SUGGESTED METHOD FOR DETERMINING STRESS BY OVERCORING A PHOTOELASTIC INCLUSION

Scope

1. (a) This test determines in situ stress by sensing strain transmitted during overcoring from the rock to a stiff inclusion coupled in a drill hole.[1] The translation of strain to stress is accomplished by calibration of the inclusion at known stresses. The hard inclusion is sometimes described as a stressmeter.

(b) Maximum and minimum stresses are measured in the plane normal to the drill hole axis. At least three tests in separate drill holes will generally be needed to estimate directions and magnitudes of principal stresses.

(c) The method is relatively inexpensive.

(d) Rock anisotropy and fine dependent deformations complicate interpretation, and may lead to serious errors if ignored.

(e) Another overcoring method measures strain of the drillhole rather than the response of a hard inclusion, See RTH-341.

Apparatus

2. Equipment for drilling a 3-in. emplacement hole in any direction.[2]

3. Equipment for overcoring in any direction at the diameter of 9-in. Included is an axial stabilizer or other device for maintaining concentricity with the smaller center hole.

4. Optical transducer assembly (Figure 1) consisting of:

(a) Hard disk inclusion of glass or other photoelastic material, with axial hole.

(b) Waterproof light source positioned beyond the inclusion, powered by an outside source. Leads from the outside source pass axially through the inclusion.

(c) Means of mechanically or chemically bonding the inclusion to the hole wall.

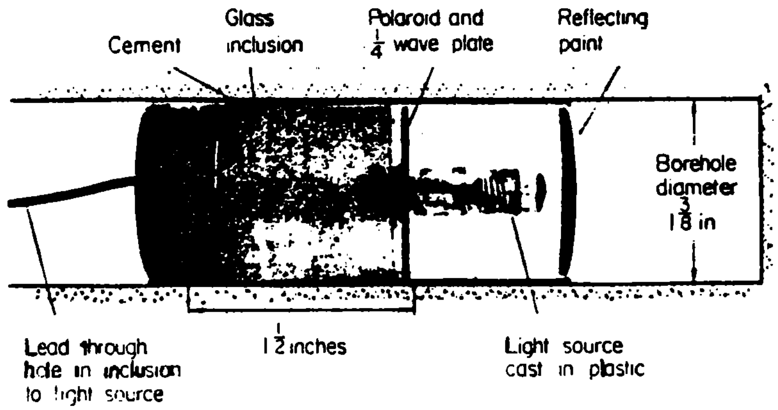

Figure 1. Example of photoelastic stressmeter.

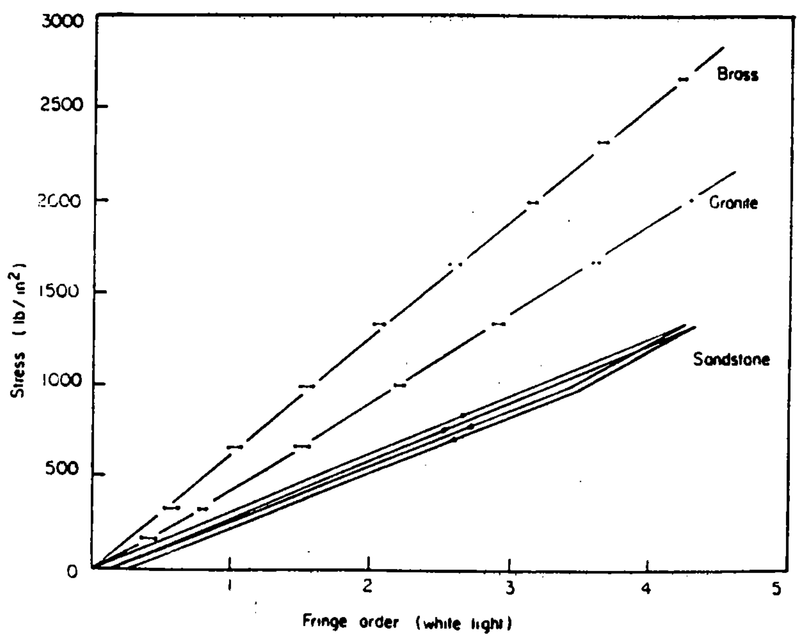

Figure 2. Example calibration curves for photoelastic glass inclusion in three materials.

(d) Analyzing and polarizing plates supplemented with telescope for distant viewing.

5. Tools for positioning and wedging or bonding the inclusion.

6. Calibrating equipment consisting of:

(a) Block of material having modulus like rock of interest and containing a 3-in. hole.

