APPROPRIATENESS OF CRUSHED CONSTRUCTION WASTE IN CONCRETE AND MOTAR PRODUCTION

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INTRODUCTION

The demand for construction aggregates exceeds 26.8 billion tons per year globally (Ashraf *et al*., 2013) and there is a significant increase in the use of Natural Aggregates (NA) in Sri Lanka due to recent infrastructure development projects. Usage of mineral aggregate such as broken natural rock else, coarse aggregate for concrete and river sand or fine aggregate for both concrete and mortar creates to degradation of environmental at an alarming rate.

Also, the annual amount of construction and demolished waste generate in Sri Lanka is about 4.0 million tons, while the current ways of managing such amount of waste is becoming an environmental problem (Ramezden, 2006). Moreover, the operation associated with aggregate extraction and processing creates further damage to the environment. As an alternative solution to this, Crushed construction waste like Demolished Concrete Aggregate (DCA), Demolished Block Fine Aggregate (DBFA) and Ceramic Tile Coarse Aggregate (CTCA) has been identified as potential alternative partial substitutions for river sand and mineral rock aggregate in preparation of mortar and concrete mixes. Therefore, it was intended in this study to examine how to manage and reuse of demolished crushed construction waste in order reduces their negative impact on the environment.

The aim of this study was to investigate the suitability of crushed construction waste (demolished concrete, ceramic tile and demolished cement blocks) as a raw material for the preparation of concrete and mortar in construction purpose. The following aspects were investigated in this respect.

- Comparative study of physical properties of demolished-crushed construction material and natural aggregates.
- Most appropriate mixed proportions of demolished construction material that can be replaced with natural aggregates in producing concrete and mortar.
- Cost effectiveness of producing concrete and mortar using such demolished construction materials.

METHODOLOGY

Sample Preparation

In the process of sample preparation, demolished concrete, ceramic tile and demolished block waste were collected from three different sites. Ceramic tile cut pieces gathered during the construction of new buildings at respective sites were used for the study. Collected demolished material was manually broken into smaller size aggregates by hammer crushing, and this was in order to make identical size material to match the natural aggregates. The comminuted products were sieved to separate fine and coarse fractions using (6 mm mesh size) sieve to make Demolished Concrete Coarse Aggregate (DCCA), Demolished Concrete Fine Aggregate (DCFA), CTCA, and DBFA in adequate quantities to proceed with the study.

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Material Testing

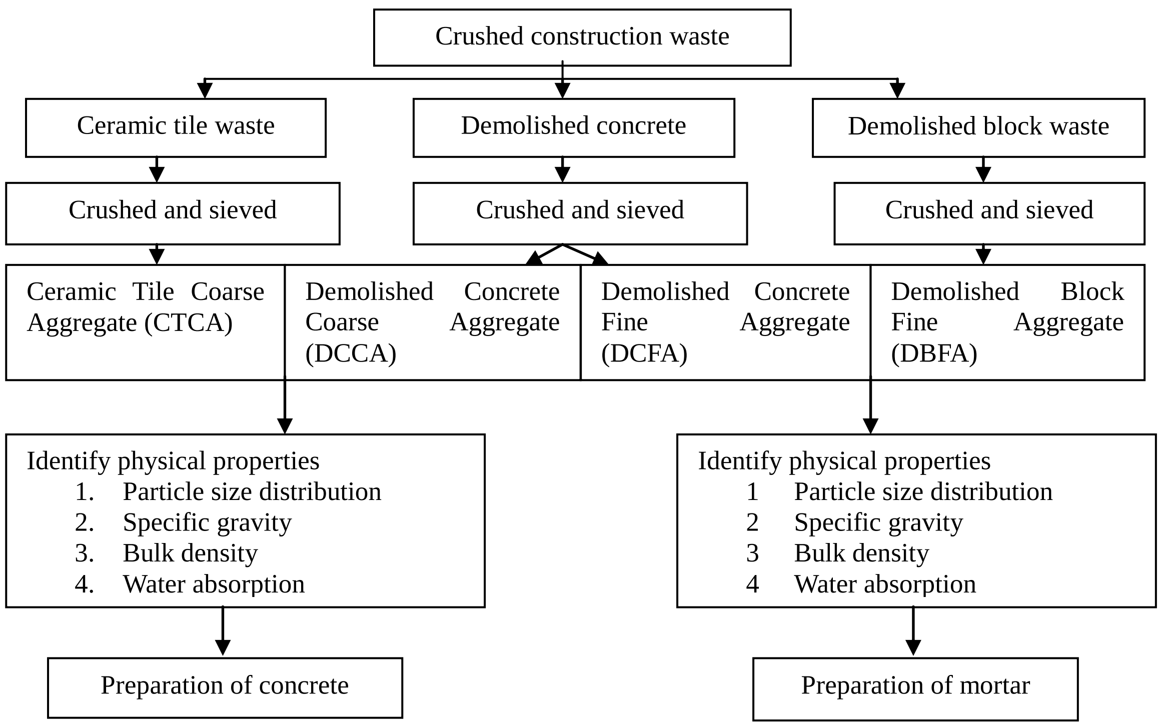
In order to compare the physical properties of above with Natural Aggregates (NA), tests such as Sieve Analysis, Specific Gravity, Bulk Density and Water Absorption were performed in the laboratory. These tests were carried out according to the standard method described in BS 812, BS 882 and BS 1881. To study the engineering properties of concrete tests such as slump test, unconfined compressive strength, tensile splitting strength, flexural strength and Brazilian disc test were performed according to the BS 1881. Batching of concrete was done by weighing the constituent materials based on the adopted mix ratio of 1:1 $^{1}/_{2}$: 3. The materials were mixed manually. Two types (DCA and CTCA based) of concrete were produced during the study. DCA based concrete specimens were cast replacing coarse and fine aggregates by 0 %, 30%, 60 % and 100 % with DCCA and DCFA. CTCA based concrete specimens were cast replacing only coarse aggregates by 0 %, 30 %, 60 % and 100 % with CTCA. The water/cement ratio was maintained depending on the workability of concrete such that to produce a slump of 100 mm ± 25 mm.

