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General Discussion

A good *in situ* modulus test is one that will yield a modulus that agrees with measured prototype deformations. There are two basic components of deformation: closure of fractures and joints and elastic strains. Usually joint closure contributes much more to deformation of a rock mass than elastic strains. A good test will have a measuring system that can distinguish between movements that are largely due to joint closure and those principally due to elastic strains. Knowing the component parts of the deformation, a more realistic extrapolation can be made for larger rock masses based on the rock types, fractures, joints and shear zones observed in borehole television surveys and logs of drill holes blanketing the foundation area.

The size and geometry of the test surface should be based on the prototype boundary conditions and the extent of discontinuities in the rock mass. For example, if a dam or pressure tunnel is loading a large volume of rock having significant shear zones, then a large radial test will be best suited for determining the load-time deformation properties of the rock mass. On the other hand, if the rock is homogeneous or contains only tight uniform joint sets, a reliable modulus can be obtained at much less cost by utilizing smaller plate jacking tests. For medium size foundations such as those for heavy buildings, piers, retaining walls, and so forth, plate jacking tests may be sufficient even when significant discontinuities are present. Deformations of foundations for small structures containing reasonably uniform rocks are frequently estimated with sufficient accuracy solely from laboratory tests combined with experience and judgment based on careful inspection of drill cores.

The intensity and cycling of test loads should, of course, be based on prototype loads, and in some cases the deformability of the rock must also be considered. Peak test pressures which are about 50 percent higher than the estimated prototype loads are frequently used. However, for very

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deformable rock it may be desirable to lower this somewhat to provide a greater accuracy of measurements at the design load and reduce the cost of test equipment. The location and orientation of the test load is also important. To evaluate the influence of joints deep within an abutment for an arch dam, it is usually necessary to drill an exploratory tunnel into the abutment having a test adit located sufficiently close to the joints, that they will be loaded by the test at the prototype intensity and oriented so that test load is parallel to the line of thrust from the dam.

Creep is sometimes very important, especially for pressure tunnels designed to utilize the rock for partial support. If the rock creeps under the working load, its contribution of restraint is reduced accordingly.

An abutment for an arch dam which is extremely inelastic may "set" when unloaded and not maintain full contact with the dam as it resumes its unstrained position. Although a good measure of primary creep and set may be obtained *in situ,* it is probably not often feasible to leave the test load on long enough to completely define the creep equation or determine the ultimate set upon unloading. Under design loads, primary creep is usually much larger than secondary creep. Therefore a practical estimate can be obtained by combining primary creep values obtained from *in situ* tests with secondary creep values based on long-time laboratory tests.

ASTM test methods are used to:

1. Control quality of products
2. Determine design constants required by a code or specification
3. Evaluate different materials for research purposes

At present rock mechanics is not greatly concerned with the first two uses. However, there is considerable effort expended on determining the physical properties of different rock masses. For example, many plate jacking tests are performed by various engineering organizations in a period of a year. If these were performed in accordance with a standard test method, the results over several years could be correlated and reduced to guide lines on the influence of different rock types, fractures, and joint sets of various configurations on the deformation characteristics of rock masses. The cost and availability of test equipment might also be reduced as a result of an acceptable standard test method.