CHAPTER IV
TEST APPARATUS AND METHODS

4.1 Introduction

Presented in this chapter are test apparatus and test methods for determining CERCHAR abrasivity index (CAI). Additional parameters include ploughing force and mean groove volume. Methods for determining effect of rock joint and aperture of rock specimens on CAI are also described.

4.2 CERCHAR test

The CERCHAR abrasivity test used have follows the ASTM D7625-22 standard. This test is a widely recognized method for evaluating the abrasiveness or abrasive potential of rocks and other geological materials, as shown in Figure 4.1. Figure 4.2 presents the schematic drawing of the CERCHAR device and shows the torque wrench that are used to determine the rotation torque to scratch the steel stylus. They are used to calculate ploughing force and determine mean groove volume to assess effect of rock joint and rock aperture. Steel stylus pin with rockwell hardness of 55 ± 1 (Figure 4.3) are used with 90 degrees conical tip. Equations for calculating the CAI are shown in Eq (4.1) and Eq (4.2).

Figure 4.1 Device based on West CERCHAR apparatus West, (1989) with additional torque (Kathancharoen and Fuenkajorn, 2023).

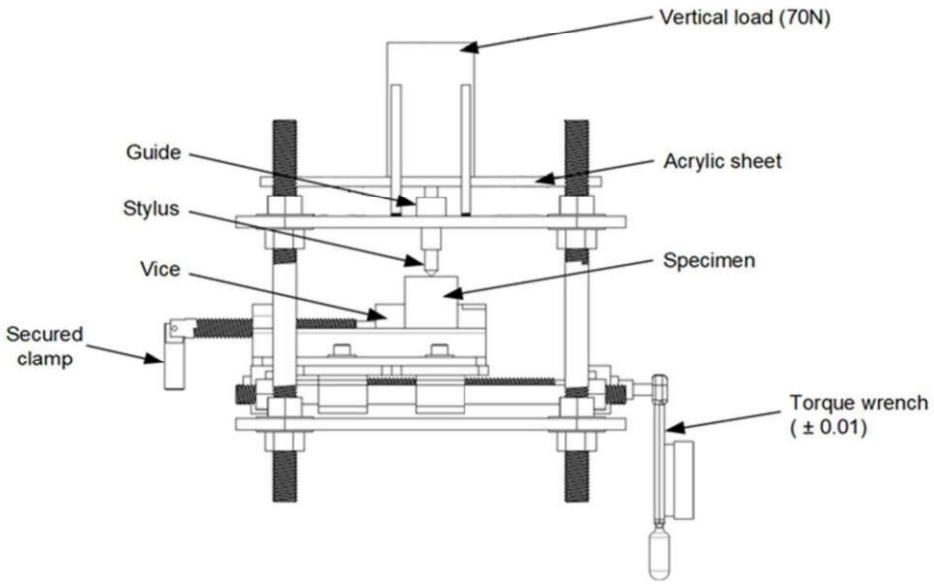

Figure 4.2 Schematic drawing of CERCHAR device used in this study. (Kathancharoen and Fuenkajorn, 2023).

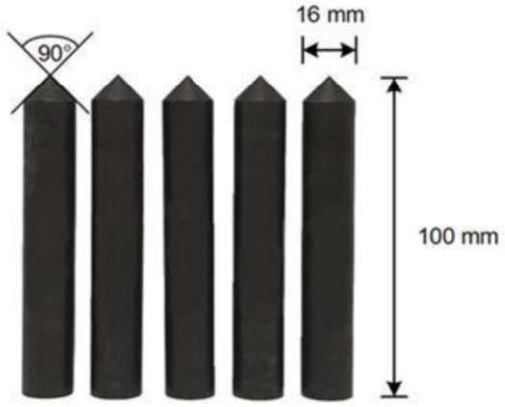

Figure 4.3 Example steel stylus pin with rockwell hardness of 55 ± 1 HRC for CERCHAR testing.

For each saw-cut rock surface specimen, scratching is repeated 5 times. Each time with a new stylus on a new scratch location. Wear flat width (d) of stylus tip is used to calculate CAI as follows:

$$CAI = d \times 10 \quad (4.1)$$

where CAI is CERCHAR abrasivity index for natural surface, d is diameter of wear flat area of stylus tip with an accuracy of 0.01 mm. If saw cut specimen is tested, wear flat of stylus tip is calculated from:

$$d = 1.14\ d_{sc} \tag{4.2}$$

where d_{sc} is wear flat of stylus tip for saw cut surface specimen performed in this study.

The schematic drawing of wear flat width of the stylus tip is shown in Figure 4.4. The wear tip is measured using a stereomicroscope (Nikon SMZ745T) at a magnification of 50x. The variables added beyond the standard suggestions in this study are shown in Figure 4.4.

