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Flexural Strength Effect of Granulated Cow Bone on Blended Cement-Cassava Peel Ash Concrete

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ABSTRACT – There has been tremendous increase in the price of construction materials, most especially the cement, a major binder in concrete. There is a need for cheap and readily available alternative which can act as a binder. The indiscriminate disposal of animal waste and agricultural waste in the environment led to the search for solution by recycling these wastes which include the cow bone waste and cassava peel in the construction industry, as a partial replacement of cement in concrete. This research aimed to evaluate the effect of Granulated Cow Bone on Engineering Properties of Blended Cement-Cassava Peel ash concrete at 5%, 10% and 15% by weight in concrete produced with Cement-Cassava Peel ash. The Cassava Peel Ash was obtained by open burning method and Granulated Cow Bone was initially burnt and later grinded to be the particle needed for the replacement. The Oxide test on GCB and CPA was determined at Rolab Research and Diagonistic Laboratory Ibadan showing that SiO_2, Al_2O_3 and Fe_2O_3 on CPA is 72.16% which is above 70% recommended for Pozzolan. The Specific Gravities was done on Cement, Sand, Granite, GCB and CPA and the results were 3.0g, 2.6g, 2.9g, 2.2g and 2.8g respectively. The result on the workability test shows that all the slump height are True Slump and the concrete is less workable (Stiff) and the Consistency test increases with increase of pozzolan replacement and more water was required to make a concrete workable. Also the Initial and Final setting time results shows that all the values increases with the increase of percentage replacement and all the results meet the IS standard. On the strength analysis a Total number of 60 concrete beams were casted and cured for 56days. The greatest yield strength was achieved on the beam produced with 0% of CCPA/GCB combined (3.792N/mm^2) at 56days curing.Beam produced with 10% CCPA/GCB have a higher average strength of 2.776N/mm^2 at 14days beyond beam produced with 0% of CCPA/GCB combined (3.792N/mm^2) at 56days curing. This implies that as the quantity of replacement increases of CCPA/GCB combined, their respective strengths reduces. It can be concluded that Incorporation of Granulated Cow Bone on blended Cement-Cassava Peel Ash, has an implication effect on delaying hydration in cement and early strength development. Also, there is limited potential for Granulated Cow Bone to be used as a pozzolanic activities from the result of Oxide composition and strength development with curing ages, although it is classifies as a ''Natural Pozzolan''. However, as the percentage replacement of Granulated Cow Bone with blended Cement-Cassava Peel Ash increases, water binder ratio to achieve workability (Slump) and blended concrete also increases. It is then suggested that an optimum water binder of 0.7 should be adopted.

Keywords: Cassava Peel Ash (CPA), Granulated Cow Bone (GCB), Concrete, Beam, Pozzolan, Flexural Strength, Ordinary Portland Cement (OPC).

I. INTRODUCTION

Concrete is the most commonly used man-made construction material in which aggregates both fine and coarse are bonded together by cement when mixed with water. The selection of the respective amounts of cement, water and aggregate is called mix design (Charles, 2016).

Any material that can be made plastic and that gradually hardens to form an artificial rock-like substance is called a cementitious material (Irving, 2010). Cement being the most high-priced and main active constituent of the ingredients of concrete, needs a detailed study to find out the optimum requirements. On the odd occasion when things go wrong and strength does not develop as expected, rightly or wrongly the cement usually gets the blame. In most cases, cement contributes directly to the problem maybe one time in three, although it's mostly one of several contributing factors (Nicholas, 2014).

A large number of researches have been directed towards the utilization of waste materials, for the construction industry, the development and use of blended cements is growing rapidly. Since their uses generally improve the properties of the blended cement concrete and particularly granulated cow bone and cassava peel ash has been used as a highly reactive pozzolanic material to improve the microstructure of the interfacial transition zone between the cement paste and the aggregate in high-performance concrete. Granulated cow bone and Cassava peel ash improves the properties of concrete or cement paste due to the pozzolanic reaction and its role as a micro-filler. It is often thought that the first function (pozzolanic reaction) is most important.

The partial replacement of cement by Granulated cow bone and Cassava peel ash in cement paste and mortar would provide micro-structure improvement, poor filling effects, and better packing characteristics of the mix (Yusaket al., 2016). The workability of the blended cement paste and mortar is greatly modified due to the finer Pozzolana particles such as Granulated cow bone, Cassava peel ash, fly ash, silica fume etc. This addition depends both on the quality of Granulated cow bone and Cassava peel ash and the stipulated requirements of strength and durability. Presently, Granulated cow bone and Cassava peel ash and cement contents in a mix are determined by laboratory trials (Musbauet al., 2012).

