RTH-368-89

SUGGESTED METHOD FOR DETERMINING ROCK MASS DEFORMABILITY USING A DRILLHOLE-JACK DIALOMETER

Scope

1. (a) This test determines the deformability of a rock mass by subjecting a section of drill hole to mechanical jack pressure and measuring the resultant wall displacements. Elastic moduli and deformation moduli are calculated in turn.

(b) The results are employed in design of foundations and underground construction but are mostly used as semiquantitative index values revealing variability from point to point in a rock mass.

(c) The dilatometer is self-contained, and tests are relatively inexpensive compared to similar tests at a large scale.[1] Also, the wall is damaged only minimally by the drilling of the hole and usually remains representative of the undisturbed rock condition. These advantages, however, come at a sacrifice of representation of the effects of joints and fissures which are usually spaced too widely to be fully represented in the loaded volume around the drill hole.

(d) This method reflects practice described in the references at the end.

(e) Another type of dilatometer for drillholes transmits hydraulic pressure to the rock through a soft membrane. See RTH-363.

Apparatus

2. Drilling equipment to develop the access hole, in a given orientation without disturbing the wallrock.[2]

3. A drill hole-jack dilatometer similar to that in Figure 1, which consists of:

(a) Metal frame holding the other units and having parts and connections to external equipment.

(b) Two half-cylindrical, rigid steel plates of same curvature as wall of drillhole. Alternatively, the plates can be flexible as where they are faced with curved flat jacks as shown in Figure 2.

(c) Loading jacks or wedges functioning to drive the plates against the wall. A stroke of about 5 mm is needed beyond any requirements for seating the plates.

(d) Linear differential transformers oriented diametrically with potential resolution of 2 microns.

4. Hand-operated hydraulic pump and flexible hose and steel plumbing to withstand working pressure to 70 MPa.

5. Hydraulic pressure gages or transducer of suitable range and capable of measuring the applied pressure with accuracy better than 2 percent.

Procedure

6. Preparation

(a) The positions for testing are planned with due regard to the location of drilling station and the rock conditions to be investigated. The effects of geological structure and fabric are particularly important.

(b) The hole is drilled and logged. The log is studied for possible modifications in positions for testing. Multiple testing positions in one hole should not overlap but may join where two or more loading directions are to be distinguished.

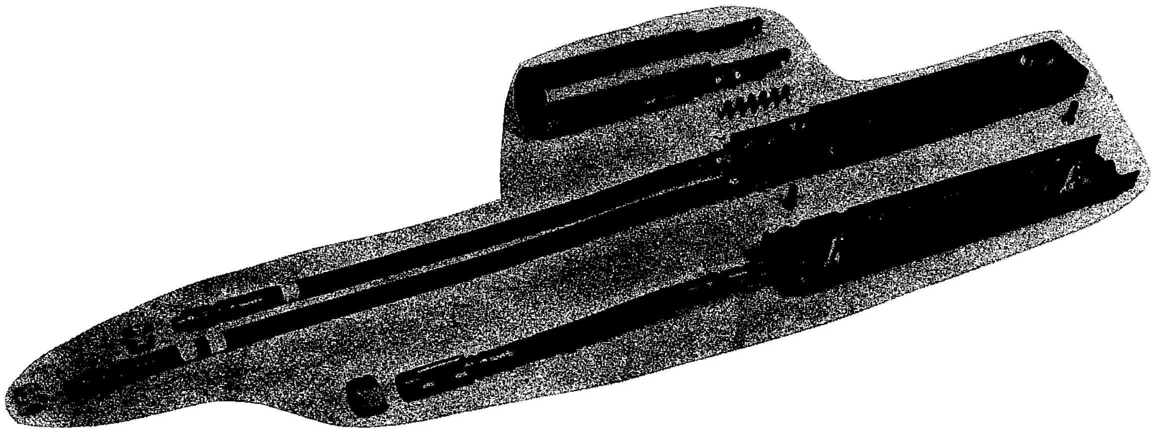
(c) Evaluate the texture and strength of the wall to confirm suitability of method. Otherwise, consider relocation or use of another dilatometer.

