# PREDICTION OF THE VARIATION OF AGGREGATE PROPERTIES IN QUARRY MINING, BASED ON EXPLORATORY CORE SAMPLES

*Kumaratunga W.D.K.S, Mendis B.M.S.W, Rishanthan Y, Sandanayake D.S.S,*
**U G A Puswewala, G V I Samaradivakara*

*Department of Earth Resources Engineering, University of Moratuwa, Moratuwa*
**Corresponding Author email:head@earth.mrt.ac.lk.*

## ABSTRACT

Quarry industry is a growing industry because of the need of aggregates for the construction industry. One of the most widely used construction material is aggregate which is mined in quarry mines. Most frequently asked parameters for the quality of quarry aggregates are Loss Angeles Abrasion Value and Aggregate Impact Value, which are unpredictable at the initial stages of quarrying for the rock underneath the surface. Hence, the risk of running the quarry is always there. Therefore this article examines the variation of aggregate properties in quarry mining, based on exploratory core samples. The study is carried out by using core samples from a selected quarry in the western province, Srilanka. This research indicates the relationship between Uniaxial Compressive Strength (U.C.S) and Los Angels Abrasion Value (L.A.A.V), between U.C.S and Aggregate Impact Value (A.I.V), and between L.A.A.V and A.I.V. correlation between the parameters are indicated, and a relatively strong correlation is found between L.A.A.V and A.I.V. these will assist to initially predict some test results based on other test results, and thus save initial expenditure on testing for quality of aggregates.

## KEYWORDS

Aggregate Impact Value, Compressive Strength, Los Angels Abrasion Value, Regression Analysis, R-square value, Uniaxial

## INTRODUCTION

Rock aggregate is an important material for many civil engineering works. For different construction purposes, the required aggregate properties can change. Mainly the consultants of the construction industry ask for the L.A.A.V and A.I.V to determine the strength, durability characteristics of aggregates, particularly for road construction ASTM (American Standards for testing materials) and BS (British Standards) specify testing procedures for the L.A.A.V and A.I.V and there are local standards which specify the requirements for various construction purposes (e.g. RDA specifies acceptable LAAV and AIV ranges). Thus whenever a quarry begins there will be feasibility studies to ensure that the rock in the quarry meets the requirement of the construction industry. However, these aggregate property values can be found only for the surface of the rock mass. These tests need specified masses of rock samples such as 5Kg for L.A.A.V test and 1 Kg for A.I.V test, and rock from underneath the surface will not be available at the commencing stage. Therefore, the risk of running the quarry is always there even though the A.I.V and L.A.A.V values of surface rock aggregates meet the requirement. Aggregates, which are at depth, may not meet those requirements because the rock layers can differ as in the case of unconformities and intrusions, and mineral composition of the same rock may

Change with depth. Thus a quick prediction for A.I.V, L.A.A.V is necessary for the rock at depth. For this purpose, this work aims to find out these values by using the core sample drilled up to the depth we want. Nevertheless, core samples are not enough for this because of the requirement of large rock mass, but UCS can be measured. Thus any relationship between theses intended aggregate property values and uniaxial compressive strength are investigated this study was conducted at the Lanka Quarry (Pvt) Ltd which is a main quarry in the western province of Sri Lanka.

## METHODOLOGY

### Data collection

To get the data for the regression analysis 19 boulders from Lanka Quarry were collected which contained different rock types (biotite gneiss, quartzite feldspethic gneiss) and following tests were done on those boulders separately;

1. U.C.S test
2. L.A.A.V test
3. A.I.V test

### Uniaxial Compressive Strength

In this test, cylindrical rock specimens are tested in compression without lateral confinement. The test procedure is similar to the unconfined compression test for soils and concrete. The test specimen should be a rock cylinder of length-to-width ratio (H/D) in the range of 2 to 2.5 with flat, smooth, and parallel ends cut perpendicular to the cylinder axis. Originally, specimen diameters of NX size (54mm) were used; the peak value of the axial stress is taken as the unconfined compressive strength (U.C.S)

$$\text{Compressive Strength} = \frac{\text{Axial Load at Failure}}{\text{Cross Section Area}}$$

To get the NX core hilty drilling machine was used on the boulders were drilled by that and Electric driven masonry saw was used to smoothen the end surfaces of the core. Cores were oven dried before the test.

### Los Angeles Abrasion Value

The cored boulders were taken to the crusher plant of Keangnam at Athurugiriya, Sri Lanka, and crushed using the baby crusher. The Jaw crusher available at the Earth Resources engineering Department was also used to crush the over sized samples. The crushed sample was sieved using the standard sieve apparatus. Samples of 2.5 kg of 9.5 mm-12.5 mm size range and 2.5 kg of 12.5 mm-19 mm size range were prepared .The most suitable grading for L.A.A.V test was selected comparing the availability of the required amounts for each of the four BS standards grades. Thus grade B was selected; the samples were washed separately and dried in the oven for four hours at temperature of 105 $^0$C. Samples of 2.5 kg from the two size ranges given in the grade B were from each boulder to carry out the L.A.A.V test. Each 5 kg sample was subjected to the LA.A.V test at the Rock Mechanics Laboratory of the Civil Engineering department.

