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RESEARCH ARTICLE

Slake durability and point load indices of shale in Zuangtui sliding area, Aizawl, Mizoram

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Zuangtui is situated in the Eastern limbs of the Aizawl anticline. Human settlement in the study area is greatly affected by the ground movement that has been occurring since 1987. A geotechnical investigation was carried out using Slake Durability Test and Point Load Index Test in order to understand the weathering rate and strength of the rock. Out of 21 collected rock samples,16 samples show a durability range of 76 - 90%, and the other samples fall under the durability range of 90%-95%. Most of the samples showing lower durability are from disturbed areas. The lowest point load value is 1MPa shown by samples in a disturbed area and most of the point load strength of the rock in an unstable area is comparatively lower than in a stable area. From the study, it is considered that the durability and strength of the rock greatly contribute to triggering ground movement.

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Introduction

A landslide can be defined as a movement of rock mass, debris, or earth down the slope.[1] It may be triggered by an earthquake, modification of slope for development or heavy and continuous rainfall. Landslide is one of the most serious hazards, especially in hilly terrain like Mizoram. More than 50% of natural hazards in Mizoram is due to landslide. According to the landslide inventory database of India published by Landslide Atlas of India, Mizoram is recorded as the highest landslide-prone area in India.[2] While most of the landslide hazards in Mizoram especially in Aizawl are human-induced, many are also due to weak properties of the soil or rock of the area. The study area Zuangtui is in Aizawl (Fig.1) and falls under Aizawl Municipal Corporation (AMC) ward number 1. Geologically Mizoram lies in the Upper Bhuban Formation of the Surma Group which belongs to the Miocene to Oligocene age. It lies in the Western part of Aizawl and falls under toposheet 84A/9. Zuangtui is an important settlement area as it connects many important centers for the people living in and around Aizawl. The study area has been suffering ground movement since 1987. Huge debris movement was observed in the lower part of the study area at a boundary between the Thuampui and Zuangtui border. Ground movement is observed every year disturbing the life of people settling in this area. Since outcrop is observed in both the disturbed and undisturbed area, and rock strength depends on their contact with water, geotechnical investigation using rock analysis like the point load index test which is considered the most competent tool and slake durability test could be a great help in understanding the ground movement that will greatly help in suggestion and mitigation measures.

Materials and Methods

Geotechnical analysis was carried out in the study area using Slake Durability Test and Point Load Index Test. Slake durability is the resistance offered by a rock against disintegration when treated under a cycle of wetting and drying.[3] The study area was divided into three locations. In total, 21 samples

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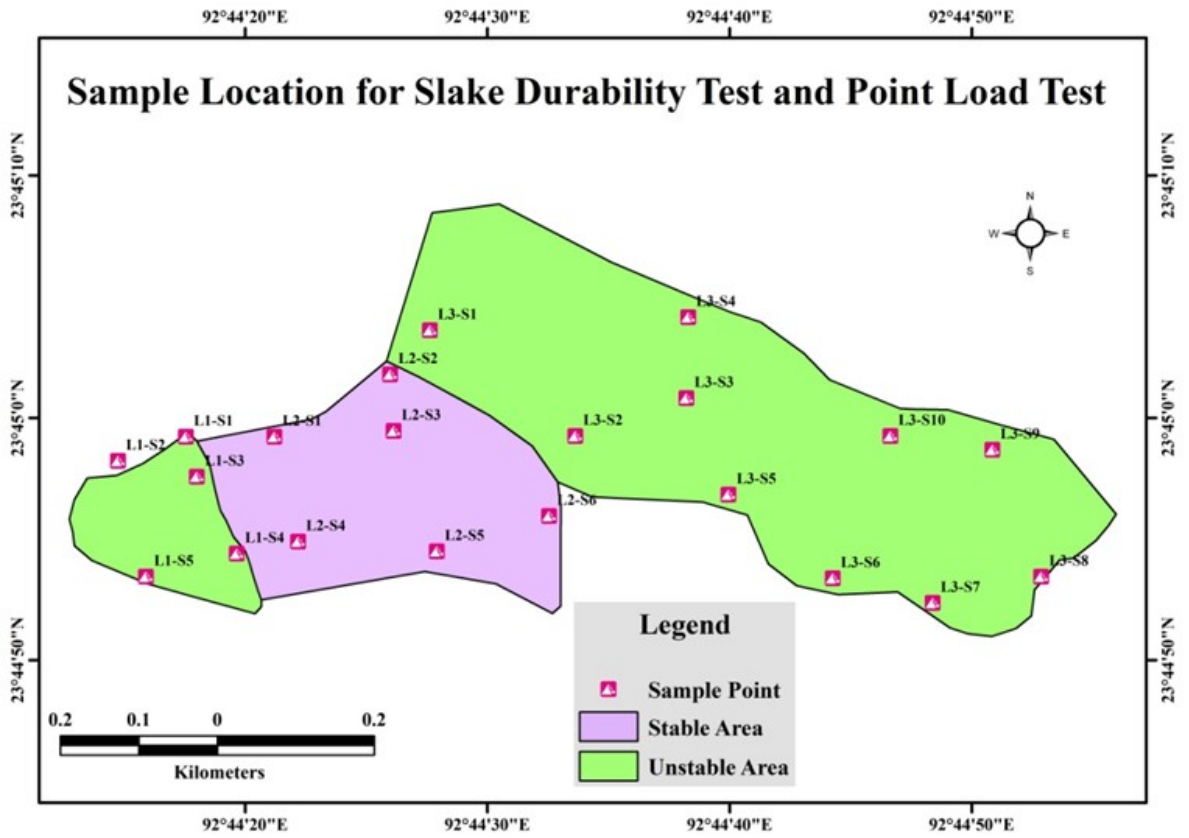

