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COMPARATIVE STUDY OF THE PHYSICAL AND MECHANICAL PROPERTIES OF CONCRETE PRODUCE WITH DIFFERENT SANDS IN BUI DIVISION-NORTHWEST CAMEROON

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ABSTRACT

The utilization of three different sands (Noni sand, Oku sand, Mbo-Nso sand) from Bui Division for concrete production was investigated. Their physical and mechanical properties were compared at different stages to determine the best sand for concrete production. Gravel from Dreamland quarry in Mankon and CIMAF 32.5R cement brand were used for the study. The study focuses on the comparative study of some properties of the three sands to ascertain their suitability for concrete production and to determine by comparison which of the sands will produce a compressive resistance of acceptable standards (20 MPa to 25 MPa) in 28 days. The tests carried out on these materials were : sand equivalent, grain size distribution, specific gravity, and apparent density. The DREUX-GORISSE method of concrete formulation was used to determine the batching of aggregates, binder and water for the mix. The mixing was done by hand and the Abrams cone method used to determine the slump of each batch. Eight (8) cubes of 150 mm x 150 mm x 150 mm were produced per batch for the compressive resistance test and densities. The curing was done by submerging the cubes in water for the required period. The compressive resistance which is the most effective property of concrete was investigated for 7, 14, 21 and 28 days.

The results of aggregates study and concrete compressive strength reveals that, Noni sand has the highest compressive strength of 21.5 MPa after 28 days which is within the acceptable range for structural works in the North-west region, followed by Mbo-Nso sand with a resistance of 19.35 MPa which can be improved upon by the use of admixtures and Oku sand gives the lowest compressive Strength of 10.22 MPa which cannot be recommended for structural works.

Keywords: Physical Properties, Mechanical Properties, Noni Sand, Oku Sand, MBO-NSO Sand, Concrete.

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1. INTRODUCTION

Concrete is a major component of most of our infrastructures today. It is used more than any other man-made material in the construction industry all over the world. As of 2006, about 7.5 cubic kilometers of concrete were made each year, more than one cubic meter for every person on earth. For example, cement consumption in the United States reached 102 million metric tons in 2020 and was strongly linked with construction industry demands (Wagih et al, 2013). Concrete is used in making pavements, bungalows, high-rise buildings, bridges, roads, railways, poles and others. In a nutshell, concrete is an artificial stone-like material used for various construction purposes and it is manufactured by mixing cement and various aggregates, such as sand, pebbles, gravel, stones, shale, water and sometimes admixtures. The materials that are used to make concrete all have their role in the final strength of concrete, (Yaceinthe et al., 2020). Therefore, this research is focused on the physical and mechanical properties of concrete produce with Noni, Oku, and Mbo-Nso sands in Bui Division and their comparative effects on some properties of concrete.

Sand is a granular material composed of finely divided mineral particles. It has various compositions but is defined by its grain size (Tetsopgang et al., 2020). Sand grains are smaller than gravel and coarser than silt. Sand can also be referred to as a textural class of soil or soil type containing more than 85% sand sized particles by mass. The most common constituent of sand in inland continental setting and non-tropical coastal setting is silica (silicon dioxide, $\mathrm{Si}O_2$) usually in the form of quartz.

Sand is also a mixture of small grains of rocks and granular materials which are mainly defined by size. It ranges from 0.06 mm to 2 mm in diameter. Particles that are larger than 0.0078125 mm but smaller than 0.0625 mm are termed silt (Tetsopgang et al., 2020).

The composition of sand varies depending on the local rock source and conditions of formation but the most common constituent of sand is silica in the form of quartz (Praveen, 2015). Its primary chemical component is silica, followed by small amounts of alumina, iron oxide and calcium oxide (Tetsopgang et al., 2020). Silica is a component of soil, rock, and other minerals. It is a non-renewable resources over human time scale and the one suitable for making concrete is in high demand. Sand is gotten from many sources such as pits, rivers, or beaches (Praveen, 2015). Rocks erode or weather over long periods of time mainly by water and wind, and their sediments are transported downstream. These sediments continue to break apart into smaller pieces until they become fine grains of sand. The type of rock the sediment originated from, and the intensity of the environment gives different compositions of sand.

Sand from rivers is collected either from the riverbanks or flood plains and accounts for the majority of the sand used in the construction industry. Sand is ideal for construction and is a very valuable commodity.