II. MATERIALS AND METHODS

2.1 Cement is used as a major binding agent in casting of concrete works. There are different companies producing cement but the one we used in this research is a product of Dangote cement factory along Lokoja road (OBAJANA) Kogi Sate, Nigeria, but was obtained from a retailer shop along General Hospital area off Federal Polytechnic Permanent site Offa, Kwara State

The Cassava Peel and Granulated Cow Bone used for this study were both collected from Cassava possessing industry and Abbatoir at Owode Market Offa, Kwara State, Nigeria. The Sample was then sun dried before it was burned in a metal container using uncontrolled open air burning method. The cooled ashes were further grinded and sieved through a 700µm sieve in order to remove any impurity and larger size particles. The GCB and CPA were taken to Rolab Research and Diagonistic Laboratory Ibadan, Nigeria for chemical composition analysis. The fine sand obtained from a dealer in Offa and the coarse aggregate obtained from a quarry site in Ijagbo, Kwara State, were used as fine and coarse aggregate respectively.

2.2 Preparation of Testing Specimens:

The concrete investigated was of mix ratio of 1:2:4 with a constant water/cement ratio of 0.50. The cement was replaced with CCPA/GCB at 0%, 5%, 10%, and 15% by weight and mixed with sand and granite as fine and coarse aggregates respectively. A total number of 60 concrete beams of sizes 100mm x 100mm x 500mm were casted.After setting for 24 hours, the concrete beams were removed from their moulds and immersed in water tank for curing for 7, 14, 21, 28 and 56days.

2.3 Chemical Composition:

Chemical Composition Atomic Absorption Spectrophotometer and Gravimetric methods at the Rolab and Diagnosis Laboratory, Ibadan, Nigeria were used to determine the chemical composition of the Cassava Peel Ash (CPA) and Granulated Cow Bone (GCB).

2.4 Specific Gravity:

Specific gravity test on cement, Sand Granite CPA and GCB was done using density bottle in accordance to ISTM C618 (Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan)and ACI Education Bulletin E1.

2.5 Slump and Consistency Test:

Slump test was done in accordance to ensure the workability of the blended concrete, while the Consistency Test was determined by following the procedures specified in Indian Reference standards (IS)

2.6 Flexural Strength:

After the required age of curing, the concrete beams were removed from the curing tank and allowed to surface dry after which they were weighed on a balance to obtain the weight of each beams. The weighed beams were carefully placed in a Universal Testing Machine with a capacity of 100kN at NCAM IdofianKwara State using (ASTM)Testometric materials testing machine as show in Figure 2. The concrete beams were crushed at the end of curing age of 7, 14, 21,28 and 56days respectively.

2.7 SEM Analysis Procedure

Little sample was obtained from the crushed sample from the compressive machine. The sample was cutted to the specification and

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dimension needed for the sample holder to hold firmly using Ultratrim cutting machine. A blower machine was then set to blow off the top surface of the sample so as to remove any other particle or substance present on the surface of the specimen. The base of the sample was then scraped so that it will be well placed firmly on the sample holder. The sample holder containing the sample was well placed in a PSEM stage and then closed to start scanning operation. The result was saved and the system was turned off to as to properly clean back the sample holder completely before leaving the PSEM.

III. RESULTS AND DISCUSION

3.1 Chemical Composition The chemical composition of the CPAand GCB are as shown in Table 3.1.

The chemical composition analysis was done on both Cassava Peel Ash and Granulated Cow Bone. It was revealed that it is only the CPA this is a pozzolan as classified based on the property of Pozzolans as given by ASTM C618-2010 as the values gotten from the silica oxides, aluminium oxides and ferric oxides which has the values above 70% but GCB is not a good pozzolans. The result summaries of chemical Oxide test were shown in Table 3.1 below:

Table 3.1: Chemical Composition Analysis Test

Sample (s)	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	P_2O5	K_2O	TiO_2	SO_3
GCB	0.1	0.08	0.09	1.33	51.03	34.55	0.07	0.05	1
CPA	60.14	10.13	1.89	0.01	8.16	0	41.08	0.67	2.07
Std. Dev	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Exp. Value	20.5	4.2	3.4	1.02	2.2	1.02	1.02	1.2	1.01
X-RAY FLOURECENT TEST CONT.									
	Na_2O	MgO	Cl	LOl	Rbo	ZnO	Cr_2O_3	SrO	NiO
GCB	0.02	0.12	0	0.26	0	0.09	0.01	0.01	0.02
CPA	0	6.42	0	4.37	0	0	0	0	0
Std. Dev	0.01	0.01	0.62	0.22	0.42	0.4	0.1	0.1	0.05
Exp. Value	1.01	1.05	0.21	0.02	0.02	0.02	0.01	0.01	0.02

The silica content (SiO2) of the CPA and GCB are 60.14% and 0.1 respectively. The silica content of CPA is more greater than that of the GCB. This indicates that the CPA has potential of high pozzolanic activity compared to GCB.