(b) Loading machine and recorder.

Procedure

7. Preparation

(a) The inclusion is calibrated by mounting the complete assembly in the test block and subjecting the block to known loads. Calibration curves are prepared (Figure 2).

(b) The site is selected emphasizing hard, homogeneous rock with no fractures in the volume to be overcored.

(c) If testing will be below the water table, the test volume should be dewatered and kept dry during testing.[3]

(d) The 3-in. hole should be cored to the full depth for all testing and the core should be logged and inspected to confirm suitability of the test intervals.[4]

(e) The optical transducer assembly is emplaced in the 3-in. hole and the hard inclusion is bonded to the side wall. There should be at least 9-in. of open hole between collar and inclusion and inclusion and far end.

8. Testing:

(a) The assembly is checked, a pretest observation of birefringence is made and documented, and lead lines are temporarily disconnected from the outside.[5]

(b) The 9-in. overcore hole is drilled precisely along the same axis to a depth 9-in. beyond the hard inclusion. The drill is withdrawn.

(c) Lead lines are reconnected.[5]

(d) Birefringence is observed (Figure 3 and 4) and is recorded photographically and/or by accurate drawing. A vertical reference should be established. Retrievable portions of the assembly are withdrawn.

(e) The inclusion and polarizing plate are usually not retrieved.

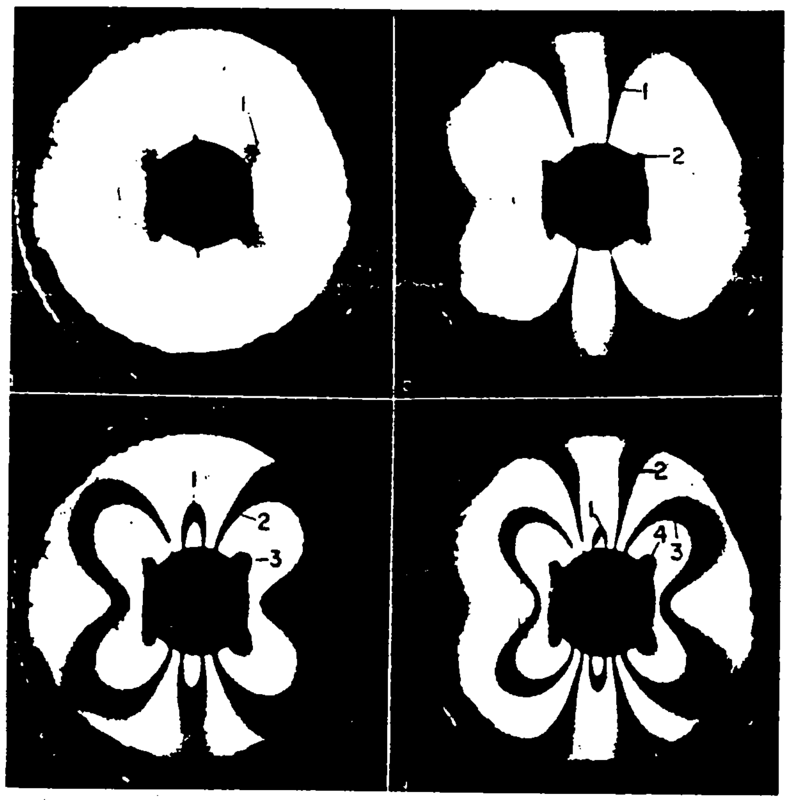

Figure 3. Patterns displayed by the photoelastic disk under increasing uniaxial loading

(f) Where another test is needed at greater depth, the overcored rock stub is broken and removed to reopen the 3-in. hole.

Calculations

9. The glass inclusion with hole along its axis forms a biaxial gage displaying birefringence patterns which identify strain in the glass and, by calibration, stress in the rock. The following characteristics are diagnostic (Figures 3 and 4):

(a) The axes of symmetry of the signal identify the principal stress directions.

(b) The direction in which the signal moves with increase of stress, and the presence of isotropic points in biaxial fields, identifies the major principal stress direction.

(c) The fringe order at a selected point of reference on the pattern is measured to give the major principal stress directly in terms of a calibration factor for any particular principal stress ratio (Figure 1).

(d) The ratio between major and minor principal stresses is indicated approximately by the shape of the signal and precisely by the measured distance between two isotropic points on the major axis.

(e) The manner in which the optical pattern changes, when the analyzer of the polariscope is operated in the process of taking the measurement, identifies whether the measured stress is tensile or compressive.

