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Manufacturing of Laterite Bricks as an Environmental Friendly Alternative Row Material

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Abstract: There is a deficiency of row materials for housing in Sri Lanka because of population growth. So there is an unfulfilled demand for traditional row materials such as river sand and clay. Serious environmental problems are caused because of over excavation of above row materials. To minimize the environmental problems, it should be focused towards low cost and environmental friendly alternative row materials which are occurring in sufficient amount in Sri Lanka. In order to fulfill the demand of row material for housing and other constructions, laterite soil can be used with quarry dust and cement as additives. Particle size distribution of the laterite was poorly graded and addition of quarry dust corrected this deficiency. The bricks which are made from laterite and quarry dust mixture can be stabilized using low amount of cement while achieving required compressive strength for walling. This material mixture is more economical and environmental friendly for bricks production.

Keywords: Laterite soil; Quarry dust; Bricks production

Introduction

Masonry construction is essential for housing industry because it provides the main structure of the house, weather protection and fire protection, act as thermal and sound insulations and divides the space of the house in to sub divisions (Isaac Olufemi Agbede,2008, Eze Uzomaka et al., 2010). Traditional row materials such as mud and timber were mainly used in the past for masonry construction which has very low strength and durability. In present both clay bricks and sand-crete blocks are mainly used as traditional walling materials (Jayawardena et.al., 2006).

There is a deficiency of row materials for housing in Sri Lanka because of population growth. So there is an unfulfilled demand for traditional row materials such as river sand and clay. Therefore the prices of those row materials are increasing day by day. Also serious environmental problems are caused because of over excavation of above row materials. To prevent this situation we should focus towards low cost and environmental friendly alternative row materials which are occurring in sufficient amount in Sri Lanka. Sustainable concept and green concept are also very important and well accepted concepts which mainly based on environmental friendly construction materials and methods.

Laterites are soil types rich in iron and aluminum (Lecomte-nana et al., 2009). They are developed by intensive and long-lasting weathering of the underlying parent rock. In Sri Lanka laterites are mainly located in south-western part of Sri Lanka specially in Colombo and Gampaha districts (Dahanayake, 1980, Dissanayake et al., 1980, Herath et al., 1983). The main chemical compounds found in Sri Lankan laterites are silicon dioxides, aluminum oxide and hematite.

Compressed Stabilized Earth Bricks (CSEB) and blocks are newly introduced material for walling under sustainable construction concept (Jayasinghe 1976).

CSEB are manufactured using mainly laterite soil and cement. Because of the lack of the required particle size distribution the strength of the earth bricks can be reduced. Differential shrinkage can be happened when drying because of high amount of finer particles (Walker, 1995, James Isiwu). Then the shape of the brick can be changed and cracks can be raised and strength of the brick is reduced.

Quarry dust is a waste obtained during quarrying process which consists of crushed and powdered rock particles (Sivakumar et al. 2011) . The addition of quarry dust for fine to course aggregate, enhance the compressive properties as well as elastic modulus. Under this research it is experimented that enhanced properties of laterite brick after adding various ratios of quarry dust and cement.

Materials and Methods

Laterite samples which have suitable physical characteristics to produce bricks were collected from various locations in the Gampaha district (Fig.1).

All the samples were analyzed manually considering purity, particle size, the thickness of the layer, how easy to extract and abundance volume of the laterite. By considering all above parameters one sample was selected which has high purity and considerable particle size distribution. Three granitic gneiss crushing plants were inspected around Vayangoda area and one was selected to get quarry dust for experiment which has low impurities, low particle size distribution and low amount of ferro magnesium minerals s such as biotite and hornblende. Portland limestone cement was purchased from the open market.

Laterite and quarry dust were air dried for 24 hours and passed through 10 mm sieve. Particles passing through the sieve were used for brick production. Predetermined quantities of air dried lateritic soil and quarry dust were mixed with constant amount of Portland cement (5% by weight). Thereafter an amount of water necessary to give the required moisture content was added to the dry mixtures.

