DETERMINATION OF SUITABILITY OF THE LIMESTONE AGGREGATES AS COARSE AGGREGATE FOR CONCRETE

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Abstract: The use of limestone in the construction industry has been increasing due to its potential as aggregate. Some of the benefits of limestone include good strength, low possibility of alkali-silica reaction and the decrease in drying shrinkage in concrete.
In the northern part of the Sri Lanka, limestone is used as aggregate in concrete due to its availability. The aim of this research is to observe, evaluate, compare and discuss general characteristics of the limestone aggregate in the northern part of Sri Lanka and check the suitability of the limestone as coarse aggregates in concrete. There are two different kinds of limestone there, namely Red limestone and white limestone. Then experiments are conducted for both kinds of limestone together with the normal coarse aggregates. The properties of density, water absorption, particle size distribution, Flakiness Index, Los Angeles Abrasion Value, Aggregate Impact Value, Aggregate Crushing Value and Soundness of the aggregate are observed. The results are compared with the properties of the coarse aggregates and then suitability of limestone aggregates is evaluated.

Keywords: Limestone Aggregate, Properties, Concrete

1. Introduction

In Sri Lanka, Gneiss (for Granite group) or Charnockite rocks are mainly used as coarse aggregates in production of concrete. However, in the northern part of Sri Lanka, due to unavailability of normal aggregates and high cost in transportation of aggregates to the region, limestone aggregates which are freely available in Jaffna region are used to produce concrete. Average size limestone boulders can be collected by excavating them manually at several locations. After removing these limestone rubble, the land can be used for agricultural purposes. Therefore, most of the landowners prefer to remove the limestone rubble and use the land for the agricultural and other purpose. Therefore, lands became usable leading to the sustainable development.

Limestone (LS) aggregates are used as coarse aggregates to produce concrete in different parts of the world. However, composition of limestone can change from location to location and hence properties may vary. Therefore, it is necessary to investigate their suitability for concrete production before use. Regarding the limestone available in Jaffna region, scientific investigations about their suitability have not been documented. Therefore, it is necessary to have knowledge and clear understanding about the suitability of Jaffna limestone as coarse aggregates and its properties and performance in structural concrete.

There are two types of limestone aggregates available in Jaffna region as red limestone (from Walikamam west, Jaffna) and white limestone (from Chavakachcheri, Jaffna). This paper presents the suitability of limestone available in Jaffna region as an alternative aggregate for production of concrete by studying about the properties of limestone aggregates and comparing them with the properties of normal aggregates.

2. Methodology

The following experiments were conducted to determine the properties of aggregates and the results were compared with normal aggregates and standards to check their suitability for production of concrete.

- Determination of Flakiness Index according to British Standard 812:Section 105.1:1989
- Determination of particle size distribution according to BS 812:Section 103.1:1985
- Determination of density and water absorption according to BS 812:part 2:1995
- Determination of aggregate crushing value (ACV) according to BS 812; Part 110: 1990
- Determination of aggregate impact value (AIV) according to BS 812; Part 112:1990
- Determination of Los Angeles Abrasion Value according to ASTM Standards of C 131 Test for resistance to degradation of small-size coarse aggregates by Abrasion and Impact in the Los Angeles Machine
- Determination of Soundness value according to ASTM Standards of C

Red limestone sample (taken from Walikamam west, Jaffna) with two different sizes; 3/4" and 5/8" and White Limestone (taken from Chavakachcheri, Jaffna) of size of 3/4" were used in this study. Normal aggregates of 3/4" size were used to compare the properties.

3. Results and Discussion

Results obtained by particle size analysis are shown in Figure 1. Results obtained by density and water absorption measurements are given in Table 1.

It can be see that, with reference to Figure 1, the percentage passing of Red and White LS are not within the region of specification of BS 882:1992. For single size 20 mm aggregates, limits are 85 to 100%. But Percentages passing from the White LS , Red LS (size 1) and Red LS (size 2) are 20.51%, 44.21% and 49.29% respectively in 20 mm size. So the grading of LS is not within the standard limit.

Relative density on saturated and surface dry basis, apparent relative density and Relative density on oven dried basis for Limestone aggregate are less than those values of normal aggregates. However, for both Red LS and White LS density values were same. Lesser density of aggregates can result in lesser self-weight of concrete and may be an advantage in production of concrete.

