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Mix-composition of PolyCrete and Suitability of Under-frame Bonded for Structural Supports

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ABSTRACT

This paper aims to report the design of a mix-composition of PolyCrete, having its crushing strength >2.5MPa and density > 650kg/m^3, to meet the criteria for acceptance as a walling material. In addition, it aims at reporting the walling under-frame bonded to cement 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 a control. Each trial composition containing at least 250kg of CEM 11/B-L 42.5 R is designed to mix with siliceous filler powders. Water to cement ratio (w/c) is to be kept at 0.5 while foam volume is assumed constant at 25% more than slurry volume. Hence, the compressive strength of the design mix of PolyCrete at 2.5 Mpa, on average, recorded for the test specimen proves the mix design is acceptable.

Keywords: *PolyCrete, Crushing Strength, Aerated Concrete.*

1.0 INTRODUCTION

PolyCrete is the name of cellular concrete with at least 2.5Mpa of crushing strength and a density 650kg/m^3, classified as lightweight [Neville 1981], can results from expanded composition of EPS-Concrete involving recycled EPS granules, Portland cement and natural silica powder, water. A cellular concrete formulation typically is comprised of Portland cement and ground silica. Other formulations can include inert fillers such as Ash, limestone or calcium carbonate

[Wikipedia, 2019]. Research 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 dosages 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.

PolyCrete adorn 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. PolyCrete 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 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 silicious powder such as Quartz-powder.	150-700 kg/m^3
Saw Dust Wood Ash [WA]	30 – 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 350 g/m2 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, PolyCrete is expected to increase the material-choice available to construction professionals while innovating a solution, in line with global best practices (Umoh and Lugard, 2014).

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.

OBJECTIVES OF THE RESEARCH

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

i. To explore a set of mix proportioning for PolyCrete, with density at 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 for bonded to structural supports, after 28-days of curing, to provide the basis for rigidity-study.

MATERIALS & METHOD

The materials and methods to be used are outlined as follows: Each trial composition of PolyCrete 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 filler powder, with additives. Water to cement ratio (w/c) is 0.5, while foam-volume produced to ASTM C 796, is assumed to be constant at 25% more than slurry volume.

PROCEDURES

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

Table 2: Compositions of specimen-samples of PolyCrete

		CEM11 /B-L 42.5R, kg	24% / 76% ratio of Activated Ash WA, kg	Silica [Q = 1.25 wt. BDR], take [1.0wt BDR], kg	[Q = 0.04…0,12wt BDR], Take [0.12wt BDR] for recycled EPS grls, kg	Slurry vol, Vs, lit	A = 0.39 < 0.4 Foam vol, Vf, lts	Exp. density > 650 kg/m^3
w/c = 0.50	A0	200	63	263	-	131.5	-	1450
	A1	200	63	263	32.4 = 1200 lts	215	350	669
	A2	200	63	263	32.4 = 1200 lts	215	350	669
	A3	200	63	263	32.4 = 1200 lts	215	350	669

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.

TEST PROCEDURES AND RESULTS

Thereafter, the compressive strengths of concrete are measured for the specimens and the bulk density of the concrete is both measured and predicted according to the model. The density of specimen A0 obtained by mass/volume and the results of all are shown in Table 2.

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Table 2: The comparative density of specimen Concrete of all composition

S/N	Shape	Compressive Strength Mpa	Calculated Density [kg/m^3]	Simulated Density [kg/m^3]
A0	70x70x70	17	1450	-
A1	70x70x70	2.5	650	669
A2	70x70x70	2.4	653	669
A3	70x70x70	2.6	650	669

RESULTS 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, that compressive Strength is expected to drop slightly lower, on introduction of fiber reinforcement, boosting its tensile strength.

CONCLUSION

This paper aims at reporting the design of mix-composition of PolyCrete, having its crushing strength >2.5Mpa and density > 650kg/m^3, to meet the criteria for acceptance as walling material. In addition, it aims at reporting the walling under-frame bonded to cement 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. The density of A1 and A3 > 650 kg/m^3 meets requirement for adoption as PolyCrete. The compressive strength of design mix of PolyCrete at 2.5 Mpa, on the average, recorded for test specimen proves the mix-design is acceptable.

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