. I.V. Koval, Ph.D., Assoc. Prof. Kovalchuk Ya.O., Ph.D., Assoc. Prof. Kramar H.M.. – Ternopil: TNTU, 2020. – 38pp.

Compiler: Ph.D., Koval I.V., Ph.D., Assoc. Prof. Kovalchuk Ya.O., Ph.D., Assoc. Prof. Kramar H.M.

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Approved at the meeting of the Department of Structural Mechanics (minutes 3 from 29 October 2020 p.)

Approved by methodological committee of the faculty of engineering of machines, structures and technologies (minutes №3 from 26 November 2020)

Content

INTRODUCTION

Course "Building Materials Science" is one of the fundamental in the preparation of specialists of specialty educational program 192 “Building and Civil Engineering”.

In laboratory practice, great attention is paid to the methods for determining the properties of building materials in accordance with the requirements of state standards of Ukraine. Students will acquire such knowledge and skills in the future to provide the optimum choice of necessary building materials, to evaluate their properties, and, to provide high reliability and durability of building products, structures and structures.

Laboratory course covers various aspects in assessing the characteristic of building materials (mechanical properties, waterproofing, physical). Methodically, the proposed works can be used for a number of modern building materials based on polymers and composites.

The list of laboratory works corresponds to the work program of discipline "Building Material Science" for students of 192 “Building and Civil Engineering”

The purpose of the manual is to enable students to independently prepare for laboratory work.

RULES OF SAFETY TECHNIQUES IN THE EXERCISE OF LABORATORY WORKS

Laboratory works on the course "Building Material Science" are carried out in the educational and research laboratories of the Department of Structural Mechanics. Observance of safety rules is a prerequisite for admission to work. To ensure this, each student must familiarize himself with the requirements of the safety rules and get the teacher's permission to perform the work.

It is prohibited to stay in laboratories in upper clothing. Students who are temporarily not engaged in work with equipment must be in a place specified by the teacher.

Equipment used for laboratory work is equipped with electric drives with a voltage of 220/380 Volt. To prevent electric shock, general requirements for the use of laboratory equipment are compliance with the rules of operation of industrial electrical equipment. Students are prohibited from switching on equipment that is not intended to perform the current laboratory work, open the door of electrical cabinets and knobs. Without the instruction of a teacher or laboratory technician it is forbidden to switch on or off switches and knobs.

All unnecessary items that are not related to the work to be performed must be removed from the workplace. Before starting the equipment, make sure that it is safe. If the flaws are detected, do not turn on the tension and inform the teacher or the laboratory technician, without taking the measures to correct the problems.

When performing work that involves the heating of materials, it is necessary to be protected from thermal burns of the skin and the burning of clothing.

Do not let the crap in the labs! Do not use equipment that does not apply to laboratory work. Do not transfer laboratory equipment from one work place to another. Students who violate the safety rules are not allowed to perform laboratory work and are subject to re-passing of these rules.

Violation of safety rules can lead to accidents. Strictly follow the rules. It will save your health and life. Warns against violation of safety rules of their colleagues.

Laboratory work 1. Determination the density of sand

Purpose of work

Density is the dry mass per unit volume of a substance under absolute compact conditions. The understanding of density is useful for mastering the quality and performance of materials. And density can be used to calculate the porosity.

Devices and materials

Lee's density bottle (see Test Figure 1.1) (the smallest scale of 0.1 mL), balance (sensitivity of 0.01 g), thermometer, glass container, oven, dryer, ladle and funnel.

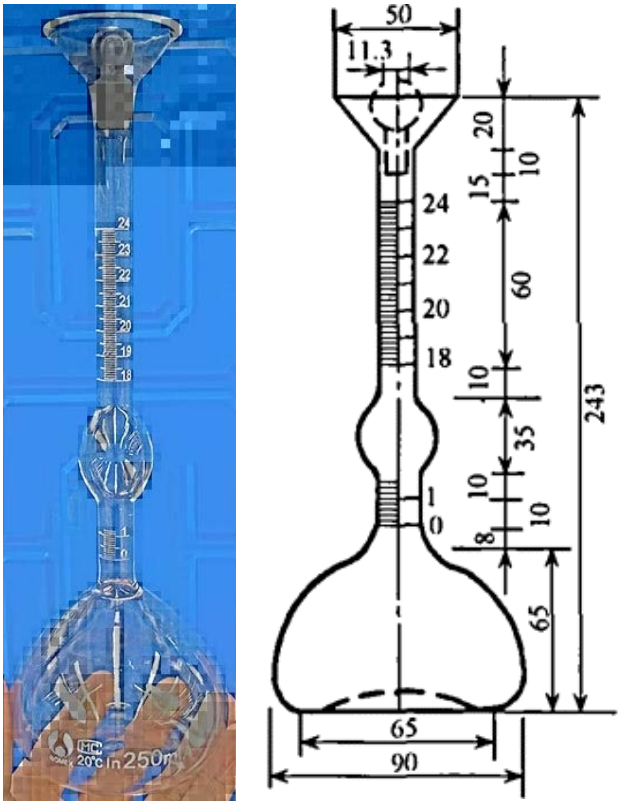


Figure 1.1. Lee's density bottle.

Steps of work performance

I. Grind the sample into powder, and sift out screenings with a screen of 900 holes/cm^2. Put the screened powder into an oven of 105-110°C and dry it to constant quality. Then cool it to room temperature in a dryer.

II. Pour the liquid that does not react with the sample into Lee's density bottle to the liquid level of 0~1 mL.

III. Put Lee's density bottle in a glass container with water. Dip it into water completely and clip it with stent to prevent it floating or slanting. The temperature of

the water in the container should be the same with the standard temperature of Lee's scale, namely, (20±2)°C.

IV. After 30 min, read the scale value V_1 (accurate to 0.1 mL, the same below) of the concave liquid surface.

V. Pull Lee's density bottle out of the glass container, and dry the inside of bottleneck over the liquid surface with filter paper.

VI. Weigh 70~80g (accurate to 0.01 g, the same below) powder with a balance scale, marking it m_1. Pour the powder into Lee's bottle with a ladle and a funnel slowly (to prevent blockage in the throat of the bottle) until the liquid surface rises to 20 mL.

VII. Weigh the mass of the remaining sample m_2 (g). Tilt Lee's bottle to a certain angle and rotate it so that the air bubbles in the powder will escape.

VIII. Put the bottle into the glass container again. After 30 min when the temperature of the liquid becomes the same with water, read the scale value of the concave liquid surface V_2 (mL).

Results

Calculate the density with the following formula (accurate to 0.01 g/cm^2):

$$\rho = \frac{m}{V}$$

In this formula:

m is the mass of the powder in Lee's bottle (g), namely, the difference between m_1 and m_2;

V is the absolute volume of the powder in Lee's bottle (cm^3), namely, the difference between V_1 and V_2.

The average value of the results of the above two test is the test result of the density. The difference of the two results should not be greater than 0.02 g/cm^2. Or, it should be re-tested.