Figure 1: Sample location map of the study area Zuangtui

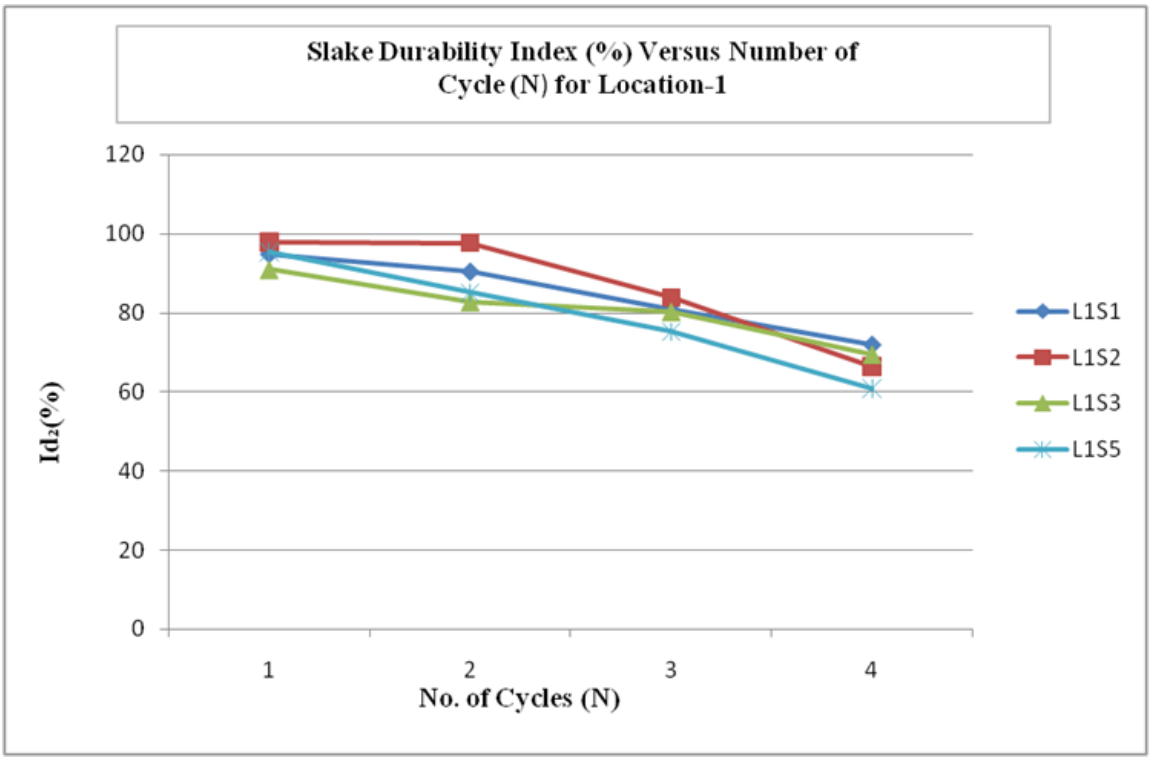

Figure 2: Average Slake Durability Index versus Number of Cycles (N) for location-1

were collected (Fig.1). 5 rock samples from location 1, 6 samples from location 2, and 10 samples from location 3 were collected for the analysis.

