Japanese Geotechnical Society Standard (JGS 0527-2020)
Method for triaxial compression test on unsaturated soils

1 Scope

This standard specifies a test method to obtain the strength and deformation properties of unsaturated soils under air drained conditions when subject to axial compression after consolidation under isotropic stress conditions. The standard applies to soils in the unsaturated state with a suction of 1,000 kN/m^2 or less. When testing, there may be a limitation on the magnitude of the suction that can be tested, due to the performance of the ceramic filter used.

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).

JGS 0520 Preparation of soil specimens for triaxial tests

Matters not prescribed in this standard shall be in accordance with the following related codes and standards.

JIS A 1217 Test method for one-dimensional consolidation properties of soils using incremental loading
JGS 0151 Test method for water retentivity of soils
JGS 0522 Method for consolidated-undrained triaxial compression test on soils
JGS 0523 Method for consolidated-undrained triaxial compression test on soils with pore water pressure measurements
JGS 0524 Method for consolidated-drained triaxial compression test on soils

If a test for water retentivity of soils is carried out with triaxial compression test apparatus using this method, it shall comply with the following method.

JGS 0151 Test method for water retentivity of soils, Section 6.1 Suction method and pressure method

3 Term and definitions

The main terminology and definitions used in this standard shall be as follows.

3.1 Unsaturated state

The state in which both water and air exist in the pores of a soil.

3.2 Axial stress

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

3.3 Lateral stress

The stress acting on a specimen in the radial direction. The stress value shall be defined at the mid-height of the specimen.

3.4 Cell pressure

The pressure applied within a triaxial cell.

3.5 Isotropic stress state

The state in which the axial stress and the lateral stress are equal.

3.6 Principal stress difference

The difference between the axial stress and the lateral stress.

3.7 Compressive strength

The maximum principal stress difference that can be applied to a specimen.

3.8 Suction

The matric suction defined as the pressure difference between the pore air pressure and the pore water pressure.

3.9 Net normal stress

The magnitude of the total stress relative to the pore air pressure, and shall be defined by the following equation.

$$\sigma_{\mathrm{net}} = \sigma - u_{\mathrm{a}}$$

where

σ_{net}: Net normal stress
σ: Total stress
u_{a}: Pore air pressure

4 Equipment

The triaxial compression test apparatus shall include a triaxial pressure cell, a cell pressure assembly, a back pressure assembly (pore air pressure, pore water pressure), a compression device, and devices for measuring stress, displacement, volume change, water drainage, pore water pressure, and air pressure. These shall satisfy the following conditions. Figure 1 shows an example of the layout of apparatus for the unsaturated triaxial compression test.

a) The test apparatus shall have sufficient capacity and load resistance with respect to the maximum cell pressure, back pressure, and the maximum axial load. The triaxial pressure cell used for unsaturated soil shall be equipped with a pedestal with a ceramic filter fixed by epoxy resin placed on the bottom of the specimen, to control drainage and to measure the pore water pressure, and a loading cap with a filter with low water retentivity (for example, glass fiber cloth) to control the exhaustion of air and to measure the pore air pressure. An example of triaxial cell for unsaturated soil is shown in Figure 2.

b) The apparatus shall be capable of applying the prescribed pressure continuously within a range of pressure fluctuation of ±2 kN/m^2 for pressures less than 200 kN/m^2, and ±1% for pressures equal to or greater than 200 kN/m^2, until completion of the test on the specimen.

c) The apparatus shall be capable of continuously applying an axial displacement in excess of 15% the height of the specimen.

d) The apparatus shall be capable of measuring the pressure within an allowable tolerance of 2 kN/m^2 for pressures less than 200 kN/m^2, and ±1% for pressures equal to or greater than 200 kN/m^2.

e) The apparatus shall be capable of measuring the axial load within an allowable tolerance of 1%, up to the maximum axial load applied to the specimen. For apparatus with a load cell installed outside the triaxial cell, the friction force between the piston and the pressure cell shall be measured, and the measured value of the axial load shall be corrected accordingly. When a load cell is installed inside the triaxial cell, the effect of the change of cell pressure shall be measured, and the measured value of the axial load shall be corrected.

