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Test Methods of Rock for Highway Engineering

公路工程岩石试验规程

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Table of Contents

Foreword.....	4
1 General Provisions	7
2 Terms and Symbols	7
2.1 Terms.....	7
2.2 Symbols	9
3 Physical Property Tests.....	10
T0201-1994 Simple petrologic authentication	10
T0202-2005 Water content test.....	12
T0203-2005 Density test	13
T0204-2005 Gross volume density test	16
T0205-2005 Water absorption test.....	21
T0206-2005 Expansion test	24
T0207-2005 Slake durability test.....	29
4 Mechanical Property Test.....	31
T0221-2005 Uniaxial compressive strength test	31
T0222-2005 Uniaxial compressive deformation test	34
T0223-1994 Splitting strength test	38
T0224- 2005 Shearing strength (straight snips) test	40
T0225-1994 Point load strength test	45
T0226-1994 Folding strength test	53
5 Long Duration Test.....	55
T0241-1994 Frost resistance test	55
T0242-1994 Solidness test	57
Annex Density of the Uncontaminated Water (g/cm ³).....	60

1 General Provisions

1.0.1 This specification is formulated to unify the test methods of rocks for highway engineering

1.0.2 This Standard is applicable to rock test for engineering of subgrades, pavements, bridges and culverts and tunnels in highway engineering.

1.0.3 Instruments used for test in this specification shall be proved as qualified by relevant national detection mechanisms and meet requirements in this specification.

1.0.4 Test subject of rock shall have geological representatives; and test content, test methods and technical specifications shall meet basic requirements and characteristics of exploration survey, design and construction of the highway engineering. Test for stress and deformation of rock mass shall be carried out according to relevant current national standards.

2 Terms and Symbols

2.1 Terms

2.1.1 Rock

Mineral assemblage that is formed in a certain mode under all kinds of geological actions; and it is main substance to make up lithosphere and mantle of the earth.

2.1.2 Water content

It is the ratio between the water of rock sample lost in baking to the constant mass at 105°C ~ 110°C and the dry mass of the specimen; and the ratio is represented by percentage.

2.1.3 Density

Under specified conditions, mass of the unit volume of the dried rock minerals (excluding pore volume of the opening and closing).

2.1.4 Gross volume density

Under specified conditions, the mass of the solid materials per unit volume of dried rock including pores.

2.1.5 Percentage of porosity

3 Physical Property Tests

T0201-1994 Simple petrologic authentication

1 Purpose and application scope

This method is applicable to simple tests using general instruments and reagents; evaluating rock characteristics of rock samples for highway engineering via visual inspection to determine the name and category of rock.

2 Apparatus

- (1) Hammer.
- (2) Hardness gauge or other instruments used for hardness inspection (such as fingernail, iron knife edge, steel knife edge, glass sheet, etc.).
- (3) Magnifier or microscope.

3 Reagent

Dilute hydrochloric acid: concentration 10%.

4 Samples

In order to get representative rock samples, the number of samples to be selected in the fieldwork shall be at least 3. As for irregular samples, the specification of the samples shall be cube-like with volume no less than 100cm³; and loose parts and attachments on the surface shall be removed.

5 Test Procedures

5.1 Knock the rock sample with a hammer to make a new cross-section.

5.2 Examine the rock texture and structure of the new rock cross-section with naked eye and with the help of a magnifier or a microscope; pay attention to eigenstructure, such as joint, crack, degree of crystallinity, size of ore grain and agglutinate, and make a description.

5.3 Carry out scratch test with a hardness gauge or other instruments used for hardness inspection on the new sections to determine the rock hardness.

Criteria of hardness comparison (from soft to hard) consist the following 10 minerals: (1) talc (2) gypsum; (3) calcite; (4) fluorite; (5) apatite; (6) kali-feldspar; (7) quartz; (8) lite; (9) corundum; (10) diamond.

neutral solution, such as kerosene as the test solution.

2 Apparatus

- (1) Density bottle: short-neck volumetric flask, capacity of 100mL.
- (2) Balance: sensibility of 0.001g.
- (3) Disintegrator, ball mill, porcelain mortar, agate mortar, magnet and sieve with the hole diameter of 0.315 mm (0.3mm)
- (4) Sand bath, constant temperature water tank (sensitivity $\pm 1^{\circ}\text{C}$) and vacuum pumping equipment.
- (5) Oven: the temperature can be controlled at $105^{\circ}\text{C}\sim 110^{\circ}\text{C}$.
- (6) Dryer: filled with desiccants, such as calcium chloride or silica gel, etc.
- (7) Tapered glass funnel, porcelain dish, dropper, metatarsal spoon and thermometer etc.