Using IS:10050-1981, Slake durability test was done in order to assess the resistance which is offered by a rock sample on weakening and

disintegration when subjected to a phase of drying and wetting in the slaking fluid. Ten roughly spherical shapes of rock samples with each sample weight 40-60g giving a total weight of 400-600g were prepared.[4] The rock samples were placed in a clean drum and dried at a temperature of 105°. The dried samples along with the drum are then measured. The weight was recorded as weight A. The drum with the lid was then mounted in the trough and coupled to the motor. The trough was filled with water up to the level of 2mm below the drum axis. The drum was then rotated for 10 minutes with 20 revolutions per minute. The drum was taken out and dried to constant weight at 105° without the lid. The dried sample was then weight and recorded as weight B. The test was repeated and weight C was recorded for the dried weight. The weight of the clean dry drum was recorded as weight D and calculation was done using the formula.

Calculation

Slake durability Index (first cycle) I_{d1}=

$$\frac{B-D}{A-D}100$$

Slake Durability Index (second cycle) I_{d2} =

$$\frac{B-D}{A-D}100$$

The result was classified into different categories based on the classification made by Franklin and Chandra (Table 4)

Irregular Lump Test of Point Load Test was performed according to IS:8764. It can be used only in intact and massive rock.[5] The specimen can be tested either by an irregular lump or rock core.[6] At least 10 test specimens per sample with a size defined under IS: I8764 were used for the point load lump test. Fresh samples should be taken as weathered and fractured rock always give a lower strength.[7] Then reading at the point of failure is recorded and calculation was done using the equation

$$I_L(50) = \frac{P}{(DW)^{0.75}\sqrt{D^*}}\ MN/m^2$$

Conversion of Slake Durability Index to Uniaxial Compressive Strength (UCS)

$q_c = 15 \times I_L(50)$

Results

Result of Slake durability analysis

Among the 21 samples collected from the three locations (Fig.1), 5 samples (L1S1, L1S2, L2S1, L2S6, L3S2) were silt shale samples and the other 16 samples were clay shale. In location 1 (Disturbed Area), silt shale samples L1S1 and L1S2 collected from the adjacent stable show 90.4% and 97.63% retention percentages after the second cycle respectively (Table1). The samples fall under the Very high and extremely high value of durability (Table 2) and belong to Type I according to SDI classification8 (Table 3). The shale samples L1S3, L1S4, and L1S5 from the disturbed area are classified as Type II as they show large and small pieces retention after the second cycle of the test. The SDI% after the second cycle ranges from 76 - 90% (Table 1) and is under high durability. L1S4 and L1S5 are highly weathered.

Out of the 6 samples collected from location 2 which is considered a stable area, 2 samples (L2S1 and L2S5) are silt shale and the other 4 samples (L2S2, L2S3, L2S4 and L2S6) are clay shale(table1). They fall under Very High and High durability as they range between 91-95 and 76-90 respectively in SDI% after the second cycle of the test. Most of the samples in location 2 fall under Type I as the sample remains virtually unchanged after the completion of the different cycles.

Slake Durability Indices for clay shale in location 3 after the second cycles range between 76 - 90% (Table1) and are classified as High durable rock. Only L3S2 shows a range of 91 - 95% SDI and has Very high durability. Most of the samples are under Type II as they show large and small pieces fragments after the completion of the cycle

Slake durability index versus the number of cycles for location 1 shows that there is a sharp decline in the curve trend after the third cycle (Figure 2). Mostly rapid slaking results in slope instability.[9] For locations 2 (Figure 3) and 3 (Figure 4), the trending of the curve is almost similar which shows a continuous decrease of durability with an increase in the cycle. Long-term repetition of the cycle will result in further fragments of the rock sample.[10]

For Point Load Index Test, a total of 21 samples were collected from three locations (Fig.1). Out of 5 rock samples in location 1, only L1S3 and L1S5 have PLI more than 2MPa (Table.4). In location 2, which is considered as a stable area, the PLI for all the rock samples fall under the range of 2-4MPa (Table.5). Samples from Location 3 which is an actively sliding area show a very low value of PLI. Only two out of 10 samples fall under the 1-2MPa range (Table. 6).

Discussion

From the result of slake durability test, it was observed that the rate of weathering of rocks in the study area is different in both stable and unstable areas. Most of the rock exposed in the unstable area has low durability compared to those rocks observed in stable area. Also, the result of the point load lump index test shows that rocks in the unstable area have lower point load strength compared to those in the stable area. The geotechnical properties of rock in the study area where low strength and fewer durable rocks were observed in the unstable area could be a triggering factor for the ground movement in Zuangtui.

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