3.2 Physical Properties:

The results of the slump, specific gravity and Consistency test conducted on CPA,GCB and CCPA/GCB on cement and concrete are shown in Table below.

3.2.1 Slump Test:

The slump values for CPA concrete ranges between 14 – 8, slump values of GCB concrete ranges from 13 – 3 and slump values of CCPA/GCB ranges from 13 – 7 as shown in Table below From the table, it is observed that as the percentage of replacements increases, the slump values decreases. These results indicate that concrete becomes less workable as the percentage content of Pozzolan increases, thus more water is required to make the concrete mixes more workable.

Table 3.2: Slump Test Result

CONCRETE PROPERTIES	CONTROL	**CPA**			**CBA**			**CCPA/GCB**		
	0%	5%	10%	15%	5%	10%	15%	5%	10%	15%
SLUMP HEIGHT (mm)	13	14	11	8	9	7	3	11	8	7
SLUMP TYPE	True Slump	True Slump	True Slump	True Slump	True Slump	True Slump	True Slump	True Slump	True Slump	True Slump

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Table 3.3 Consistency of Concrete

% OF **POZOLAN BLENDED CEMENT**	% OF WATER	PENETRATION
OPC 0%	22	34
CPO 5%	27	35
CPO 10%	28	35
CPO 15%	29	33
CBO 5%	23	33
CBO 10%	28	35
CBO 15%	30	35
CCO 5%	26	34
CCO 10%	31	35
CCO 15%	32	35

3.2.2 Specific Gravity:

The specific gravity values ranges from 3.0 to 2.2 as shown in table below. The specific gravity for pure Cement, Granite, CPA, Sand and GCB are 3.0, 2.6, 2.9, 2.8 and 2.2 respectively. It is observed that as the GCB content in cement paste increases, there is a consequential reduction in its specific gravity.

Table 3.4: Specific Gravity of Sand

Empty Pycometer (Specific Bottle) = M_1	496g
Specific Bottle and Sample = M_2	868g
Specific Bottle + Sample + Water = M_3	1609g
Specific Bottle + Water = M_4	1325g
Specific Gravity Value = SG	2.6g

Table 3.5: Specific Gravity of Granite

Empty Pycometer (Specific Bottle) = M_1	496g
Specific Bottle and Sample = M_2	1029g
Specific Bottle + Sample + Water = M_3	1723g
Specific Bottle + Water = M_4	1375g
Specific Gravity Value = SG	2.9g

Table 3.6: Specific Gravity of Cement

Empty Specific Gravity Flask = M_1	58g
Specific Gravity Flask and Cement = M_2	108g
Specific Gravity Flask + Cement + Kerosene = M_3	178g
Specific Gravity Flask + Kerosene = M_4	149g
Specific Gravity Value = SG	3.0g

Table 3.7: Specific Gravity of Cassava Peel Ash (CPA)

Empty Specific Gravity Flask = M_1	58g
Specific Gravity Flask and CPA = M_2	72g
Specific Gravity Flask + CPA + Kerosene = M_3	183g
Specific Gravity Flask + Kerosene = M_4	174g
Specific Gravity Value = SG	2.8g

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Table 3.8: Specific Gravity of Granulated Cow Bone (GCB)

Empty Specific Gravity Flask = M_1	58g
Specific Gravity Flask and GCB = M_2	82g
Specific Gravity Flask + GCB + Kerosene = M_3	187g
Specific Gravity Flask + Kerosene = M_4	174g
Specific Gravity Value = SG	2.2g

3.2.3 Flexural Strength Test

The variation of Flexural strength of Control sample, CPA, GCB and CCPA/GCB concrete with curing ages are as shown in Table below.

Tables 3.9 to 3.12 present the bending test results obtained for 100mm x 100mm x 500mm concrete beams. The results revealed the bending strength and strain obtained on each beam with their respective bending capacities at yield, peak and break respectively. However, for materials that deform significantly but do not break, the load at yield, typically measured at 5% deformation/strain of the outer surface is reported as the flexural strength or flexural yield strength. The test beam is under compressive stress at the concave surface and tensile stress at the convex surface.

