Japanese Geotechnical Society Standard (JGS 0521-2020)
Method for unconsolidated-undrained triaxial compression tests on soils

1 Scope

This standard specifies a test method to determine the strength and deformation characteristics of an unconsolidated and undrained soil specimen when subjected to axial compression. The test shall be carried out on three or more specimens prepared from a same sample, under different isotropic stresses within required stress range. This standard applies mainly to saturated cohesive soils.

Note: This standard is also applicable, with modifications, to soils with a high degree of saturation.

2 Normative references

The following standards shall constitute a part of this standard by virtue of being referenced in this standard. The latest versions of these standards shall apply (including supplements).

The specimens to be used in this test shall be prepared and installed in accordance with the following standard.

JGS 0520 Preparation of soil specimens for triaxial tests

For coarse-grained soil with a maximum particle size exceeding about 20 mm, the specimens to be used in this test shall be prepared and installed in accordance with the following standard.

JGS 0530 Preparation of specimens of coarse granular materials for triaxial tests

3 Terms and definitions

The terms and definitions used in this standard are as follows:

Note: The test covered by this standard can be referred to in abbreviated form as UU triaxial test.

3.1 UU

Shearing soil in the undrained condition without first consolidating it (Unconsolidated and Undrained: UU).

3.2 Axial stress

The stress acting on the specimen in the cylinder axis direction.

3.3 Lateral stress

The stress acting in the radial direction of the specimen.

3.4 Principal stress difference

The difference between the axial stress and the lateral stress. The value of stress shall be defined at the mid-height of the specimen.

3.5 Isotropic stress state

The stress state when the axial stress is equal to the lateral stress.

3.6 Cell pressure

The pressure applied to the triaxial pressure cell. The lateral stress is equal to the cell pressure.

3.7 Unconsolidated and undrained compressive strength of soil

The maximum principal stress difference that can be applied to the unconsolidated soil specimen such that no pore water flows in or out of the specimen.

4 Equipment

4.1 Triaxial compression test apparatus

The triaxial compression test apparatus shall consist of a triaxial pressure cell, a system for applying cell pressure, a compression device, and measurement instruments for load and displacement. The apparatus shall satisfy the following conditions. Figure 1 shows an example of the configuration of triaxial compression test apparatus. Figure 2 shows the schematic structure of the triaxial pressure cell: (a) is an example in which the piston and cap are rigidly connected while (b) is an example in which the two are not rigidly connected. Both forms must allow for mounting of a specimen having the same diameter as the cap and pedestal between the cap and pedestal, covered with a rubber sleeve, and sealed with an O-ring, etc.

a) The apparatus shall have sufficiently high load-bearing strength and load capacity to handle the maximum cell pressure and maximum axial compression force to be applied to the specimen.

b) The apparatus shall be capable of maintaining the cell pressure within ±4 kN/m^2 of a target value for pressures up to 200 kN/m^2, and within ±2 % of the target value for pressures of 200 kN/m^2 or greater, for the duration of a single test.

c) The apparatus shall be capable of applying and maintaining axial displacement up to 15 % or more of the specimen height.

d) The apparatus shall be capable of measuring the cell pressure with an allowable tolerance of 2 kN/m^2 for pressures up to 200 kN/m^2 and of 1 % for pressures of 200 kN/m^2 or greater.

e) The apparatus shall be capable of measuring the axial compression force up to the specimen's maximum axial compressive strength within an allowable tolerance of 1 %. If the test apparatus is set up such that the load cell is located outside the triaxial pressure cell, the frictional force at the point of sliding between the piston and the triaxial pressure cell shall be measured. This friction value shall be used to correct the measured value of axial compression force. If the load cell is located inside the triaxial pressure cell, the effect of cell pressure shall be determined and the measured value of axial compression force shall be corrected.

f) The apparatus shall be capable of measuring the axial displacement up to 15 % of the specimen height within an allowable tolerance of 0.1 %.

g) The cap and pedestal shall be impermeable. If the cap and pedestal incorporate a weep hole or a porous plate, etc., the holes and perforation shall be closed using a flat, smooth and rigid water-blocking disc of the same diameter as the specimen.

5 Test method

5.1 Preparation and set-up of test specimen and application of isotropic stress

The specimen shall be prepared and then isotropic stress shall be applied as follows.

a) The specimen shall be prepared and set up in accordance with JGS 0520 Preparation of soil specimens for triaxial tests. Additionally, the specimen shall have a height not less than twice its diameter. For coarse-grained soils with a maximum particle diameter greater than about 20mm, the specimen shall be prepared in accordance with JGS 0530 Preparation of specimens of coarse granular materials for triaxial tests.

b) Pressure shall be applied to the specimen to achieve the prescribed isotropic stress state.