(d) The dilatometer is assembled and inserted into the hole, commonly using an attachable pole to position and rotate and taking special care with trailing lines.

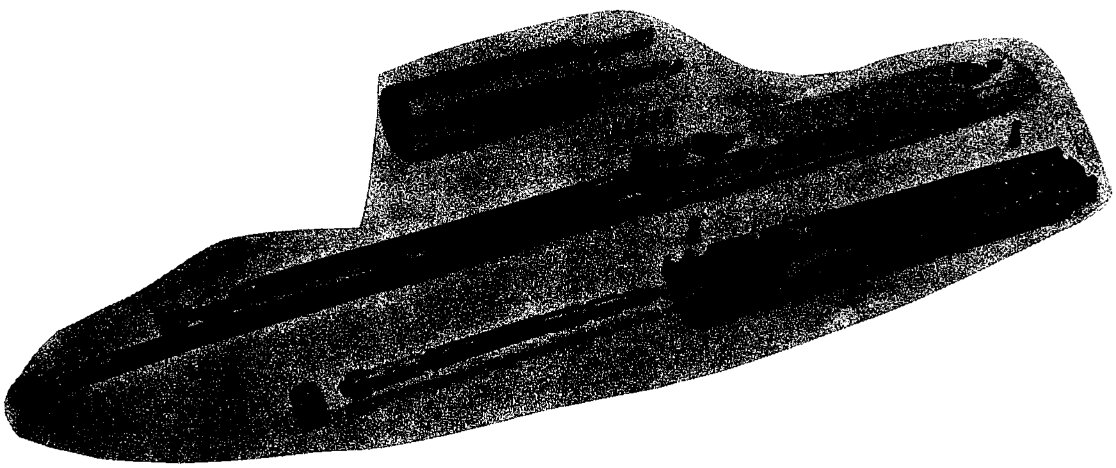
(e) The bearing plates are brought into initial contact with the wall with adjustments as necessary to minimize eccentricity and stress concentrations.

(f) The rods of the linear differential transformers are seated against the wall.

BOREHOLE TESTS



(a) Goodman jack model 52101 hard rock jack (Courtesy Slope Indicator Co.).



(b) Goodman jack model 52102 soft rock jack (Courtesy Slope Indicator Co.).

Figure 1. Example dilatometers using hard-faced jacks for loading. (Lama and Vukuturi, 1978)