Laboratory work 2. Determination of apparent density

Purpose of work

Apparent density is the dry mass per unit volume of a substance under natural conditions. The strength, thermal conductivity and water absorption can be evaluated by apparent density; and also it can be used to calculate the porosity, volume, quality and the structure weight.

Devices and materials

A balance (weighing of 1000 g and division value of 0.1 g), liquid balance (Archimedes balance, division value of 0.0lg). Vernier calliper (accuracy of 0.1 mm), oven, dryer, paraffin wax, alcohol and so on.

Steps of work performance

A – for the materials in regular shape:

I. Put the three test pieces in each group in oven of (105±5)°C to dry them to constant quality. Then cool them to room temperature in a dryer and weigh the mass m(g).

II. Measure the size of every test piece with Vernier calliper and calculate their volume V (cm^3).

a. For a hexahedral specimen, measure their length, breadth and height three times at different points in each direction, and calculate their average a, b, and c, then:

$$V_0=a\cdot b\cdot c$$

b. For a cylinder specimen, measure the diameter in the two mutually perpendicular directions on the two parallel sections and the waist of the specimen. Calculate the average of the six values d. Then measure its height at the four endpoints of the two mutually perpendicular diameters on the circle. Calculate its average h.

$$V_0=\pi\cdot d^2\cdot h/4$$

B – for the materials in irregular shape:

I. Process (or select) 5~7 specimens of 20~50mm long. Put them into a (105±5)°C oven and dry them to constant mass. Then cool them to room temperature in a dryer.

II. Weigh the mass of one specimen, m (accurate to 0.1 g, the same below).

III. Put the specimen into melt paraffin wax, and take them out after l~2s. There is a wax film (no more than 1 mm thickness) on the specimen.

IV. Weigh the mass of the waxed specimen, m_1 (g).

V. Weigh the mass of the waxed specimen in water, m_2 (g).

VI. Calculate the density of the paraffin wax ρ (normally 0.93g/cm^3).

Results

The apparent density ρ_0 defined by (accurate to 10kg/m^3 or 0.01 g/cm^3):

A – for the materials in regular shape:

$$\rho_0 = \frac{m}{V}$$

The average results of three specimens can be the test results. The error of each result should be within 20 kg/m^3 or 0.02 g/cm^3;

B – for the materials in irregular shape:

$$\rho_0 = \frac{m}{m_1 - m_2 - \frac{m_1 - m_2}{\rho}}$$

The test results should be the average results of five specimens and the maximum and the minimum should be marked.

Laboratory work 3. Determination of water-absorption

Purpose of work

Water-absorption ratio refers to the ratio of the mass or volume of water to the dry mass or volume of a material when the material is saturated. The water-absorption ratio affects the strength, frost resistance, thermal conductivity and other functions greatly. The test of water-absorption ratio is useful for evaluating various functions. Now, take stone as an example to introduce the testing methods.

Devices and materials

Balance (1 kg, division value of 0.1 g), sink, oven, dryer, and so on.

Steps of work performance

Process (or select) cube specimens with the edge length of 4~6cm or cylinder specimens with the diameter or height of 4~6cm.

Put them into a 105~110°C oven and dry them to constant mass. Then cool them to room temperature in a dryer.

Take specimens out of the dryer and measure their mass, m (g).

Put the specimens in a sink and remain 1~2cm distance between every two specimen. Lay glass bars under the bottom of the specimens to avoid direct contact with the bottom of the sink.

Inject water into the sink until the water rose to 1/4 height of specimens, add water to 1/2 height after two hours, add water to 3/4 height after another two hours, and add water to l~2cm above specimens after two hours. Then take them out after a day and night.

Press the surface of specimens slightly with screwed wet towel until the water on the surface is absorbed (do not wipe). Then weigh the mass. Then put them back into the water. Follow the above procedures every other day and night until the mass of the soaking specimens are constant (the quality difference between a day and night should be within 0.05g), and then weigh the mass, m_b (g).

Results

The water-absorption ratio is calculated by:

Specific Absorption of Quality:

$$W_m = \frac{m_b - m}{m} \cdot 100\%$$

Specific Absorption of Volume:

$$W_V = \frac{m_b - m}{V_0} \cdot \frac{1}{\rho_w} \cdot 100\%$$

In this formula:

W_m is the specific absorption of quality;

m_b is the mass of a saturated specimen (g);

m is the dry mass (g);

W_V is the specific absorption of volume (%);

V_0 is the volume of a specimen in natural state (cm^3);

ρ_w is the density of water (g/cm^3) it dependence on temperature.

Laboratory work 4. Determination of thermal expansion coefficient

Purpose of work

Known that solids increase in volume when heated. The thermal expansion coefficient is a characteristic of the material, which is numerically equal to the elongation of the rod length of 1 mm when the temperature changes by 1 degree. Thermal expansion of crystals is anisotropic (different in different crystallographic directions).

Devices and materials

Vernier calliper (accuracy of 0.1 mm), oven, dilatometer (See fig. 4.1), samples of metals of different classes (aluminium, copper, brass, steel).

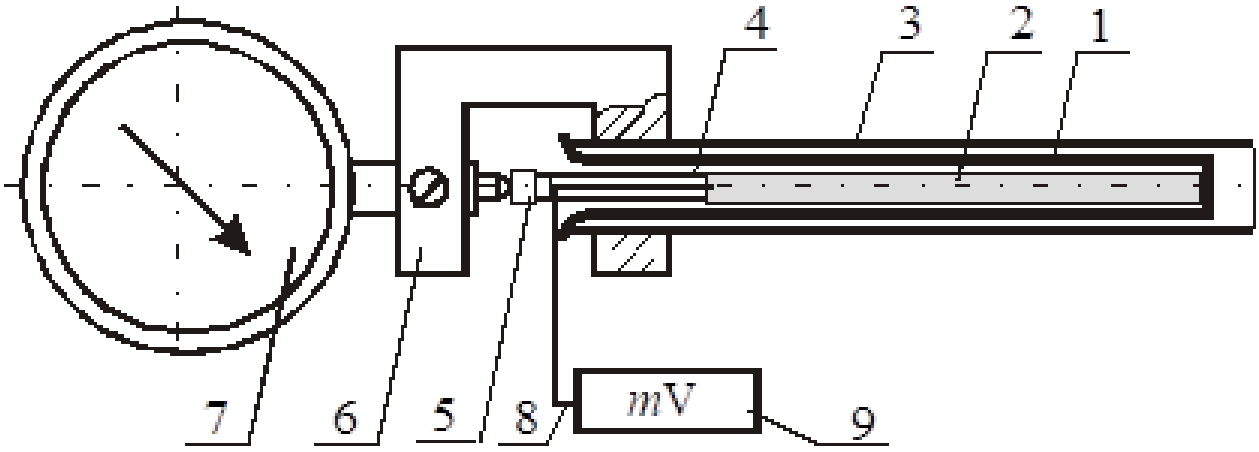


Figure 4.1. The structure of the dilatometer: 1 - quartz tube; 2 - sample; 3 - protective cover; 4 - quartz rod; 5 - the cylinder; 6 - bracket; 7 - indicator; 8 - thermocouple; 9 - thermovoltmeter

Steps of work performance

I. Get acquainted with the construction of a dilatometer – a device for determining the thermal expansion coefficient.

II. Obtain samples and determine their initial length L_0.

III. Install the sample in the dilatometer and place the working part of the dilatometer in the oven.

IV. Turn on the oven. Heat up to 400°C.

V. After every 200 seconds record the readings of the indicator, the results of the experiment recorded in table 4.1.

Table 4.1

Temperature, T°C								
Indicator displays, n								

VI. Plot the graph n = f (T)

Results

Determine the thermal expansion coefficient in different temperature ranges by the formula:

$$\alpha_t = \alpha_q + \frac{(n_2 - n_1) \cdot B}{(t_2 - t_1) \cdot L_0}$$

Where, α_q=0,56·10^{-6} – thermal expansion coefficient of quartz (dilatometer material);

L_0 – initial length of the sample, mm;

t_1 – initial temperature of the sample, °C;

t_2 – final temperature of the sample, °C;

n_1 and n_2 – indicator readings (in scale divisions) at t_1 and t_2, respectively;

B – the mark value of the indicator, mm/mark.

