RTH-364-89

SUGGESTED METHOD FOR DETERMINING ROCK MASS DEFORMABILITY BY LOADING A RECESSED CIRCULAR PLATE

Scope

1. (a) This test determines the deformability characteristics of a rock mass by loading a flat surface at the end of a drill hole or other recess and measuring the resultant displacement of that surface. Elastic or deformation moduli are calculated as well as time dependent (creep) properties.

(b) Several depth horizons may be tested from the same setup using a large-diameter drill to advance between tests. The direction of loading necessarily coincides with the drill hole axis, usually near-vertical, so that no information can be obtained regarding rock anisotropy.

(c) Plate bearing tests are commonly used to provide information for the design of foundations.

(d) This method is a modification of practice suggested by the International Society for Rock Mechanics. See Reference. That previous version provides details not included here.

(e) Another method, differing in the loading system, is available for comparison and consideration in RTH-365.

Apparatus

2. Equipment for drilling, cleaning, and preparing a test hole at least 500 mm[1]* in diameter. The hole may need casing. A reamer and other special tools are useful in flattening the bearing surface ($\pm$ 5 mm) perpendicular to the hole axis ($\pm 3^{o}$) and for removing water and debris.

3. Core drill for taking samples to at least 3 m below the bearing surface, the diameter to be less than 10% that of the bearing plate.

* Numbers refer to NOTES at the end of the text.

4. Circular bearing plate of diameter at least 500 mm and sufficiently rigid to distort by not more than 1 mm under the test conditions (Figures 1 and 2)[2].

5. Hollow loading column to transmit the applied force centrally to the test plate without detrimental buckling.

6. Hydraulic jack and reaction anchors such that:

(a) Loads can be varied throughout the required range and can be held constant to within 2% of a selected value for a period of at least 24 hr.

(b) The travel of the jack is greater than the sum of anticipated displacements of the plate and reaction beam.

(c) Reaction anchors are located further than 10 test hole diameters from the bearing plate.

7. Equipment (load cell or proving ring) to measure the applied load with an accuracy better than ± 2% of the maximum reached in the test.

8. Equipment to measure axial displacement of the plate[3] with accuracy better than 0.05 mm. The reference anchors should be at least 10 test hold diameters from the loading plate and reaction anchors.

Procedure

9. Preparation

(a) The site is selected to allow testing at the actual foundation level with loading in the direction of foundation loading. Alternatively rock considered typical of anticipated conditions may be tested. Attention should be given to locations for reaction and reference anchors and to ground water and other influential conditions.

(b) Test hole and anchor holes are drilled and logged. The test hole is cased if necessary for stability throughout the test.

(c) Exploratory core is taken to a depth of at least 3 m below the proposed test horizon, and the choice of horizon confirmed or modified.

(d) Ground water encountered in the test hole should be lowered by pumping from well points surrounding the test area or otherwise during installation of the bearing plate.

(e) The bearing surface is trimmed, one or more layers of mortar or plaster are placed, and the bearing plate installed before the last layer has set. The delay between excavation of the surface and installation of the plate should not exceed 12 hr.[4]