At 0% replacement, beams made with CCPA/GCB combined have it greatest bending strength at yield as 3.792 N/mm^2 at 56 days curing, representing a 0.2% decrease. In addition, at 5% replacement, beams made with CCPA/GCB combined having an average strength of 3.368 N/mm^2 at 7 days curing, representing 3.3% decrease. This was followed by beams produced with CCPA/GCB combined having strengths at yield of 2.711 N/mm^2 at 14 days curing. In addition, the strength at yield at 15% replacement having their value for beams made with CCPA/GCB combined as 2.414 N/mm^2 at 56 days curing.

Table 3.9: Flexural Strength at Yield for 100mm x 100mm x 500mm Concrete Beams at 0% Replacement

	7 days curing @ 0% CCPA/GCB (1)	7 days curing @ 0% CCPA/GCB (2)	Avg.	14 days curing @ 0% CCPA/GCB (1)	14 days curing @ 0% CCPA/GCB (2)	Avg.	21 days curing @ 0% CCPA / GCB (1)	21 days curing @ 0% CCPA/GCB (2)	Avg.	28 days curing @ 0% CCPA/GCB (1)	28 days curing @ 0% CCPA / GCB (2)	Avg.	56 days curing @ 0% CCPA/GCB (1)	56 days curing @ 0% CCPA/GCB (2)	Avg.
Force (N)	4210.0	1626.0	2918.0	4911.0	4911.0	4911.0	574.0	1504.0	1039.0	1430.0	1466.0	1448.0	7142.0	6901.0	7021.5
Deflection (mm)	0.803	1.022	0.912	1.113	1.113	1.113	0.825	0.880	0.852	1.313	0.992	1.152	1.173	1.323	1.248
Bending Strength (N/mm^2)	2.273	0.878	1.576	2.652	2.652	2.652	0.310	0.812	0.561	0.772	0.792	0.782	3.857	3.727	3.792
Strain (%)	0.372	0.473	0.422	0.515	0.515	0.515	0.382	0.407	0.395	0.608	0.459	0.534	0.543	0.613	0.578

Table 3.10: Flexural Strength at Yield for 100mm x 100mm x 500mm Concrete Beams at 5% Replacement

	7days curing @ 5% CCPA/ GCB (1)	7 days curing @ 5% CCPA/ GCB (2)	Avg.	14 days curing @ 5% CCPA/ GCB (1)	14 days curing @ 5% CCPA/ GCB (2)	Avg.	21 days curing @ 5% CCPA/ GCB (1)	21 days curing @ 5% CCPA/ GCB (2)	Avg.	28 days curing @ 5% CCPA/ GCB (1)	28 days curing @ 5% CCPA / GCB (2)	Avg.	56 days curing @ 5% CCPA/ GCB (1)	56 days curing @ 5% CCPA/ GCB (2)	Avg.
Force (N)	6992.0	5482.0	6237.0	6922.0	5070.0	5996.0	2217.0	6702.0	4459.5	5421.0	4393.0	4907.0	4947.0	4964.0	4955.5
Deflection (mm)	2.520	1.941	2.230	2.071	1.429	1.750	0.943	1.815	1.379	1.224	1.665	1.444	1.997	1.778	1.887
Bending Strength (N/mm^2)	3.776	2.960	3.368	3.738	2.738	3.238	1.197	3.619	2.408	2.927	2.372	2.650	2.671	2.681	2.676
Strain (%)	1.167	0.899	1.033	0.959	0.662	0.810	0.437	0.840	0.638	0.567	0.771	0.669	0.925	0.823	0.874

Table 3.11: Flexural Strength at Yield for 100mm x 100mm x 500mm Concrete Beams at 10% Replacement

	7 days curing @ 10% CCPA/ GCB (1)	7 days curing @ 10% CCPA/ GCB (2)	Avg.	14 days curing @ 10% CCPA/ GCB (1)	14 days curing @ 10% CCPA/ GCB (2)	Avg.	21 days curing @ 10% CCPA/ GCB (1)	21 days curing @ 10% CCPA/ GCB (2)	Avg.	28 days curing @ 10% CCPA/ GCB (1)	28 days curing @ 10% CCPA / GCB (2)	Avg.	56 days curing @ 10% CCPA/ GCB (1)	56 days curing @ 10 % CCPA/ GCB (2)	Avg.
Force (N)	3935.0	5496.0	4715.5	4705.0	5575.0	5140.0	1428.0	5087.0	3257.5	4791.0	4555.0	4673.0	4101.0	4248.0	4174.5
Deflection (mm)	2.083	2.462	2.272	1.501	2.018	1.759	1.111	1.734	1.422	2.401	1.627	2.014	1.675	1.465	1.570
Bending Strength (N/mm^2)	2.125	2.968	2.546	2.541	3.010	2.776	0.771	2.747	1.759	2.587	2.460	2.523	2.215	2.294	2.254
Strain (%)	0.964	1.140	1.052	0.695	0.934	0.815	0.514	0.803	0.659	1.112	0.753	0.932	0.775	0.678	0.727