Laboratory work 5. Determination of normal viscosity of the gypsum mixture

Purpose of work

Gypsum is one of the oldest binders. The quality of gypsum binders is determined by the curing time, fineness of grinding, water consumption, compressive and bending strength. Depending on the curing time, gypsum binders are divided into three groups: fast-curing, normal-curing and slow-curing.

Devices and materials

Gypsum, water, Suttard's viscometer (Fig. 5.1), which consists of a metal cylinder (1) with a height of 100 mm and an inner diameter of 50 mm and a glass plate(2) with concentric circles from 150 mm to 220 mm.

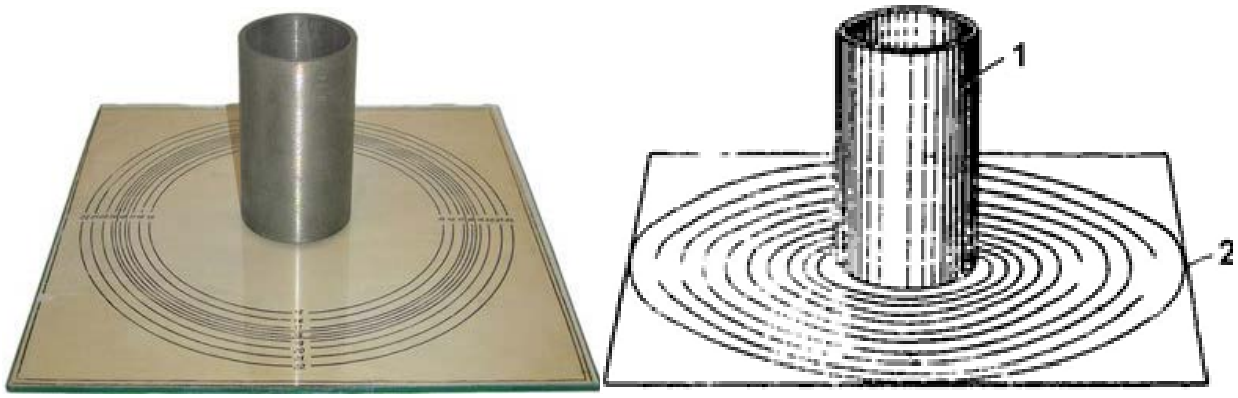


Figure 5.1. Suttard's viscometer:

Steps of work performance

I. For the experiment, take a sample of gypsum weighing 300 g, pour into a cup containing 150 g of water (start working with a water-gypsum ratio of 0.5).

II. The mass is stirred for 30 s, starting from the moment of pouring the binder into the water.

III. The cylinder and the glass of the viscometer are pre-wiped with a damp cloth. After mixing, the cylinder, which installed in the centre of the glass, filled with gypsum mixture. Excess of mixture in the cylinder cut off.

IV. 45 seconds after pouring the mixture into the cylinder, it quickly lifted vertically to a height of 15… 20 cm and set aside.

V. The diameter of the mixture spread measured immediately after lifting the cylinder, in two perpendicular directions with an error of not more than 5 mm and is determined as the arithmetic mean.

VI. The diameter of the spill should be 180±5 mm

VII. Otherwise, the test repeated with another amount of water to obtain the desired consistency of the mixture.

Results

Tasks are performed according to steps of work performance, in addition, a graph of the dependence of the filling diameter on the gypsum ratio is built. The results are entered in the table below.

Table 5.1

№	Gypsum fineness of grinding	Mass of water, g	Mass of water / Mass of gypsum	Diameter of the spill, mm

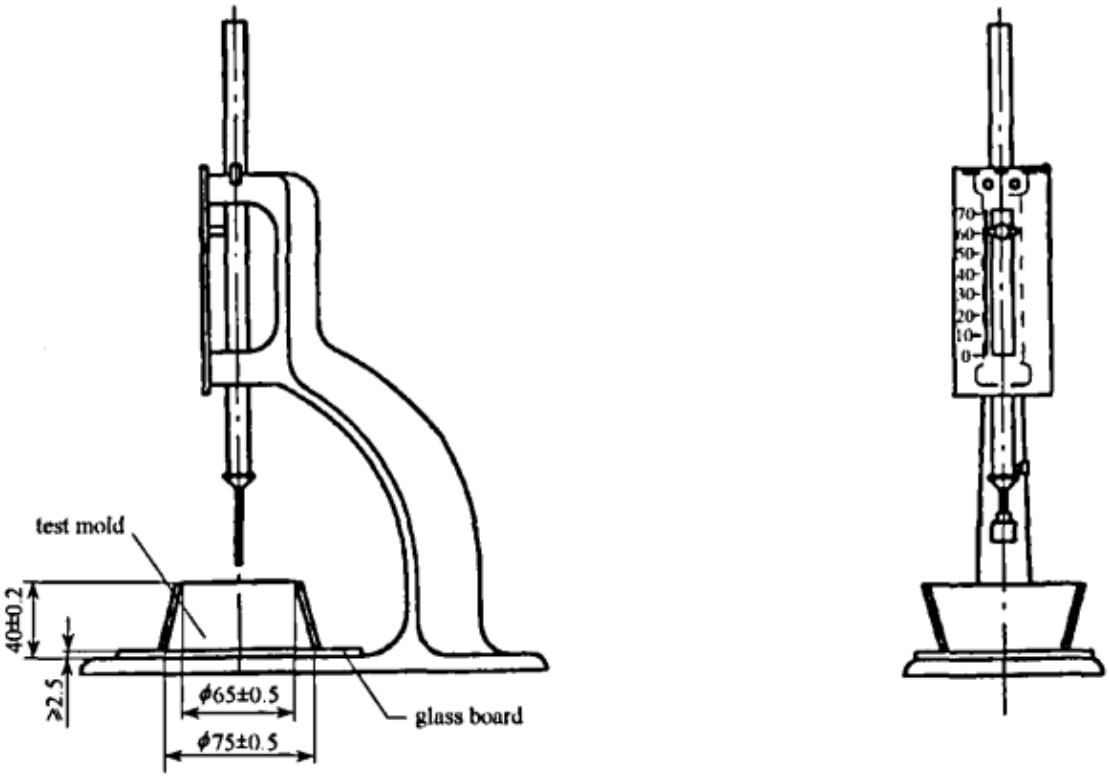
Laboratory work 6. Determination of the water consumption for cement normal consistency

Purpose of work

The test of the water demanded by purified cement paste when it achieves to the normal consistency will facilitate the test of setting time and soundness of cement with standard purified paste. The testing methods include standard method and substitution method (to adjust water demand and fixed water demand). If there is conflict, the result is subject to the standard method.