3 Sample preparation

Put representative rock samples on a small disintegrator for preliminary crushing (or stamp breaking with a steel hammer); and put on the ball mill for further grinding; comminute with a mortar to slime, which could pass the 0.315mm sieve mesh.

4 Test Procedures

4.1 Put the finished slime in a porcelain dish, which shall then be put into a dry oven at $105^{\circ}\text{C}\sim 110^{\circ}\text{C}$ to dry to the constant mass for 6h~12h; and then it shall be placed in the dryer to cool to the room temperature ($20^{\circ}\text{C}\pm 2^{\circ}\text{C}$) for later-use.

4.2 Take two shares of slime by quarter dividing method; weigh 15g (m_1) from each share, accurate to 0.001g (the weighing accuracy is the same in this test); use a hopper to fill the slime into a clean and dried density bottle; and inject test solution to fill half of the bottle; and shake the density bottle to disperse the slime.

4.3 If uncontaminated water is used as the test solution, gas could be eliminated by boiling or vacuum-pumping method. if kerosene is used as the test solution, gas shall be eliminated by vacuum-pumping method. if boiling is used to eliminate gas, the boiling time shall be calculated from suspension boiling and shall be no less than 1h; if vacuum-pumping is used to eliminate gas, the reading of the vacuum pressure gauge should be 100kPa; and the pumping time shall be 1h ~ 2h till no bubble appears.

4.4 Take out the gas-eliminated density bottle, dry it and make it cool to the room temperature; inject gas-eliminated test solution of the same temperature condition till

ρ_w - density of the gas-eliminated uncontaminated water (refer to Annex) (g/ cm³).

5.2 The arithmetic average of the two test results shall be used as the measured value; if the difference of the two test results is larger than 0.02g/cm³, resample and test shall be carried out.

5.3 Test record

Records of the density test shall include rock name; test number; sample coding; test solution temperature; test solution density; sample mass of dried slime; mass of the bottle and test solution; and the total mass of bottle, test solution and slime; mass of the density bottle.

T0204-2005 Gross volume density test

1 Purpose and application scope

Gross volume density of rock is a parameter indirectly reflecting rock densification degree, pore abundance, and is also a necessary calculation index for assessment of project stability of rock mass and determination of the surrounding rock pressure. According to water containing state and gross volume density of rock, there are dry density, saturated density and natural density.

Gross volume density test of rock can be divided into quantity accumulating method, in-water weight method and wax sealing method.

Quantity accumulating method is applicable to all kinds of rock, which can be made into regular specimens. In-water weight method is applicable to all the rock other than the rock, which shall crumble, dissolve entering water and has a property of shrinking in dry state and swelling in wet state. Wax sealing method is applicable to the rock which could not use quantity accumulating method or direct in-water weighing for test.

2 Apparatus

- (1) Stonecutter, rock drill, stone mill and other processing devices of rock specimens.
- (2) Balance: the sensibility is 0.01g, and the weighing is larger than 500g.
- (3) Oven: the temperature can be controlled at 105°C~110°C.
- (4) Paraffin and wax-melting devices.
- (5) in-water-weighing device.
- (6) Vernier caliper.

oven and place them into a dryer to make the specimens cool to the room temperature, and weigh the mass of dried specimens. The measured specimens shall be used as specimens for uniaxial compressive strength test in the dry state.

4.6 Weighing of this test shall be accurate to 0.01g; measurement shall be accurate to 0.01mm.

5 Test procedures for in-water weighing method

5.1 If the natural density is measured, representative rock shall be used for the preparation of specimens, and be weighed. If the dry density is measured, put specimens into a dry oven at 105°C ~110°C, dry the specimens to the constant mass for generally 12h~24h. Take out specimens from the dry oven and put them into a dryer to make them cool to the room temperature; and the dried specimens shall be weighed.

5.2 Put the dried specimens into water to make them saturated; and boiling method or vacuum-pumping method can be used for saturation according to the rock property. Saturation process and weighing of specimens shall meet requirements of the relevant clauses in T 0205 of this specification.

