Determination of Slake Durability Index (SDI) Values on Different Shape of Laminated Marl Samples

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Abstract. The slake durability index (SDI) test is widely used to determine the disintegration characteristic of the weak and clay-bearing rocks in geo-engineering problems. However, due to the different shapes of sample pieces, such as, irregular shapes displayed mechanical breakages in the slaking process, the SDI test has some limitations that affect the index values. In addition, shape and surface roughness of laminated marl samples have a severe influence on the SDI. In this study, a new sample preparation method called Pasha Method was used to prepare spherical specimens from the laminated marl collected from Seyitomer collar (SLI). Moreover the SDI tests were performed on equal size and weight specimens: three sets with different shapes were used. The three different sets were prepared as the test samples which had sphere shape, parallel to the layers in irregular shape, and vertical to the layers in irregular shape. Index values were determined for the three different sets subjected to the SDI test for 4 cycles. The index values at the end of fourth cycle were found to be 98.43, 98.39 and 97.20 %, respectively. As seen, the index values of the sphere sample set were found to be higher than irregular sample sets.

1. Introduction

The slake durability is an important property for rock materials. The aim of the slake durability test is to provide an index that is related to resistance of rock against degradation when subject to two standard cycles of wetting and drying ([1-3]). The slake durability index (SDI) test was firstly developed for shale rocks by [4] and then improved by [1]. The slake durability test was suggested as a standard test for rocks by [5] and also became an ASTM standard [6]. It can be said that SDI has become an important engineering parameter, and it is used extensively in literature in order to determine the durability of the rocks, especially weak and clay bearing rocks. The research reported in [7], [8], [9] and [10] can be given as examples of this kind of studies. In the study of [10], SDI tests were carried out on the samples collected from various regions of Turkey, and also, a new test (Disintegration Index test) and a new classification system based on the results of the new test were suggested. Besides, there are a lot of studies (e.g. [11-15]) that try to establish a correlation between SDI value and rock durability, strength, mineral compositions and various geomechanical properties of rocks.

The SDI can be considered as one of the most important properties for shales, clay-bearing rocks and similar weak rocks. The results of slake durability test are affected by the following factors [1]:

- Porosity and permeability of the tested rock,
- Nature of the testing fluid,
- Resistance of rocks against swelling and disintegration,
- Properties of testing equipment,
- Conditions of sample storing,
- Number of wetting-drying cycles,
- Shape of specimen pieces,
- Size and weight of specimen pieces.

Tests omitting any of the factors listed above would lead to erroneous results [2]. Some of these factors are the shape, size and weight of the test specimens used in test. Changes in the size and shape of the specimens were observed after the different cycles of the slaking test [9]. The profile or shape changes in the slake durability test were evaluated on five siltstone specimens with an average diameter equal to 2.2 cm [16]. The shape of rock specimens before the testing is subangular. It was observed that the shape of the specimen after the test changed in rounded [17]. The specimen chunks of different degrees of surface roughness such as angular, subangular, subrounded and rounded were prepared and each group of chunks were subjected to slake durability test. The test results indicate that the surface roughness and the structural properties of chunks used in experiments affect the SDI of the rock tested. The rounded and angular specimen chunks prepared from the rocks which are massive and do not possess lamination and bedding such as clayey limestone, tuff and weathered granite resulted in substantially different index values, which significantly affect the slake durability of the rocks tested.

In this study, the variations of the index values in terms of shape and laminated direction were investigated on the sphere specimens subjected to the SDI test. The marble rock block samples used in the test were collected from Seyitomer Lignite Collary at Kutahya province in Turkey. The equal size and weight sphere and irregular specimen shapes were prepared for laminated marble as three groups. In addition, each group was subject to the SDI test for 4 cycles.
2. Materials and methods

2.1. Materials

Laminated Marl samples in this study were collected from SLI colliery located near to Kutahya province in Turkey. Seyitomer contains the two coal seams, lower and upper, in the lower-middle Miocene age. The Seyitomer formation is presented by green claystone, lower coal seam, bituminous marl (laminated), coal lenses, upper coal seam, claystone and fossiliferous. The mineralogical structure of laminated marl consists of calcite, aragonite, quartz, clay minerals, gypsum, feldspar, and amorphous material. Major element chemical analyses are given in Table 1.

![Table 1. Chemical content of laminated marl](image)

| SiO₂  | Al₂O₃ | Fe₂O₃ | MgO  | CaO   | Na₂O | K₂O  | LOI  |
|-------|-------|-------|------|-------|------|------|------|
| 25.07%| 6.54% | 6.15% | 6.25%| 17.06%| 0.25%| 0.67%| 36.8%|

2.2. Sphere and irregular test sample preparation

The preparation of sphere test samples (from collected rock block) consists of three stages. First stage is to cut cubes whose size is in accordance with final sphere sample diameter. Since the standards mention that the final sample weight is required to be 50 grams, the diameter of the sphere specimens is calculated from volume and dry density of the rock. Second stage is performed on the cubes in order to obtain a pre-sphere shape which is called Pasha Cut. The final stage is to obtain equal-sized sphere specimens from pre-sphere shaped specimens by means of an instrument modified for this purpose [20], [21]. Irregular test samples were prepared to be parallel to the layers and to be vertical in respect to the layers according to standards.

2.3. SDI test

The SDI tests were carried out on three test groups. The SDI test conducted on each group was repeated for 4 cycles. The test results for all groups are given in Table 2, Figure 1. Sphere, Parallel to layers and vertical to layers were labelled with sphere, parallel and vertical, respectively.

![Figure 1. The SDI values of three groups](image)

3. Results and discussions

One of the major problems in the SDI test is determination of the ideal SDI index. Therefore, in this study, changes in index values on the laminated marl have been determined on three different sets subject to the SDI test for 4 cycles in order to depending on the test sample shapes.
The index values after second cycle were found to be 99.51 % for sphere group, 98.43 % for parallel and 98.58 % for vertical. The differences in Id2 values were determined as between 0.49 % and 0.93 % according to sphere sample group.

| Indexes | Sphere | Parallel | Vertical |
|---------|--------|----------|----------|
| Id1     | 99.63  | 99.36    | 99.16    |
| Id2     | 99.51  | 99.12    | 98.58    |
| Id3     | 98.87  | 98.77    | 97.89    |
| Id4     | 98.43  | 98.39    | 97.20    |

The index values after fourth cycle were found to be 98.43 % for sphere group, 98.39 % for parallel and 97.20 % for vertical. The differences in Id4 values were determined as between 0.04 % and 1.23 % according to sphere sample group. As seen, the index value of the sphere-sample group was found to be higher than other groups. Moreover, it could be claimed that vertical groups tended to present more disintegration due to layers.

4. Conclusions
In this study, slake durability tests were carried out on the sphere and irregular laminated marl samples taken from Seyitomer Lignite Open Pit Mine as a first in the literature. The index values of sphere and parallel groups were close to each other. High index values were obtained from the sphere samples when compared to irregular sample results. It can be said that sphere samples can give ideal index values in terms of SDI test.

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