Australian Standard®

# Methods of testing soils for engineering purposes

# Method 6.2.2: Soil strength and consolidation tests—Determination of the shear strength of a soil—Direct shear test using a shear box

**1 SCOPE** This Standard sets out a method for determining the shear strength of a soil (in terms of effective stress) by direct shearing in a shear box. Separate test procedures are described for the testing of low permeability soils such as clays or sandy clays (herein called ‘cohesive soils’) and highly permeable soils such as sands. For cohesive soils, different procedures are described for carrying out drained (or slow) shearing tests for determining the peak shear strength and for determining the residual shear strength. A procedure for obtaining the undrained strength of a cohesive soil is not given. The test procedures apply only to small shear boxes which are usually designed to test specimens 60 mm to 100 mm square. The procedures do not apply to large shear boxes which are generally 300 mm square, as the method of assembly of the larger boxes differs from that used for small boxes.

**2 REFERENCED DOCUMENTS** The following documents are referred to in this Standard:

| AS | |
|---|---|
| 1289 | Methods of testing soils for engineering purposes |
| 1289.0 | Method 0: General requirements and list of methods |
| 1289.2.1.1 | Method 2.1.1: Soil moisture content tests—Determination of the moisture content of a soil—Oven drying method (standard method) |
| 1289.2.1.2 | Method 2.1.2 Soil moisture content tests—Determination of the moisture content of a soil—Sand and bath method (subsidiary method) |
| 1289.2.1.4 | Method 2.1.4: Soil moisture content tests—Determination of the moisture content of a soil—Microwave-oven drying method (subsidiary method) |
| 1289.2.1.5 | Method 2.1.5: Soil moisture content tests—Determination of the moisture content of a soil—Infrared lights method (subsidiary method) |
| 1289.2.3.1 | Method 2.3.1: Soil moisture content tests—Establishment of correlation—Subsidiary method and the standard method |
| 1289.F6.1 | Method F6.1: Soil strength and consolidation tests—Determination of the one- dimensional consolidation properties of a soil |

**3 APPARATUS** The following apparatus is required:

(a) A shear box consisting of two separate halves which can be moved relative to each other, thus shearing a soil sample along a predetermined plane. The shear box shall be designed so that the soil sample can be subjected to a normal stress applied perpendicular to the plane of shearing, and allow porous stones (see Note 1) to be placed above and below the soil specimen to be tested so that drainage can be provided, if required. The normal load is to be applied through a plate which rests on top of the soil specimen and upper drainage stone, if used.

Provision shall be made so that the vertical movement of the upper loading plate and the relative horizontal movement of the top and bottom halves of the box (the shear displacement) can be measured.

Shear boxes may be designed to accept samples which are square or circular in cross-section at the plane of shearing. Square shear boxes are commonly designed to test specimens 60 to 100 mm square.

Boxes shall be constructed of non-corrosive material such as brass. A plan and section of a typical shear box are shown in Figure 1.

(b) An outer box or carriage (running on ball or roller races) in which the shear box can be placed so that the specimen can be totally submerged in water.

(c) A loading frame capable of pushing or pulling at the level of the shear plane in such a way that the bottom half of the shear box moves relative to the top half. This is usually done with a motorized worm drive unit. The speed at which the drive unit shears the soil shall be adjustable so that a range of shearing speeds can be attained and this is usually done through a gear box. Shearing speeds shall be calculated for drained tests on clays using the equations given in Clause 8. The selected rate of shearing shall not vary more than ±10% during the test. The load applied by the worm drive, and the reaction applied by the proving ring to the swan neck yoke shall be in the plane of shearing so that no moment is applied to the two halves of the box.

(d) A device for applying the normal force. This is usually a hanger loaded by dead weights directly or loaded by weights through a lever system. The hanger shall apply the normal load centrally to the upper loading plate of the shear box through a ball bearing in a spherical seating.

(e) A device for measuring the shear force applied to the specimen. This may consist of a load transducer or a proving ring mounted as shown in Figure 2 between the loading frame and the upper half of the shear box, with a dial gauge or transducer from which the load can be obtained after calibration.

(f) A dial gauge or transducer attached to measure the horizontal displacement of the lower half of the box with respect to the upper half of the box to a precision of ±0.01 mm and having a travel of at least 15 mm.

(g) A dial gauge or transducer for reading the vertical displacement of the upper loading plate of the shear box to a precision of ±0.002 mm and having a travel of at least 12 mm.

(h) A specimen cutter which may be used to cut undisturbed specimens of the required shape and size for the shear box being used.

(i) Trimming equipment such as a wire saw, a spatula or a suitable knife for preparing specimens.