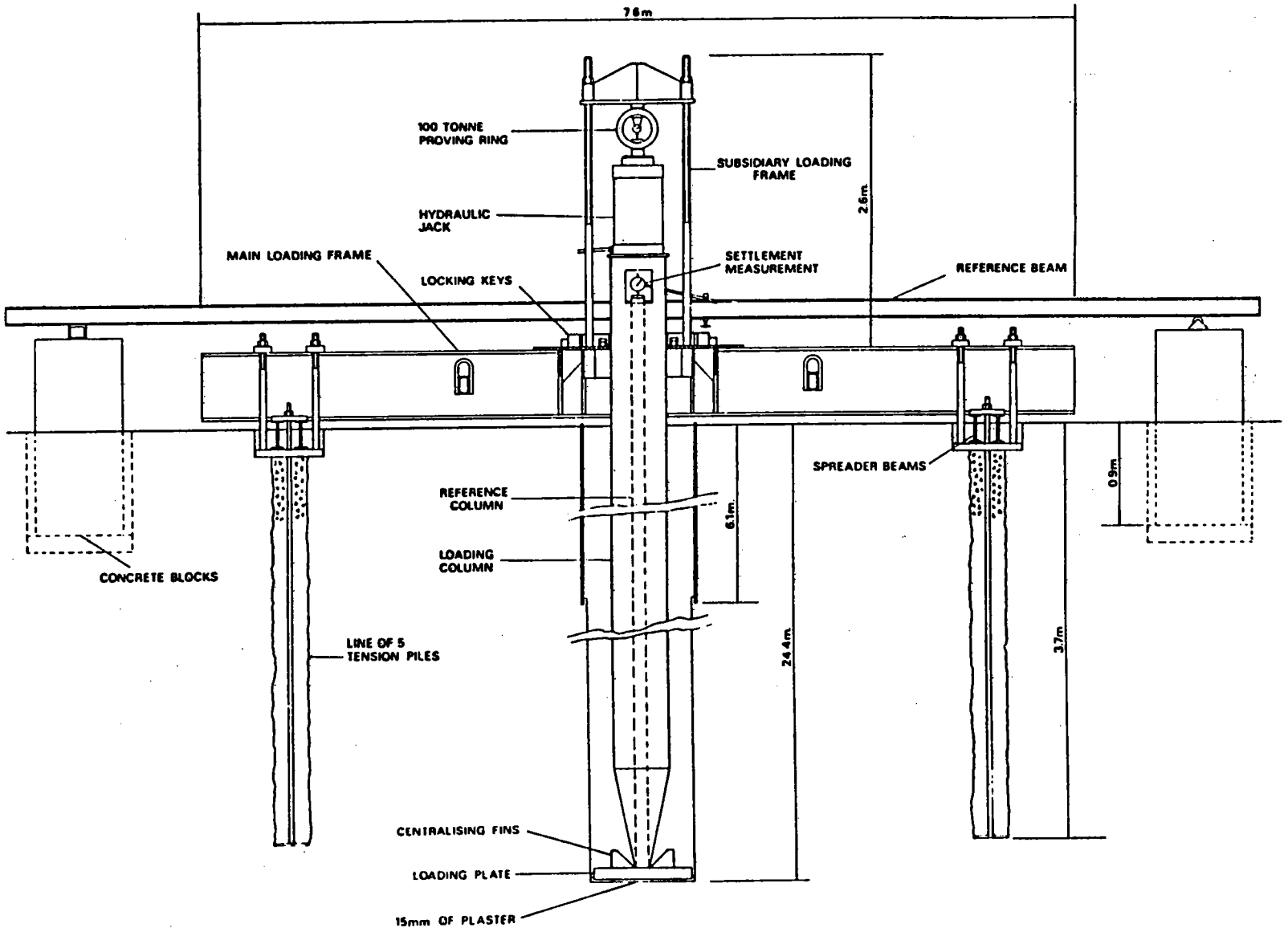

Figure 1. Example plate-loading equipment.

