

USE OF LIMESTONE AS COARSE AGGREGATE FOR CONCRETE IN NORTHERN PROVINCE OF SRI LANKA

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INTRODUCTION

Demand for concrete is very heavy in Northern Province of Sri Lanka due to the massive drive to reconstruct the super structure devastated during the thirty year civil war. Granite is the rock type typically used in Sri Lanka to obtain coarse aggregate, main ingredient for concrete, and aggregates crushed from any other type of rock have hardly been used. Geological formation of the Northern Province is of a limestone rock origin (Cooray, 1984) and as a result aggregates of granitic origin are not available there and need to be transported over long distances resulting in an artificially high price for concrete compared to other provinces of the island.

Cost analysis carried out using typical material and transport costs indicated that concrete is generally about 25% more expensive in Northern Province due to the prohibitively high transport cost. All this is amidst aggregates crushed from limestone being freely and abundantly available there. This is due to the general reluctance to use concrete produced using limestone as coarse aggregate since there is no guidance and conclusive scientific evidence about the consequences of using limestone as a substitute for granite. As a result, limestone aggregates have not been put to good use there. People still use concrete produced with limestone for non structural works.

Three quarters of concrete is made up of aggregates (Neville, 1995) and hence it is very important that the material selected as coarse aggregate possess the strength and other physical and chemical properties recommended by the relevant codes of practice.

This study was carried out to find suitability of aggregates quarried from limestone as a substitute for Granite in concrete by studying the physical and strength properties of limestone aggregate and concrete produced using limestone aggregate.

METHODOLOGY

Samples of limestone brought from the Northern Province were first separated to individual sizes using mechanical sieve analysis and calculated amounts from each size were mixed together to obtain a well graded aggregate sample. Required weights from each individual size were calculated so that the resulting gradation curve of limestone, as shown in Figure 1, falls within the envelope recommended for concrete aggregates (Neville, 1995) and closely match with the grading curve of the granite sample used for comparison purposes of cube strength. All the subsequent tests were carried out using aggregates from this well graded limestone sample.

Following physical and chemical properties of the limestone aggregate, prepared as described above, were determined in the laboratory to establish the fact that they are within the recommended limits for a coarse aggregate.

1. Flakiness and Elongation Index - Excessive flakiness and elongation influences the mix properties requiring more water for a given workability which is not recommended.
2. Aggregate Crushing Value – This gives an indication of the strength of aggregates. Strength of concrete is heavily influenced by the strength of aggregates.

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3. Aggregate Impact Value – This is an indication of resistance to failure by impact.
4. Chloride Content – Steel reinforcements are subjected to chloride induced corrosion and hence chloride content should be maintained within tolerable limits.

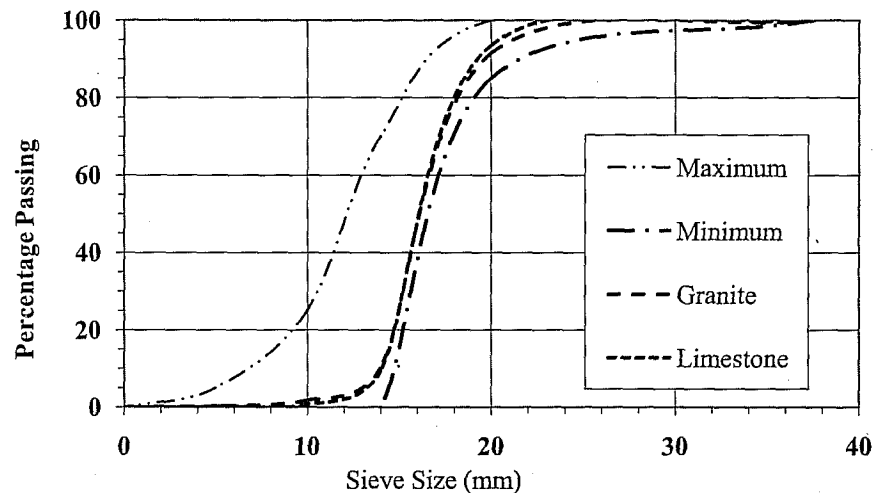


Figure 1 – Grading curves of limestone and granite aggregates used for testing

In addition, concrete cubes were cast separately using granite and limestone aggregates to determine the cube strength after 7, 14, 21 and 28 days for comparison purposes.

Volume batching method was adopted to cast Grade 25 concrete cubes by mixing cement, sand and coarse aggregate in the ratios of 1:1½:3 and the water cement ratio was maintained at 0.5%. This popular mix was selected since it is one of the most widely used mixes in small scale construction activities in Sri Lanka.