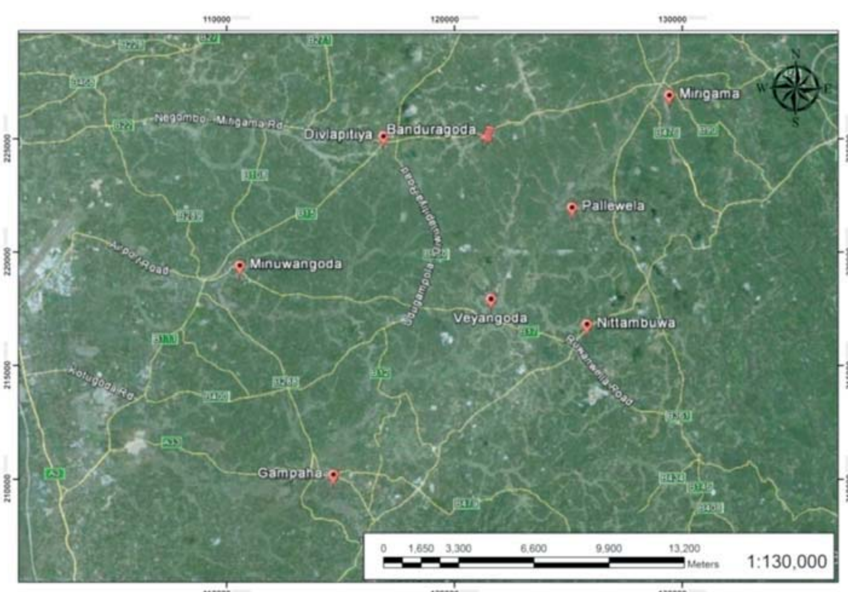

Figure 1: Map of sample collected area

Six bricks from each samples were made using 10cm*10cm*10cm mould by providing homogeneous force and conditions (Fig.2). Tamping was carried out with a 20 mm diameter rod. The produced bricks were kept under controlled condition for 28 days and compressive strength test was done for three bricks in dry condition and three from wet condition from each sample. Wet compressive strength is determined after placing brick in water for 24 hours.

Figure 2: Prepared brick

Based on the above 28 days results, laterite bricks were produced using laterite soil, quarry dust and cement mixtures with 0 and 45% quarry dust content and 2, 4, 6, and 8 cement content. The dry and wet compressive strength was measured as above steps. Sieve analyze was done for laterite soil, quarry dust and the best material mixture to get the particle size distribution of above materials. Also the wet and dry masses and sizes of the every bricks were measured.

Results and Discussion

Preliminary test: The load at failure of bricks samples which produced using various ratios of laterite soil and constant percentage of cement (5% by volume) were tested. The areas of all the bricks are constant (100mm*100mm) and the maximum compressive strength of all the bricks can be calculated as bellow formula.

$$\text{Compressive strength} = \frac{\text{Maximum load at failure (N)}}{\text{Average area of bed face (mm}^2\text{)}}$$

Average area of bed face = 10000mm^2

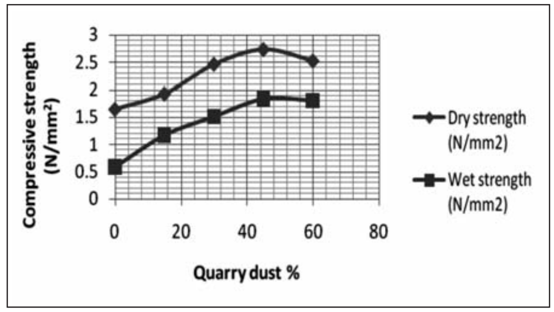

Figure 3: The compressive strength variation of laterite brick with quarry dust percentage

According to fig. 3 it can be seen that the wet and dry compressive strengths of the blocks are increasing with the quarry dust percentage. The maximum strength was obtained from the mixture which content 45% of quarry dust.

According to the fig. 4 it can be observed that the laterite soil is poorly graded. Quarry dust has a good particle size distribution. The size distribution of the small particles of the quarry dust is well graded. Quarry dust does not contain much larger particles. The distribution curve for laterite admixed with quarry dust is smooth, implying that the poorly graded laterite soil was greatly improved by the addition of quarry dust.

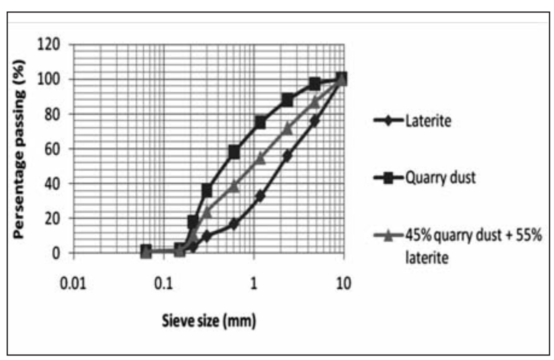

Figure 4: Particle size distributions of laterite, quarry dust and laterite treated with quarry dust.