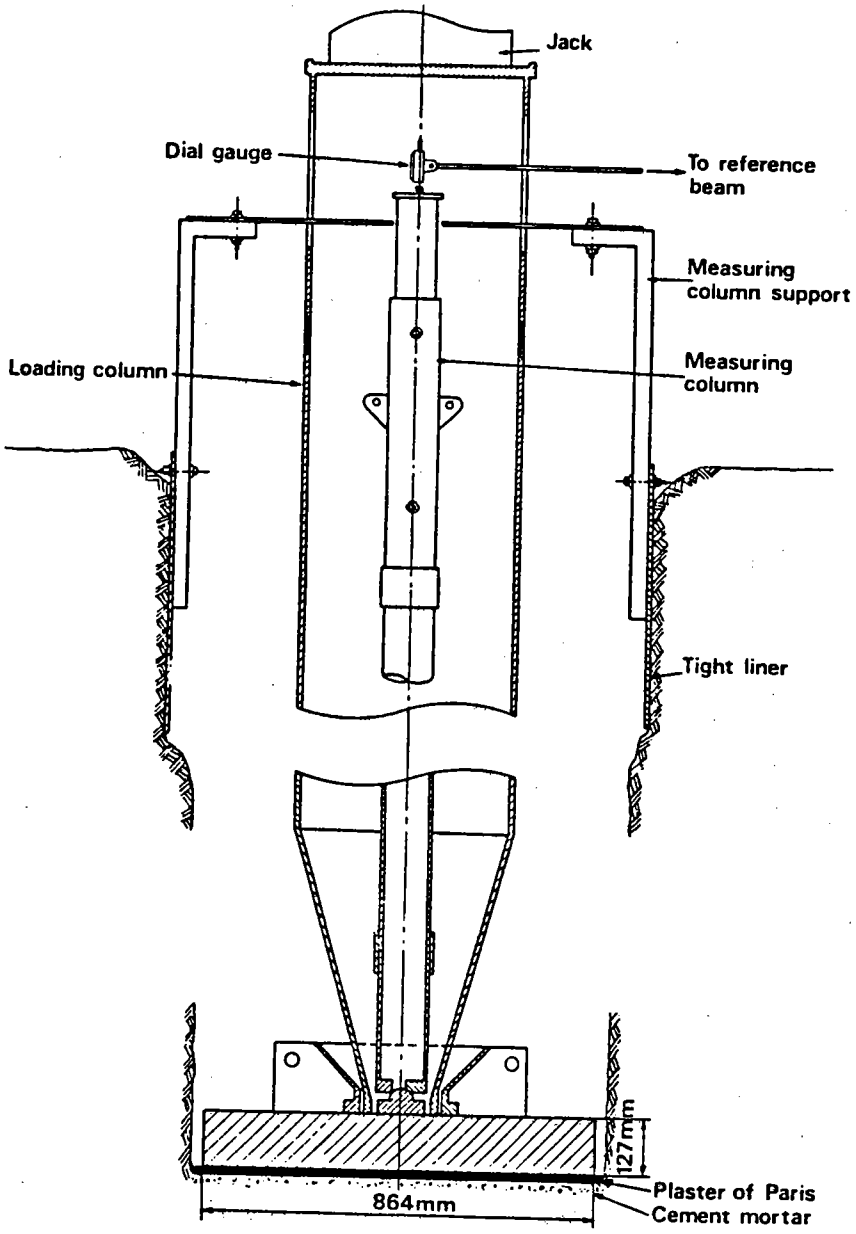

Figure 2. Details of plate test equipment.

(f) Reaction and reference anchors are installed 10 or more diameters away and the equipment assembled and checked. A small seating load (approximately 5% of the maximum test value) is applied and held until the start of testing.

(g) The water table should be allowing to return to its normal elevation before the start of testing.

10. Testing

(a) With the seating load applied, load and displacement should be observed and recorded over a period not less than 48 hours to establish datum values and to assess variations due to ambient conditions.[5]

(b) Loads and load increments to be applied during the test should be selected to cover a range 0.3-1.5 q_o, where q_o is the stress intensity produced by the proposed structure.[6]

(c) Load is increased in not less than five approximately equal increments to a maximum of approximately 1/3 the maximum for the test. At each increment the load is held constant (±3%) and plate displacement recorded intermittently until it stabilizes.[6] The procedure is continued for decreasing load increments until the seating load is again reached.

(d) Procedure (c) is repeated for maximum cycle loads of approximately 2/3 and 3/3 the maximum for the test.

(e) The equipment is removed from the test hole and further tests may be carried out on deeper horizons by re-drilling in the same hole.

Calculations

11. (a) Graphs are plotted of incremental settlement (or uplift in the case of unloading) against the logarithm of time (Figure 3).

(b) Bearing pressure versus settlement curves are plotted for each test (Figure 4).