Devices and materials

A – Vicat Apparatus of Standard Method. As shown in Test Figure 6.1, the normal consistency will be measured by cylindrical test bar, made of corrosion-resistant metals, with effective length of (50±l) mm and diameter of 10±0.05 mm. The surface of connecting sliding bar should be smooth, free falling by gravity, and without any tight and loose phenomenon.



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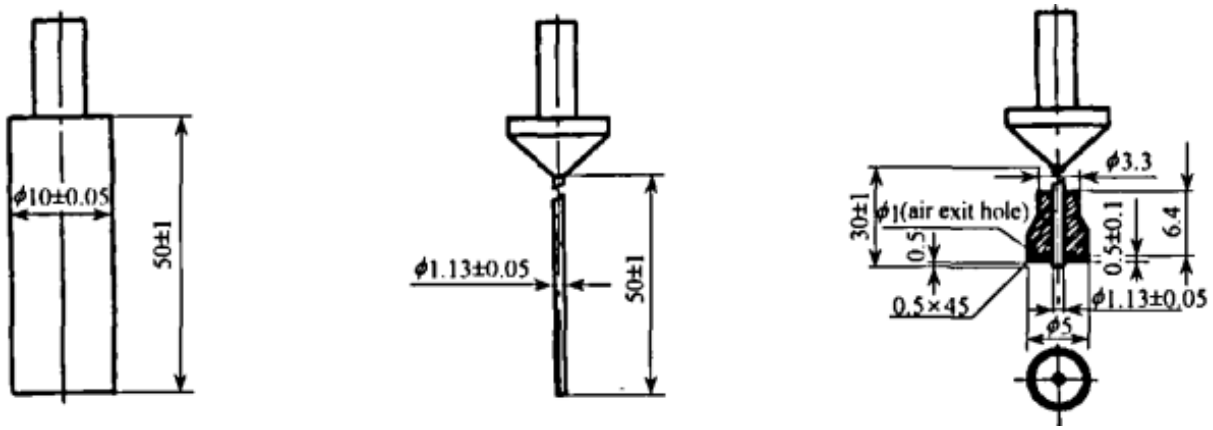


c d e

Figure 6.1. The Vicat Apparatus for the Test of Normal consistency and Setting Time: a – the vertical view of vertical test mold for the test of the initial setting time; b – the front view of reversal test mold for the test of the final setting time; c – test bar of normal consistency; d – the index finger for the initial setting; e – the index for the final setting.

The test mold containing purified cement paste [see Figure 6.1 (a)] should be made by corrosion-resisted and hard metals. The test mold is a truncated cone with the depth of (40 ± 0.2)mm, the top diameter of 65 ± 0.5mm, and bottom diameter of 75 ± 0.5mm. Each test mold should be equipped with a flat glass backboard bigger than test mold whose thickness should be more than 2.5mm.

B – as shown in Figure 6.2, the mass of the sliding part of the cone is (300±2)g, the bottom diameter and the height of the hollow metal test cone are 40mm and 50mm respectively, and the upper diameter and the height of the cone mode used for containing paste are 60mm and 75mm respectively (see Figure 6.3).

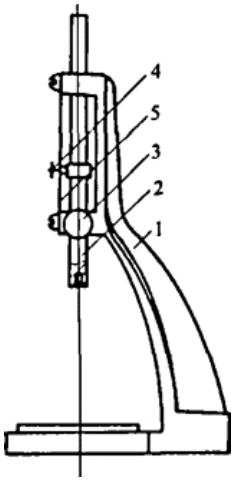


Figure 6.2. Normal Consistency Detector: 1 – iron steadier; 2 – metallic bar; 3 – elastic screw; 4 – index finger; 5 – yardstick.

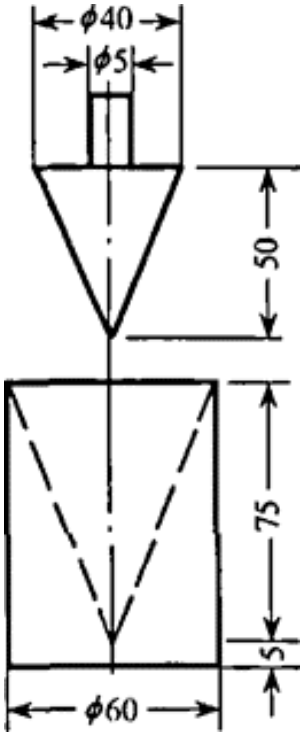


Figure 6.3. Test Cone and Cone Mold

Cement purified paste mixer includes agitator kettle, mixing blade, transmission mechanism, and control system. The mixing blade rotates with double wheels in double-speed. It is regulated: the space between agitator kettle and mixing blade should be (2± 1) mm; the stirring process and time should be like this: slow stirring for 120s, halting for 15s, and fast stirring for 120s.

Water gauge (with the minimum scale of 0.1 mL and accuracy of 1%), balance (accurate to 1 g).

Steps of work performance

A – The Test of the Water Consumption of the Standard Consistency (Standard Method):

I. Pre-test Check: can the metal bar of the device slide smoothly; does the index finger point at zero when the test cone fall down to the top of the mold; and can the agitator kettle work normally.

II. The Mixing of Cement Purified Paste: before mixing, wipe the stirring tools (agitator kettle, mixing blade, test cone or mold) with wet cloth, pour the mixing

water into mixing pot, and then put the weighed cement of 500g into the water within 5~10s carefully; in mixing, fix the agitator kettle on its steadier, raise it to the mixing position, and start it; make it stir slowly for 120s and halt for 15s, meanwhile scratch the cement paste left on the blades and the pot wall into the pot, and make it stir fast for 120s and then stop. The mixing water is used by experience (accurate to 0.5mL).

III. The steps to test the water requirement of normal consistency: after mixing, fit the mixed purified paste into the mold standing on the glass board immediately, disturb it with knife, and scratch the excess paste after several-time vibration; move the mold and the board to the vicat apparatus quickly after towelling, fix its center under the test bar, lower the bar until it contacts with the paste, tighten the screw for 1~2s, and release it suddenly (that is to open the screw) to let the bar vertically sink into the paste; record the distance between the bar and the board after it stop falling or release for 30s, raise the bar and clean it right away; the whole operation should be finished within 1.5 min after mixing.

B – The Test of the Water Consumption for the Standard Consistency (Substitution Method: Adjusting Water Consumption Method and Fixed Water Consumption Method):

I. Pre-test Check: can the metal bar of the device slide smoothly; does the index finger point at zero when the test cone fall down to the top of the mold; and can the agitator kettle work normally.

