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Mix-Design of Non-autoclaved StoneCrete on Ash-Cement Composition

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ABSTRACT

This paper intends, on the one hand, to report the design of the mix-composition of StoneCrete, having its crushing strength >2.5MPa and density > 650kg/m^3, to meet the criteria for acceptance as a walling material. On the other hand, to report the walling under-frame bonded to StoneCrete boards, after curing for 28 days. On this account, 3-trial mixes for specimens measuring 100x100x100mm are prepared for laboratory evaluation of crushing strength, and grouped as it were, into mix-A1 to mix-A3 and tagged, with mix-A0 serving as the control. Each trial composition containing at least 250kg of CEM 11/B-L 42.5 R is designed to mix with siliceous filler powders and reinforcing, where necessary. The Water-to-cement ratio (w/c) is to be kept at 0.5, while 1.25kg plasticiser powder is added to all mixes as needed to avoid separation and foam volume is assumed constant.

Keywords: *StoneCrete, Crushing Strength of StoneCrete, Aerated-foam concrete.*

1.0INTRODUCTION

StoneCrete is the name of cellular concrete with at least 2.5Mpa of crushing strength and a density of 600 - 650kg/m^3, classified as lightweight [Neville 1981], which can result from an expanded composition of concrete involving Portland cement and natural silica powder, water and fiber reinforcement. A StoneCrete or cellular concrete formulation typically is comprised of refined cellulosic fibers, cement and ground silica. Other formulations can include inert fillers such as limestone or calcium carbonate [Wikipedia, 2019]. Researches shows that it is similar to aerated concrete having 60 to 80% of its volume occupied by air-pores and a compressive strength of 2.8 MPa and density 600kg/m^3 or more, with dosage of aluminum powder expanding agent at 0.04%, 0.08%, 0.12% or 0.16% of total weight of dry matter. Although 25Mpa crushing strength is achievable at 1:2 cement sand ratios, about 25% volume occupied by air-pores and a density of 1822kg/m^3.

StoneCrete adorns walls and partitions, and the use of expanded concrete in this process is intended to revolutionizing Construction worldwide, because it is affordable and requires no compaction to consolidate. StoneCrete is easier and faster to handle, requiring fewer workmen to reach key milestones, looks prettier, smarter, cost-effective and green. With super-smooth surfaces, it requires no plastering, much unlike traditional unreinforced masonry (TUM) [Mowrtage, *et al.* 2015]. It is expected to be a versatile walling material with unparalleled fire resistance, because, it is not combustible, providing high fire resistance level (FRL). It has the advantages of higher strength to weight ratio, better tensile resistance, lower coefficient of thermal expansion with enhanced sound and acoustic insulation (Chen & Liu, 2013).

Table 1 below shows limit to utilization for cement, established by the Materials Testing Laboratory of the Engineering School, Abia State Polytechnic, Aba.

Table 1: Research-established material limits

Material Components	**Utilization Limit**
Portland Cement	200 - 600 kg/m^3
Natural siliceous powder such as Quartz-powder.	150-700 kg/m^3
Saw Dust Wood Ash [WA]	90 – 270 kg/m^3
Recycled Polystyrene (RPS)	300 -1200 lit/m^3

***Remarks:** Density of polystyrene is between 16 – 27kg/m^3 and of cement/sand powder is 1440/1500kg/m^3.

Rapid setting cement is to be used to avoid excessive shrinkage and collapse of foam volume [Jingwen Zhang *et al*. 2018; Mohamed Abd Elrahman *et al*. 2019].

Corrosion protection & treatment: Corrosion protection of reinforcement in a porous environment require pre-treatment. Similarly, lightweight concrete should contain fiber reinforce, and about 25% of pore volume is assumed or steel reinforcement is recommended with 250kg or more of cement content per m^3 of concrete and can be reinforced in single or double strand of mat, less than 5mm in diameter each.

Cold-form steel CFS frames, brackets and accessories shall be manufactured from galvanized steel (Grade G550), with zinc coating not less than $350g/m^2$ or equivalent. Galvalum surfaces and accessories where in contact with concrete shall be painted with a suitable silicon-paint, to safeguard against adverse reaction. In the same vein, all screws shall be self-drilling. Therefore, BuildingCrete is expected to increase the material-choice available to construction professionals while innovating a solution, in line with global best practices (Umoh & Lugard, 2014).

1.1 PROBLEM STATEMENT

In Nigeria, use of industrialized building system **(IBS),** started many decades ago, by outsourced contracting companies. To meet demands for affordable housing, for a growing population, the urban-rural migration, will need local investigations.

