CHAPTER IV

LABORATORY TEST AND PHYSICAL MEASUREMENT

This chapter describes methodology, and calculations involving the laboratory testing and physical measurements. Laboratory tests emphasize determining the durability index and density. The fragment sizes and shape are measured to identify the change of rock fragments. The equations for evaluating the weight percent of passing materials are proposed.

4.1 Test scheme

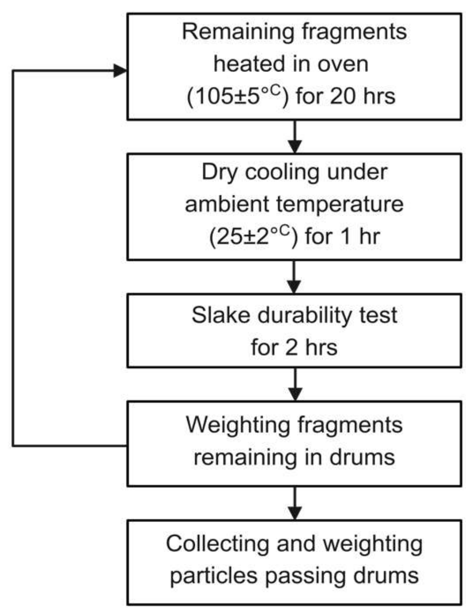


Figure 4.1 Diagram representing one test cycle

According to the diagram of schematic process in Figure 4.1. Two sets of fragments for all rock types are subjected to the slake durability index test: one under dry condition, the other under wet condition. The test duration is about 2 hours (included the process of drums installation) Before testing in the next cycle, fragments in both conditions are left air-cooled at ambient temperature (25±2°C) for 1 hour, after heated in the oven under temperature of 105±5°C for 20 hours, the weight is measured. After each test cycle, particles that pass through the opening from every test cycles and the remaining fragments in the drum from test cycle 80 are collected for further mineral analysis.

4.2 Slake Durability Index test

The durability test and calculation follow the standard test specifications in accordance with the American Society for Testing and Materials, ASTM D4644-16 (ASTM, 2016). Figure 4.2 shows the test apparatus used in this study. A detailed schematic diagram of the apparatus is presented in Figure 4.3. The device comprises with 2 rotating drums. Each with a diameter of 140 mm and length of 100 mm, connecting to the controller with an axle. The drums are wraped with 2 mm mesh wires with a constant rotational speed of 20 rpm. Figure 4.4 illustrates the cross section and side view of the drums.

The test is modified from the standard by using a different shape of fragments from irregular lump to cubic. Every cycles are tested beyond the standard by increasing the drum rotations from 200 to 2,000 revolutions and tested for 80 cycles instead of 2 cycles. This is to accelerate the erosion process of the fragment specimens.

The durability index for each test cycle are determined as $Id_i = (m_i/m_0)\times100$, where m_i is the total mass of fragments retained after test cycle i (g), m_0 is the total mass of fragments before test cycle i (g), and i is the number of test cycle.

To evaluate the relative values for passing materials in each test cycle. The total mass loss between each cycle is defined as particles that pass through the drum opening. The passing materials are calculated as:

$$P_i = m_i - m_{i-1} \tag{4.1}$$

where P_i represents mass of passing materials from test cycle i (g).

To determine accumulative percentage of passing materials, P_A. The following calculation can be applied:

$$P_A = \sum_{i=1}^{80} P_i \tag{4.2}$$

The aforementioned relationship serves as a standardized to compare rocks with variation of initial mass. To correlate with the durability index, the relative percentage of cumulative passing materials are represented by the following equation:

$$P_A = (P_i / \sum_{i=1}^{80} P_i) \times 100 \tag{4.3}$$

Figure 4.2 Slake durability index test apparatus.

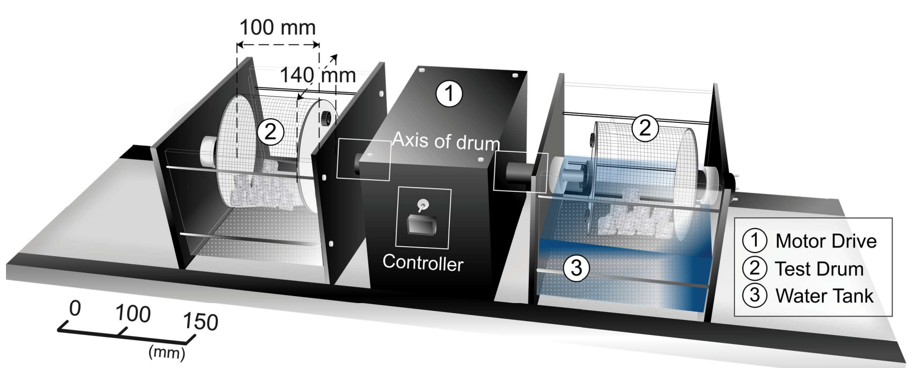
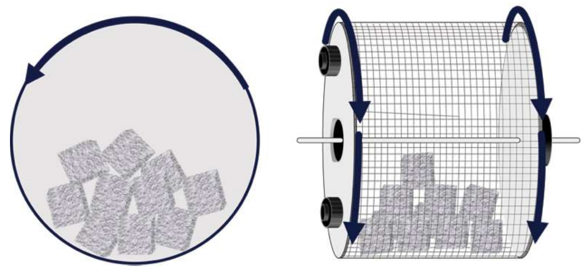


Figure 4.3 3D schematic diagram for durability test.