Secondary test: The compressive strength results of bricks which produced from the mixture of 45% quarry dust and 55% laterite by changing the cement percentage are shown below for dry and wet conditions. The average load at failure was calculated by testing three bricks from each composition

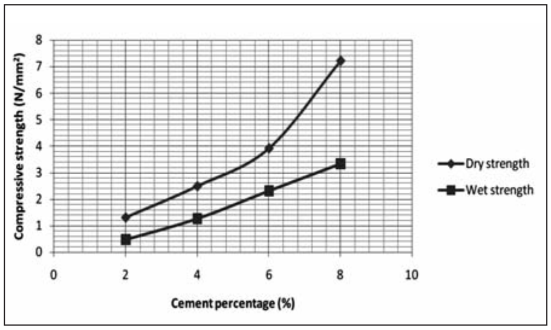

Figure 5: The compressive strength changing with cement percentage for 45% quarry dust and 55% laterite

According to figure 5and 6 both wet and dry compressive strengths of the blocks (45% of quarry dust and 100% of laterite) were increased with cement percentage. But the strength of material mixture (45% of quarry dust) is higher than 100% quarry dust at both wet and dry conditions. It was obtained that the dry strength of the mixture (45% quarry dust and 55% of laterite) is increasing at increasing rate with cement content. The wet strength of above mixture is increasing at constant rate.

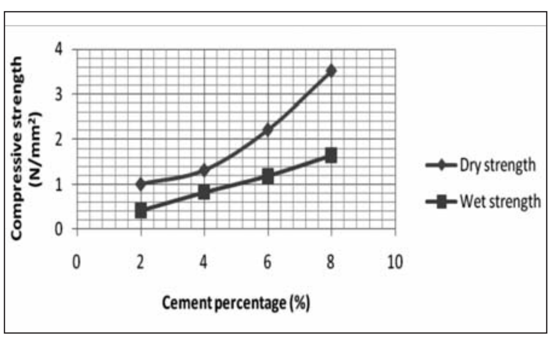

Figure 6: The compressive strength changing with cement percentage for 100% laterite

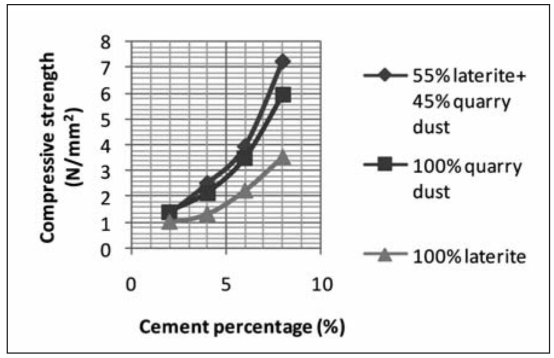

Figure 7: The compressive strength changing with cement percentage for various material percentages (dry strength)

According to the fig. 7 it can be seen that when cement percentage is increased the strengths of all brick types are increased. Bricks which are produced from 55% of laterite and 45% of quarry dust need less amount of cement to obtain certain strength when considering other bricks typed. Also the bricks which are produced from 100% laterite soil need a large amount of cement to obtain certain strength.

Cost analysis for material was done to produce 10cm cube to identify the costs of various material combinations. Before doing the cost analysis all require market prices and other information were was gathered. The prices for cement, quarry dust and laterite were gathered from various locations in Gampaha district on 3rd week of October 2012 with transport cost. But the values can be snidely changed with time, place and quality of the material.

Table 2:
Cost analysis for 10cm cube which has 20 N/mm2 compressive strength after 28 days

Material type	Laterite required (cm³)	Quarry dust required (cm³)	Price for materials (Rs)	cement required (g)	Price for cement (Rs)	Total price (Rs)
100% quarry dust	0	1500	2.7	90	1.62	4.32
100% laterite	1500	0	0.75	126	2.26	3.01
45% Q dust +55% laterite	825	675	1.65	72	1.29	2.94

According to above table 1 it can be seen that price for quarry dust is higher than laterite soil. Also the required amount of cement and price for cement is higher in the brick which made from laterite. The lowest price for cement is shown in the brick which produced from 45% quarry dust + 55% laterite material mixture.

When considering total costs for material, for the brick which produced from 100% quarry dust has highest price (Rs 4.32). But the bricks which are produced from 100% laterite and 45% quarry dust + 55% laterite mixture show considerably same and low price for materials (Rs 3).

Conclusion

Particle size distribution curve of the laterite was used in this study was poorly graded and addition of 45% quarry dust corrected this deficiency. The brick which is made from laterite and quarry dust mixture can be stabilized using low amount of cement which gives higher compressive strength than 100% laterite soil. This brick is more suitable for wet conditions as well as dry conditions. Because of this brick, 55% of quarry dust can be saved while achieving higher compressive strength than 100% quarry dust. The bricks which are made from 100% laterite have very low compressive strength in wet conditions. The material mixture (45% of quarry dust with laterite) is more economical and environmental friendly for brick production for walling.

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