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The Effect of Local Brewery Waste and Bitter Cassava Flour on Compressive Strength and Shrinkage of Plaster Mortar for Eco-House

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***Abstract*:** Cement is a major construction material worldwide. However, given the escalating costs of cement and the environmental hazards associated with the use of cement there is need to develop alternative, cost-effective, non-conventional, locally available materials, especially those that can partially or wholly replace cement. This paper presents the results on the study of the effect of local brewery waste and bitter cassava flour on the compressive strength and shrinkage of plaster. The test was made with cement replaced by local brewery waste or bitter cassava (10-50%) and cement/sand mix as a control. The results showed an optimum of 20% cement replacement with bitter cassava for plaster mortar for high cost houses (18.1Mpa) and 10% cement replacement with local brewery waste for plaster mortar for low cost houses (2.1Mpa). Result show a maximum shrinkage of 8mm at 50% replacement with bitter cassava and zero shrinkage for 50% replacement with local brewery waste. Furthermore only the control, 40% and 50% with bitter cassava flour showed cracks of about 2mm for mix ratio 1:3 and 1:4.
***Keywords*:** Bitter cassava, Compressive strength, Local brewery waste (Local brewery waste), Shrinkage

I. Introduction

Globally cement is a major construction material ([1]; [4]). However, given the escalating costs of cement and the environmental hazards associated with the use of cement there is urgent need to source, develop and use alternative, cost-effective, non-conventional, locally available materials suitable for construction, especially those that can partially or wholly replace cement. The production of one ton of cement generates one ton of carbon dioxide [4]. Mehta [9]-[10] suggested that materials that use few natural resources, less energy, and minimize carbon dioxide emissions should be used to make environment-friendly concrete. Al-Jabri [6] investigated the properties of hollow sandcrete blocks made from cement kiln dust as an additive and as a replacement for ordinary Portland cement and reported that the compressive strength and density of blocks generally decreased with higher replacement levels of cement. Ettu [7] investigated the compressive strength of binary and ternary blended cement containing cassava waste ash and plantain leaf ash and found that the compressive strength of cement sandcrete and soilcrete blocks increased at 150 days, as compared to the control mix with 10% cement replacement. Ogunbode and Akanmu [2] tested the strengths of cassava ash blended cement in laterized concrete and found a 46% reduction in the compressive strength. Olusola [5] showed that the compressive strength reduces beyond 50% replacement whereas, Faseyemei [11] found that cement replacement up to 10% with silica fume leads to an increase in the compressive strength, for C30 grade of concrete.

Currently, almost 50% of the world's population lives in Earth based dwellings [3]. Most of these earth constructions are found in the developing countries and are always plastered with mud plaster and rendered with cow dung slurry which is not resistant to weather. Therefore there is need to find weather resistant and environmentally friendly material for plastering low, medium and high cost houses.

II. Methodology

2.1 Shrinkage test

Bitter cassava flour and local brewery waste is a hydrophilic material that expands when wet and contracts as it dries. This test was done to predict cracking behavior and/or to examine the relative performance of different plaster mixtures with differing proportions of cassava flour, local brewery waste and cement. To perform shrinkage test the ready mix plaster was packed in a wooden formwork with interior dimensions of 50x300x300mm. The plaster was mixed, tamped firmly into the box and the top surface was screeded off level with the top of the formwork. The sample was completely cured. Then the shrinkage was measured by pushing the entire sample (including separated lumps) tightly up to one end of the box and measuring the gap created by the shrinkage for 7 days, 14 days and 28 days (Figure 1).

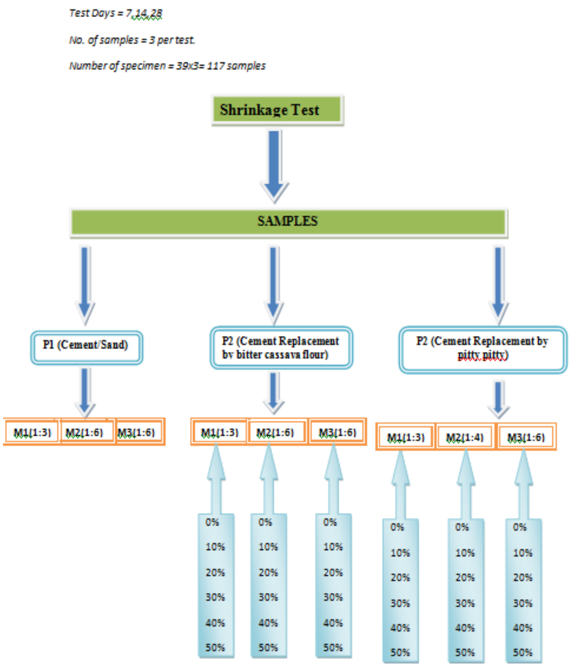

Figure 2.1: The schematic design for the shrinkage test

2.2 Compression tests

Specimens test for compressive strength for plaster cubes was conducted from the laboratory according to the Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (ASTM C109).