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

g) The apparatus shall be capable of measuring the volume change in the specimen within an allowable tolerance of 0.1% of the initial volume of the specimen, up to the maximum amount of the change. In this standard, the volume change is measured in principle by the change in water level of the inner cell, and the quantity of soil water drained shall be measured in principle by a burette. However, other measurement methods may be adopted provided the conditions are satisfied, and the items to be reported are clearly stated.

h) The ceramic filter for measuring the pore water pressure shall have an air-entry value of 120% the maximum suction estimated.

5 Test method

5.1 Preparations

The following preparations shall be made.

a) Vacuum-deair the pedestal with ceramic filter that is immersed in water using deaerated water, to saturate the ceramic filter.

b) Pour deaired water into the pore water pressure measurement system to saturate it. After saturation, supply deaired water to the burette.

c) Remove the saturated pedestal from the deaired water, and install on the bottom of the triaxial pressure cell, while supplying deaired water little by little from the burette. When installing the saturated pedestal on the bottom of the triaxial pressure cell, take care not to entrain air bubbles in the connector. During the test preparations, there is always excess water on the ceramic filter surface due to surface tension. If the excess water is reduced, be sure to replenish it.

d) Confirm the zero on the pore water pressure gauge.

5.2 Preparation of test specimen

Preparation of the test specimen shall be as follows.

a) The test specimen shall be prepared in accordance with JGS 0520 Preparation of soil specimens for triaxial tests, Section 4 Method of Preparation and Setting the Specimen. However, the specimen height shall be not less than double the diameter.

b) A circular film sheet shall be placed on the top and bottom ends of the prepared specimen to prevent drying, and the specimen shall be covered with a rubber membrane. The rubber membrane shall be turned back over the ends. A low water retention film sheet shall be selected, and it shall be removed when the specimen is placed on the pedestal with ceramic filter.

Note: The rubber membrane shall be placed in a rubber membrane stretcher, and powder, etc., on the inside of the rubber sleeve shall be wiped off using a damp cloth. Also, the inside should be dampened as appropriate to reduce the absorption of soil moisture into the rubber membrane.

5.3 Placement of specimen

The specimen shall be installed as follows.

a) Close the drainage water valve to enable the pore water pressure to be measured.

b) Remove excess water from around the pedestal and from the surface of the ceramic filter. During this operational procedure, constantly monitor the pore water pressure meter, and prepare the water supply bottle close to the pedestal. At the preparation stage if a negative pressure in excess of -30 kN/m^2 is generated, promptly supply water to the surface of the ceramic filter, to release the negative pressure. Thereafter, repeat the operation from 5.3b) onwards.

c) After moving the specimen near the pedestal, gently wipe out water from the surface of the ceramic filter with a dry cloth to remove the water, and confirm the prescribed negative pressure indication on the pore water pressure meter. During this operational procedure, constantly monitor the pore water pressure meter, and prepare the water supply bottle close to the pedestal. At the preparation stage if a negative pressure in excess of -30 kN/m^2 is generated, promptly supply water to the surface of the ceramic filter, to release the negative pressure. Thereafter, repeat the operation from 5.3b) onwards. If the pore water pressure meter indicates -30 kN/m^2, promptly proceed to the next operation. If the negative pressure is virtually unchanged even after wiping with a dry cloth, then it is possible that the pedestal is not sufficiently deaired and saturated, or that air bubbles remain within the tube of the measurement system. In this case, repeat the operation from 5.1a). In this standard the limiting initial suction of the specimen shall be 80 kN/m^2, and if this is exceeded some appropriate measuring method must be taken for the cavitation within the measurement system.

d) Place the specimen that has been prepared in 5.2b) on the pedestal, gently press the top of the specimen to ensure good contact between the specimen and the ceramic filter, and place the loading cap.

Note: In the case of a frozen sample, the method prescribed in JGS 0520 Preparation of soil specimens for triaxial tests Section 4.5 Installation of specimens shall be applied.

e) Extend the rubber membrane that has been turned back over the ends, and fasten the two ends to the cap and the pedestal with O-rings or similar.

f) Immediately after placing the specimen on the pedestal, the pore water pressure meter readings shall be recorded at appropriate time intervals to measure the initial suction value of the specimen.