5.3 Take out the saturated and submerged specimen; and wipe off the moisture on the specimen surface by wet gauze; and weigh the mass immediately.

5.4 Put samples on the wire net of the weighing apparatus in the water; weigh the sample in the water (the mass of the wire net can be equilibrated by the counter weight in advance). In the process of weighing, the liquid level of the weighing apparatus shall be kept at the same height; and the water temperature shall be recorded.

5.5 The weighing in this test shall be accurate to 0.01g.

6 Test procedures of wax sealing method

6.1 If the natural density is measured, representative rock shall be used for the preparation of specimens, and be weighed. If the dry density is measured, put specimens into a dry oven at 105°C ~110°C, dry the specimens to the constant mass for generally 12h~24h. Take specimens out of the dry oven and put them into a dryer to make them cool to the room temperature.

6.2 Take out specimens from the dryer and place them on the balance for weighing, accurate to 0.01g (weighing accuracy of this test is the same).

6.3 Paraffin shall be put in a clean iron basin for heating and fusing to a temperature slightly higher than the fusion point (common paraffin melting point is 55°C~58°C). Rock specimens can be coated with a paraffin layer, which is about 1mm thick by roller coating or brushing; and accurately weigh the mass of the wax-sealed specimens after cooling.

clean flask.

(5) Boiling water tank.

3 Specimen preparation

3.1 Regular specimen: the size of specimen shall comply with provisions of 3.1 of T 0221 in this specification.

3.2 The irregular specimen should adopt perfectly round rock block with side length or diameter of 40mm~50mm.

3.3 The number of the specimens in each set shall be at least 3; for the rock with uneven texture, each set shall include at least 5 specimens.

4 Test procedures

4.1 Place the specimen in to 105°C~110°C oven and bake it till constant mass; the oven drying time is generally 12h~24h; take it out from dryer and cool to room temperature (20°C±2°C); weigh the mass and accurate to 0.01g (the same below).

4.2 Place the weighed specimen into water container; inject water to 1/4 height of specimen, and respectively inject water to 1/2 and 3/4 height of the specimen every other 2h; add water to 20mm higher than the top surface of specimen after 6h to help the air ran off the specimen. Absorb water freely for 48h after the entire specimen submerged by water.

4.3 Take out the submerged specimen; and wipe off the moisture on the specimen surface by wet gauze; and weigh the mass immediately.

4.4 Select one of the following methods for the forced saturation of specimen:

Saturate specimen by boiling method: place the weighed specimen into water tank; add water to the half of the specimen height, and stand for 2h. Add water to submerge specimen; boil it for 6h above; and keep the water depth constantly. Keep the water tank still after stopping boiling; take the specimen out after it has been cooled; and wipe off the moisture on surface by wet gauze; weigh the mass immediately.

Saturate the specimen by vacuum-pumping method: place the weighed specimen into vacuum drier; inject uncontaminated water and make the water surface 20mm higher than specimen top surface. Start the air pump; and the vacuum pressure during pumping shall reach to 100kPa; keep this vacuum state till no air bubble occurs (no less than 4h). The vacuum-pumped specimen shall be placed in the original container; stand for 4h at atmospheric pressure; take out the specimen; and wipe off the moisture on its surface by wet gauze; and weigh the mass immediately.

5 Results disposal

surface mudding or softening shall be described in detail.

4.2 The sidewise restraint expansion ratio test shall be carried out according to the following procedures:

- (1) Place the specimen into metal ring coated with Vaseline in the inside; and place thin filter paper and porous disk on and under specimen, respectively.
- (2) Place fixed metal load block on the top; and install vertical dial indicator. The mass of metal load block shall be able to produce 5kPa sustained pressure against the specimen.
- (3) The examination and stabilized reference shall be in accordance with Items (3) ~ (6) in Sub-clause 4.1 in this test method.
- (4) After the test, the mudding and softening phenomena on specimen surface shall be described.