(j) A balance of suitable capacity with a limit of performance not greater than 0.1% of the specimen mass or 0.15 g.

(k) Moisture content tins.

(l) A drying oven in accordance with AS 1289.0 or other apparatus for determination of moisture content in accordance with AS 1289.2.1.1, 2.1.2, 2.1.4, 2.1.5, or 2.3.1.

(m) A rule graduated in millimetres and vernier callipers with a precision of 0.1 mm.

(n) Equipment for preparing remoulded specimens, if required.

**4 PREPARATION OF APPARATUS** The apparatus shall be prepared as follows:

(a) Determine the mass of the hangers, $m_h$, used for applying the normal load, to the nearest 0.1 kg. The mass shall include the weight of the upper loading plate, upper grid plate (if used), and upper stone (if used), as all of these components add to the normal load on the sample. Alternatively, a load cell may be used in the position of the specimen to establish the mass, $m_h$. If the box halves are separated before shearing (see Step 4(p)), the mass of the upper half of the box shall be included in the mass of the hanger.

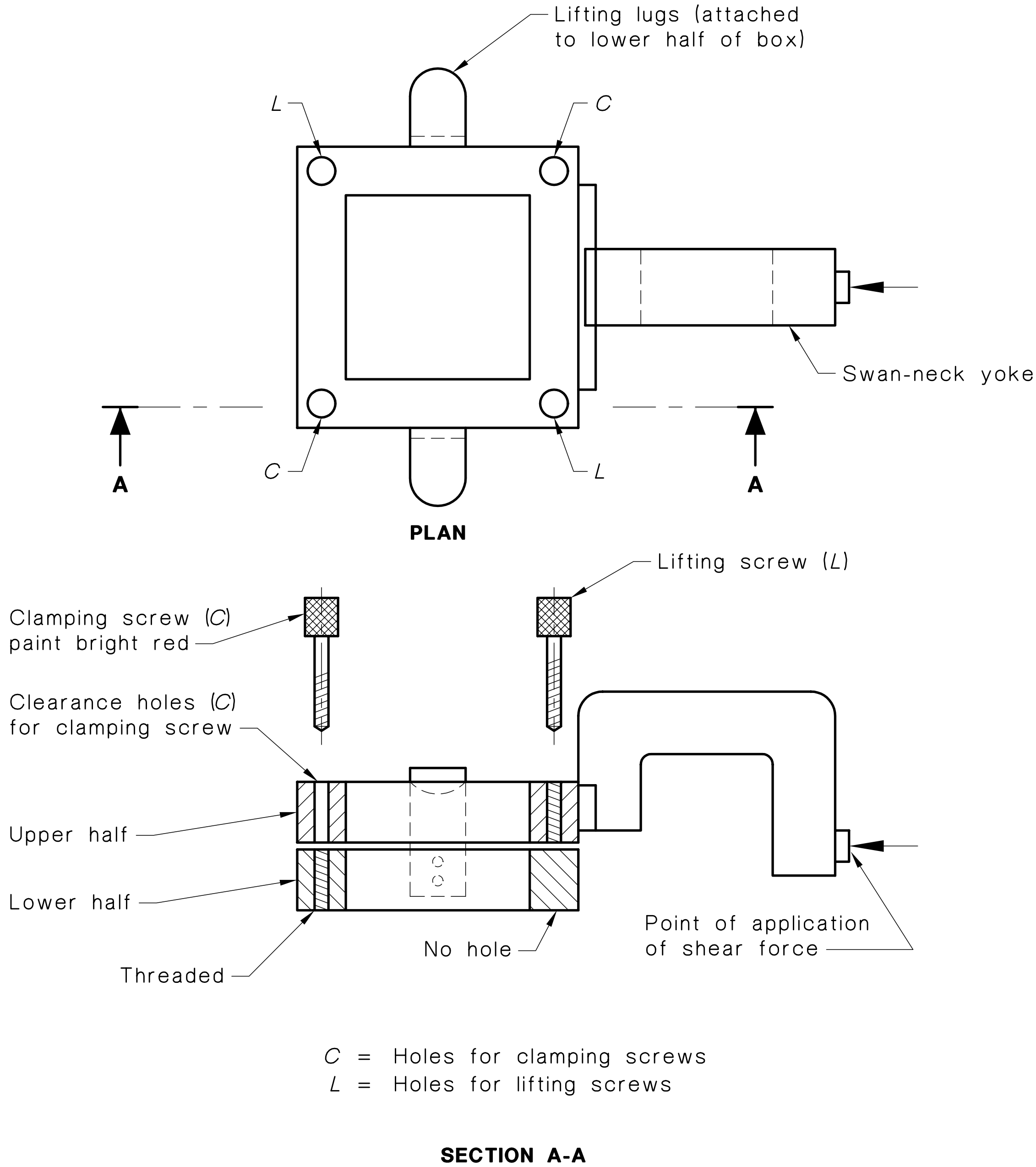



FIGURE 1 TYPICAL DESIGN OF A SHEAR BOX

(b) Using vernier callipers, measure the inner length, $L$, of the sides, and the overall depth, $B$, of the box to a precision of ±0.1 mm. Measure the thickness of the base plate, $t_1$, and the mean thickness of the grid plates (if used), $t_2$, to a precision of ±0.1 mm (see Figure 3). The mean thickness shall be calculated from the following equation:

$$t_2 = T + \frac{n.d.q}{L} \quad \ldots (4.1)$$

where

$t_2$ = the mean thickness of the grid plates, in millimetres

$T$ = the thickness of the body of the grid plate, in millimetres

$n$ = the number of ribs, in millimetres

$d$ = the depth of the ribs, in millimetres

$q$ = the thickness of the ribs, in millimetres

$L$ = the inner length of the sides of the box, in millimetres

(c) Ensure that the shear box is clean and dry and apply a thin film of silicone grease to the mating surfaces of the box (see Note 2).

(d) Assemble the two halves of the shear box and locate and tighten the locating pins. If the upper box contains separating screws, these screws shall be wound back so that they do not protrude before assembling the box.