Note: The equilibrium state for measuring the initial suction value shall be confirmed by measuring the pore water pressure meter readings and the elapsed time, and applying the method prescribed in Section 5.2d) Note of JGS 0522 Method for consolidated-undrained triaxial compression test on soils.

g) Assemble the inner cell and the triaxial pressure cell, and pour deaired water into the inner cell until the loading cap is immersed in water. Assembly of the equipment is carried out while continuing the measurements of 5.3f), and the assembly procedures shall be in accordance with the structure of the respective testing apparatus. Measurement of the volume change shall be carried out by the method of measuring the fluctuation in water level within the inner cell, or using another device with equal or better performance. In each of the following items, the device for measuring the volume change is represented by the inner cell method. Also, the device for measuring the quantity of water drainage is represented by a burette.

Note: In order to reduce entrainment of air bubbles, deaired water should be used as the water within the inner cell.

5.4 Consolidation process

The test shall be carried out in accordance with the following requirements for the consolidation process.

a) Check and adjust the origin of the volume change gauge.

b) Confirm the initial suction equilibrium state of the specimen. If the initial suction is not measured, this may be omitted.

c) The pore air pressure shall be assumed to be atmospheric pressure, and a prescribed cell pressure shall be applied under the undrained state. The cell pressure and suction shall be determined by the applied stress path when loading is applied incrementally, or by the consolidation conditions when loading is not applied incrementally. Here as a rule the pore air is always under the drained condition, therefore by controlling the pore air pressure u_a>0, and the pore water pressure u_w=0, a prescribed suction is applied, and this pressure method is adopted.

d) The volume change gauge reading shall be recorded at appropriate intervals up to about 30 minutes. A guide to the time interval of each measurement in the consolidation process shall be the method prescribed in JIS A 1217 Test method for one-dimensional consolidation properties of soils using incremental loading. If necessary, the reading of the axial displacement gauge shall be recorded at each loading stage. If the reading of the axial displacement gauge is not taken as time passes, the reading of the axial displacement gauge shall be recorded at the end of each loading stage, or upon completion of the consolidation process. If a convergence trend is not observed in the volume change (or in the axial displacement) in the record at 30 minutes, the measurements shall be further continued, and the convergence trend of the volume change and the axial displacement shall be confirmed.

e) Close the water drainage valve, and set the air pressure equal to the prescribed suction. At the same time increase the cell pressure in accordance with the increment of the pore air pressure. In the case of incremental loading, the amounts of cell pressure and suction shall be determined from the stress path applied. In other cases, they shall be determined from the consolidation condition. Here as a rule the pore air is always under the drained condition, and the pressure method is adopted by controlling the pore air pressure u_a>0, and the pore water pressure u_w=0. If the suction method is adopted, apply a negative pressure equal to the prescribed suction to the double tube burette for water drainage, and let u_a be the atmospheric pressure. In this case the cell pressure shall not be allowed to increase.

f) Open the water drainage valve, and record the readings of the burette that measures the quantity of water drainage and the volume change at appropriate intervals up to about 30 minutes. A guide to the time interval of each measurement in the consolidation process shall be the method prescribed in JIS A 1217 Test method for one-dimensional consolidation properties of soils using incremental loading. If necessary, the reading of the axial displacement gauge shall be recorded at each loading stage. If the reading of the axial displacement gauge is not taken as time passes, the reading of the axial displacement gauge shall be recorded at the end of each loading stage, or upon completion of the consolidation process. If a convergence trend is not observed in the volume change (or in the axial displacement) in the record at 30 minutes, the measurements shall be further continued, and the convergence trend of the volume change and the axial displacement shall be confirmed. When the water drainage valve is opened, check that the burette for water drainage is released to atmospheric pressure.

g) Apply the prescribed cell pressure, and record the burette and volume change gauge readings at appropriate intervals up to about 30 minutes. A guide to the time interval of each measurement in the consolidation process shall be the method prescribed in JIS A 1217 Test method for one-dimensional consolidation properties of soils using incremental loading. If necessary, the reading of the axial displacement gauge shall be recorded at each loading stage. If the reading of the axial displacement gauge is not taken as time passes, the reading of the axial displacement gauge shall be recorded at the end of each loading stage, or upon completion of the consolidation process. If a convergence trend is not observed in the volume change (or in the axial displacement) in the record at 30 minutes, the measurements shall be further continued, and the convergence trend of the volume change and the axial displacement shall be confirmed.

h) Repeat the operations in e) to g) until the prescribed suction and cell pressure are reached.

i) After the prescribed suction and cell pressure are reached, continue recording each of the measurements, and confirm that the consolidation process has reached the equilibrium state. The equilibrium state of the consolidation process shall be confirmed by measuring the volume change gauge and burette for water drainage readings and the elapsed time, and applying the method prescribed in Section 5.2d) of JGS 0522 Method for consolidated-undrained triaxial compression test on soils.