The vertical displacement is measured by using the digital displacement gages with a precision of 0.001 mm to measure groove depth during scratching. The horizontal force applied on the steel stylus can be calculated from torque on the crank using load torque required for driving a ball screw equation from Nidec corporation as shown in Eq. (4.3).

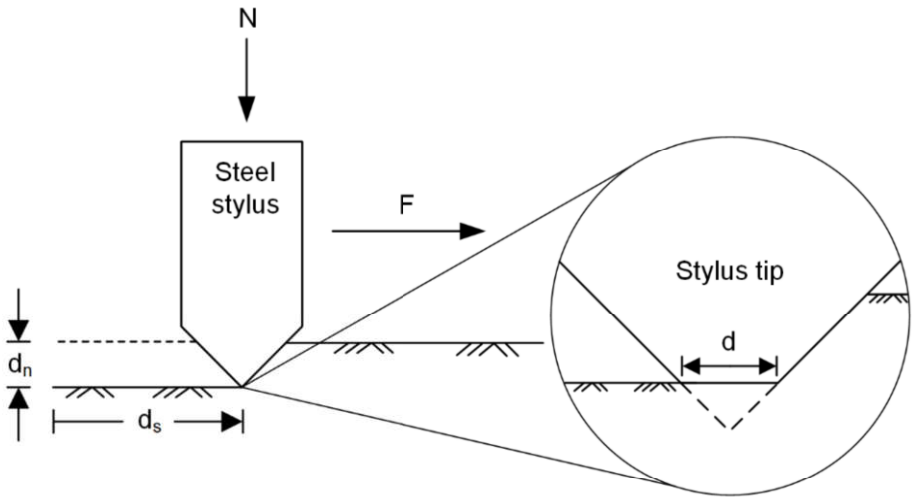

Figure 4.4 Steel stylus test variables, N is normal load (N), F is horizontal force (N), dn is vertical displacement (mm), ds is scratching distance (mm), and d is wear flat width of stylus tip (Kathancharoen and Fuenkajorn, 2023).

$$F = 2\pi T/P \text{ (N)} \quad (4.3)$$

where F is ploughing force (N), T is torque (N•m) and P is screw pitch (0.001 m). Rock surface after CAI testing have been laser-scanned to observe groove shape and to calculate the groove volume. The measurements are made to the nearest 0.001 mm. The torque for moving the specimen to scratch the steel stylus could be obtained from the torque wrench, the additional torque measuring device from the West apparatus, with an accuracy of 0.01 N•m is shown in Figure 4.5.

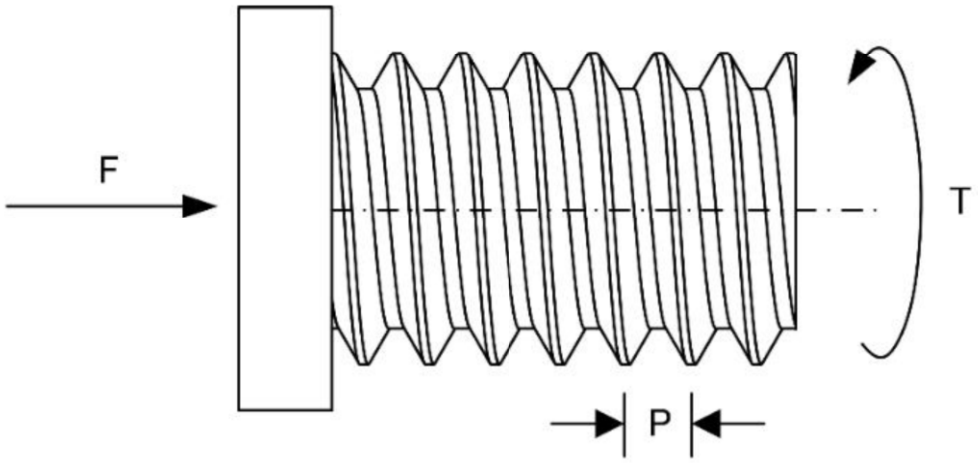

Figure 4.5 Force diagram used to convert torque (T) to horizontal force (F) (Kathancharoen and Fuenkajorn, 2023).

4.3 X-ray diffraction

Post-test CERCHAR specimens are ground to produce powder particles that pass through a #60 mesh. Approximately 5 to 10 grams of the powder are then analyzed using an X-ray diffractometer. The Topaz software is employed to determine the weight percentages of the mineral compositions, as shown in Figure 4.6.

Figure 4.6 X-ray diffraction Bruker, D8 advance (Center for Scientific and Technology Equipment University of Technology).