4.3 The lateral expansion pressure test shall be carried out according to the following procedures:

- (1) Place the specimen into metal ring coated with Vaseline in the inside; and place thin filter paper and metal porous disk on and under specimen, respectively.
- (2) Install pressurizing system and measuring gauge to measure the specimen deformation.
- (3) All parts of instrument shall be kept at the same axes with specimen; and no eccentric load is allowed.
- (4) Impose 0.01MPa load on specimen; measure and read the measuring gauge display for the specimen deformation once every other 10 min, till the 3 times readings are constant.
- (5) Inject uncontaminated water into water container slowly till the top porous disk is immersed. Observe the change of deformation measuring gauge; where the amount of deformation is larger than 0.001 mm, adjust the applied load; and maintain the specimen height constant during the test.
- (6) Read once every other 10 min in the beginning. When the reading difference of 3 continuous displays is less than 0.001 mm, the frequency is changed to once every 1h. When the reading difference of 3 continuous displays every 1h is less than 0.001 mm, it is considered to be stable and record the test load. After water soaking, the overall testing time shall be no less than 48h.
- (7) During the test, the water level shall be kept constant. And the change of water temperature shall be no larger than 2°C.

The compressive strength of rock cube (or cylinder) specimen under saturated state is adopted in this method to assess the rock strength (including the original rock strength of crushed stone or pebble).

In certain cases, the water containing state of specimen may be adopted with natural state, drying state or state after freezing-thawing cycle according to requirements. The water containing state of specimen shall be indicated in test report.

2 Apparatus

- (1) Compression testing machine or universal testing machine.
- (2) Rock drill, stonecutter, stone mill and other rock specimen processing devices.
- (3) Oven, dryer, Vernier caliper, L-square and water tank, etc.

3 Specimen preparation

3.1 The cylinder is adopted as the standard specimen for rock test of building foundation; diameter is $50\text{mm} \pm 2\text{mm}$, and the ratio of height and diameter is 2:1. There are 6 specimens in each set.

3.2 The cube specimens are adopted for the test of building stone for bridge engineering; side length is $70\text{mm} \pm 2\text{mm}$. There are 6 specimens in each set.

3.3 The cylinder or cube specimens are adopted for the test of building stone for pavement engineering; the diameter or side length and height are $50\text{mm} \pm 2\text{mm}$. There are 6 specimens in each set.

For the rock with notable stratification, take 6 specimens along the parallel and vertical stratification directions, respectively. The upper and lower end surfaces of specimen shall be parallel and be worn flat. The flatness tolerance of specimen end surface shall be less than 0.05 mm; and the verticality deviation of end face to specimen axes shall not exceed 0.25° . For the nonstandard cylinder specimen, the compressive strength test value after test shall be conversed according to Formula (T0221-3) in the article description of this Clause.

4 Test procedures

4.1 Measure the specimen size by Vernier caliper (accurate to 0.1mm). For the cube specimen, measure the side length on the top surface and bottom surface; and calculate the carrying area according to the arithmetic average of two parallel side lengths. For the cylinder specimen, measure two orthogonal diameters on the top surface and bottom surface; calculate the areas of bottom surface and top surface according to respective arithmetic average; and take the arithmetic average of top surface and bottom surface areas as the sectional area to calculate the compressive

be listed simultaneously; for the rock with notable stratification, the average specimen strength in the vertical and parallel stratification directions shall be reported, respectively. The calculated value is accurate to 0.1 MPa.

The calculated value of softening coefficient is accurate to 0.01; test 3 specimens parallelly, and take the arithmetic average. The difference between the maximum and minimum value of the 3 values shall not exceed 20% of the average value; otherwise, test the fourth specimen; and take the average value of 3 specimens (the proximal 3 specimens of the 4) as the test result; meanwhile provide the 4 values in the report.

5.3 Test record

Records of uniaxial compressive strength test shall include rock name, test number, specimen coding, specimen description, specimen size, breaking load and failure form.

T0222-2005 Uniaxial compressive deformation test

1 Purpose and application scope

The rock uniaxial compressive deformation test is used to determine the axial and radial strain of rock specimens under uniaxial compression stress condition, hereby to calculate the modulus of elasticity and Poisson's ratio of rock.

The modulus of elasticity is the ratio of axial stress and axial strain; Poisson's ratio is the ratio of radial strain and axial strain at the corresponding condition of modulus of elasticity.

This test is divided into resistance strain gage method and dial indicator method; and it is applicable to every kind of rocks that can be made into regular specimens. Hard and comparable hard rocks shall be adopted with resistance strain gage method; while comparable soft rock shall be adopted with dial indicator method.