5.5 Axial compression process

The test shall be carried out in accordance with the following requirements for the axial compression process.

a) Check and adjust the origin of the load cell and the displacement gauge.

b) For the undrained test, close the water drainage valve (for the drained test, leave the water drainage valve open). In this standard, as a rule the pore air shall be always under the drained condition. In the undrained test, if there is a possibility of generation of negative pore water pressure associated with shearing, increase the pore air pressure maintaining the undrained state unchanged. At the same time increase the cell pressure by an amount equal to the increment in pore air pressure. At this time, the pore water pressure increases by just the increment of pore air pressure (the applied suction does not change).

c) Apply axial load to the specimen continuously under prescribed constant cell pressure at a constant strain rate. In order to ensure a uniform pore water pressure distribution within the specimen, as a guide the strain rate in an undrained test shall be 0.05%/minute or less for samples with high sand and silt fraction, and 0.01%/minute for samples with high clay fraction. For unsaturated soils, it is necessary to take into consideration the degree of saturation in addition to the particle size when controlling the strain rate.

d) During axial compression process, in the case of the undrained test, the pore water pressure u_w (kN/m^2), the axial displacement ΔH (cm), the volume change ΔV (cm^3), (and in the drained test, the amount of water drained ΔV_w (cm^3) also), and the axial load P (N) shall be measured. The measurement intervals if not recording continuously shall be sufficient to smoothly draw the principal stress difference – axial strain curve and the suction – axial strain curve.

e) A guide to termination of axial compression process shall be any one of the following criteria: when there has been a further 3% or more axial strain has occurred from the maximum reading of the load cell, when load cell reading has reduced to about 2/3 of its maximum value, and when an axial strain of 15% has been reached.

f) After observation and recording of the deformation and failure state of the specimen, remove the specimen from the triaxial cell. The deformation and failure state of the specimen after termination of axial compression process shall be observed and recorded from the direction in which the state can be most distinctly seen. If a failure surface is visible, observation shall be from the direction in which the gradient of the failure surface is most steep, and recorded so that the angle of the failure surface can be approximately read. Also, if the specimen is inhomogeneous or if it contains some substance mixed in, that shall be recorded.

g) Immediately after removal of the specimen, water shall be supplied to the surface of the ceramic filter, and the origin of the pore water pressure gauge shall be confirmed.

h) Measure the oven dried mass of the specimen m_s (g). After measurement of the wet mass of the specimen, if possible the water content of the specimen shall be measured at the top, middle, and bottom parts, in order to confirm the distribution of water content in the specimen. In this case, the oven dried mass of the specimen shall be obtained from the wet mass and the average water content.

6 Processing test results

6.1 Initial state of specimen before testing

The volume of the specimen before testing V_0 (mm^3) shall be calculated from the following equation.

$$V_0 = \frac{\pi}{4} D_0^{\,2} H_0$$

where

D_0: Diameter of the specimen before testing, and shall be considered to be equal to the initial diameter when the specimen was prepared D_i (mm)

H_0: Height of the specimen before testing, and shall be considered to be equal to the initial height when the specimen was prepared H_i (mm)

6.2 Consolidation process

The calculations for the consolidation process shall be as follows.

a) The volume of the specimen during consolidation V_t (mm^3) and the volume of the specimen after consolidation V_c (mm^3) shall be calculated from the following equations.

$$V_t = V_0 - \Delta V_t$$

$$V_c = V_0 - \Delta V_c$$

where

ΔV_t: Volume change of specimen during consolidation (mm^3)
ΔV_c: Volume change of specimen after consolidation (mm^3)

Note: If the volume change of the specimen is measured from the change in water level of the inner cell, the volume change ΔV (mm^3) shall be calculated from the following equation.