(c) Deformation modulae may be determined using tangents to the pressure-settlement curves as follows:

$$E = \frac{dq}{dp} \frac{\pi}{4} D(1 - \nu^2).I_c$$

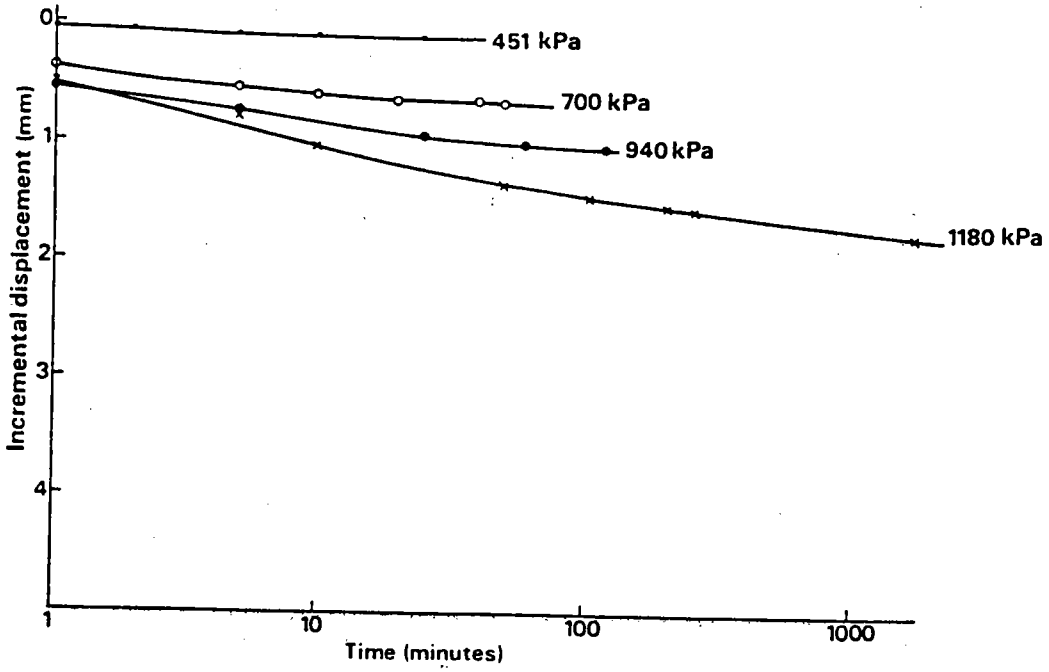

Figure 3. Typical relations between small displacement and time for various load intensities.

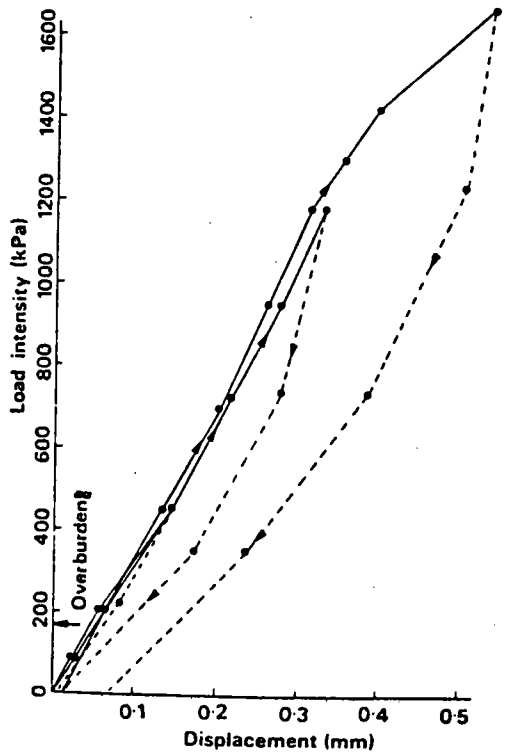

Figure 4. Example plate test results.