Then the crushed samples were sieved using the 1.7 mm sieve and the retaining samples were measured to get the L.A.A.V values the equation according to the following equation:

$$LAAV = \left[\frac{\text{Original Weight} - \text{Final Weight}}{\text{Original Weight}}\right] \times 100$$

### Aggregate Impact Value

The A.I.V tests were carried out at the Building Material Laboratory of the Civil Engineering Department using the A.I.V apparatus according to the BS standards as follows. The cored boulders were crushed similar to the procedure followed for LAAV testing. The crushed sample sieved using the standard sieve apparatus. Samples passing the 14 mm size sieve and retaining on 10 mm size sieve was taken to prepare for the A.I.V test. The samples were washed separately and dried in the oven for four hours at temperature of 105 $^0$C. The dried samples were put into the cylindrical metal measure in three layers and each layer was subjected to 25 blows by the steel tamping rod in order to have a fully compacted sample. The weight of the sample and container were measured separately. The sample container was leveled and the sample compacted was put into the steel cylinder of 75 mm diameter and again compacted by 25 blows using the steel tamping rod. The sample was then crushed using the blow hammer for 15 times. The crushed sample was sieved using the 2.36 mm sieve and the weight of the pan + sample and weight of the 2.36 mm sieve + sample were measured. Two tests were carried out for each boulder and the average A.I.V value obtained.

The weight difference of the initial sample and the crushed sample was measured and AIV calculated as;

*Aggregate Impact Value (AIV) = {M2/M1}*100*

Where
M1 =Mass of the test specimen; and
M2 = Mass of the test specimen passing 2.36 mm test sieve

## Regression analysis

After getting all the data, regression analysis was done and curve was fitted through the points by using MINITAB software.

A linear was selected for all curve fittings, mainly due to the simplicity of the relationship it provides.

## RESULTS

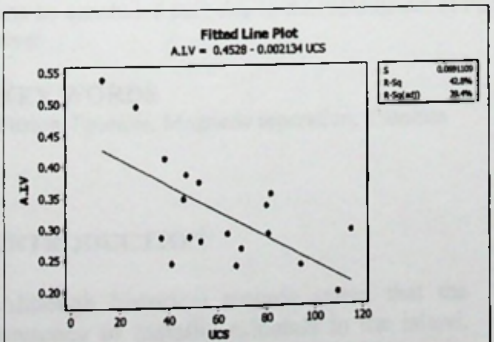


**Fig 1: AIV vs. UCS Graph**

The regression equation given by the software after analysis was

A.I.V = 0.4528 - 0.002134 U.C.S
The adjusted R-square was 39.4%. Fig 1 shows the line fitted through the data points.

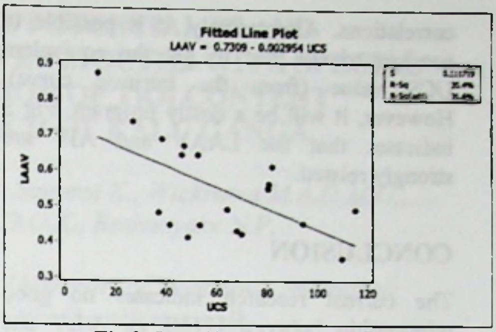


**Fig 2: LAAV Vs UCS Graph**

The regression equation is
L.A.A.V = 0.7309 - 0.002954 U.C.S
The adjusted R-square was 31.6%. Fig B shows the line fitted through the data points.

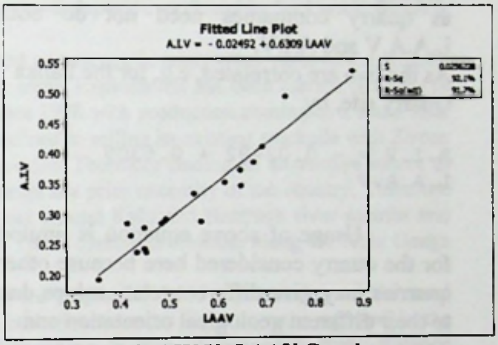


**Fig 3: AIV Vs LAAV Graph**

The regression equation is
A.I.V = - 0.02492 + 0.6309 L.A.A.V
The adjusted R-square was 91.7%. Fig 3 shows the line fitted through the data points.

## DISCUSSION

Fig 1 and 2 indicate that the scatter in data is considerable when UCS is correlated with LAAV and AIV. One reason for this may be methodology adopted in testing; the UCS is strongly dependant on the direction of foliations, especially in anisotropic rocks. However, this effect is not strongly felt in LAAV and AIV when the boulders are crushed, and broken surfaces are randomly oriented. To improve the correlation of UCS with other indices, it is possible to record the foliation orientation in the core samples with respect to the direction of load application. This will clarify the issue of poor correlations. Alternatively, it is possible to conduct triaxial test to get the equivalent UCS value (from the intrinsic curve). However, it will be a costly program. Fig 3 indicates that the LAAV and AIV are strongly related.

## CONCLUSION

The current research indicates no good relationship between U.C.S vs. A.I.V and U.C.S vs. L.A.A.V because the value adjusted R-square for these relationships are less than 40 %( which is very low). However, a better relationship is found between A.I.V vs. LA.A.V. the latter relationship could be an advantage in running quarries in a cost effective manner, as quarry companies need not do both L.A.A.V and A.I.V.
As the two are correlated, e.g. for the Lanka Quarry site, by

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A.I.V = - 0.02492 + 0.6309
L.A.A.V
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Usage of above equation is limited for the quarry considered here because other quarries may give different relationships due to their different geological orientation and formation. This is only a pilot study to indicate possible correlation between various rock strength and durability parameter. This work is based on tests carried out for 19 samples, and a more comprehensive program should involve more samples and multiple sites.

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