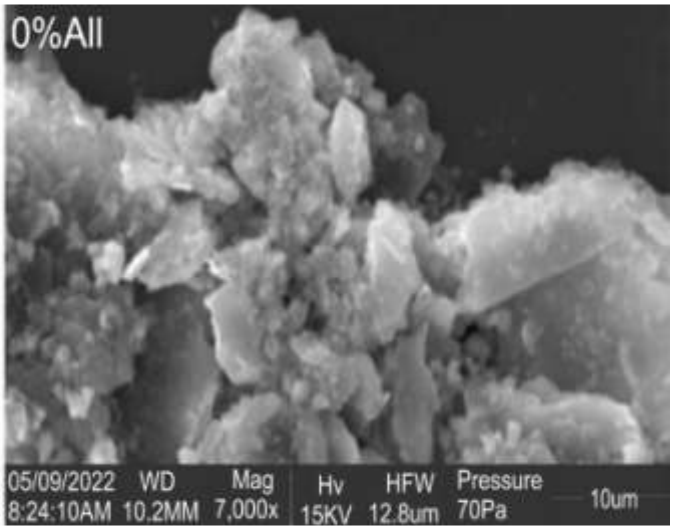
Table 3.12: Compressive Strength at Yield for 100mm x 100mm x 100mm Concrete Cubes at 15% Replacement

	7 days curing @ 15% CCPA/ GCB (1)	7 days curing @ 15% CCPA/ GCB (2)	Avg.	14 days curing @ 15% CCPA/ GCB (1)	14 days curing @ 15% CCPA/ GCB (2)	Avg.	21 days curing @ 15% CCPA/ GCB (1)	21 days curing @ 15% CCPA/ GCB (2)	Avg.	28 days curing @ 15% CCPA/ GCB (1)	28 days curing @ 15% CCPA / GCB (2)	Avg.	56 days curing @ 15% CCPA/ GCB (1)	56 days curing @ 15% CCPA/ GCB (2)	Avg.
Force (N)	5691.0	1470.0	3580.5	4158.0	737.0	2447.5	3750.0	4887.0	4318.5	3870.0	3870.0	3870.0	4530.0	4409.0	4469.5
Deflection (mm)	1.996	1.132	1.564	1.398	0.886	1.142	1.246	1.721	1.484	1.918	1.918	1.918	2.290	1.435	1.862
Bending Strength (N/mm^2)	3.073	0.794	1.933	2.245	0.398	1.322	2.025	2.639	2.332	2.090	2.090	2.090	2.446	2.381	2.414
Strain (%)	0.924	0.524	0.724	0.647	0.410	0.529	0.577	0.797	0.687	0.888	0.888	0.888	1.060	0.664	0.862

Summary on Flexural Result

1. The greatest yield strength was achieved on the beam produced with 0% of CCPA/GCB combined ($3.792N/mm^2$) at 56days curing.
2. Beam produced with 10% CCPA/GCB have a higher average strength of $2.776N/mm^2$ at 14days beyond beam produced with 0% of CCPA/GCB combined ($3.792N/mm^2$) at 56days curing. This implies that as the quantity of replacement increases of CCPA/GCB combined, their respective strengths reduces.

The following are the Pictorial representation of the SEM on the Composite Materials



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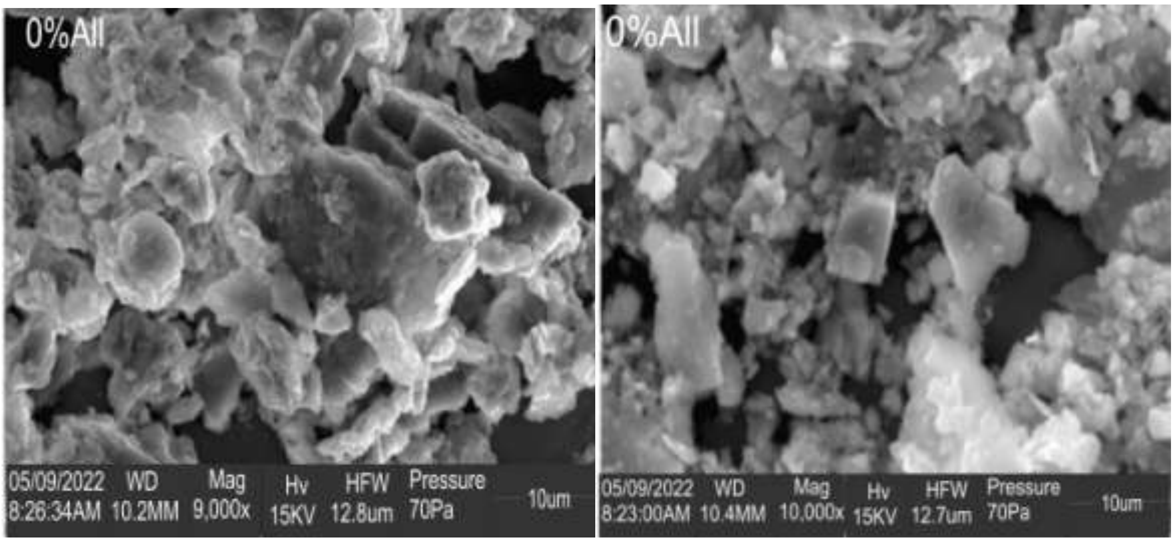