II. The Mixing of Cement Purified Paste: the same with the above standard method. When adjusting water consumption method is adopted, the amount of mixing water depends on experience; if the fixed method is adopted, the amount of mixing water should fixed to 142.5mL. If there is a conflict, the adjusting method prevails.

III. The steps to test the water requirement of normal consistency: after mixing, fit the mixed purified paste into the test cone immediately, disturb it with knife, and scratch the excess paste after several-time vibration; move it to the fixed position under test cone quickly after trowelling, lower the cone until it contacts with the paste surface, tighten the screw for 1~2s, and release it suddenly (that is to open the screw) to let the cone vertically sink into the paste; record its sinking depth after it stop falling

or release for 30s, and the whole operation should be finished within 1.5 min after mixing.

Results

A – The Water Consumption for Cement Normal Consistency (Standard Method):

When the distance between the test bar and the board is (6±l)mm, the cement paste is known as purified paste. Its amount of mixing water is the water requirement of normal consistency (P), calculated by the percentage of the cement mass. If the distance is more than or less than (6± l)mm, the proper amount of mixing water should be found according to experience.

B – Adjusting Water Consumption Method:

When the sinking depth of the test cone is (28 ± 2)mm, the purified paste is the paste of normal consistency. If the sinking depth is beyond the range, try to re-conduct the experiment until it accords with the standard. The water requirement for the normal consistency (P) is calculated as the percentage of the cement mass, as follows:

$$P = W/500 \cdot 100\%$$

In this formula: W is the amount of mixing water.

C – Fixed Water Consumption Method:

Based on the tested sinking depth of the test cone S (mm), the water consumption for the normal consistency P can be calculated as follows (or refer to the corresponding scale):

$$P=33.4-0.185S$$

If the sinking depth is less than 13mm, the adjusting method should be adopted.

Laboratory work 7. Determination of mortar consistency

Purpose of work

To determine the consistency of mortar is to calculate the required water quality for the regulated consistency.

Devices and materials

Mortar consistometer: is consisted of test cone, container and bearing, the three parts (see Figure 7.1); the test cone made of steel or copper is 145mm high and its bottom diameter is 75mm, and the mass of the test cone and slid bar is 300g; the container made of steel board is 180mm high and its bottom's inner diameter is 150mm; the bearing contains base, supporter and consistency dial, made of iron, steel or other metals.

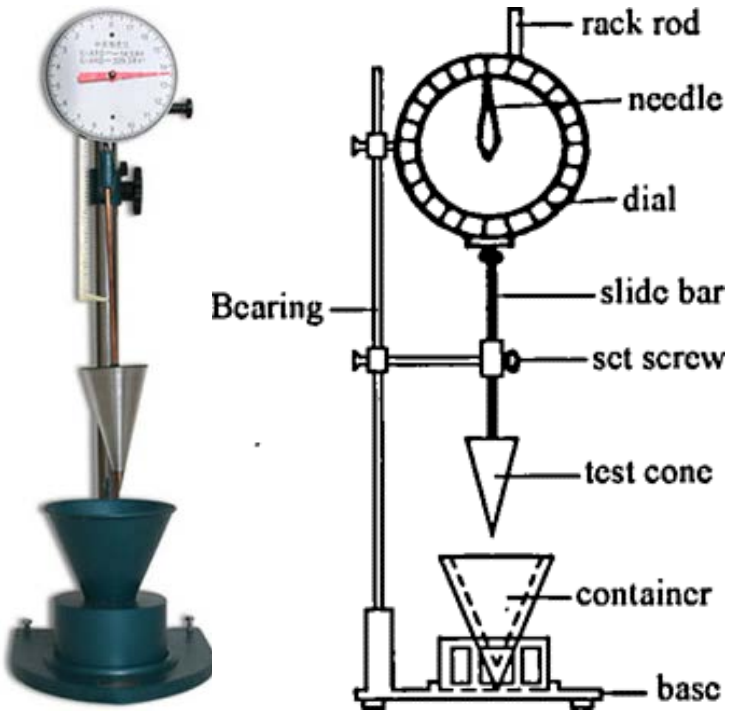


Figure 7.1 Mortar Consistometer

Copper tamper: is 350mm long and its diameter is 10mm, with rounded ends. Stopwatch, spade and other tools.

Steps of work performance

I. Clean the surface of container and test cone with a damp cloth, wipe the slid bar with a small amount of lubricant and clean the excess oil by oil-absorbing sheets to make the slide bar move freely.

II. Fill the container with the mortar mixture once and make the surface of the mortar 10mm lower than the mouth of the container; tamp the mortar from the center to the edge by tamper for 25 times and slightly shake or knock the container for 5~6 times to smooth the surface of mortar; and then put the container on the base of consistometer.

III. Loosen the set screw of the slide bar and let it slide downward; when the conical tip just touches the mortar surface, fasten the set screw and let the bottom of the rack rod just touch the top of the slide bar and the needle hand point just point at zero.

IV. Loosen the set screw and record time at the same time; after 10s, fasten the screw at once and let the bottom of the rack rod touch the top of the bar; and then read the sinking depth on the dial (accurate to 1mm), namely, the consistency value of mortar.

V. The mortar in the cone container just can be tested for one time. New samples are needed for the re-determination of the consistency.

Results

The arithmetic mean of two results is the final result, accurate to 1mm. If the difference between the two tested results is more than 20mm, new samples should be mixed for re-determination.

Laboratory work 8. Size deviation and appearance quality tests of fired common brick

Purpose of work

The formation principle and size of the inspection batch is regulated in Standards. 35,000-150,000 blocks is one batch, and less than 35,000 is calculated as one batch. The samples used for appearance quality check are taken randomly from each batch; the samples used for size deviation check and other tests should be taken randomly from the samples used for appearance quality check.

Devices and materials

Brick Caliper (See Figure 8.1): division value of 0.5mm; steel ruler: division value of 1mm.

Figure 8.1. Brick Caliper: 1 – Vertical Ruler; 2 – Support feet.

Steps of work performance

A –Dimensional Measurement:

Measure the two sizes of length and breadth on the middle parts of the two big faces of a brick respectively, and measure two sizes of height on the middle parts of the two strip faces (see Figure 8.2). If there is defected or convex part on the measured place, measure the adjacent part, but it would be better to choose the bad side (accurate to 0.5mm).

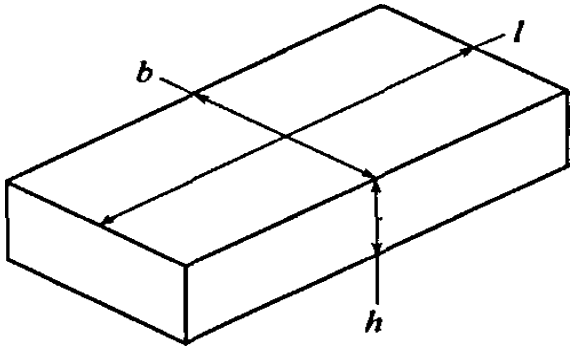


Figure 8.2. Dimensional Measurement: l – Length; b – Breadth; h – Height.