10. Calculations based on elastic theory are unnecessary in following the procedure presented in paragraph 9. However, the calibration must be well founded in theory. Fortunately, the effects are similar for all materials of great stiffness[1] and even metal may be substituted for site rock during calibration.

Reporting

11. The report should include the following:

(a) Position and orientation of test.

(b) Logs and other geological descriptions of rock near the test. Geological structure and elastic properties are particularly important.

(c) Record of test activities.

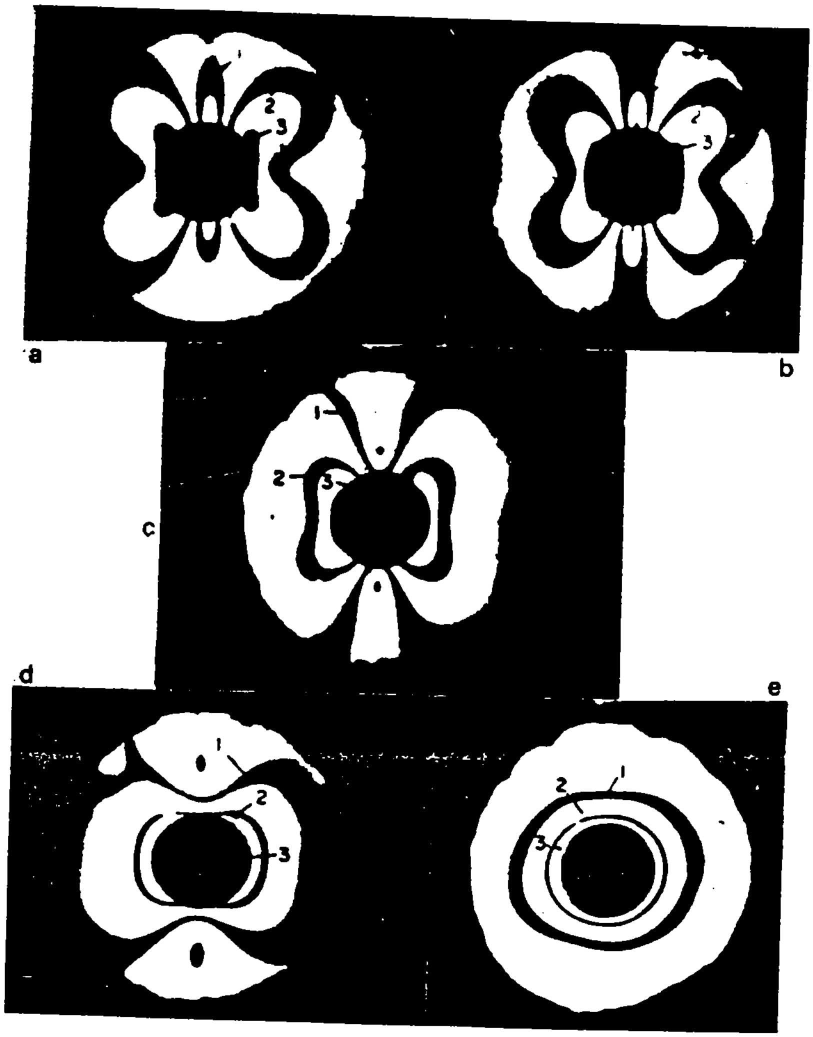

Figure 4. Patterns displayed by photoelastic disk in various stress states, all at third fringe order.

(d) Accurate drawings or photographs of birefringence patterns including that prior to overcoring.

(e) Biaxial stresses indicated from calibration curves.

(f) Description of calibration investigations and resultant curves. Where several inclusions are calibrated at once, a reference to description elsewhere may be sufficient.

Notes

[1]The stress induced in a stiff inclusion will be about 1.5 times the comparable stress in the host rock provided the elastic modulus of the inclusion exceeds that of host by a factor of 5 or more (Roberts 1968).

[2]Diamond core drilling is recommended for obtaining the necessary close tolerance between wall and inclusion.

[3]The test is most commonly conducted in tunnel walls where water is usually not a major problem.

[4]The 9-in. hole is sometime started first and advanced beyond any disturbed zone along the excavated surface.

[5]If the light is retrievable, it is withdrawn temporarily for overcoring.

References

1. Roberts, A., "The Measurement of Strain and Stress in Rock Masses," Chapter 6 in Rock Mechanics in Engineering Practice, John Wiley & Sons, New York, 1968.