1.2 OBJECTIVES OF THE RESEARCH

This project aims to report on the optimal composition of StoneCrete, with density benchmarked at 600 - $650kg/m^3$, to meet criteria for acceptability, after 28-days of curing. Therefore, the following objectives are set to be pursued:

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i. To explore a set of mix proportioning for FiberCrete, with density at 600 - 650kg/m^3, crushing strength of 2.5Mpa, while tensile strength, drying shrinkage and other parameters to await laboratory confirmation.
ii. To develop suitable under-frame bonded to cement board, after 28-days of curing, to provide the basis for rigidity-study.

2.0 MATERIALS AND METHOD

The materials and methods to be used are outlined as follows: Each trial composition of StoneCrete should contain at least 250kg of cement mixed with ash per 1.0m^3 of concrete, from CEM 11/B-L 42.5 R mixed with other natural Ash-filler powder, with additives. Water to cement ratio (w/c) is 0.5, while 1.25kg of powder plasticizer, is added as needed to avoid mix separation and foam-volume produced to ASTM C 796**,** is assumed to be constant.

PROCEDURES

The procedure leading to optimal composition of StoneCrete starts with mix design calculations relevant to 1.0m^3 of cellular or aerated concrete (Puput Risdanareni *et al* 2016; Okore and Kalu 2020).

Table 2: Compositions of specimen-samples of StoneCrete

t = 20mm		CEM11 /B-L 42.5R, kg	[1:3.16 ratio] of Ash to Cem, kg	Sand pdr [Q = 1.0 wt. Cem.], kg	Activator = 0.02%wtcem NaOH + 0.03%wtcem Na2SO4, kg	FRC Additive [3%wt Cem], kg	Slurry vol, Vs, lit	Foam vol, Vf, lit = kVs/0.6, A = 0.39 < 0.4	Exp. density 600 - 650 kg/m^3
w/c = 0.50	A0	200	63	263	-	-	131.5	-	1450
	A1	200	63	263	0.05+0.08	7.9	215	349	631
	A2	200	63	263	0.05+0.08	7.9	215	349	631
	A3	200	63	263	0.05+0.08	7.9	215	349	631

Remarks: *notable mixes **Density of cement powder = 1440kg/m^3.

SAMPLE PREPARATION:

The procedure starts with cleaning of conventional concrete mixer. Portland cement and natural siliceous powders, plasticizer and fiber may be added then, mixing for 20 seconds. Then warm water (less the water needed for foaming) is added and stirred evenly while maintaining the temperature of the slurry at approximately 45∘C for 100 seconds.

On this account, three trial mixes for specimen-cubes measuring 70x70x70mm each, are prepared for laboratory evaluation, grouped into A0, A1 to A3 and tagged, with A0 having no additives, and acting as control. The ready mix is carefully transferred to the mold i.e., poured into 4 well-lubricated specimen-cubes. Cover the finished samples for curing to 7-8 hours before, samples are demolded.

Each mix however, is cured at room temperature and humidity, covered with jute blanket and plastic to reduce evaporation. This means humidifying twice daily (in the morning and evening 8days) to enhance the hydration process and bonding. This curing process helps to improve the strength of the panels. After the 8days, continue curing by arranging the material in direct sunlight for 21days for the cement to attain its maximum strength.

3.0 TEST PROCEDURES/RESULTS

Thereafter, we measure the compressive strengths of cellular concrete for the specimens and the bulk density of the cellular concrete predicted according to the model, as well as density of specimen A0 obtained by mass/volume and the results of all are shown in Table 2.

Table 2: The comparative density of all compositions

S/N	Shape	Compressive Strength Mpa	Calculated Density [kg/m^3]	Simulated Density [kg/m^3]
A0	70x70x70	17	1450	-

A1	70x70x70	2.6	640	631
A2	70x70x70	2.4	638	631
A3	70x70x70	2.8	658	631

4.0 RESULT AND DISCUSSION

It can be seen that lightweight cellular concrete of model has comparatively lower density than normal weight concrete, generally. The relationship between mass of cement and expected density of lightweight concrete show that increase in mass of cement result in rising density. It shows that the compressive strength of normal-weight concrete, represented by the control, is higher compared with cellular concrete. Note however, the compressive Strength is expected to drop slightly lower, on introduction of air.

5.0 CONCLUSION

This study on the design of mix-composition of StoneCrete, having its crushing strength >2.5Mpa and density > 650kg/m^3, to meet the criteria for acceptance as walling material. While on the other hand, to report the walling under-frame bonded to StoneCrete boards, after curing for 28-days. On this account, 3-trial mixes for specimens measuring 100x100x100mm are prepared for laboratory evaluation of crushing strength, and grouped as it were, into mix-A1 to mix-A3 and tagged, with mix-A0 serving as control. Conclusively, the average density of A1 and A3 ~ 650 kg/m^3 and meets requirement for adoption StoneCrete. Hence, the compressive strength of design mix of StoneCrete at 2.5 Mpa, on the average is acceptable.

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