The sizes of length, breadth and height should be the arithmetic means of their respective two measured values, accurate to 1 mm.

B – Appearance Quality Check:

Defects: if a brick lacks a comer angle, the damaged part should be measured by its projective size on length, breadth and height of the brick, called failure size (see Figure 8.3). The failure surface is the projective area of the damaged part on strip and top surfaces of the brick (see Figure 8.4).

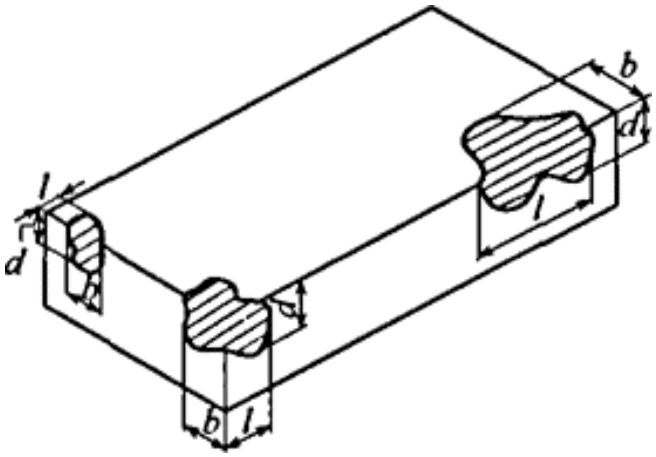


Figure 8.3. Measurement of Failure Size: l – Projective Size at the Length Direction; b – Projective Size at the Breadth Direction

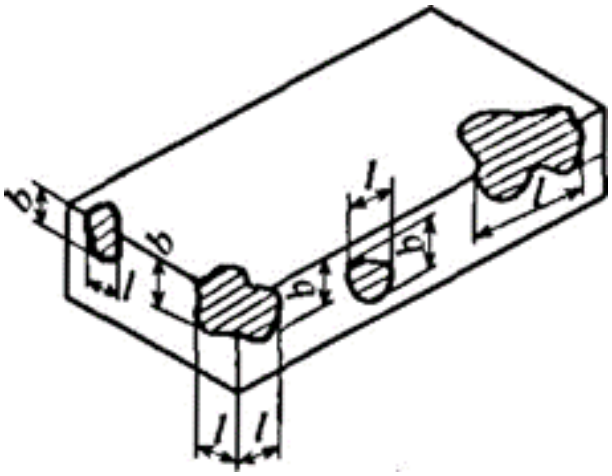
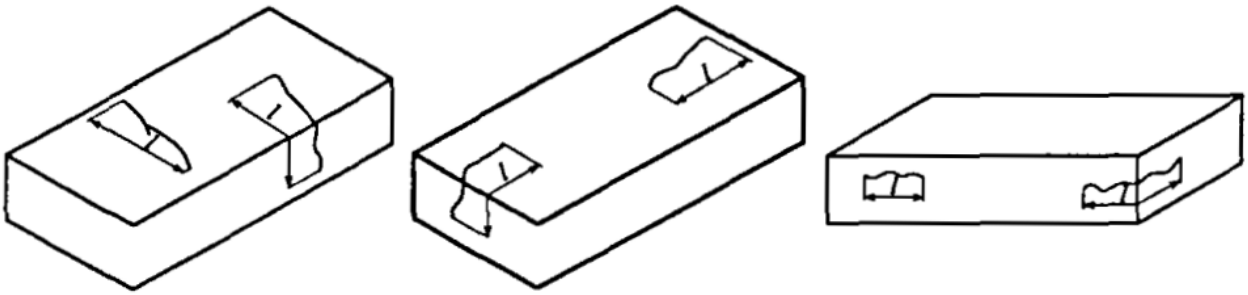


Figure 8.4. Measurement of Failure Face: l – Projective Size at the Length Direction; b – Projective Size at the Breadth Direction; h – Projective Size at the Height Direction

Cracks: there are three kinds of cracks respectively at the directions of length, breadth and height, expressed by the projective length at the measured direction. If a crack extends from one face to another face, its projective length should be

accumulated (see Test Figure 8.5). The crack length should be the longest one measured respectively at the three directions.



a b c

Figure 8.5. Measurement of Crack: a – Measurement of Crack Length at the Breadth Direction; b – Measurement of Crack Length at the Length Direction; c – Measurement of Crack Length at the Horizontal Direction.

Bends: bended part is measured on the big face and the strip face respectively. Put the two feet of a brick calliper on the two ends of the edge and use the vertical ruler to measure the most bended part (see Figure 8.6). The concave part caused by impurities or bump should be excluded.

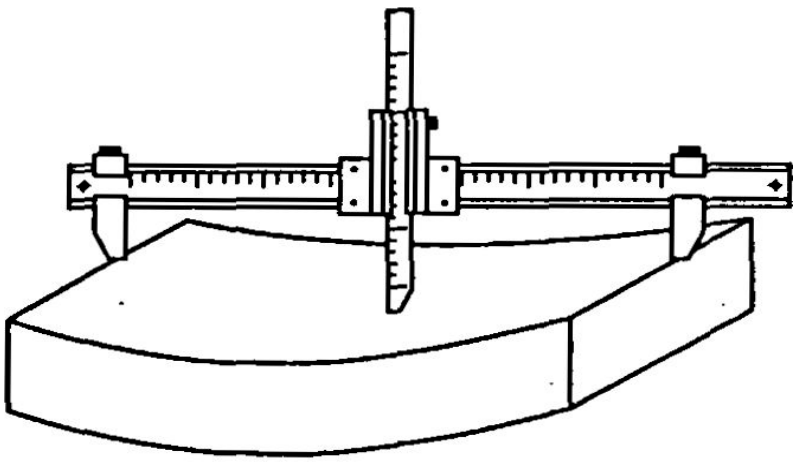


Figure 8.6. Measurement of Bend.

The bigger bended size is the measured result.

Results

The convex height of impurity: impurities may produce convex heights on the surface of brick, expressed by the biggest distance between the impurity and the brick surface. Put the two feet of a brick calliper on the two sides of the convex part on the brick surface and use the vertical ruler to measure it (see Figure 8.7).

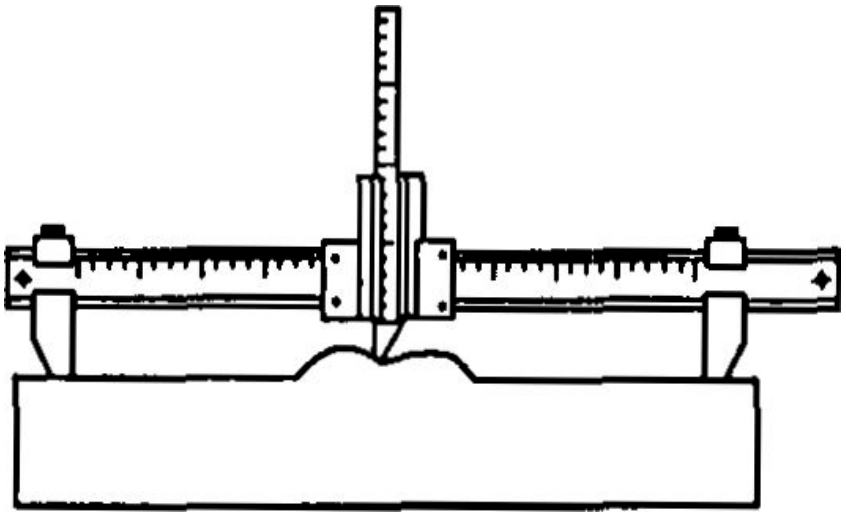


Figure 8.7 Measurement of Convex Impurity.