It is an aggregate material (fine aggregate) and its role in concrete mixed is to fill-up the spaces left by gravel in order to have a more compact concrete element (Madhav and Er., 2017). This makes it an indispensable ingredient in the construction and maintenance of rigid structures.

The effects of fine aggregate types on the compressive strength of concrete depends on aggregate type (Ozioko et al., 2020). The compressive strength of concrete depends on the source of fine aggregate use in the mixed. Fine aggregates strongly affect the properties of concrete freshly made or harden (Rahman, 2020). The strength of cement mortar increases with the increase in sand content to an extent (Bu et al., 2017). Crushed sand has a high compressive Strength at all ages than its corresponding natural sand (Donza et al., 2002). Sand is ideal for construction and is a very valuable commodity. Sand is an aggregate material (fine aggregate) and its role in concrete mixed is to fill-up the spaces left by gravel to have a more compact concrete element. Aggregates also decrease the consumption of cement and water and contribute to the mechanical strength of concrete. This makes it an indispensable ingredient in the construction and maintenance of rigid structures. Therefore, it is very important to study the physical and mechanical properties of concrete produce with different sands in Bui Division to establish the best sand for the production of quality concrete in the area.

This paper presents a comparatively model of concrete strength properties using some locally available sands in Bui Division, Northwest Cameroon. The principal objective of this paper is to inspect some properties of concrete made with three different sands in Bui Division and to establish the sand with the best properties of concrete to be used in the area.

2. MATERIAL AND METHODS

2.1. Materials

The materials use for this research work were sand, cement, coarse aggregate, and water. Portland limestone cement of grade 32.5R named type 2 produced with conformity to the requirements of CEM II of (NIS 444, 2014), as specified by the manufacturer, was used. The materials were collected and were graded through sieves for a good grain size analysis. Then, batching was done to form a uniform unit (sand, gravel, cement) and water added to form a fresh concrete that was being used for the concrete output. The analysis of the materials was done in Bamenda, Northwest region of Cameroon. The materials used are naturally occurring such as the different sands from three different sources in Bui Division. The gravel used came from a quarry site in Bamenda precisely dreamland quarry in Mankon. Table 1 shows the three sand sources used for this study.

Table 1: sources of different sands in this study.

S/N	sand	Source
1	Noni sand	River Mii
2	Oku sand	Chak stream
3	Mbo-Nso sand	Mbo-Nso sand pit.

2.2. Methods

The samples for this work were tested in a material and geotechnical laboratory (GEOSTRUCT) in Nkwen-Bamenda. Tests such as sand equivalent (degree of cleanliness of the sands), granulometry (grains size distribution of the aggregates), specific gravity (weight of unit volume to equal volume of water), apparent density (mass of aggregates that will fill a container of unit volume), Gorrise dreux's method of concrete formulation was used to determine the various quantities of aggregates and water for a meter cube of concrete.

The batches were properly mixed by hand until the concrete appeared to be homogeneous and of desired consistency. A slump test was then carried out on each of the mix to ensure its workability. Eight (8) cubes of 150 mm x 150 mm x 150 mm were cast for each of the sands. After 24 hours, the forms were removed and the specimens placed in water for 7, 14, 21 and 28days. Compressive strength test was performed on two cubes of each sand at each strength level after two hours of removal from the curing tank in accordance with BS EN 12390-3:2009.

3. RESULTS AND DISCUSSION

3.1. Results

Slump: The slump of concrete was determined before casting of the samples as shown in Table 2 and Figure 2. The following notations were used: S_1 for Noni sand, S_2 for Oku sand and S_3 for Mbo-Nso sand.

Table 2: Slump test results for various mix.

Mix Design	Slump in cm	State Of Concrete
Noni sand	7	Plastic
Oku sand	6	Plastic
Mbo-nso	6.5	Plastic