Plate 4.1: 0% Cassava Peel Ash and Granulated Cow Bone at diffeent Magnifications

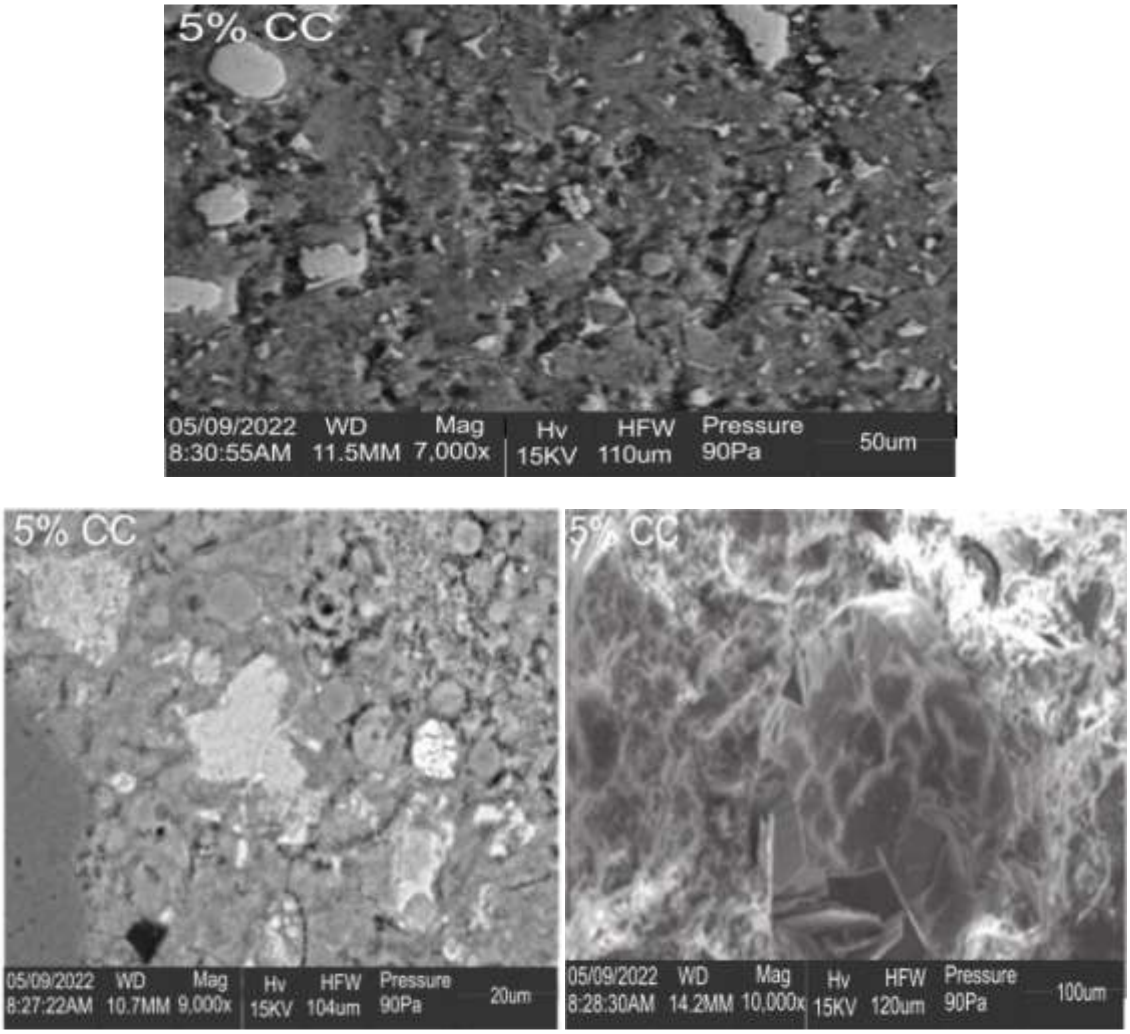

Plate 4.2: 5% Cassava Peel Ash and Granulated Cow Bone at diffeent Magnifications