To perform this test, different plaster mixes were made from the cement-sand mix, cassava-flour-sand mix, local brewery waste-sand mix, cement-cassava sand mix, cement-local brewery waste-sand mix. A total of three cubes were made from each sample and tested for the compressive strength for 7, 14 and 28 days of curing.

The testing was done in accordance with the standard procedures of cube testing using a Universal Testing Machine (UTM).The cube was removed from the curing place and dried by exposing it to air for a period of about two hours and then weighed with 0.5 g accuracy.

The dimension of the cube was measured and the cube loaded in the compression test machine with trowelled faces perpendicular to the vertical axes to the machine. The cube was then tested, the maximum load and the compressive strength recorded.

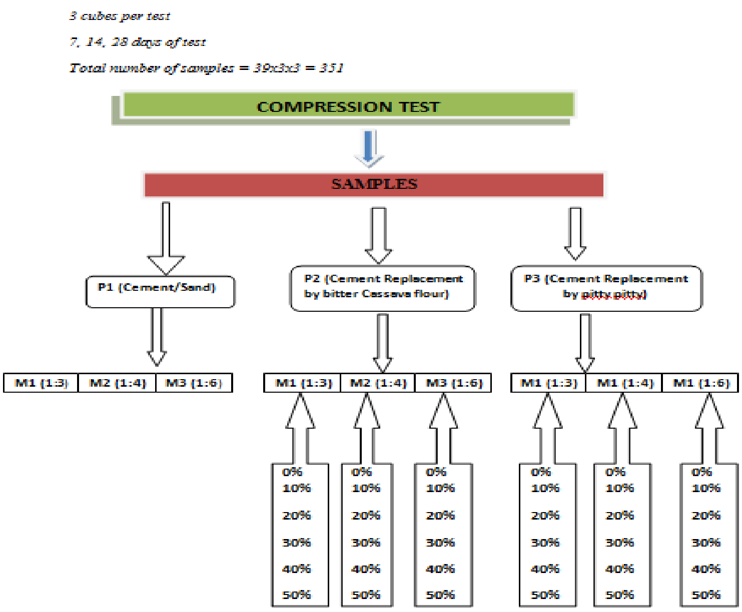

Figure 2.2: Diagram showing the schematic design of compression test

III. Results and Discussion

3.1 Compressive strength test of bitter cassava flour of mix 1:3

The results showed that at 10% bitter cassava replacement the strength was 21.9Mpa at 28 days of curing then dropped to 18.1Mpa at 20%. However, there was a great reduction in the compressive strength at 30% to 3.7Mpa but this strength is above the minimum requirements of plaster for eco house (BS 5628 part1, ASTM D1663, KS02-1070:1993). At 40 and 50% the strength was below the minimum requirement for the above standards. However, it can still be used for plastering other low cost houses constructed from weak materials of below 2Mpa Mbereyaho et al (2014) reported that the compressive strength of un burnt brick is 1.14Mpa. Saul (2006) found that the compressive strength of stabilized block using cassava powder increased at 1.5% then greatly reduced to beyond 7% replacement. Several studies on the replacement of cement with other locally available materials reported a reduction in compressive strength for Balwaik and Raut (20110) reported that reduction in the compressive strength when cement was replaced with paper pulp, Ogunbode et al reported reduction in compressive strength when cement was replaced with cassava ash, Kula et al (2002) reported that a cement replacement with tincal waste at 5% caused a significant reduction in the compressive strength. All the above studies finding relates well to the results found in this study. The reduction in the compressive strength could have been due to the increased water/cement ratio in the mix because the floor table results showed that the required water/cement ratio of 0.5 could not be used even at 10% cassava replacement. Therefore the water cement ratio was adjusted from 0.5 to 0.6,07, and 0.8 for different levels of replacement. (Neville, 1995)

