ICS 73.010
CCS D 04

NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/T 23561.11-2024

Replacing GB/T 23561.11-2010

Methods for determining the physical and mechanical properties of coal and rock - Part 11: Methods for determining shear strength of coal and rock

煤和岩石物理力学性质测定方法 第11部分：煤和岩石抗剪强度测定方法

Issued on: April 25, 2024 **Implemented on: August 1, 2024**

Issued by: State Administration for Market Regulation;
Standardization Administration of the PRC

Table of Contents

1 Scope

The document describes four methods of determining the shear strength of coal and rock: on standard specimens, on non-standard specimens, in double shear and in single shear.

Determination on standard specimens applies to coal and rock that can be machined into standard specimens; determination on non-standard specimens applies to soft coal and

rock that cannot; the double shear and single shear methods apply where only the shear strength of the coal or rock is to be determined. The only normative reference is Part 7 of the same series, GB/T 23561.7-2009.

3 Terms and definitions

Shear strength is defined as the maximum shear stress that a given cross-section of a coal or rock specimen can bear under a given normal stress.

4 Determination of shear strength on standard specimens

The apparatus comprises a core drill, a rock saw and a grinder or surface grinder; the variable-angle shear jig shown in Figure 1, made up of an upper and a lower seat, a cylindrical specimen shear die, steel bearing plates and rollers; a vernier caliper reading to 0.02 mm; a steel rule; a universal bevel protractor with a dial gauge and stand; a levelling table; and a materials testing machine of accuracy class not lower than 0.5, whose load cell range shall be more than 1.25 times and less than 5 times the expected maximum failure load.

Standard specimens should be cylinders 48 mm to 56 mm in diameter and 50 mm high, machined to the accuracy of 5.2 of GB/T 23561.7-2009 and conditioned to the moisture state of 5.4 of the same part. The number of specimens follows the test scheme: with five or more shear angles and one specimen at each angle, at least five specimens are needed; with three shear angles and four specimens at each angle, whose shear strengths are averaged, at least twelve are needed. Under the second scheme the deviation is calculated together with the mean, and if it exceeds 20 % more specimens are added until it does not.

Before the test the sample name and number are checked and the colour, grain, bedding, jointing, fissures, degree of weathering and moisture state of the specimen, together with any problem met in machining, are described on the form of Annex A. Three or more, or five or more, shear angles are chosen within the range 38 degrees to 65 degrees, the specimens are grouped and numbered by angle and the shear line is drawn on each. The machining accuracy is checked and the diameter and length at the shear plane are each measured twice and averaged.

The dial of the testing machine is zeroed, the lower seat of the jig, set to the chosen angle, is placed with its centre line on the centre line of the bearing plate, the specimen and the upper seat are fitted and the spherical seat is adjusted so that the jig is loaded evenly. A pressure of 0.1 kN to 0.5 kN is applied to check the seating, and if the parts are out of line the load is removed and they are reset. Loading then continues at 0.5 MPa/s to 1.0 MPa/s until failure, the operator standing clear of the bench with suitable protection in place. The failure load and everything observed during loading are recorded and the failure pattern described; from a specimen that was not dry, pieces are sealed at once in a plastic bag and

the moisture content determined as soon as possible.

In the data calculation the normal stress and the shear stress on failure plane AB are obtained for each specimen from the failure load, the area of the shear plane and the angle between the shear plane and the horizontal, and are then averaged over the specimens tested at each shear angle. The deviation of the normal stress and of the shear stress is calculated from their standard deviations and the corresponding means; if it exceeds 20 % more specimens are added. The mean and the deviation are calculated when three shear angles with four specimens each are used and are not calculated when five or more angles with one specimen each are used.

The mean values are plotted as the shear strength curve of Figure 2, the plotted points being the mean measured values at each angle or, where one specimen was tested at each of five or more angles, the individual values. For use in engineering the curve is simplified to a straight line fitted by least squares. The intercept of that line on the shear stress axis is the cohesion and the arc tangent of its slope is the angle of internal friction; the cohesion is given to three significant figures and the angle of internal friction to the nearest minute.

5 Determination of shear strength on non-standard specimens

The apparatus is the testing machine and the variable-angle shear jig used for standard specimens, together with a cubic mould of 70.7 mm side, a vernier caliper reading to 0.02 mm, a glass plate or tracing paper, a planimeter or graph paper, a steel rule, high-alumina or high-strength cement stronger than the rock, mica flakes or mica powder, and waterproof paint or a waterproof sleeve.

The specimen should be roughly cylindrical with a smooth surface, and neither conical nor bi-conical; the diameter should be 48 mm to 56 mm and the height should not exceed 50 mm. The number of specimens and the moisture state follow the rules for standard specimens.

To make the casing the specimen is painted with waterproof paint and air-dried, or bound in a waterproof sleeve, and then cemented into the cubic mould with high-strength cement, a layer of mica flakes or mica powder about 1 mm thick being spread on the mid-plane of the mould to form the shear plane, as shown in Figure 3. The mould is stripped after 24 h and the block is covered with a wet towel and water-cured for 28 d, then machined to a cube of 70 mm side. The remaining steps and the calculation follow those for standard specimens.

The shear area of a non-standard specimen is obtained by tracing the shear face on a glass plate or tracing paper and measuring the traced figure with a planimeter or by counting squares on graph paper.

6 Determination of double shear strength

The apparatus is a testing machine of accuracy class not lower than 0.5 with a load cell range meeting the same condition as before, the double-shear jig of Figure 5 with its pressure bar, jig seat and two shear faces, a core drill, a cutting machine and a grinder or surface grinder, and a vernier caliper reading to 0.02 mm.

The specimen is a cylinder 25.0 mm plus or minus 0.1 mm in diameter and about 120 mm long; the number of specimens and the moisture state follow the rules for standard specimens.

Before the test the sample name and number are checked and the specimen described on the form of Annex B. The sheared positions are marked in red pencil and the diameter there is measured twice with the caliper and averaged. The specimen is placed in the double-shear jig, the jig is centred on the bearing plate of the testing machine and the spherical seat is adjusted so that the upper bearing plate is parallel to the loaded face of the jig. The dial is zeroed and the load is applied smoothly at 0.03 MPa/s to 0.05 MPa/s until the specimen shears.

The failure load and the phenomena observed during loading are recorded and the state of the failed specimen is described; from a specimen that was not dry, pieces are sealed at once in a plastic bag to prevent water loss and the moisture content is determined as soon as possible. The double shear strength is calculated from the failure load and the specimen diameter and the arithmetic mean is taken, the result being given to three significant figures, with the individual values listed in the test report.

7 Determination of single shear strength

The apparatus is the same testing machine, the single-shear jig of Figure 6 with its pressure plate, ball, clamping plates and the normal and shear loads acting on the shear plane, a core drill, a cutting machine and a grinder or surface grinder, and a vernier caliper reading to 0.02 mm.

The specimen is a cube of 50 mm, 70 mm, 100 mm, 150 mm or 200 mm side; the number of specimens and the moisture state follow the rules for standard specimens. Before the test the sample is checked and described on the form of Annex B, the sheared position is marked and its length measured twice and averaged.

The specimen is placed in the single-shear jig, which is centred on the bearing plate so that the resultant of the normal and the tangential force passes through the centre of the shear plane. The normal stress is divided into five grades within the design range and a round value is loaded at each grade. The normal load is applied in five steps, one every 5 min, with the vertical deformation read before and after each step; once the intended load is reached and the vertical deformation reading changes by not more than 0.01 mm over 5