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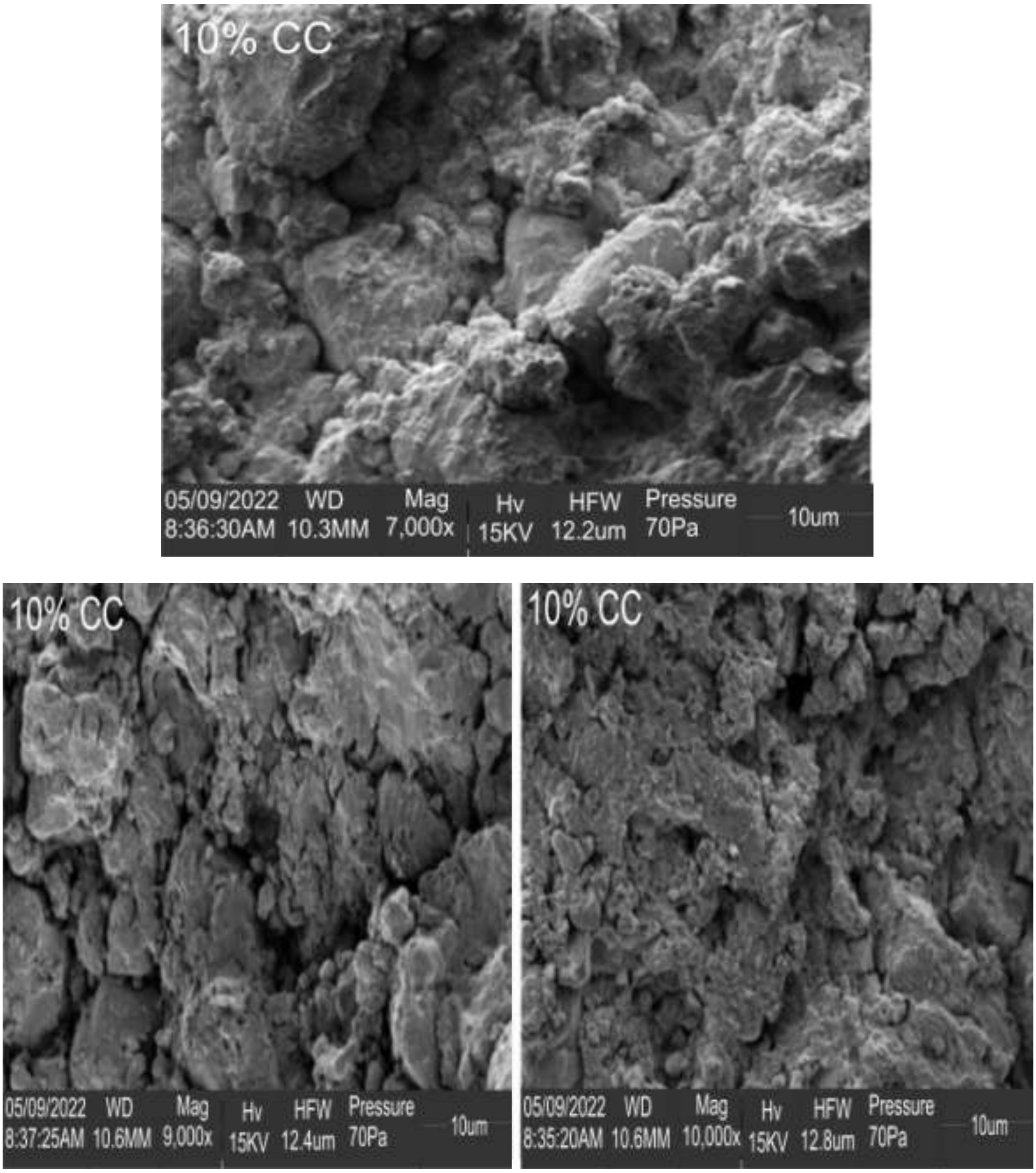

Plate 4.3: 10% Cassava Peel Ash and Granulated Cow Bone at diffeent Magnifications