2 Apparatus

- (1) Rock drill, stone sawing machine, stone mill and other rock specimen processing devices.
- (2) Wheatstone bridge, multimeter, Megohmmeter and dial indicator.
- (3) Resistance strain gage.
- (4) Resistance strain foil (the length of wire grid is larger than 15mm); and various instruments and binder used to bond resistance strain foil.
- (5) Compression testing machine or universal testing machine.

metal shielded wire should be used for welding in order to avoid the mutual interference of the generated magnetic fields. The resistance strain gage shall be near the compression testing machine to reduce the lead length; the lead shall be fixed after welding to avoid being pulled off. The insulation resistance value of system shall be larger than 200MΩ.

4.2.4 Operate according to the operation instruction of the adopted resistance strain gage; connect the power; inspect the voltage; and adjust sensitivity factor. Connect the measuring lead of specimen, and place it on the ball seat of compression testing machine. Connect the temperature compensation resistance strain foil; the specimen stuck with temperature compensation resistance strain foil shall be in the same set with tested specimen; and shall be placed near the tested specimen. The operation procedure requirements of sticking temperature compensation strain foil shall be the same as work strain foil as possible.

4.2.5 Repeatedly prepress the specimen for 2~3 times; and the loading pressure is about 15% of the rock ultimate strength.

4.2.6 According to the specified loading method and load grading, the loading speed shall be 0.5 MPa/s~1.0MPa/s; measure and read the load and strain step by step till the specimen being destroyed. The reading shall be no less than 10 sets of tested values.

4.2.7 Record the phenomena appeared during the loading process and when the specimen is destroyed; describe the destroyed specimen.

4.3 Dial indicator method

4.3.1 Where the dial indicator method is adopted to measure the rock specimen deformation, for the comparable hard rock, the measuring gauge support may be installed on specimen directly to measure the deformation of specimen in longitudinal and transversal directions. For the soft rock and extreme soft rock with large deformation and low strength, the measuring gauge may be installed at magnet stand; the magnet stand is installed at the lower bearing plate of testing machine; the longitudinal measuring gauge head contacts with upper bearing plate edge, and the transversal measuring gauge head contacts with specimen directly; measure and read the initial reading. Two pairs of orthogonal longitudinal measuring gauges and transversal measuring gauges shall be installed at symmetric position of specimen diameter, respectively.

4.3.2 Other procedures shall comply with the provisions in Sub-clause 4.2.5~4.2.7 of this test.

5 Results disposal

5.1 Each level stress is calculated according to Formula (T0222-1):

D - The diameter of cylinder specimen (mm);

H - The height of cylinder specimen (mm).

5.2 For the rock tensile splitting strength test result, the test value of each specimen and the average value of test result of 3 specimens in the same set (depends on required load carrying direction or water containing state; 3 specimens shall be prepared for each condition) shall be listed; and the test results is accurate to 0.1 MPa.

5.3 Test record

Records of tensile splitting strength test shall include rock name, test number, specimen coding, specimen description, specimen size and failure load.

T0224- 2005 Shearing strength (straight snips) test

1 Purpose and application scope

This test aims to offer the rock elementary calculation criterion for relation between normal stress and shear stress when specimen slides.

Rock direct shear test is to make a horizontal shear of same category of rock specimens in one set under different normal load. To confirm the rock shear strength parameter in accordance with coulombs law formula. This test is applicable to direct shear test for rock texture surface (for instance, joint plane, bedding plane, lamination plane, and cleavage plane), rock, and cementation interface between concrete or mortar and rock.

2 Apparatus

- (1) Rock drill, stonecutter, stone mill, etc. and rock specimen processing device.
- (2) Device for preparation of concrete and mortar, maintenance tank, etc.
- (3) Saturated sample equipment: water channel, vacuum-pumping equipment, etc.
- (4) Meter measuring normal and shearing displacement, with accuracy of 0.01mm.
- (5) Vernier caliper.
- (6) Direct shear apparatus including normal and shearing compression equipment, see Figure T0224-1.

3 Specimen preparation

3.1 Specimen for cementation interface between concrete or mortar and rock

fracture should be controlled at around 10mm.

3.3 Rock specimens

- (1) To determine the specimen size, the equipment capacity of instrument and the strength of rock shall be considered. The diameter or side length of the specimen for rock direct shear test shall be no less than 50mm; and the height of specimen shall be equal to diameter or side length. Irregular specimens may also be adopted.
- (2) The specimen shall be wrapped by high strength reinforced concrete or steel outer frame. The space between specimen and outer frame must be filled densely; and shear fracture should be controlled at around 10mm.