Absorption, which is a measure of pore space in concrete, was also determined for the concrete produced with limestone. Two types of absorption tests were done; one to determine the surface absorption which gives a better idea about the protection of steel reinforcements and the other to determine the percentage weight gain using the whole specimen.

RESULTS AND DISCUSSION

Flakiness and Elongation Index

The upper limit prescribed by BS 882: 1992 – Section 4.2 for Flakiness Index is 40% for aggregates crushed from rock. Flakiness Index observed for the tested limestone aggregates was 18%, falling well below the prescribed upper limit.

The Elongation Index observed for the tested limestone aggregate was 21.6%. This is slightly higher than the upper limit of 15% recommended by Neville, 1995.

Aggregate Crushing Value (ACV)

Aggregate Crushing Value observed for the tested aggregates was 27% which is satisfactory compared to the maximum recommended values (Shetti, 2010) of 30% for concrete used for pavement wearing surfaces, runways and roads and 45% for normal concrete.

Aggregate Impact Value

BS 882:1992 - Table 2 recommends a maximum value of 25% for Aggregate Impact Value of concrete. The result observed for the tested limestone sample was 17.4%, well below the recommended higher limit.

Chloride Content

BS 882:1992 – Table 7 recommends a maximum limit of 0.05% for chloride content expressed as mass of combined aggregate. The result observed for tested limestone sample was 0.003%, well below the tolerable limit.

Absorption of Concrete

Absorption Test – Absorption test involving the whole specimen was carried out according to BS 1881: Part 122: 1983. The result observed was 5.5% which is well below 10% recommended by Neville, 1995.

Surface Absorption Test – Absorption test involving only one face of the specimen to determine the surface absorption was carried out according to BS 1881: Part 5: 1970. Initial absorption observed after 10 minutes was 0.22 ml/m²/s and the recommended range is from 0.25 to 0.50 ml/m²/s. Similarly, the value observed after 2 hours was 0.05 ml/m²/s and the recommended range is 0.07 ml/m²/s to 0.15 ml/m²/s. Both values are slightly less than the minimum values of the prescribed range.

Cube Strength of Concrete

Cube strength of concrete, cast separately with limestone and granite aggregates, tested 7, 14, 21 and 28 days after casting are shown in Figure 2. Tests were carried out according to the procedure prescribed by BS 1881: Part 108:1983. Considering the Uniaxial Compressive Strengths of granite (181 N/mm² - Neville, 1995) and limestone (159 N/mm² - Neville, 1995) the results show good agreement.

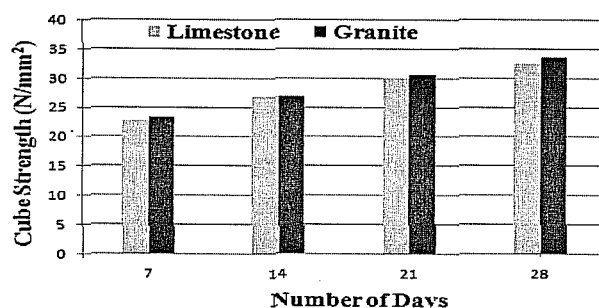


Figure 2 – Comparison of the cube strength of concrete made from granite and limestone aggregates.

Cost Comparison of Concrete Produced using Granite and Limestone

Table 1 provides the cost of producing concrete in five major cities of the Northern Province using granite and limestone separately as coarse aggregates and a percentage variation for each based on the cost of producing 1 m³ of concrete using limestone in Vavunia.

Town	Cost per m ³ (Rs)				Percentage variation	
	Granite	Limestone	Concrete produced using Granite	Concrete produced using Limestone	Concrete produced using Granite	Concrete produced using Limestone
Vavuniya	3,000	1,800	10,900	9,900	0	-9.2
Kilinochchi	4,900	1,800	12,400	9,900	13.8	-9.2
Mannar	4,400	1,800	12,100	9,900	11.0	-9.2
Mullathiv	4,800	1,800	12,300	9,900	12.8	-9.2
Jaffna	6,500	1,800	13,800	9,900	26.6	-9.2

Table 1 – Cost of producing concrete in five major cities of the Northern Province.

CONCLUSIONS / RECOMMENDATIONS

Physical properties of the tested limestone aggregate provide sufficient evidence that the strength characteristics of limestone satisfy all the requirements to qualify as a coarse aggregate for concrete.

Cube strength values obtained, in comparison with concrete produced using granite as coarse aggregate, after different time periods of curing is a good indication that both the rate of strength gain and the final cube strength are satisfactory to substitute granite to produce concrete suitable for structural concrete works.

However, due to the limitations of the facilities available at the University Laboratory all the tests required to determine the durability of concrete to make a conclusive recommendation could not be carried out and it is recommended to carry out further research on the topic to produce concrete evidence in favour of using limestone since it is much cheaper to do so.

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