$$\Delta V = \Delta D_p \times (A - a) + \Delta D_G \times a$$

where

ΔD_p: Change in water level of the inner cell (mm)
A: Cross-sectional area of the inner cell water level measuring unit (mm^2)
a: Cross-sectional area of the loading piston (mm^2)
ΔD_G: Axial displacement of the specimen (mm)

b) The water content of the specimen during consolidation w_t (%) and the water content of the specimen after consolidation w_c (%) shall be calculated from the following equations.

$$w_t = \frac{m_i - m_s - \Delta V_{wt}/1000 \times \rho_w}{m_s} \times 100$$

$$w_c = \frac{m_i - m_s - \Delta V_{wc}/1000 \times \rho_w}{m_s} \times 100$$

where

m_i: Initial mass when the specimen was prepared (g)
ρ_w: Density of water (Mg/m^3)
ΔV_{wt}: Quantity of water drainage from the specimen during consolidation (mm^3)
ΔV_{wc}: Total quantity of water drainage from the specimen after consolidation (mm^3)

c) The void ratio during consolidation e_t and the void ratio after consolidation e_c shall be calculated from the following equations.

$$e_t = \frac{V_t/1000 \times \rho_s}{m_s} - 1$$

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

d) The degree of saturation during consolidation S_{rt} (%) and the degree of saturation after consolidation S_{rc} (%) shall be calculated from the following equations.

$$S_{\mathrm{rt}} = \frac{m_{\mathrm{i}} - m_{\mathrm{s}} - \Delta V_{\mathrm{wt}}/1000 \times \rho_{\mathrm{w}}}{V_{\mathrm{t}}\rho_{\mathrm{s}} - m_{\mathrm{s}}} \times \frac{\rho_{\mathrm{s}}}{\rho_{\mathrm{w}}} - 100$$

$$S_{\mathrm{rc}} = \frac{m_{\mathrm{i}} - m_{\mathrm{s}} - \Delta V_{\mathrm{wc}}/1000 \times \rho_{\mathrm{w}}}{V_{\mathrm{c}}\rho_{\mathrm{s}} - m_{\mathrm{s}}} \times \frac{\rho_{\mathrm{s}}}{\rho_{\mathrm{w}}} - 100$$

e) The height of the specimen during consolidation H_{t} (mm), the height of the specimen after consolidation H_{c} (mm), and the cross-sectional area of the specimen after consolidation A_{c} (mm^2) shall be calculated from the following equations.

$$H_{\mathrm{t}} = H_0 - \Delta H_{\mathrm{t}}$$

$$H_{\mathrm{c}} = H_0 - \Delta H_{\mathrm{c}}$$

$$A_{\mathrm{c}} = V_{\mathrm{c}} / H_{\mathrm{c}}$$

where

ΔH_{t}: Axial displacement during consolidation (mm), where compression is defined to be positive
ΔH_{c}: Total axial displacement due to consolidation (mm), where compression is defined to be positive

6.3 Axial compression process

The calculations for the axial compression process shall be as follows.

a) The axial strain of the specimen ε_{a} (%) shall be calculated from the following equation.

$$\varepsilon_{\mathrm{a}} = \frac{\Delta H}{H_{\mathrm{c}}} \times 100$$

where

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

b) The volumetric strain ε_{v} (%) when the axial strain is ε_{a} (%) shall be calculated from the following equation.

$$\varepsilon_{\mathrm{v}} = \frac{\Delta V}{V_{\mathrm{c}}} \times 100$$

where

ΔV: Volume change of the specimen in the axial compression process (mm^3), where compression is defined to be positive

Note: If the volume change of the specimen is measured from the change in water level of the inner cell, the volume change ΔV (mm^3) shall be calculated from the following equation, where compression is defined to be positive.

$$\Delta V = \Delta D_{\mathrm{p}} \times (A - a) + \Delta D_{\mathrm{G}} \times a$$

where

ΔD_{p}: Change in water level of the inner cell (mm)
A: Cross-sectional area of the water level measuring unit of the inner cell (mm^2)
a: Cross-sectional area of the load piston (mm^2)
ΔD_{G}: Axial displacement of the specimen (mm)

c) The principal stress difference $(\sigma_{\mathrm{a}} - \sigma_{\mathrm{r}})$ (kN/m^2) at the axial strain ε_{a} (%) shall be calculated from the following equation, which shall be rounded to three significant digits.