(e) Wind back the worm drive to the carriage using the handwheel, and lifting the shear box by the lugs provided, place the shear box in position with the bottom half of the box resting firmly against the rear shelf in the carriage and the swan neck yoke located against the proving ring plunger or transducer used for measuring shear load.

If the shear box is to be reversed, the worm drive shall be connected to the outer box, a spacer shall be placed in front of the shear box (between the shear box and the outer box) and the swan neck yoke shall be connected to the proving ring plunger. For shear boxes that do not have the facility for reversing, a suitable modification is shown in Figure 4.

Place the lower porous plate, if needed, and the grid plate (if used) with grooves uppermost, into the bottom of the box. The grooves shall be perpendicular to the direction of shear.

(f) Prepare the specimen in the box as given in Clause 5, taking note that different procedures are required for sands and clays. Place the upper grid plate, porous plate (if needed) and upper loading plate on top of the specimen, ensuring that there is a small clearance around the edges of the loading plate.

For the preparation of some specimens, (e.g. dense sand) it is more convenient to place the material with the box out of the loading frame and then transfer the shear box to the frame. In this case, wind back the worm drive with the handwheel, leaving a little space so that the box can be positioned after the sample has been prepared.

(g) Adjust the worm drive with the handwheel so that it is just beginning to contact the outer box. An example of a shear box in the loading frame is shown in Figure 2. Ensure that contact has been made at the points ‘a’ to ‘e’ before loading. If there is proper contact of the shear box with the proving ring or transducer and no slack in the system, then a small movement of the handwheel should produce a small movement of the proving ring dial gauge, or reading on the load measuring transducer.

Adjust the proving ring gauge to a convenient initial reading, or check that the load transducer is showing an initial reading, making sure there is no preload.