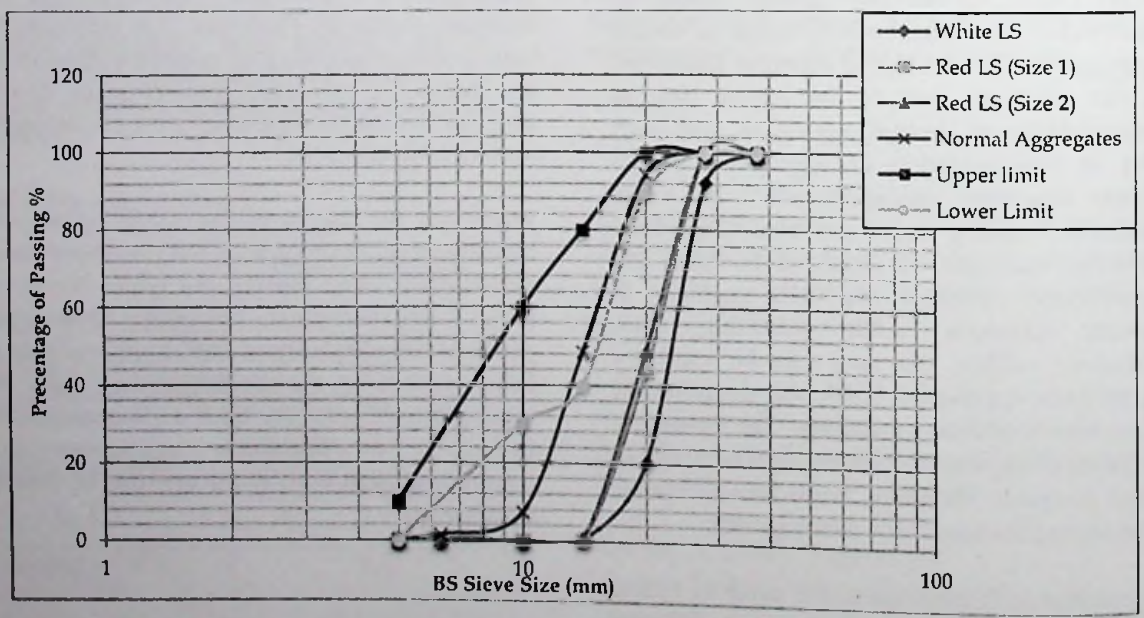

Figure 8: Particle Size Distribution of Limestone and Normal Aggregates

Table 2: Results of Density and Water Absorption for Limestone and Normal Aggregates

Aggregate Type	Density			
	Relative density on saturated and surface dry basis	Apparent Relative Density	Relative Density on Oven-Dried Basis	Water Absorption
Normal Aggregates	2.73	2.76	2.72	0.53
Red LS (5/8")	2.63	2.71	2.58	1.90
Red LS (3/4")	2.63	2.71	2.59	1.67
White LS (3/4")	2.63	2.71	2.58	1.80

According to BS 8007, aggregates should comply with either BS 882 or BS 1047 and have absorption, as measured in accordance with BS 812-2. This value is generally not greater than 3%. According to the Table 1 the water absorption of Limestone aggregates are less than 3%. However, water absorption of Limestone aggregates are about 250 % higher than that of normal aggregates. Also water absorption for Red and White Limestone are approximately similar. However due to high water absorption in aggregates used in concrete, curing becomes an important task. Also, this can have an adverse effect on the workability and other properties of concrete.

Values obtained for Aggregate Impact Value (AIV), Aggregate Crushing Value (ACV), Flakiness Index (FI), Soundness Test and Los Angeles Abrasion Value are given in Table 2.

The Aggregate Crushing Value (ACV) is restricted to 30% for concrete used for roads and 45% may be permitted in other structures. (Shetty, 1982)

According to the specification all the crushing values for Red LS, White LS are less than 40%. However, ACVs of limestone aggregates are about 27% to 37% higher than the ACV of Normal Aggregates. ACV of Red LS and White LS are approximately similar.

According to the BS 882: 1992, Specification for aggregate in Concrete AIV should be less than 30%. According to the test results AIV for both red and white limestone AIV is less that 30%. The values agree well with that of Normal Aggregates.

According to BS 882:1992, Flakiness Index of the combined coarse aggregates shall not be exceed 50 for uncrushed gravel and 40 for crushed rock or crushed gravel. For special circumstances for pavement wearing surfaces, a lower flakiness index may be specified. According to the test results FI is less than 40% for all the lime stones. FIs of limestone aggregates is about 60% higher than FI of Normal Aggregates.

The abrasion value should not be more than 30 percent for wearing surfaces and not more than 50 percent for concrete other than wearing surface. (Shetty, 1982)

Table 2 shows that Abrasion Values for Red Limestone as 29.8% and for White LS as 28.7%. The values are marginally less than the specified value of 30%. The Abrasion value for normal aggregates is 36.2% which is in the ranged specified by the specifications (between 30% and 50%). Even though Abrasion value is less than 30% it is almost near to the 30%. Therefore, it may considered as suitable depending on the purpose it is to be used for

Soundness value is used to determine the resistance of aggregate to disintegration by saturated solution of Sodium Sulphate and Magnesium Sulphate. This indicates the soundness of aggregates subject to weathering action. The soundness value of aggregates used in concrete should not exceeded 12% and 18% after 10 cycles when tested with Sodium Sulphate and Magnesium Sulphate respectively The LS aggregates were tested for 5 cycles with Magnesium Sulfate. (Shetty, 1982) The values are 31.43% and 13.87 % for Red and White LS respectively which are fairly high. The Soundness for normal aggregates was 1.38% which is quite small comparing with value of LS. So LS is not suitable for concrete where concrete structure is exposed to the harsh environmental conditions. However, for other cases, limestone aggregates can be used for production of concrete.

Table 3: Properties of Limestone Aggregates and Normal Aggregates

Aggregate Type	Aggregate Impact Value (AIV) (%)	Aggregate Crushing Value (ACV) (%)	Flakiness Index (FI) (%)	Soundness Value (%)	Los Angeles Abrasion Value (%)
Normal Aggregates	15.1	18.8	10	36.2	1.38
Red LS	18.1	23.9	4	29.8	31.43
White LS	15.9	25.8	4	28.7	13.87

4. Conclusions

The results revealed that Limestone aggregates (both Red and White) obtained from Jaffna region satisfied most of the properties specified by the standards. However, higher water absorption may have an adverse effects is of concern when used for concrete production. Also they should not be used for construction of structures subject to harsh environmental conditions, as they may have durability issues.

References

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