Suitability of Light Coloured Silicate Metamorphic Rocks of Sri Lanka in Construction Industry

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Abstract: Conventionally, in the local construction industry, darker coloured (melanocratic) rocks are preferred over light coloured (leucocratic) rocks without proper scientific reasoning. Hence, the objective of the study is to assess the suitability of leucocratic rock types in construction applications as raw materials by analyzing desirable properties. Rock samples ranging from dark colour to light colour were collected by visual inspection. The degree of light colouredness was determined through a microscopic analysis. Unconfined Compressive Strength (UCS) test, Point Load Index (PLI) test, Los Angeles Abrasion Test (LAAV) and Aggregate Impact Value Test (AIV) were carried out on samples prepared according to the standard methods. Concrete mixtures made out of different aggregates with varying leucocratic contents were also tested for strength and rate of strength gain by concrete cube testing. Test results were analyzed with respect to the degree of light colouredness to identify the desirable aggregate properties to be used in construction industry.

Keywords: concrete aggregate, compressive strength, point load index, LAAV value, AIV

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1. Introduction

Mining and mineral industry is considered as the backbone for industrial expansion in any country and it is a vibrant industry in the world. The mining industry is mainly about quarrying in Sri Lanka. The rocks commonly used for the production of aggregates in Sri Lanka are hornblend biotite gneisses, biotite gneiss, charnokite and charnokitic gneiss, migmatite and granitic gneiss. These rocks commonly contain minerals such as quartz, feldspar, hornblende, biotite etc. in different percentages. (Jayawardene and Dissanayake, 2008). Crushed aggregates are used in construction industry for different applications including concrete production. The properties of the aggregates depend on the above mentioned mineralogical composition as well as the formation. It is mainly the aggregate that provides strength to the concrete, especially the coarse aggregates. Conventionally, in the rock quarrying industry, darker coloured (melanocratic) rocks are preferred over light coloured (leucocratic) rocks without proper scientific reasoning. Hence, the objective of the study is to assess the suitability of leucocratic rock types in construction applications as raw materials and also in concreting with respect to strength and durability aspects.

2. Methodology

Rock samples ranging from dark colour to light colour were collected by visual

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inspection. The degree of light colouredness was determined through a microscopic analysis. Unconfined Compressive Strength (UCS) test, Point Load Index (PLI) test, Aggregate Impact Value (AIV) test and Los Angeles Abrasion Value (LAAV) test were carried out on samples prepared to the standard methods. Concrete mixtures (grade 35M, cement: sand: aggregate = 1:1.6:2.9) made out of different leucocratic contents were also tested for strength, rate of strength gain by concrete cube testing. Test results were finally analysed with respect to the leucocratic percentage to identify the strength variations.

2.1. Sample collection

Samples were collected from quarries located in Kalutara, Naboda area; Metal Mix Private Ltd. (Lat 6.57248, Lon 80.0783) CML construction (PVT) Ltd. (Lat 6.561127, Lon 80.058843), WKDA Ariyasigha (PVT) Ltd.(Lat 6.578067, Lon 80.086760), SNB (PVT) Ltd.(Lat 6.567732, Lon 80.063328) and ROMEC (PVT) Ltd.(Lat 6.574104, Lon 80.079697) quarries. Rock types were mainly garnet biotite gneiss.

2.2 Sample preparation

From each sample collected, two cores of 54 mm diameter and 18 cm of length were cut to perform UCS and PLI tests respectively using the Hilti (DD-160E, Switzerland) core machine from each sample. The length of the core samples taken for UCS test and PLI test were 11cm and 6cm long respectively prepared using Errut (CT 16, England) machine. All core pieces were polished labelled and then dried in the oven (to remove moisture content) for 24 hrs at 105^{0}C of temperature. Rock samples were crushed with the prototype jaw crusher (DENVER BMAE211 36,England) sieved and obtained the aggregate passing 14 mm sieve and retaining on 10 mm sieve. Sample were washed and dried at 100-110 ^{0}C for four hours for the AIV test.

Crushed samples were prepared in accordance with the standard C 131 – 96 particle size distribution for the LAAV test then washed and oven dried at 110^{0}C. Concrete aggregates were directly collected from the crusher at the quarry for cube tests and were prepared in accordance with BS 812 standard particle size distribution through a sieve analysis test. Crushed 20 mm x 20 mm samples were first ground with the mechanical grinder. Then to make an even surface for microscopic analysis, coarse diamond powder, fine diamond powder and polishing powder (cerium oxide) were used to grind and polish each specimen manually and samples were stored in polythine bags and labelled until further analysis through the microscope. The samples were not thin sections; only one side of the sample was polished and made as an even surface.

2.3 Sample testing

Point load test was performed on 6 cm long cylindrical core pieces according to the ASTM standards (D 5731). UCS test was performed on core pieces which had L/D ratio between 2 and 2.5, according to the ASTM standards (D 2938). AIV test was performed in accordance with the standard D 5874 – 95 and LAAV test was performed in accordance with the standard C 131 – 96. Polished surfaces of samples were observed under a microscope (Olympus CHB S, Japan) with a magnification of 1:50 and snapshots of five positions of the specimen were taken through the software. Grid counting (on a 0.8 x 0.8 mm^2) grid was done to calculate the light coloured area of the sample. Unconfined Compressive Strength of concrete was tested using, a 35 M strength mix design. Nine cubes of

100x100x100 mm^3 were prepared from each sample and compressive strength was measured at the ages of 3,7,21 days.