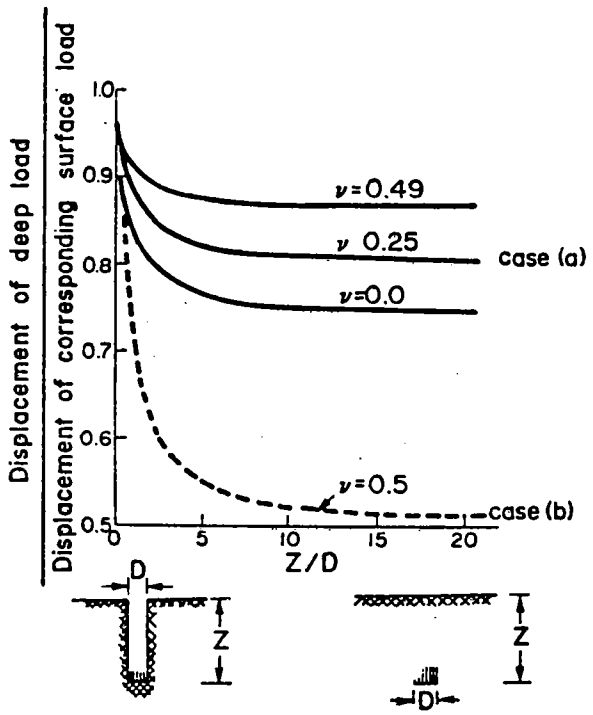

Figure 5. I_c factors for deep loading.

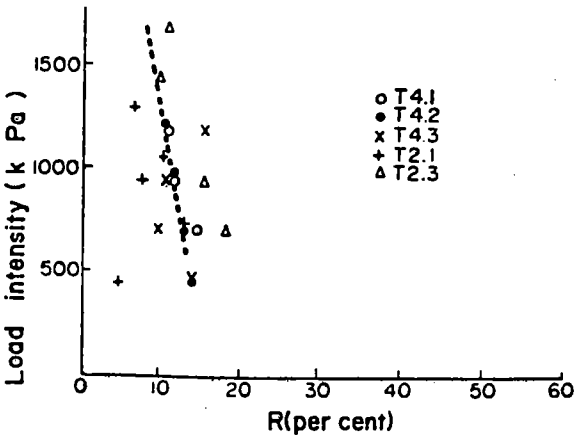

Figure 6. Relation between load intensity and creep ratio R.

where

q is applied pressure

p is settlement

D is plate diameter

ν is Poisson's ratio

I_c is a depth correction factor from Figure 5

(d) A time-dependent parameter R (known as the creep ratio) is determined for each load increment. The parameter R is defined as the incremental settlement per cycle of log time divided by the total overall settlement due to the applied pressure. The relationship between R and applied pressure may be presented graphically (Figure 6).

Reporting

12. The report should include the following

(a) Diagrams and detailed descriptions of the test equipment and methods used for drilling, preparation, and testing.

(b) Plans and sections showing the location of tests in relation to the generalized topography, geology, and ground-water regime.

(c) Detailed logs and descriptions of rock at least 3 m above and below each tested horizon.

(d) Tabulated test results, graphs of displacement versus time for each load increment, and graphs of load versus displacement for the test as a whole.

(e) Derived values of deformability parameters, together with details of methods and assumptions used in their derivation. Variations with depth in the ground should also be shown graphically as 'deformability profiles' superimposed on the log of the test hole.

Notes

[1]The test hole should preferably be of sufficient diameter to allow manual inspection, and preparation of the bearing surface. Otherwise preliminary coring is needed to provide adequate samples of ground conditions.

[2]Steel plate unreinforced by webs, should be at least 20 mm thick for a diameter of 500 mm.

[3]If required, the displacement of rock at any level below the bearing plate may be monitored, using rods passing through a hole in the center of the plate and rigidly anchored in the exploratory drillhole.

[4]Particularly when testing weaker rocks there will be rebound, loosening, and possibly swelling associated with excavation of the bearing surface and changes in ground water conditions.

[5]Small fluctuations in displacement are likely to result from changes in the ground water regime, temperature, and other environmental effects.

[6]At higher applied loads the displacement may not completely stabilize in a reasonable time; a criterion that readings should continue until the rate of displacement is less than 2% of the incremental displacement per hour may be used. This criterion may be modified to suit the purpose of the test. The final increment in any one cycle should be held for as long as practical if the displacement is still increasing.

Reference

International Society of Rock Mechanics, "Suggested Method for Field Deformability Determination Using a Plate Test Down a Borehole," International Journal of Rock Mechanics and Mining Sciences, v. 16, 1979, pp. 202 - 208