“mm” is the unit of all the above measured sizes of appearance quality. If the size is less than 1mm, it should be calculated as 1mm.

Laboratory work 9. Determination the mechanical properties of steel bar

Purpose of work

To check the bending deformation performance borne by steel bars is to determine their processing property and reveal their defects.

Devices and materials

Press, universal tester, special tester or round vice and hook bending machine.

Steps of work performance

The unturned specimen is $5a_0$+150mm long; and a_0 is the calculated diameter of the specimen (mm).

The diameter and bending angle of the bending centre should be chosen from the tables of the grades of hot rolled bars and the technical requirements in the building steel chapter.

According to Figure 9.1 (a), adjust the distance between the two rollers equal to d+2.1·a.

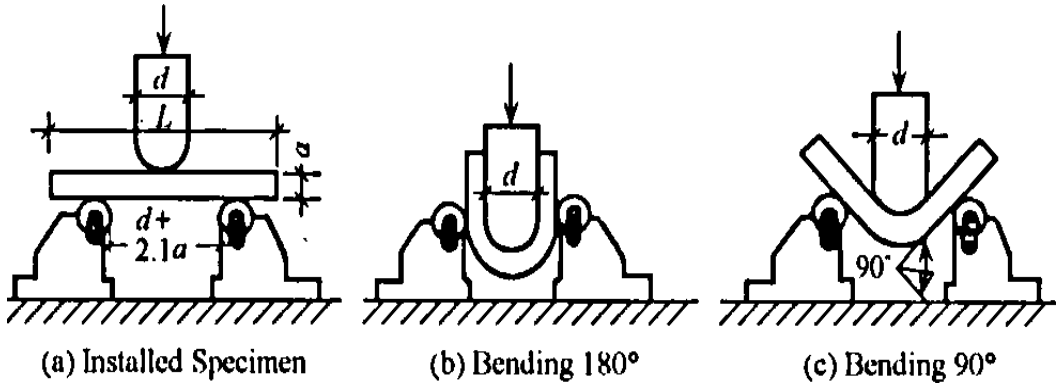


Figure 9.1 Device for the Cold Bending Test.

According to Figure 9.1 (a), stably add loads after the specimen is installed; and the steel bar should circle the bending centre and bend in line with the required bending angle [see Figure 9.1 (b, c)]

Laboratory work 10. Determination of wood moisture

Purpose of work

Experimentally determine the moisture content of wood that has been stored for a long time in the laboratory

Devices and materials

Samples, oven, scales, moisture meters.

Steps of work performance

I. Taken a sample size of 20×20×30 mm, weighed.

II. Then dried in an oven to constant weight at a temperature of 103±2ºC and weighed again.

III. Humidity of wood can also be determined by moisture meters.

Laboratory work 11. Determination the mechanical properties of wood

Purpose of work

Acquaintance with the standard method of determining the compressive strength of wood and its practical implementation. Perform recalculation of the compressive strength at standard humidity.

Devices and materials

To determine the ultimate strength in static bending, samples made in the form of a bar with a cross section of 20 to 20 mm and a length along the fibbers of 300 mm. During the test, the sample placed on two fixed supports with a distance between their centres of 240 mm. The load transmitted at one or two points. This experiment is carried out on samples, on a hydraulic press, bringing the sample to destruction. Hydraulic press, devices with hinged support, callipers.

Steps of work performance

I. One of the end surfaces of the sample is shifted in the center of the pivot support of the device.

II. The sample devices are placed between the machine heads and slightly clamped. The arrow of the power meter at this time should be at zero scale.

III. Switch on the test machine, when testing the force should be directed along the fibers of the sample (Fig. 11.1).

IV. The sample feed rate is uniform throughout the test time (25000 ± 5000) N / min.

V. The tests lead to the destruction of the sample, ie to the moment of movement of the arrow of the power meter in the opposite direction. After that, the test machine is turned off.

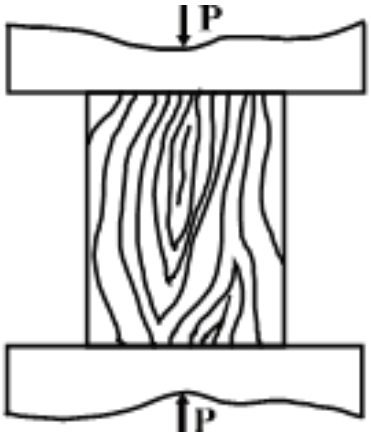


Figure 11.1. Test scheme for compression of wood along the fibers: a) sample, b) device (1, 6 – removable ball bearing; 2 – sample; 3 – punch; 4 – ball bearing; 5 – housing).

The sample is removed from the device and inspected, paying attention to the nature of the destruction.

Results

The compressive strength of wood along the fibbers at a given humidity is determined by the formula:

$$R_W = \frac{F_{max}}{ab}$$

where, F_{max} – maximum load, N; a, b – dimensions of the cross section of the sample, mm.

The determined strength limit converted to a standard humidity of 12% by the formula:

$$R_{12} = R_W[1 + \alpha(W - 12)]$$

where, α – is the correction factor equal to 0.04 per 1% humidity; W – is the humidity of the sample at the time of the test,% (wood moisture at the time of the test is determined by the standard method).

Laboratory work 12. Determination the properties of petroleum asphalt

Purpose of work

Determine the penetration rate of asphalt, judge its viscosity, and evaluate the grade of asphalt according to the index of penetration rate.

Devices and materials

Penetrometer (see Figure 12.1). Constant temperature water bath, sample dish, thermometer, stopwatch and so on.

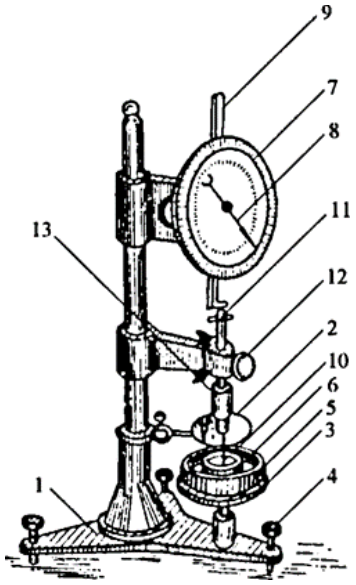


Figure 12.1 Penetrometer: 1 – base ; 2 – small mirror; 3 – round platform; 4 – leveling screw; 5 – warmer; 6 – sample; 7 – dial; 8 – pointer; 9 – movable rod; 10 – standard needle; 11 – connecting rod; 12 – button; 13 – weight.