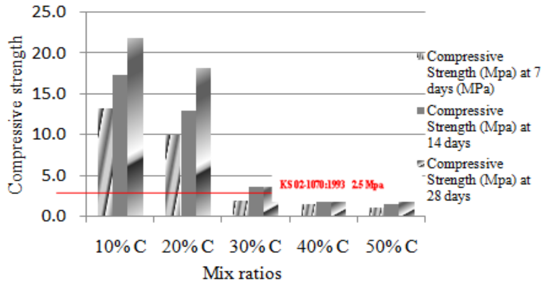

Figure 3.1: Showing compressive strength of bitter cassava mortar of mix 1:3

3.2 The compressive strength of bitter local brewery waste of mix 1:3

Local brewery waste is a bye product of cassava fermented alcohol after distillation. This waste was also investigated in this study ranging from 10-50% replacement of cement by weight, the result showed a significant reduction in compressive strength even at 10% as compared to the bitter cassava flour and cement sand mortar. This great reduction in strength could be attributed to the increase in the water cement ratio (Neville., 1995), the presence of high amount of iron (Fe) about 8% as compared to that in cement and also due to the fact that cassava is mixed with other ingredients during the fermentation of the alcohol. At 10% replacement the attained compressive strength at 28 days was about 2.1Mpa which is slightly above the minimum requirement of the British Standards (BS 5628 part1) and the New Mexico Standards of 2Mpa. This strength can be used to plaster houses made from the above blocks. However, the local brewery waste showed little reduction in the compressive strength as more cement is being replaced that is 20% 1.9Mpa, 30% 1.7Mpa, 40% 1.3Mpa and 50% 1.0Mpa. Mbereyaho et al (2014) reported that the compressive strength of un burnt brick is 1.14Mpa. Several studies on the replacement of cement with other locally available materials reported a reduction in compressive strength for Balwaik and Raut (20110) reported that reduction in the compressive strength when cement was replaced with paper pulp, Ogunbode et al reported reduction in compressive strength when cement was replaced with cassava ash. This finding relates well to the findings of this study. All levels of replacement with local brewery waste did not meet the minimum requirement for mortar for low cost housing as specified in ASTM C270 of 2.4Mpa.

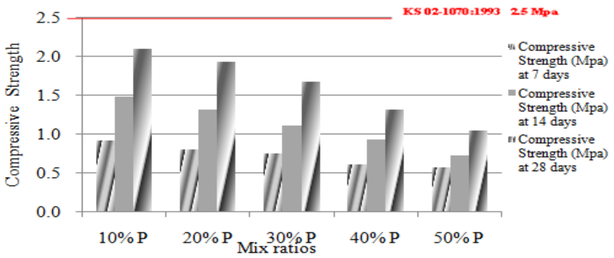

Figure 3.2: Showing compressive strength of local brewery waste mortar of mix 1:3

Similar trends were observed when cement was replaced with bitter cassava flour and local brewery waste in the mix ratio of 1:4 and 1:6 as shown in the figures below.