Engineering properties of different mortars were investigated through tests such as unconfined compressive strength, flexural strength, water absorption and cracking susceptibility conducted according to the BS EN 1015. The mortar samples were prepared in this study using Ordinary Portland cement, river sand, DCFA and DBFA. The batching of mortar was done by weighing the constituent materials based on the adopted mix ratio of 1:5.

Cost Analysis

Cost analysis was performed for the best-selected replacement ratio of recycled aggregate concrete and mortar. Price rates for this analysis was obtained from construction demolishing contractors and crusher plants and analysis was performed according to the BSR norms. Eventually, production cost per cube for both concrete and mortar that were made out from processed aggregates was compared with the similar products made with natural aggregates.

Figure 1. Indicate the flow chart for the whole process.



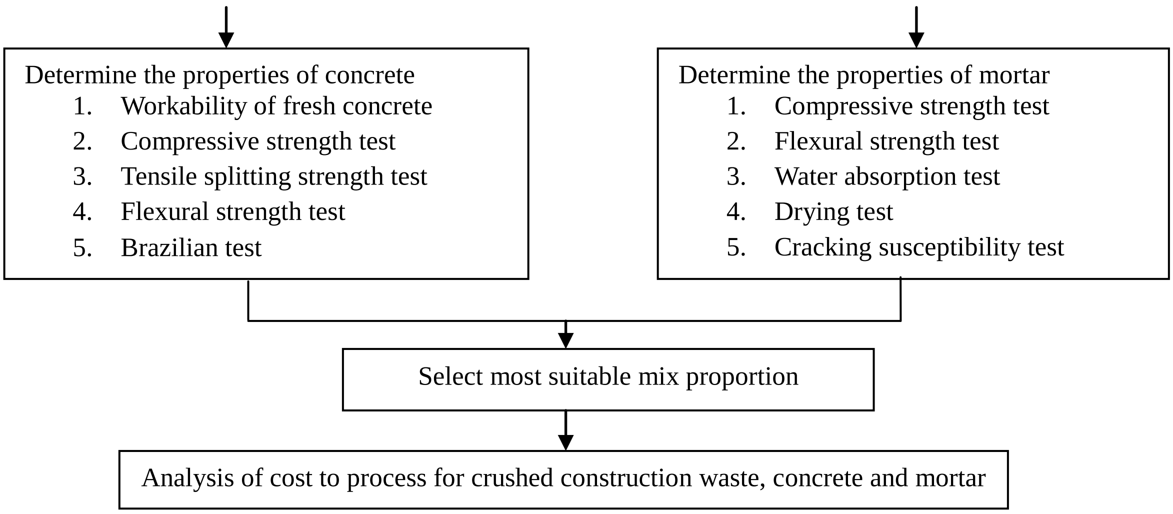


Figure 1. Flow chart of the whole process

RESULTS AND DISCUSSION

Sieve analysis test results for NA, and demolished aggregates

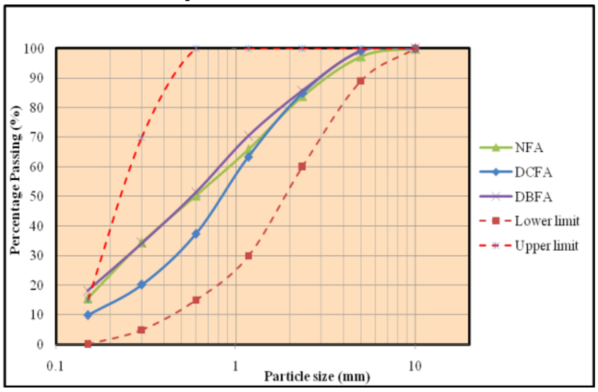


Figure 2. Particle size distribution of NFA, DCFA and DBFA

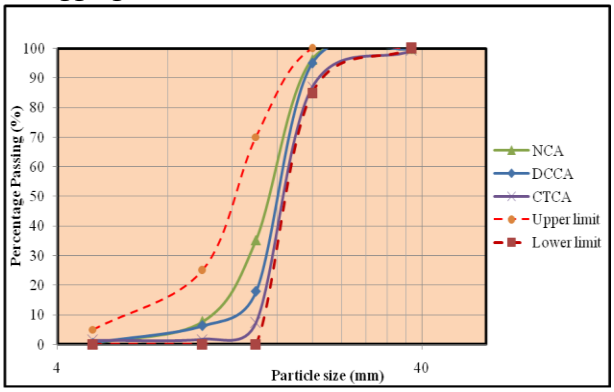


Figure 3. Particle size distribution of NCA, DCCA and CTCA

Table 1. Cost comparison with natural product

Type		Production cost (Rs. /cube*)	Profit Margin %
Type of coarse aggregates	NCA	6500.00	-
	DCCA	2625.00	60%
	CTCA	2778.00	57%
Type of fine aggregates	NFA	9000.00	-
	DCFA	2625.00	71%
	DBFA	3309.00	63%
Type of concrete	NA based concrete	37095.00	-
	DCA based concrete	35297.00	5 %
	CTCA based concrete	35271.00	5 %
Type of mortar	NA based mortar	4788.00	-
	DCFA based mortar	4596.00	5 %