5.2 Axial compression process

The axial compression shall be carried out in accordance with the following procedure.

a) Check and adjust the zero reading of the load cell and displacement transducers.

b) Compress the specimen continuously at a standard axial strain rate of 1% per minute under a constant cell pressure.

c) Record the axial compression force, P (N), and the axial displacement, ΔH (mm), during compression.

Note: If the axial compression force and axial displacement are not recorded continuously, the measurement time interval shall be sufficiently small to enable a smooth curve for the principal stress difference versus axial strain to be drawn. It is recommended, for example, to measure axial displacement at a maximum interval of 0.2 mm up to the maximum value of the axial compression force, and thereafter at a maximum interval of 0.5 mm.

d) Terminate the compression either when an axial strain of more than 3 % has been reached since the maximum axial load reading, when the load reading has fallen to about 2/3 of its peak value, or when an axial strain of 15 % has been reached.

e) Remove the specimen from the triaxial pressure cell, and observe and record its deformed shape, failure mode, and other features. The observation shall be made in the direction that captures the features of failure most clearly. If a slip surface is found, observe it from the direction in which the steepest gradient is determined and record it so that the gradient angle can be approximately read. Any heterogeneity of the specimen and the presence of any foreign materials shall be observed and recorded.

f) Measure the oven-dried mass of the specimen, m_s (g).

Note: This step in the process may be omitted if the water content of the specimen is determined from the trimmed waste of the sample.

6 Processing test results

6.1 Initial state of the specimen before testing

The state of the specimen prior to the test shall be obtained using the following equation.

Note: Calculate the void ratio e_0 of the specimen, if necessary, using the following equation, which shall be rounded to two digits after the decimal point.

$$e_c = \frac{V_c/1000 \times \rho_s}{m_s} - 1$$

where

ρ_s: Density of soil particles (Mg/m^3)

a) Calculate the volume, V_0 (mm^3), and height, H_0 (mm), of the specimen prior to the test using the following equations.

$$V_0 = V_i - \Delta V_i$$

$$H_0 = H_i - \Delta H_i$$

where

V_i: Initial volume of the specimen (mm^3)

H_i: Initial height of the specimen (mm)

ΔV_i: Volume change of the specimen between the initial state and prior to the test (mm^3), where compression is defined to be positive

ΔH_i: Axial displacement of the specimen that occurred between the initial state and prior to the test (mm), where compression is defined to be positive

b) Calculate the cross-sectional area, A_0 (mm^2), of the specimen prior to the test using the following equation.

$$A_0 = \frac{V_0}{H_0}$$

c) Calculate the dry density, ρ_{d0} (Mg/m^3), of the specimen prior to the test using the following equation, which shall be rounded to two digits after the decimal point.

$$\rho_{d0} = \frac{m_s}{V_0} \times 1000$$

where

m_s: Oven-dried mass of the specimen (g)

6.2 Axial compression process

The method of calculation for the axial compression process shall be as follows.

a) The axial strain of the specimen, ε_a (%), shall be calculated using the following equation, where compression is defined to be positive.

$$\varepsilon_a = \frac{\Delta H}{H_0} \times 100$$

where

ΔH: Axial displacement of the specimen in the axial compression process (mm), where compression is defined to be positive

b) The principal stress difference, (σ_a - σ_r) (kN/m^2), at axial strain ε_a (%) shall be calculated using the following equations.

$$\sigma_a - \sigma_r = \frac{P}{A_0}\left(1 - \frac{\varepsilon_a}{100}\right) \times 1000$$

where

P: Axial compression force (N) applied to the specimen at axial strain ε_a (%), where P=0 in the isotropic stress state

σ_a: Axial stress (kN/m^2) acting on the specimen

σ_r: Lateral stress (kN/m^2) acting on the specimen

c) Draw graphs of the principal stress difference on the vertical axis versus axial strain on the horizontal axis.

d) Obtain the maximum principal stress difference $(\sigma_a - \sigma_r)_{max}$ in the axial strain range $0 < \sigma_a \leq 15$ % from the graph, and the corresponding value of axial strain shall be taken as the strain at failure (%), which shall be rounded to one digit after the decimal point. The value of this maximum principal stress difference shall be taken as the compressive strength, which shall be rounded to three significant digits.

7 Reporting

The following test results and other items shall be reported.

a) Method of specimen preparation

b) Dimensions of the specimen prior to the test

Note: Report the void ratio of the specimen prior to the test if necessary

c) Oven-dried mass (g) of the specimen and the dry density (Mg/m^3) prior to the test

d) Cell pressure (kN/m^2) and strain rate (%/min)

e) Compressive strength (kN/m^2) and strain at failure (%)

f) Principal stress difference versus axial strain curve

g) Failure condition of the specimen

h) Relationship between compressive strength and isotropic stress, which shall be shown by drawing a graph of compressive strength on the vertical axis and isotropic stress under pressure on the horizontal axis, or by drawing a Mohr stress circle at the maximum principal stress difference