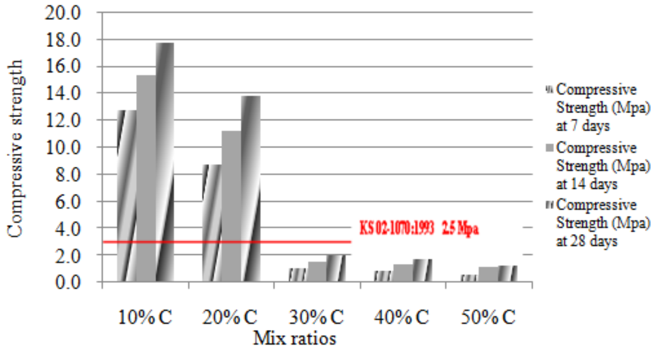

Figure 3.3: Showing compressive strength of bitter cassava of mix 1:4

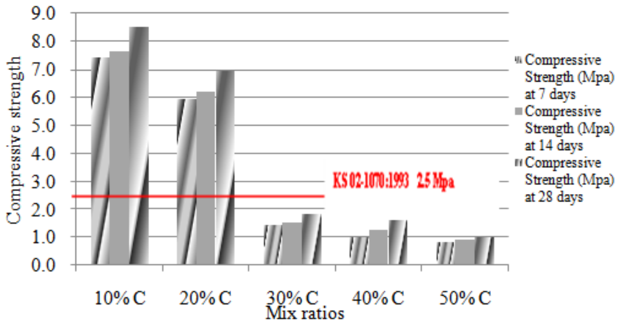

Figure 3.4: Showing compressive strength of bitter cassava mortar of mix 1:6

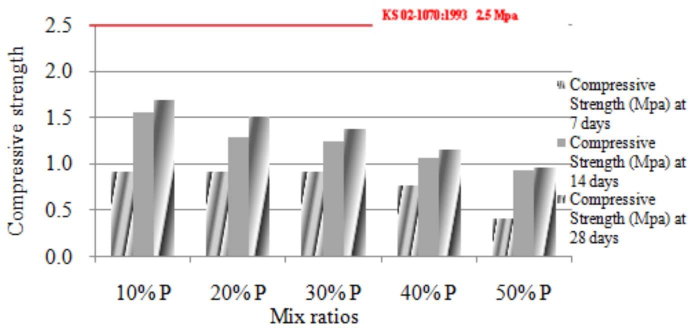

Figure 3.5: Showing compressive strength of local brewery waste of mix 1:4

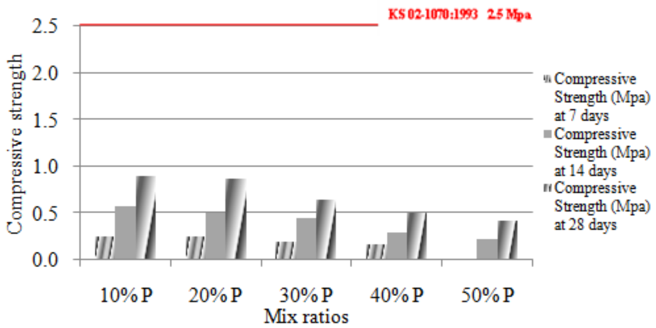

Figure 3.6: Showing compressive strength of local brewery waste of mix 1:6

3.3 Shrinkage of bitter cassava for mix ratio 1:3

Drying shrinkage was evaluated using mortar method. Increase drying shrinkage were noted for increase substitution with bitter cassava flour. At 10% 0.4mm and at 50% 0.8mm the maximum shrinkage determined in this study. This finding compared well with that of South (2004). There was no further shrinkage observed after 14 days of curing. Only 40 and 50% of bitter cassava cracked in the mix ratio of 1:3, respectively previously Markus (2011) reported that shrinkage should be minimized to avoid cracking of the mortar.

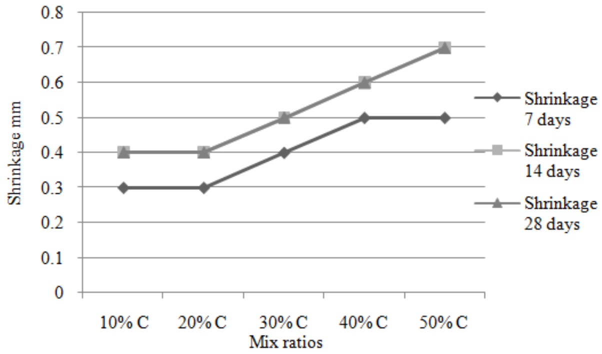

Figure 3.7: Showing shrinkage of bitter cassava mortar of mix 1:3

3.3 Shrinkage of local brewery waste for mix ratio 1:3

Decrease drying shrinkage were noted for increase substitution with local brewery waste. At 10% 0.5mm and at 50% 0.1mm. There was no further shrinkage observed after 14 days of curing. This finding is in line with Markus (2011) reported that shrinkage should be minimized to avoid cracking of the mortar. This could have been why the mortar showed no crack at all level of replacement with local brewery waste and also the presence of yeast was also responsible for the expansion in the mortar at 100% replacement.

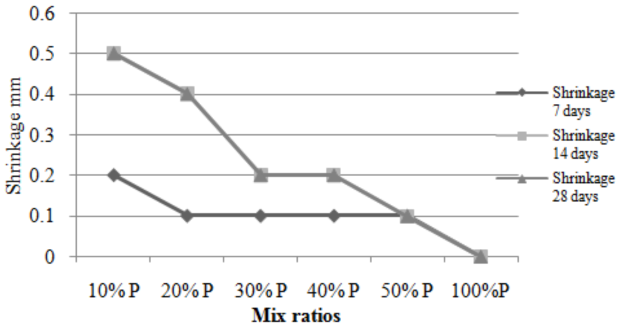

Figure 3.8: Showing shrinkage of local brewery waste mortar of mix 1:3

Similar trends were observed when cement was replaced with bitter cassava flour and local brewery waste in the mix ratio of 1:4 and 1:6 as shown in the figures below.