3.4 The specimen may be adopted with natural, saturated as well as drying state according to requirements.

3.5 The number of specimens in each group shall be no less than 5.

4 Test procedures

4.1 Specimen installation

- (1) Place the specimen on direct shear apparatus, the shearing direction of specimen shall be approximately same as the applied force direction of structure. After proving, If the shear parameters are not affected by direction of the applied force, it may not be limited by the above-mentioned conditions. The space between specimen and the inner wall of shear box shall be filled densely to make the specimen and shear box as a whole. The designed shear plane shall be located at the center of shear fracture.
- (2) The action directions of normal load and shear load shall pass through the geometrical center of designed shear plane. The normal displacement meter and horizontal displacement meter shall be arranged symmetrically; and there shall be at least one meter in each direction.

4.2 Application of normal load

- (1) The maximum value of normal load should be 1.2 times of engineering force. For the specimen containing soft filling on the structural plane, the maximum normal load shall be limited to not forcing out the filling. The normal load should be graded according to arithmetical progression; and the number of grades shall be no less than 5.
- (2) For the specimens requiring no solidification, the normal load may be applied at one time; and the normal displacement is measured and read immediately. 5min

(hereinafter referred to as loading cone); 5-oil pressure gage; 6-Vernier scale; 7-sample

② Load measuring system: two oil pressure gages with maximum ranges of 10MPa and 60MPa, respectively; the measuring accuracy shall ensure to reach 2% of the breaking load reading P . The whole load measuring system shall be able to resist hydrodynamic shock and vibration; and be free from the influence of repetitive loading.

③ The measuring part of gauge length: it is measured by steel ruler with 0.2mm graduation or displacement sensor; the measuring accuracy of space between specimen loading points shall be ensured to reach $\pm 0.2\text{mm}$.

(2) Caliper or steel tape: accuracy is $\pm 0.2\text{mm}$.

(3) Geologic hammer.

3 Specimen preparation

3.1 The specimen may be adopted with borehole core or the blocks taken from rock outcrop, prospecting pit, footrill or tunnel. Artificial cracks shall be avoided during the sampling and sample preparation periods.

3.2 Specimen size

(1) Borehole specimen

① Radial test: diameter is 30mm~100mm; and the ratio of length and diameter shall be greater than 1.

② Axial test: the space between diameter and loading point is 30mm~100mm; and the ratio of loading point space and diameter is 0.3~1.

(2) Packet or irregular block specimen

① Space between two loading points is 30mm~50mm.

② The ratio of mean width on loading position and space between two loading points is 0.3~1.

③ The specimen length shall be no less than the space between two loading points. The length (L), width (b) and height (h) of rock sample shall satisfy $L \geq b \geq h$ (as shown in Figure T0225-2) as possible. The specimen height is generally controlled at 25mm~100mm to meet the requirements for specimen size by testing machine loading system. The rock surface near the specimen loading point should not be too uneven or tilt; otherwise, it shall be repaired.

(3) The water containing state of specimen may be adopted with natural water

T0226-1994 Folding strength test

1 Purpose and application scope

Folding strength is a major mechanical index of assessing building materials, such as rock plates, boulder strip foundation, boulder strip pavement.

This test is applicable to every kind of rocks.

2 Apparatus

- (1) Stonecutter, stone mill etc. rock specimen processing devices.
- (2) Compression testing machine or universal testing machine.
- (3) Vernier caliper, L-square, etc.
- (4) oven: the temperature can be controlled at 105°C ~110°C

3 Specimen preparation

Use stonecutter and stone mill to make rock samples into 50mm×50mm×250mm specimens, which are smooth in surface and sides of which are orthogonal. For the rock with uniform lithoid (stratification or streak free), make 6 specimens; put 3 of them into a 105°C ~110°C dry oven and dry them to the constant mass, then test after cooling. The rest 3 specimens shall be tested after free saturating treatment in accordance with T 0205 of this specification. If the rock has notable streak, 6 specimens, which are perpendicular the streak, and 6 specimens which are parallel the streak shall all be prepared; if the force is perpendicular and parallel to the streak, 3 specimens shall be in one set and test shall be carried out for them in dry and saturation states, respectively.