$$\sigma_a - \sigma_r = \frac{P}{A_c}\frac{1-\frac{\varepsilon_a}{100}}{1-\frac{\varepsilon_v}{100}} \times 10$$

where

P: Axial load (N) applied to the specimen at axial strain ε_a (%), which is set as P=0 under isotropic consolidation process

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

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

d) For a drained test, the water content w_s (%) at axial strain ε_a (%) shall be calculated from the following equation.

$$w_s = \frac{m_i - m_s - \Delta V_{wc}/1000 \times \rho_w - \Delta V_{ws}/1000 \times \rho_w}{m_s} \times 100$$

where

ΔV_{ws}: Quantity of water drainage at axial strain ε_a (%) (mm^3)

e) For the undrained test, the suction (kN/m^2) at axial strain ε_a (%) shall be calculated from the following equation, which shall be rounded to three significant digits.

$$s = u_a - u_w$$

where

u_a: Pore air pressure applied to the specimen (kN/m^2)

u_w: Pore water pressure at axial strain ε_a (%) (kN/m^2)

f) Draw the principal stress difference - axial strain curve and the volumetric strain - axial strain curve, with the axial strain on the horizontal axis.

g) For the drained test, draw the water content - axial strain curve, with the axial strain on the horizontal axis.

h) For the undrained test, draw the suction - axial strain curve, with the axial strain on the horizontal axis.

i) Obtain the maximum value of the principal stress difference $(\sigma_a - \sigma_r)_{max}$ from the principal stress difference - axial strain curve, and take this value as the compressive strength (kN/m^2).

j) For the undrained test, the suction s_f (kN/m^2) at the maximum value of principal stress difference is produced shall be calculated from the following equation.

$$s_f = u_a - u_{wf}$$

where

u_{wf}: Pore water pressure at the maximum value of principal stress difference is produced (kN/m^2)

7 Reporting

The following items of test results shall be reported.

a) Method of preparing the specimen

b) Dimensions of the specimen before the test

Note: If measured, the initial suction of the specimen shall be reported.

c) The suction during consolidation and the lateral stress σ_{rnet} based on the net stress, and if incremental loading is carried out, the load path. The lateral stress σ_{rnet} based on the net stress shall be calculated from the following equation.

$$\sigma_{net} = \sigma_r - u_a$$

Note: The stress path in the case of incremental loading is indicated by the pore air pressure - cell pressure relationship, or the suction -σ_{rnet} relationship. After consolidation has been completed σ_{rnet} is equal to the mean net stress.

d) The water drainage and the volume change with elapsed time relationship in the consolidation process

Note: If necessary the following items shall be reported.

1) If measured, the relationship of the axial displacement with elapsed time

2) The relationship of the water content, the void ratio, and the degree of saturation with elapsed time

3) If incremental loading has been carried out by varying σ_{rnet}, the relationship of the water content, void ratio, degree of saturation, and mean net stress at the completion of each stage

4) If stage incremental has been carried out by varying the suction, the relationship of the water content, void ratio, degree of saturation, and the suction at the completion of each stage. The relationship of the water content, the degree of saturation, and the suction shall have the same meaning as JGS 0151 The method for water retentivity of soils.

e) The lateral stress σ_{rnet} (kN/m^2) based on the strain rate (%/min), the water drainage condition, and the net normal stress in the axial compression process

f) Principal stress difference, volumetric strain versus axial strain relationship, for the drained test the water content versus axial strain relationship, and for the undrained test the suction versus axial strain relationship

g) Specimen failure state

h) The compressive strength (kN/m^2), the lateral stress σ_{rnet} (kN/m^2) based on the net normal stress at that time, in the case of the undrained test the suction s_f (kN/m^2) when the compressive strength was reached

i) If tests have been carried out using several test specimens from the same sample, the relationship between the Mohr stress circle and the suction s_f when the principal stress difference is at the maximum value based on the net stress. Plot the compressive strength on the vertical axis and the net normal stress on the horizontal axis. If the suction during axial compression under drained conditions is constant, plot a Mohr stress circle for each suction.