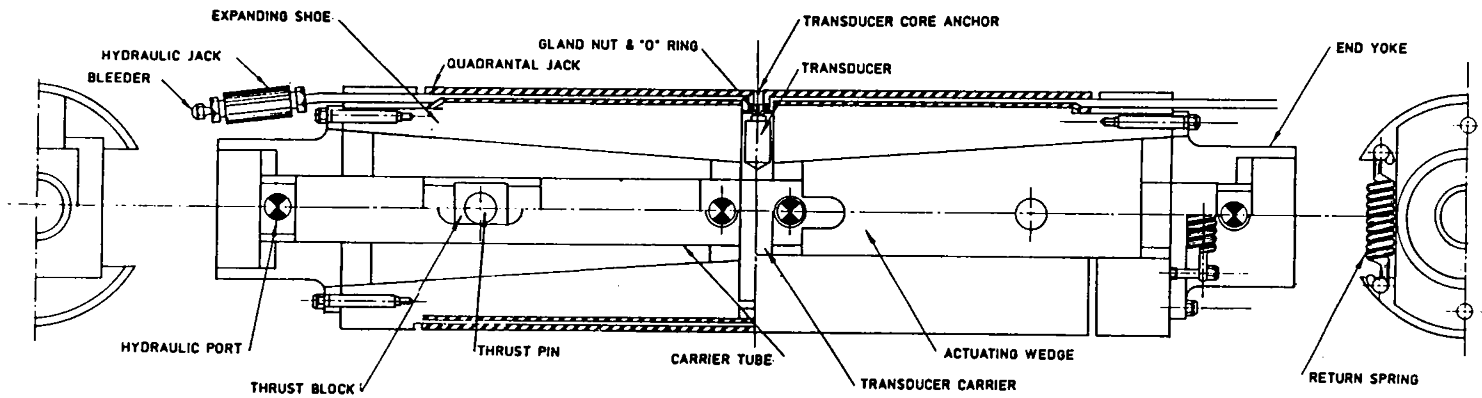


Figure 2. Example dilatometer using soft-faced flat jacks for loading. (Lama and Vukuturi, 1978)

7. Testing

(a) The dilatometer is pressurized in increased stages, with pressure released between stages. Typically the stage pressures are 25, 50, 75, and 100 percent of the planned maximum of the complete test.[3]

(b) Bearing pressure is increased at a rate of 0.5 MPa/min or less.

(c) On reaching the planned pressure for the stage, the pressure is held constant for at least 1 min to detect and define nonelastic deformation. Each stage is completed by releasing pressure at a prescribed rate up to 0.5 MPa/min.

(d) The test history is documented with four or more sets of measurements during pressure increase and two during pressure decrease. Supplementary notes are necessary to describe any complexities not otherwise revealed (such as nonelastic deformation).

(e) The hydraulic pressure is released from the loading jacks. The rods of the linear differential transformers are retracted. The loading plates are retracted from the wall and the dilatometer is removed from the hole.

Calculations

8. The axiosymmetrical relationship for elastic deformation does not apply directly for dilatometers with split loading. Modified expressions have been developed for the specific apparatus. The expression for the dilatometer in Figure 1 is:

$$E = \frac{\Delta p d}{\Delta U_d} \cdot K(\nu, \beta)$$

where

Δp = pressure increment

ΔU_d = diametral displacement increment

d = diameter of hole

$K(\nu, \beta)$ = constant dependent on Poisson's ratio and angle of loaded arc β.

Such characteristics as $K(\nu, \beta)$ are supplied by the manufacturer since they are unique to each particular design.[4]

Where permanent deformation (nonelastic) occurs also, that portion of ΔU_d should be excluded from the equation for calculating modulus of elasticity. However, total deformation should be used to compute modulus of deformation, with the same equation.

Reporting

9. The report should include for each test or all tests together the following:

(a) Position and orientation of the test, presented numerically, graphically, or both ways.

(b) Logs and other geological descriptions of rock near the test. The structural details are particularly important.

(c) Tabulated test observations together with graphs of displacement versus applied pressure and displacement versus time at constant pressure for each of the displacement measuring devices (e.g., linear differential transformers).

(d) Transverse section of hole showing the displacements resulting from the pressure in all orientations tested. Calculated moduli are indicated also.

Notes

[1] See RTH-361, -366, -367 for similar test at tunnel scale.

[2] Diamond core drilling is recommended for obtaining the necessary close tolerance when using dilatometer only slightly smaller than the hole and displacement measuring devices with very limited stroke.

[3] Typically, the maximum pressure is about 15 MPa.

[4] Representation of the effects of a combination of complexities by this empirical factor $K(\nu,\beta)$ has been found unsatisfactory for most purposes except indexing (Heuze and Amadei 1985).

References

Lama, R. D., and Vutukuri, V. S., Handbook on Mechanical Properties of Rock Vol. III, TransTech Publications, 1978, 406 pp.

Stagg, K. G., "In Situ Tests on the Rock Mass," in Rock Mechanics in Engineering Practice, John Wiley & Sons, New York, 1968, pp 125-156.

Heuze, F. E., and Amadei, B., "The N-X-Borehole Jack: A Lesson in Trials and Errors," Int. Journal of Rock Mechanics and Mining Sciences, v. 22, No. 2, 1985, pp 105-112.