(a) (b)

Figure 4.4 Cross section and side view of drum with rotational direction.

4.3 Density

The calculation of density for fragments under wet condition are from volume displacement technique, as suggested by ASTM D7263-21 standard test method. To consider the potential of water ingressing into fragment matrix under dry condition that might impact the erosion process. The density for fragment under dry condition can be calculated in term of mass subtracting by volumatic change of fragments. The equation is

4.4 Physical measurement

Shape determination follows the established method from Hryciw et al. (2016). The parameters utilized in this study include:
the roundness:

$$R = \left(\sum_{i=1}^{80} r_i / n\right) / r_{ins} \quad (4.4)$$

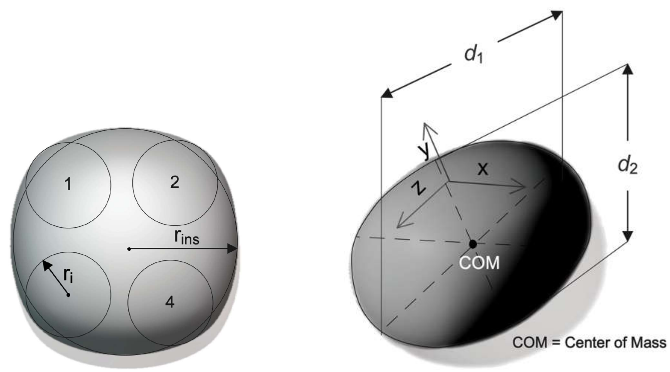
where r_i is radius of circles filled to corners of each fragment (mm), r_{ins} is largest radius of circle fitted to the entire fragment (mm), and n is the number of corners (Figure 4.5a), and the sphericity:

$$S = d_2/d_1 \quad (4.5)$$

where d_1 and d_2 represent the widest and narrowest diameters of each fragment, as shown in Figure 4.5b. The illustration classifications in Figure 4.6 are modified from

Hryciw et al. (2016) used for further tracking of shapes discussed in the next chapter. The roundness and sphericity classifications are shown in Table 4.1 through 4.2.

Fragment size assessment is obtained from three mutually perpendicular axes of the fragment, i.e. longest, intermediate, and shortest across each fragment in both conditions. The average fragment size is determined by calculating mean of these values. The measuring technique is the same as presented for sphericity (See Figure 4.5b).



(a) (b)

Figure 4.5 Dimensional parameters for roundness (a) and sphericity (b), (modified from Hryciw et al., 2016).

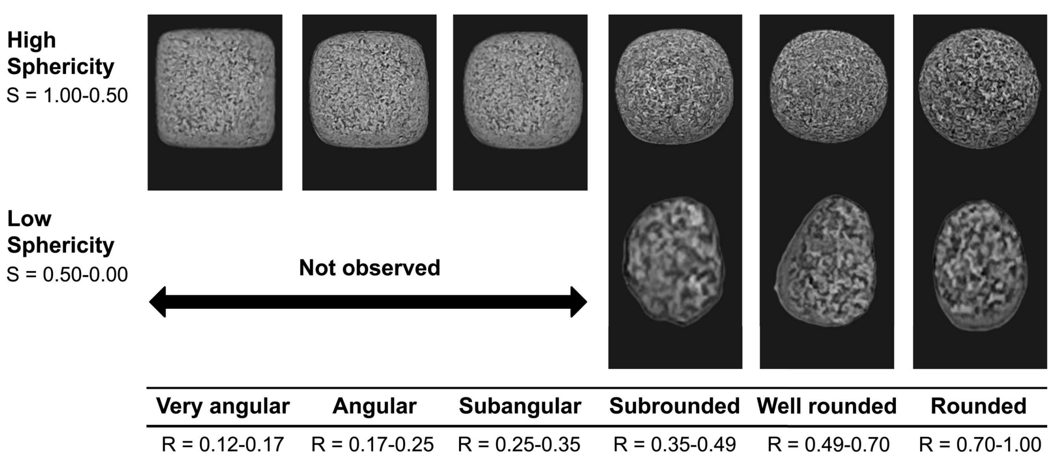


Figure 4.6 Classification for surface roundness and sphericity (modified from Hryciw et al., 2016).

Table 4.1 Roundness classifications (Hryciw et al., 2016).

Classification	Value
Very angular	0.12-0.17
Angular	0.17-0.25
Subangular	0.25-0.35
Subrounded	0.35-0.49
Well rounded	0.49-0.70
Rounded	0.70-1.00

Table 4.2 Sphericity classifications (Hryciw et al., 2016).

Classification	Value
High	1.00-0.50
Low	0.50-0.00