4 Test Procedures

4.1 Describe specimens and number them.

4.2 Measuring the dimension of the central section of the specimen, accurate to 0.1mm.

4.3 Put specimens on the flexural supports of the testing machines, as shown in Figure T0226-1, the span is 200mm; use mid-span single-point loading, then start the testing machine; continuously and uniformly apply load at a stress rate of 15MPa/min ~20MPa/min till the specimens is broken; record the breaking load and measure the section size.

5 Results disposal

5 Long Duration Test

T0241-1994 Frost resistance test

1 Purpose and application scope

Frost resistance of the rock is used to evaluate the failure resisting capacity for rock at the saturation state after the freezing-thawing cycle for specified times; and different project environment requires different rock frost resistance. Freezing-thawing times specify: in the severe cold area (in the coldest month, in which the average monthly air temperature is less than -15°C) 25 times; in the cold area (in the coldest month, in which the average monthly air temperature is less than $-15^{\circ}\text{C}\sim -5^{\circ}\text{C}$) 15 times;

For the cold area, this method shall be used for rock frost resistance test.

2 Apparatus

- (1) Stonecutter, rock drill, stone mill and other processing devices of rock specimens
- (2) Refrigerator: the temperature can be controlled at $-15^{\circ}\text{C}\sim -20^{\circ}\text{C}$.
- (3) Balance: the sensibility is 0.01g, and the weighing is larger than 500g.
- (4) Magnifier
- (5) Oven: the temperature can be controlled at $105^{\circ}\text{C}\sim 110^{\circ}\text{C}$.

3 Specimen preparation

3.1 Specimens shall comply with the provisions of 3.1 in T 0221 of this specification.

3.2 There shall be at least 3 specimens in each set, make another 3 specimens of the same category for freezing-thawing coefficient test.

4 Test Procedures

4.1 Make a detailed examination on the specimen coding by the magnifier and describe the appearance. Measure the dimension of each specimen and calculate the load area. Put the specimens into a dry oven at $105^{\circ}\text{C}\sim 110^{\circ}\text{C}$ and dry them to the constant mass for generally 12h~24h; and put them in a dryer to cool to the room temperature and take them out to weigh the mass, m_s , immediately, accurate to 0.01g (the same below).

4.2 Make the specimens freely be saturated according to the water absorption test method; then take them out and wipe off the surface moisture; and put them in an iron pan; and a certain space shall be reserved between specimens.

(4) Porcelain, glass or glaze vessels: the capacity shall be no less than 5L.

(5) Thermometer.

(6) Densimeter.

(7) Magnifier; steel needle, etc.

3 Test materials or reagents

3.1 Saturated sodium sulfate solution: take about 400g of anhydrous sodium sulfate (or 800g of crystal sodium sulfate); and make it dissolve in the 30°C ~50°C 1000mL of purified water (total required amount of the solution is about 5 times of the specimen volume). The preparation method is: heat the uncontaminated water (water temperature: 30°C ~ 50°C) and slowly add sodium sulfate; continuous agitate with a glass rod till all the sodium sulfate is dissolved and saturated and some crystallization appear. Make the solution cool to the room temperature (20°C ~ 25°C) and keep it still for 48h. Intensively mix the solution when use it, and the solution density shall be kept at 1150kg/m³ ~ 1175kg/m³ in the test.

3.2 10% Barium chloride solution

4 Specimen preparation

The same as the specimen preparation in T0221-2005.

5 Test Procedures

5.1 Put specimens into a dry oven at 105°C ~110°C to dry to the constant mass for generally about 12h~24h; take them out and put them into a dryer and cool to the room temperature; weigh their mass (accurate to 0.01g, the same below).

5.2 Soak the dried specimens into a vessel containing sodium sulfate solution; the solution shall be 2cm higher than the top surface of the specimen; cover the vessel; and stand for 20h. Then take the specimens out; and put them into a porcelain dish and deliver them to a dry oven at 105°C ~110°C for 4h. Then, take them out after 4h; make them cool to the room temperature; and soak them into the sodium sulfate solution over again till sodium sulfate crystallization dissolves; then take them out and examine for failures of the rock specimen with a magnifier and a steel needle; and take record.

5.3 Soak and dry for 5 times in accordance with the above-mentioned method; after the last time cycle, use the uncontaminated water to boil and wash for several times till the sodium sulfate solution in the specimen is totally washed out. Use 10% barium chloride solution to check, and the concrete operations is: take several mL of water to wash specimens; titrate a small amount of barium chloride solution; if there is no white

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