Note: If necessary, report the Mohr's stress circle envelope, and the shear resistance angle, ϕ_u (°), and the intercept on the vertical axis, c_u (kN/m^2), obtained from the envelope.

i) If the method used deviates in any way from this standard, give details of the method used.

j) Other reportable matters

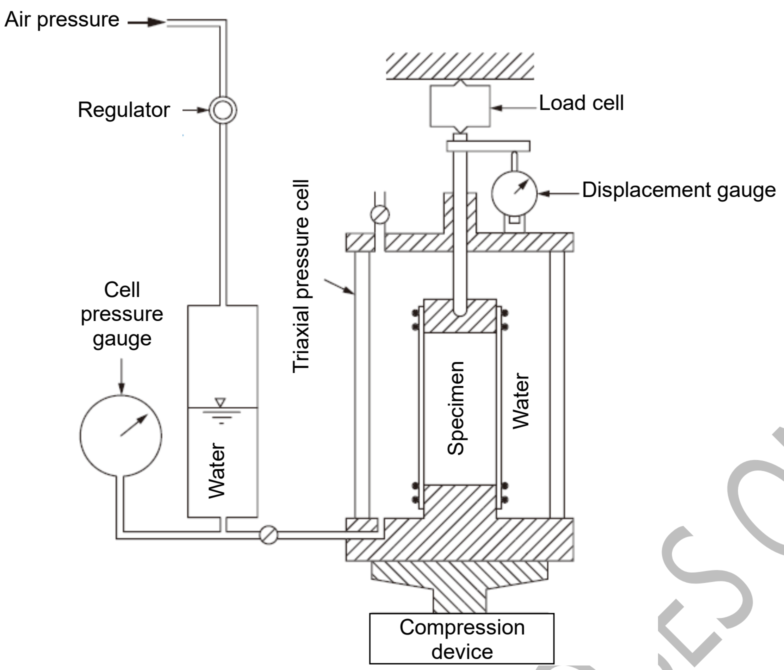
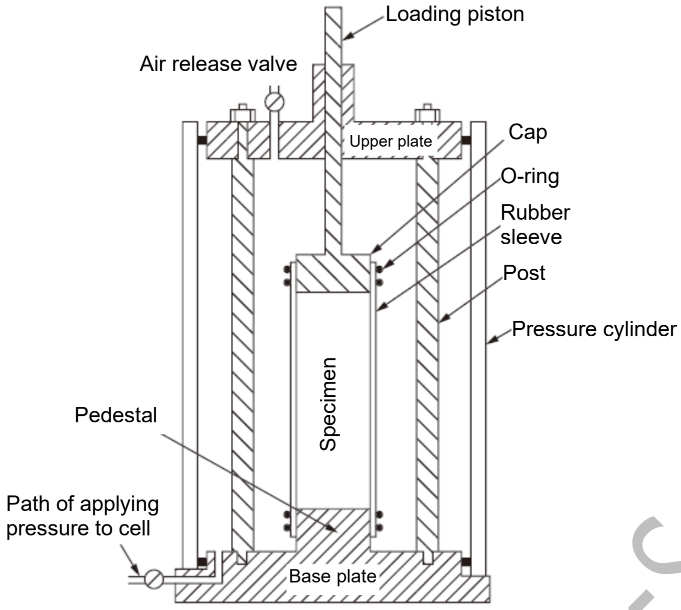
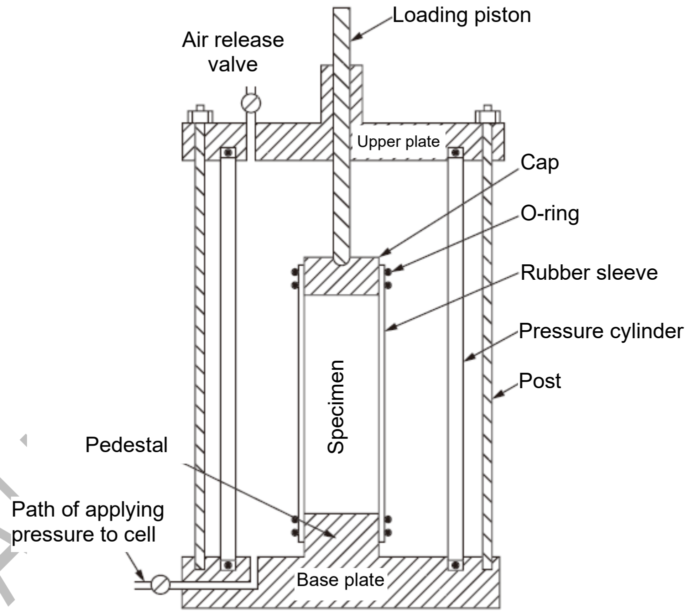


Figure 1 Example of configuration of UU triaxial compression test apparatus



(a) Loading piston and cap rigidly connected



(b) Loading piston and cap not rigidly connected

Figure 2 Schematic structure of triaxial pressure cell