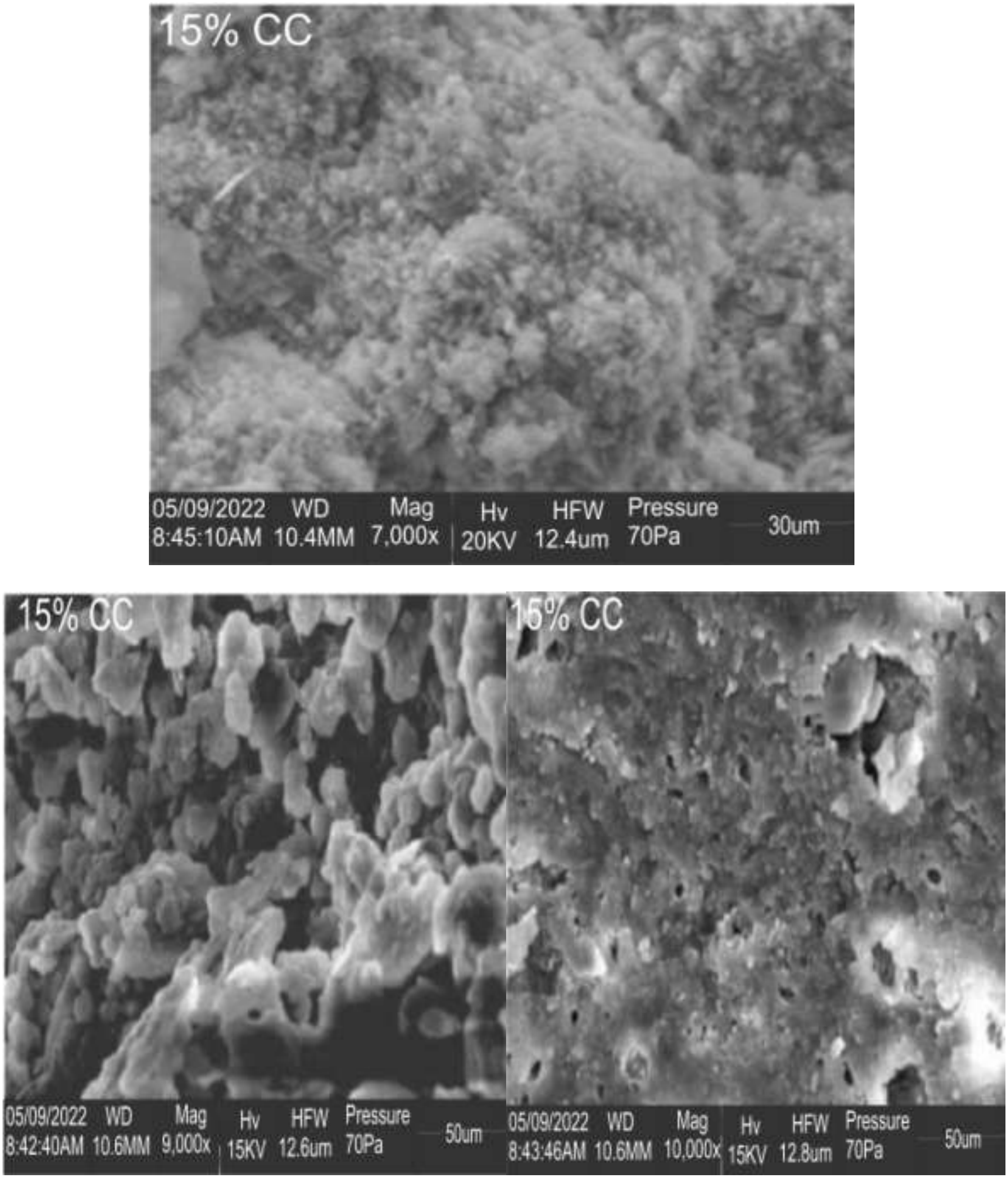

Plate 4.4: 15% Cassava Peel Ash and Granulated Cow Bone at diffeent Magnifications

3.4 CONCLUSION

Based on the result carried out on the effect of Granulated Cow Bone on Engineering Properties of Blended Cement-Cassava Peel Ash, the following conclusions were drawn

1. The value of pozzolanic activities present in Granulated Cow Bone is limited although it contains little amount of dangerous oxides (k_2O and Na_2O) that has the ability to react destructively with other concrete component that causes deterioration.
2. The Incorporation of Granulated Cow Bone on blended Cement-Cassava Peel Ash has an implication effect on delaying hydration in cement and early strength development.
3. There is limited potential for Granulated Cow Bone to be used as a pozzolanic activities from the result of Oxide composition and strength

development with curing ages, although it is classifies as a ‘’Natural Pozzolan’’

3.5 RECOMMENDATION

More percentage replacement of Granulated Cow Bone is recommended for other researchers as the highest value attained rises at 15% increment so as to evaluate its effect on blended cement-cassava peel ash.

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