Field Tests in Rock

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3.1 **INTRODUCTION**

Mechanical behaviour of rock mass cannot be determined purely from laboratory tests. Large scale insitu tests are necessary for design consideration of major projects as laboratory tests invariably lead to an overestimate of the properties of rock mass. The prediction of engineering properties of the rock mass always insists insitu tests and is usually considered to be the best means for determining the engineering properties of subsurface materials and in many cases, it may be the only way to obtain meaningful results.

In-situ rock tests are performed to determine various field parameters e.g. in-situ stresses and deformation properties of the rock/rock mass, shear strength of jointed rock mass or critically weak seams within the rock mass, residual stresses within the rock mass, anchor capacities, and rock mass permeability. Large-scaled and number of in-situ tests tend to average out the effect of complex interactions. In-situ tests in rock are usually expensive. Well-conducted tests may be useful in reducing overly conservative assumptions. Test site location and loading direction is very important for the success of tests. Site investigation in rock include tests like insitu stress determination, insitu test for deformability, insitu direct shear tests etc.

![Figure 3.1: A typical drift for insitu tests](image)
Laboratory tests have the limitations like variability and sample disturbance. Also, testing is done on small specimens and extrapolation of the measured properties for the entire site is often challenging.

In contrast, insitu test provide the response of a larger mass under natural insitu condition. The limitation includes poorly defined boundary condition, cost and time, approach and site condition, non-uniform and high strain rates imposed during testing and inability to control drainage condition etc. Despite these limitations insitu tests are most acceptable and essential part of any geotechnical site investigation and design. Large scale insitu tests are necessary for design consideration of major projects because laboratory tests invariably lead to an overestimate of the properties of rock mass. Geotechnical investigation and design in rock mass always insists insitu tests. Some important requirements of insitu tests,

- Test should affect a rockmass to the extent that it represents the behaviour of the affected rockmass or zone
- Cost should be low without compromising quality
- Equipment used should be simple and compact
- Nearest to actual stress condition
- As per theory on which the test is based
- Load should be applied in the direction representing actual anticipated direction

Type and number of insitu tests usually depends upon the type of structure and its importance and the rock strata condition. Insitu tests can be put in general following categories,

- Shear test
- Deformability tests
- Strength tests
- Tests for internal stresses
3.2 INSITU DIRECT SHEAR TEST

The test is to find out the insitu cohesion and friction values and the method is suggested in ISRM code, “Suggested Method for Insitu Determination of Direct Shear Strength”. In this test, peak & residual direct shear strength are measured as a function of stress normal to the sheared plane, on the same test horizon with each specimen tested at a different normal stress keeping it constant for the particular observation. A typical schematic diagram for the direct shear test for rock is shown in Figure 3.2. Figure 3.3 shows the picture for an ongoing test in the field.

Various equipments required for the test, equipment for cutting & encapsulating the test block- rock saws, drills, hammer & chisels, formwork of appropriate dimensions & rigidity, expanded polystyrene sheeting & steel shear box (700 x 700 x 350 mm), equipment for applying normal load usually hydraulic jacks, equipment for applying the shear force usually hydraulic jacks, equipment for measuring the applied forces, pumps and pressure gages and equipment for measuring shear, normal & lateral displacements.

![Figure 3.2: Schematic diagram for insitu direct shear test](image)
Figure 3.3: Insitu shear box test setup in a drift (Courtesy: AIMIL Ltd. New Delhi)

The equations involved are as below, and the cohesion and friction may be calculated as shown in Figure 3.4.

\[
\text{Shear stress } (\tau) = \frac{P_{t}}{A'} = \frac{P_{t} \cdot \cos \alpha}{A'}
\]

\[
\text{Normal stress } (\sigma) = \frac{P_{t}}{A'} = \frac{P_{t} \cdot \sin \alpha}{A'}
\]

Where, \(\phi_r\) = residual friction angle, \(\phi_p\) = peak friction angle, \(\phi_a\) = apparent friction angle, \(C'\) = apparent cohesion, \(C_p\) = peak cohesion

Figure 3.4: Shear strength vs. normal stress plot
Figure 3.5: Concrete casted on rock block cut in situ

Figure 3.6: Test setup for in situ rock direct shear test (Courtesy: AIMIL Ltd. New Delhi)
Figure 3.7: Sheared rock blocks after turning

Figure 3.8: A typical shear stress vs. shear displacement response of field direct shear box test in rock.

Form the Figure 3.6, it can be seen that, the shear load is being applied at some inclination (15° in the present case) to avoid any overturning moment generated on the rock block. Inclination ensures that the resultant shearing force line passes through the centre point of the block. The corresponding vertical component of the shear stress (τ\sin15°) may be compensated as the shear progresses to ensure constant normal load throughout the test.
Figure 3.9: A typical shear stress vs. shear displacement response of field direct shear box test at shear zone

y = 0.8525x + 0.957

Figure 3.10: Determination of cohesion and friction with best fit line
\( c = 0.96 \text{MPa} \) and \( \phi = 40^\circ \)