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Guest Editorial

The modulus of deformation of rock mass is a very important parameter used in analysis and design of dam and underground excavations in the rock mass. The modulus of deformation of rock mass shows a large variation in test results. For design of engineering structures on or within rock mass, the main parameters of importance are the deformability or modulus of deformation of the rock mass, joint shear strength, strength of the rock material and the in situ stresses.

It is generally known that in situ tests of the deformation modulus of rock masses are subjected to measurement errors, both from equipment, preparation and blasting damage in the test adit in addition to the measurement method and test procedure. But in order to arrive at the best possible results the persons involved in the tests must know the limits and problems involved in the tests.

There are variations in the modulus of deformation values determined by different methods. Sometimes these variations are due to the change in the rock mass properties also. The results of deformability measurements must be analysed by experience hands working in the field. The experience obtained at one project site cannot be utilized at another project site with the same type of rock mass. Therefore, the deformability of rock mass must be determined by any available method.

The experience is that different procedures used for in situ measurements provide values that often differ from one another by as much as 100%. This is inevitable, due to the fact that the volume of rock mass structure differs from one test to another particularly in terms of degree of jointing. As the modulus is notably sensitive to the presence of joints, the rock mass conditions at each test site should be carefully described as part of the test procedure. By comparing the variations in rock mass quality, some of the difference in test results may be explained.

The Central Soil and Materials Research Station (CSMRS), New Delhi, India has performed in situ deformation tests with the flat jack, plate loading, Goodman jack and plate jacking tests during the last three decades at most of the important river valley projects mainly in the Himalayan region of India, Nepal, and Bhutan. The procedures and suggested methods of the International Society for Rock Mechanics (ISRM) have been closely followed for conducting all the tests. From the test results, it has been possible to compare and correlate the in situ measurement by flat jack test, plate loading test, Goodman jack test and plate jacking test.

As earlier pointed out by several researchers, the value obtained by the various in situ deformation tests will not give the same deformation modulus. Based on CSMRS experience this may partly be explained by (i) in plate jacking test (PJT) with drill hole extensometer measurement whereby the deformations are measured inside the drill hole away from the damaged zone towards the undisturbed rock mass; (ii) in plate loading test (PLT) with surface measurement where larger deformations are measured at the rock surface in these tests include the top damaged zone and (iii) Goodman jack test (GJT) performed inside the drill hole gives lower values of the deformation modulus because the stress is applied on a very small area as compared to large size plate jacking test.

The PJT is less sensitive to the variations in the pressure distribution than displacements directly under the loaded area. The measurements of deformation in drill holes at various depths provide a check against any gross errors (blunders) of the measurements. The PJT also allows a better assessment of the properties at depth as the displacements outside loaded area are influenced to a greater extent by the behaviour of the rock mass.

Therefore, it is recommended to utilize large size plate jacking test with borehole deformation measurements to arrive at a final design value of any project. However, the modulus of deformation of rock masses obtained by plate loading tests and Goodman jack tests may have to be multiplied by a factor of 2.5 to arrive at a reasonably good representative value. This factor may be derived exactly for a particular site by conducting in situ tests.

Caused by the high cost and measurement difficulties, the value of the modulus of deformation is often estimated indirectly from observations of relevant rock mass parameters that can be acquired easily and at low cost. These parameters are then applied in approximate equations.

The use of more than one indirect procedure has been proposed by many authors, so that the results obtained may be compared and their reliability checked by in situ measurements. The indirect procedures to estimate the deformation modulus are simple and cost-effective, especially as compared with direct, in situ procedures, although it is obvious that in situ procedures should be used whenever time and means available allow for them.

When estimating the deformation modulus using different classification systems, it is not recommended to use the correlation/transition equations between the systems, as mathematical equations tend to be rude and may give wrong values. Instead, the various parameters involved in the actual classification system should be given their relevant ratings and the modulus value shall be obtained using this value (of Q, RMR or GSI).

It is a steadily increasing trend in the fields of engineering geology and rock mechanics to substitute geological reality by mathematical idealisations. This lack of interest in uncertainty and field observations easily leads to reducing the quality of the input parameters. It is, therefore, utmost important that experienced people with a background from practical rock construction are widely used in the collection of data to be used in the classification and characterization systems as well as in numerical models and mathematical analyses.

There is no substitute for in situ testing due to variations in rock mass properties. However, testing cannot be restricted to entire length of the long tunnelling projects. It is, therefore, recommended to conduct minimum of five tests in each class of rock mass at different horizons for determining average value of deformation modulus of rock mass with variations by using large size plate jacking test. The in situ testing values can be correlated with indirect methods like Q, RMR and GSI. These indirect methods can then be used to determine modulus of deformation in the entire length of tunnel. The new correlations can be developed based on the case studies in Himalayas.

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