3 Results

UCS value is an implication of strength when the rock is subjected to an axial load whilst the PLI value is an implication of strength when the rock is subjected to a point load (Griffin and Jason Allan, 2008).

Figure 1 and 2 shows that there is no significant relationship between the leucocratic content and the rock strength (R>0.5).

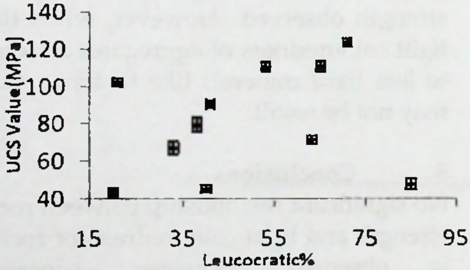

Figure 1 Degree of light colouredness Vs UCS value

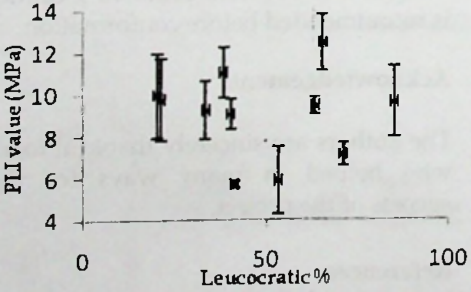

Figure 2 Degree of light colouredness Vs PLI value

AIV is a measure of resistance to impacts in the aggregates whereas LAAV is a measure of degradation of aggregates resulting from a combination of actions including abrasion or attrition, impact, and grinding in a rotating steel drum. Figures 3 and 4 show that there is no significant (R>0.5) relationship between the leucocratic content and the rock resistance to abrasion and durability.

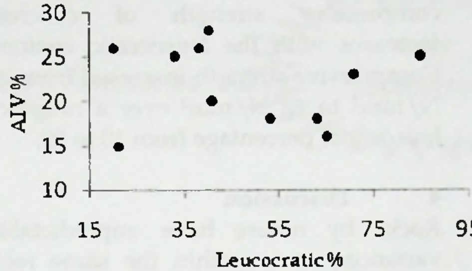

Figure 3 Degree of light colouredness Vs AIV

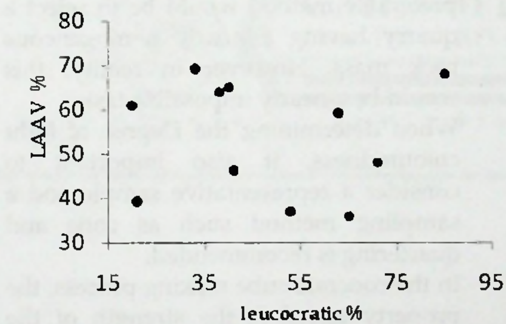

Figure 4 Degree of light colouredness Vs LAAV

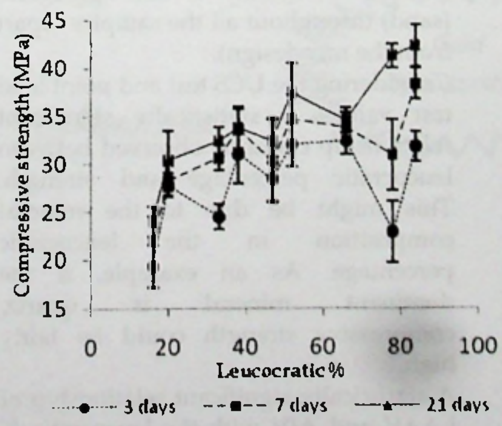

Figure 5 Variation of compressive strength of concrete over the age

The compressive strength of a concrete cube indicates the compressive strength of the concrete when it is subjected to an axial load. Figure 5 shows that compressive strength of concrete increases with the leucocratic content. Compressive strength increased from 23 N/mm^2 to 43 N/mm^2 over a range of leucocratic percentage from 18 to 89.

4 Discussion

Rocks by nature have unpredictable variances, even within the same rock type, rock mass and even from point to point making it difficult to obtain representative samples. The most preferable method would be to select a quarry having a nearly homogeneous rock mass. However in reality, this would be a nearly impossible task.

When determining the Degree of light colouredness, it also important to consider a representative sample and a sampling method such as cone and quartering is recommended.

In the concrete cube making process, the property tested is the strength of the aggregate versus leucocratic percentage. Therefore it is important to make other factors constant such as particle size distribution of aggregates, the quality of cement, the quality of fine aggregates (sand) throughout all the samples (apart from the mix design).

Considering the UCS test and point load test values, a statistically significant relationship could be observed between leucocratic percentage and strength. This might be due to the mineral composition in the leucocratic percentage. As an example, if the dominant mineral is quartz, compressive strength could be fairly high.

A statistically significant relationship of LAAV and AIV with the leucocratic % could not be observed. This also may be due to the mineral composition. If a hard leucocratic mineral like quartz is present, resistance to impact and abrasion could be high whereas a relatively less hard mineral compared with quartz like feldspar is present, resistance to above factors could be low. The compressive strength of the concrete cubes is increased with the leucocratic percentage. Compressive strength of the concrete mainly depends on the bonding of the ingredients. The dominant mineral giving light colour to rocks was observed to be quartz which has a greater angularity when crushed. Angularity increases the bonding of the concrete which could have been the reason for the higher compressive strength observed However, when the light colouredness of aggregates are due to less hard minerals like feldspar, this may not be result.

5 Conclusions

No significant relationship between rock strength and light colouredness of rocks is observed. However, concrete compressive strength was observed to increase with leucocratic percentage. However further research covering samples from several different localities is recommended before conformation.

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