	DBFA based mortar	4617.00	4 %

*** Cube = 100 ft^3**

The results demonstrated that the engineering properties (Particle size distribution, bulk density, specific gravity and water absorption) of demolished concrete have made a positive impact on using them as a partial replacement for NA. In production of concrete, results indicate that the DCA up to 30% and CTCA up to 60% can be effectively replaced with NA in 1:1½: 3 concrete mix of grade 25. Furthermore, the results regarding the properties of mortar testing have confirmed that DCFA and DBFA up to 30% were acceptable to be replaced with sand in production of mortar mix in 1:5. Also, the cracking susceptibility test was done on several samples at 30% replacement of alternative with sand and there was no surface cracking in any sample within 55 days of observation after 28 days curing.

The cost analysis results point out that the use of DCCA, CTCA, DCFA, and DBFA in production of concrete and mortar were more economical when NA were replaced with 60%, 57%, 71% and 63% respectively (Table 1.). In accordance with the results of cost analysis, to prepare concrete and mortar mixes by partial replacing demolished construction waste were more economical than using NA only by 5%.

CONCLUSIONS/RECOMMENDATIONS

Physical properties such as particle size distribution, specific gravity, bulk density and water absorption in DCCA, DCFA, CTCA and DBFA are almost similar the properties of Natural Aggregates.

Therefore, the study indicates that DCA and CTCA are suitable as a partial replacement of natural course aggregate in production of concrete and DCFA and DBFA are suitable as a partial replacement of natural fine aggregate in production in mortar.

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