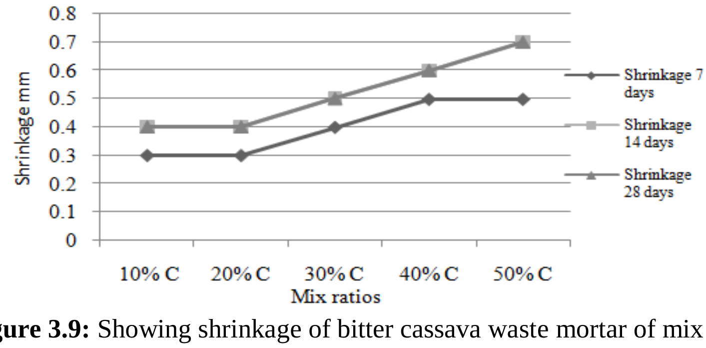

Figure 3.9: Showing shrinkage of bitter cassava waste mortar of mix 1:4

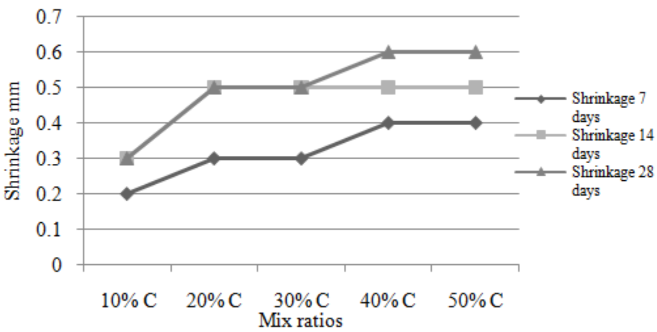

Figure 3.9: Showing shrinkage of bitter cassava waste mortar of mix 1:6

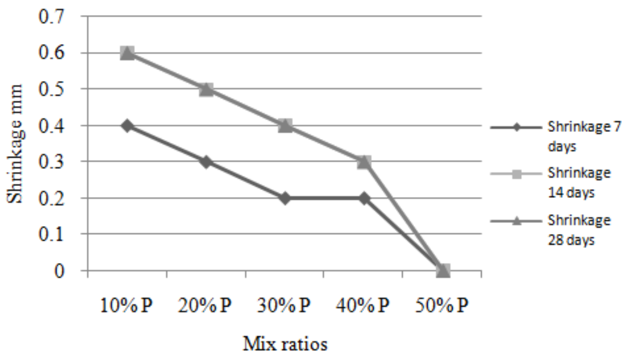

Figure 3.10: Showing shrinkage of local brewery waste mortar of mix 1:4

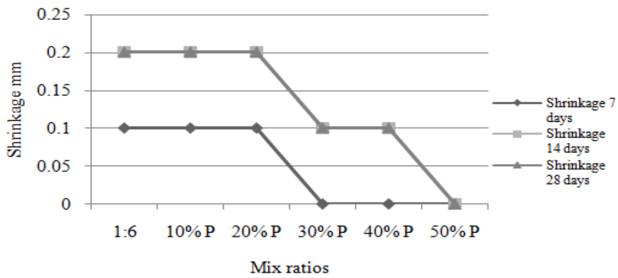

Figure 3.11: Showing shrinkage of local brewery waste mortar of mix 1:6

IV. Conclusions

From the above study the following conclusions can be made;

1. Bitter cassava increases the level of shrinkage and as more is replaced and it was observed that only 40 and 50% showed cracks in the mix ratio of 1:3 and 1:4 while local brewery waste reduces the level of shrinkage of the plaster as more of cement is replaced with local brewery waste. There was no crack observed from all levels of replacement and at 50% replacement with local brewery zero, shrinkage was observed.
2. The compressive strength reduced generally. Bitter cassava showed better compressive strength up to 20% replacement and then greatly reduced. The compressive strength of local brewery waste reduced greatly from any level of replacement but then any addition there was gradual decrease in the strength. Therefore considering the fact a mud brick has an average of 1.14Mpa, burnt brick 4Mpa and stone blocks 7Mpa. Bitter cassava replacement up to 20% can be used to build and plaster high cost buildings while 30-50% can be used mortar plaster for eco houses. All levels of local brewery waste replacement can only be used as mortar plaster for eco houses because it showed low compressive strength which is below the average compressive strength of a mud brick (1.14Mpa).

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