Steps of work performance

I. Preparation of sample. Heat the asphalt to 120~180 °C and then dewater it and then filter it with screen, put it into the sample dish, and the depth should be 10mm deeper than the expected penetration rate. Put the dish into the atmosphere whose temperature is 15~30 °C to cool for 1~2 hours, and dust should be avoided at the moment of cooling. And then put the dish into the constant temperature water bath with temperature of (25±0.5)°C for 1-2 hours. The water level of the constant temperature water bath should be 25mm higher than the sample.

II. Adjust the penetrometer to horizontal level, check the pointer, connecting rod and guide rail to ensure there is no water or other sundries, and no obvious friction, fix the preparation needle and put on the weight.

III. Take out the sample dish from the constant temperature water bath, and put it into the flat-bottom warmer of (25±0.1)°C, and the water level above the sample surface should not be less than 10mm. Put the flat-bottom warmer onto the platform of the penetrometer.

IV. Put down the needle connecting rod gradually, fix it when the needlepoint touches the surface of the sample. Pull down the movable rod to contact with the needle connecting rod, and modify the pointer or dial to make the pointer point to zero. Then press the button heavily and at the same time start the stopwatch. Make the standard needle fall down freely to penetrate into the asphalt sample. After 5 seconds, stop pressing the button to stop the pointer from falling.

V. Pull down the movable rod to contact with the top of the standard needle connecting rod. And this time the difference between the value pointed by the pointer and the original value is the penetration rate of the sample.

VI. At least three tests should be done on the same sample, and each time the water temperature in the temperature holding dish should be checked and adjusted to keep the temperature at (25±0.1)°C. And after each test, the standard needle should be taken off and cleaned with a cloth or cotton soaked with organic solvent (toluene or turpentine). The distance among determination points or between determination point and sample dish should be less than 10 mm.

Results

Take the average value of three tests as the penetration rate of the sample (l/10mm), the test result takes integer. And the difference among three tests' results should not be more than the value listed in the Table 12.1.

Table 12.1 the maximum allowed difference among the penetration rate of petroleum asphalt

Penetration rate	0~49	50~149	150~249	250~350
The maximum difference	2	4	6	10

Laboratory work 13. Determination the properties of building plastic

Purpose of work

Test the Elongation under Tension force and the Maximum Tension Force

Devices and materials

Tension testing machine: the machine can test the tensioning force and the elongation at the same time; testing range is 0-2000N, and the minimum readable number is 5N; the tension range can make the fixture distance expand by one time and the fixture clamping width is more than 50mm.

Steps of work performance

I. The test should be held under the temperature of (23±2)°C, put the samples (B,5') cut according to Test Figure 10.1 under the testing temperature for not less than 24 hours.

II. Adjust the tension testing machine (the tension speed is 50mm / min), and then fix the samples which have been treated under constant temperature in the centre of the fixture, and the fixture should not be twisted, and the distance between the upper fixture and the bottom one should be 180mm. Run the tension testing machine until the sample is broken.

III. Read the value number when the sample is broken, record the maximum tension force, and meanwhile determine the elongation value under the maximum tension force. If the distance between the broken place of the sample and the fixture is less than 20mm, the test result is ineffective, and the test should be done again.

IV. Calculate the average tension force value of five samples as the vertical and transverse tension forces of the sample. And it is measured by N/50mm.

Results

The elongation under the maximum tension force calculated through the following formula:

$$E = 100(L_1-L_0)/L$$

In the formula: E is the elongation under the maximum tension force (%); L_1 is the standard distance when the sample is under the maximum tension force (mm); L_0

is the original standard distance of the sample (mm); L is the distance between the fixtures (180mm).

Calculate the vertical and transverse elongation of five samples respectively under the maximum tension force and take the average value of them as the vertical and transverse elongation of the coiled material.

Laboratory work 14. Mathematical processing of test results

Purpose of work

The values obtained when measuring the properties of materials may differ. The reasons for this may be:

1. Inaccuracy of measuring instruments or incorrect measurement methods.
2. Errors of the employee performing the measurement.
3. Deviation of the properties of the material itself.

The first two reasons - systematic errors, can be eliminated or taken into account. The third reason is random errors. It is impossible to completely avoid the influence of random errors.

Devices and materials

The results of measurements in previous laboratory works.

Steps of work performance

I. The arithmetic mean X is a statistical characteristic that describes in one number the results of a series of measurements. The arithmetic mean value is calculated by the formula:

$$\bar{X} = \frac{1}{n} \cdot \sum_{i=1}^{n} X_i$$

where X_1, X_2 ..., X_n – the results of individual measurements; n is the number of measurements. The arithmetic mean gives an idea of the average value of the measured quantity, but does not reflect its variability, ie the limits of oscillation (variation).

II. The standard deviation S is a characteristic of the mean variability of the quantity, which is determined, has the same units as the arithmetic mean and is calculated by the formula:

$$S = \pm \sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^{n} (X_i - \bar{X})^2}$$

where $\sum_{i=1}^{n} (X_i - \bar{X})^2$ is the sum of the squares of the deviations of all measurements from the arithmetic mean; n is the number of measurements.

The sign "+" or "-" in the formula indicates that the deviation can be both in one and in the other direction from the arithmetic mean.

III. The square of the standard deviation S^2 called the variance. In practice, to characterize the scatter of measurements often use the concept of scope (variation) R_i – is the difference between the maximum and minimum values in a number of measurements:

$$R=X_{max}-X_{min}$$

The scope used in the analysis of the results of a small number of measurements (up to 10) to facilitate the calculation of the standard deviation

$$R=(X_{max}-X_{min})/d$$

where, d is a factor that depends on the number of measurements:

n	2	3	4	5	6	7	8	9	10
d	1,13	1,69	2,06	2,33	2,53	2,7	2,85	2,97	3,08

During the processing of experimental data at (n> 10) the standard deviation is calculated by the formula for finding S. For ease of calculation using a table of three graphs. In the first column, denoted by X, record the results; in the second (Δ) - the deviation of individual results (with the sign "+" or "-") from the arithmetic mean X, in the third (Δ^2) - the squares of these deviations (with the sign "+"). It should be remembered that the sum of deviations Δ with a plus sign should be equal to the sum of deviations with a minus sign.

The standard deviation is one of the most important statistical characteristics. However, its absolute value does not allow to compare the degree of variability of the studied properties in several groups of materials.

IV. The relative variability index υ is the coefficient of variation, calculated by the formula:

$$\upsilon = \frac{S}{\bar{X}} \cdot 100\%$$

During the processing of experimental data, sometimes some measurement results have much larger deviations from the average than others. In such cases, check

whether an error was made during the experiment. If it is possible to establish the exact reason for such deviation, the result must be removed from the calculations.

Results

The results of measurement processing are entered in table 14.1

Table 14.1

Measured value / Number of measurements	Bulk density of gravel	Bulk density of sand	Average density of cement-sand mortar (results of measurement of beams or cubes)	Average density of natural stone (results of measuring cubes of granite, basalt, etc.)
1				
2				
3				
…				
n				
$\bar{X}$				
S				
d				
υ				
-Δ				
+Δ				

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