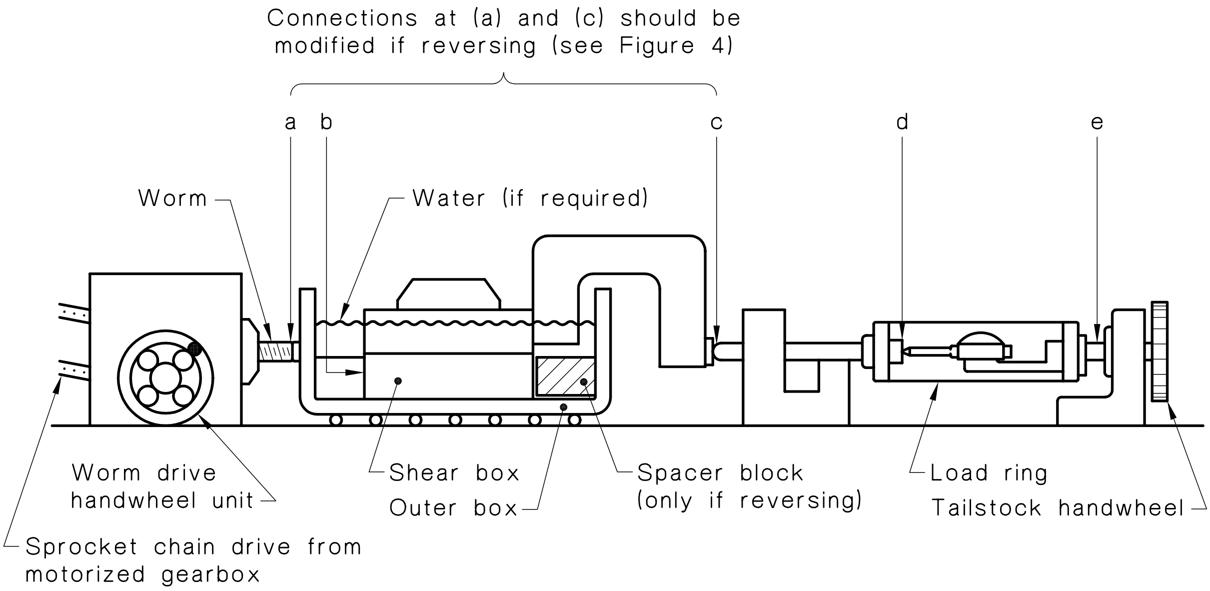
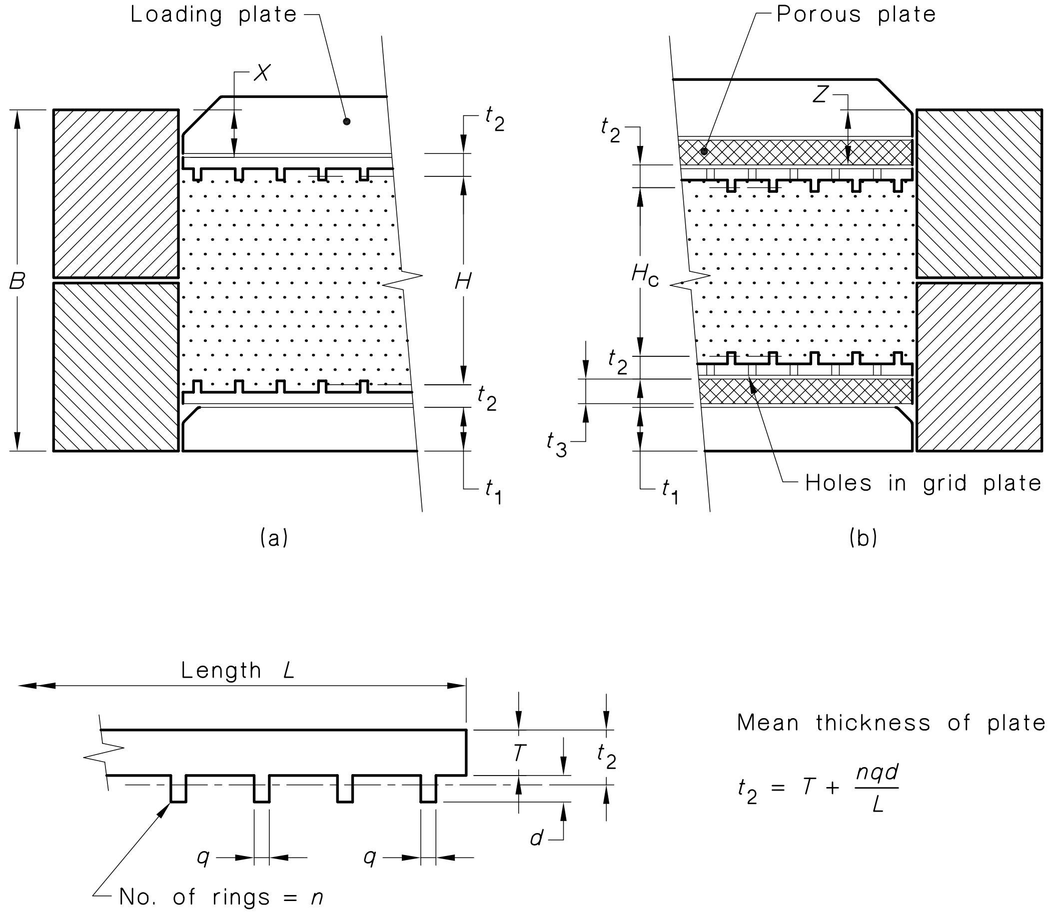



FIGURE 2 SHEAR BOX IN LOADING FRAME




$$t_2 = T + \frac{nqd}{L}$$

FIGURE 3 CROSS-SECTION OF SHEAR BOX SHOWING MEASUREMENTS REQUIRED TO DETERMINE THE SAMPLE THICKNESS