Note: At this time if necessary report the angle of shear resistance ϕ_{net} (°) obtained from the Mohr stress circle envelope, and the intercept on the vertical axis c_{net} (kN/m^2). On the same graph indicate the suction value applied in the case of drained conditions, or the suction value of s_f at the maximum principal stress difference in the case of undrained conditions. If necessary, report the following relationships. In the case of the drained test, the compressive strength -σ_{rnet} relationship based on the same suction, and, if tests with different suctions have been carried out based on the same lateral stress, or if undrained tests have been carried out based on the same lateral stress, the compressive strength - suction at failure relationship.

j) If a method that partially differs from this standard was used, give details of the points of difference.

k) Other reportable matters

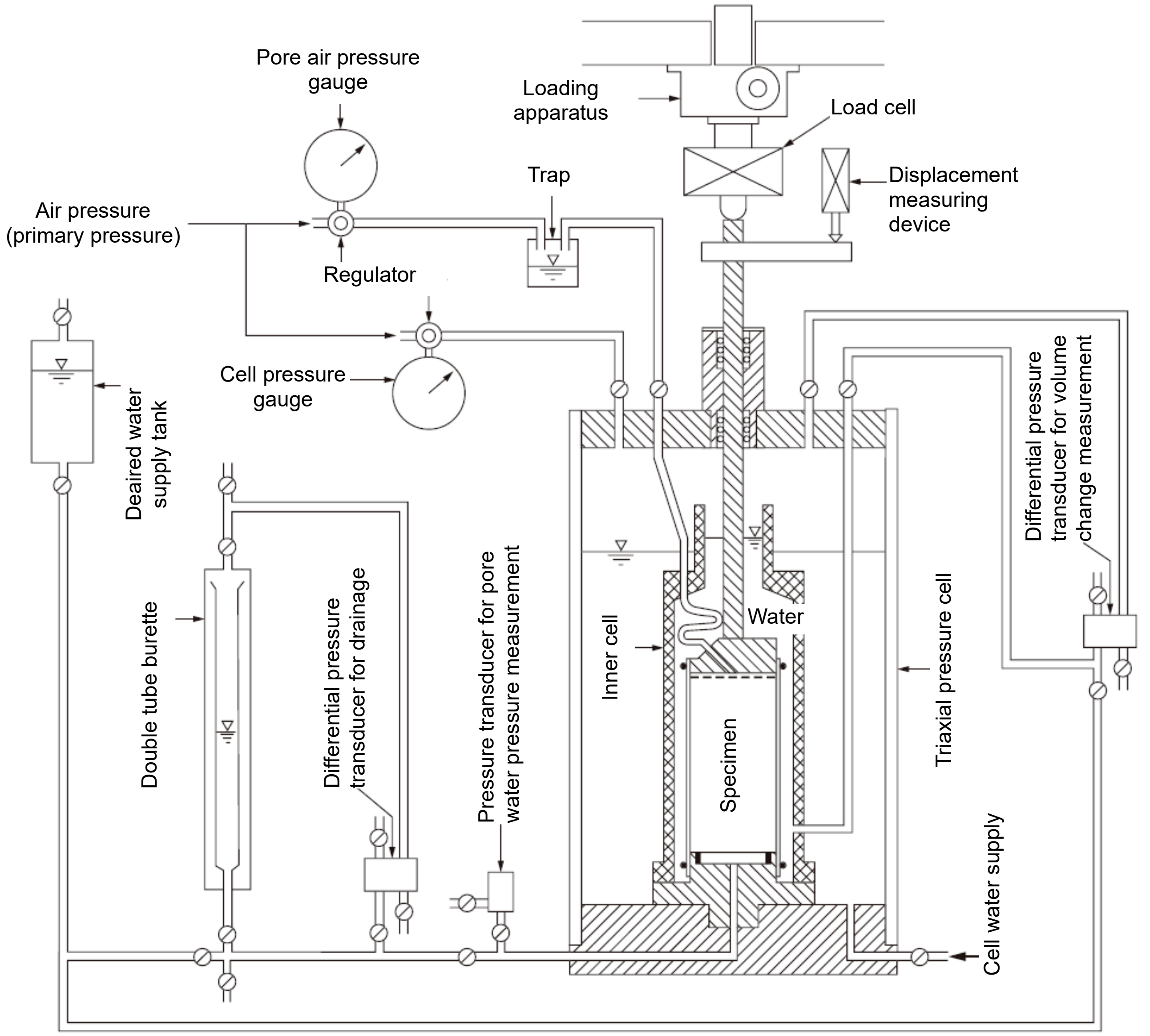

Figure 1 Example of the set-up of triaxial test apparatus for unsaturated soil

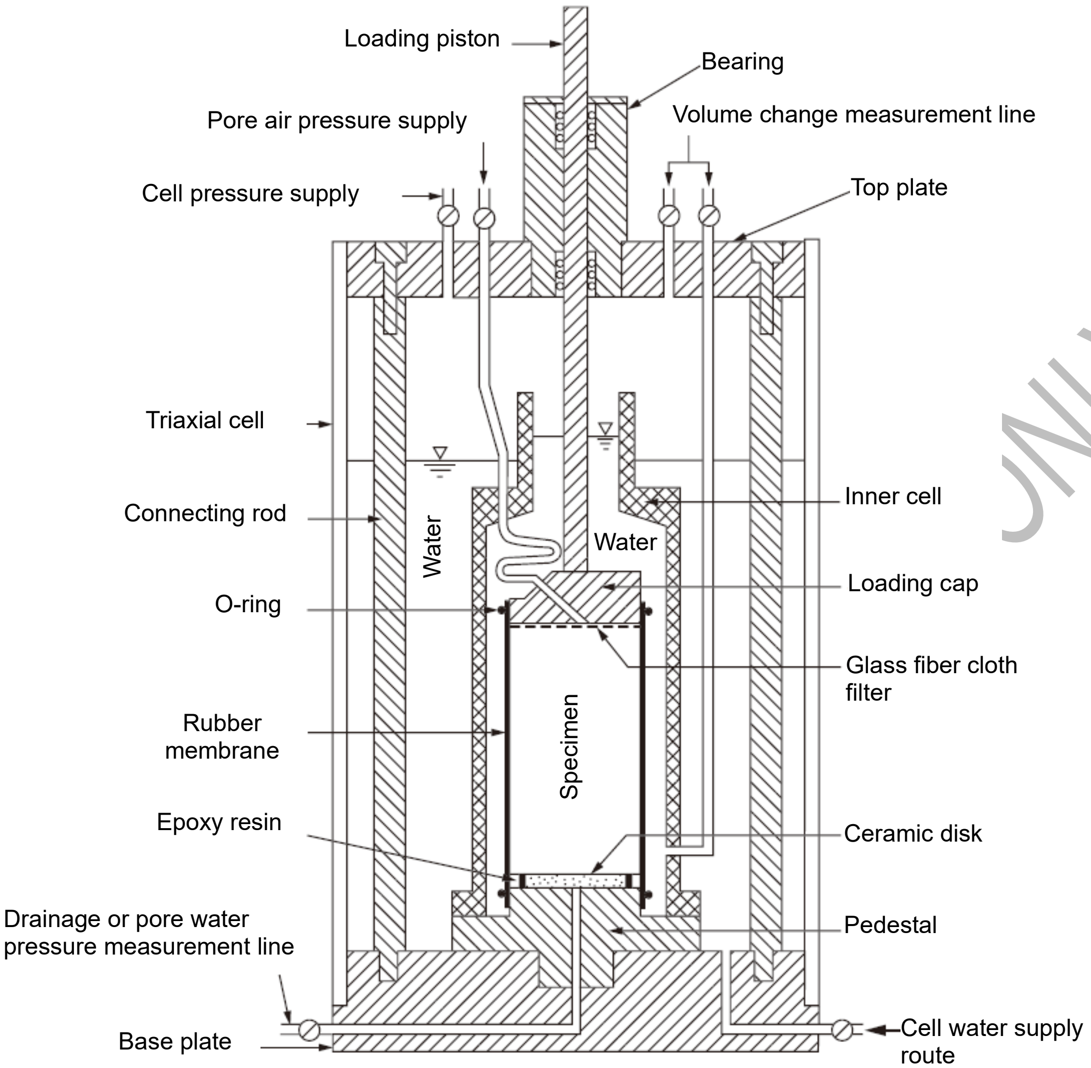

Figure 2 Example of triaxial cell for unsaturated soil