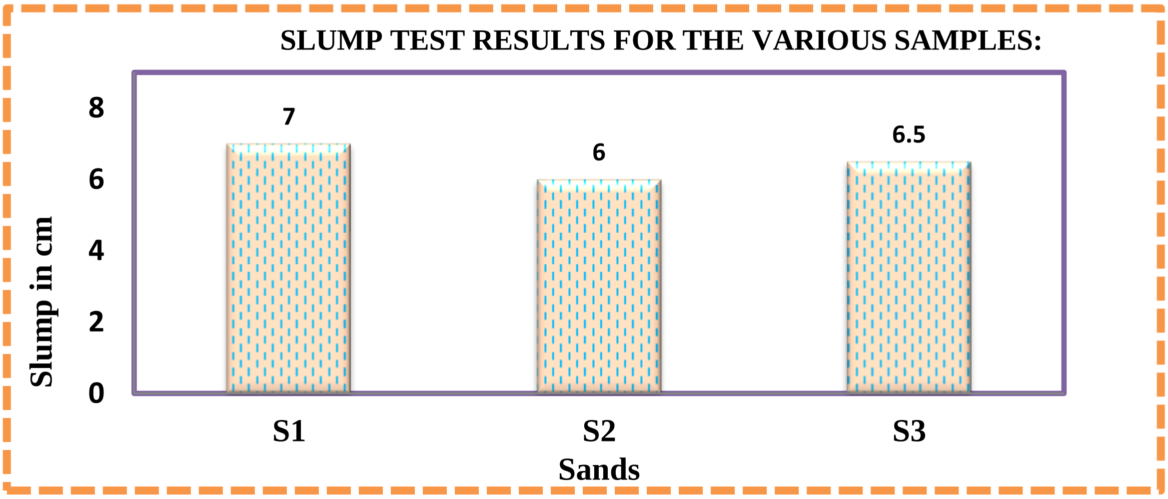

Figure 1: comparative chart of slump test of the three sands.

The slump envisaged was 6 cm. The slumps of the various mix ranges between 6 cm to 9 cm, indicating that the mix designs were homogeneous with good workability.

Compressive strength:

The compressive strength test was conducted for 7, 14, 21 and 28 days and it was observed that the different sands experienced an increase in compressive strength with respect to age (Tables 3 - 6). Based on the analysis above, it was also observed that all the results were not in accordance with the design expectation, except for Noni Sand that had values that are not exact but closer to the expected compressive resistance after 28 days. Figures 2 and 3 below shows the comparative compressive strength development of concrete made with the three different sands within 28 days of curing.

Table 3: Result of compressive strength and densities of concrete in 7 days.

Types of cement	**No of cylinder**	**Weight (g)**	**Area (mm²)**	**Force (kN)**	**Compressive strength (MPa)**	**Average (MPa)**	**Density kg/m^3**	**average density kg/m^3**
Noni sand	S1	8855	22500	310.32	13.79	**13.15**	2474.25	**2454.45**
	S2	8293.8	22500	281.36	12.50		2434.64	
Oku sand	S1	8245.1	22500	179.78	7.99	**7.51**	2385.7	**2377.61**
	S2	8165.3	22500	157.84	7.02		2369.51	
Mbo-Nso sand	S1	8373.2	22500	236.62	10.52	**11.88**	2480.95	**2476.03**
	S2	8340	22500	297.76	13.23		2471.11	

Table 4: Result of compressive strength and densities of concrete in 14 days.

Types of cement	**No of cylinders**	**Weight (g)**	**Area (mm²)**	**Force (kN)**	**Compressive strength (MPa)**	**Average (MPa)**	**Density kg/m^3**	**average density kg/m^3**
Noni sand	S1	8570.5	22500	355.28	15.79	**14.43**	2475.5	**2466.46**
	S2	8330.6	22500	293.86	13.06		2457.42	
Oku sand	S1	8051.7	22500	206	9.16	**8.27**	2358.99	**2383.13**
	S2	7997.1	22500	165.86	7.37		2407.26	
Mbo-Nso sand	S1	8483.8	22500	288.08	12.80	**13.35**	2493.69	**2503.26**
	S2	8672.7	22500	312.46	13.89		2512.86	

Table 5: Result of compressive strength and densities of concrete in 21 days.

Types of cement	**No of cylinders**	**Weight (g)**	**Area (mm²)**	**Force (kN)**	**Compressive strength (MPa)**	**Average (MPa)**	**Density kg/m^3**	**average density kg/m^3**
Noni sand	S1	8514	22500	419.5	18.64	**19.00**	2522.67	**2499.94**
	S2	8360.6	22500	434.98	19.33		2477.21	
Oku sand	S1	7961.6	22500	207.34	9.22	**9.00**	2336.29	**2403.55**
	S2	8124.5	22500	197.18	8.76		2470.81	
Mbo-Nso sand	S1	8416.2	22500	39216	17.43	**16.55**	2496.53	**2520.65**
	S2	8480.9	22500	352.3	15.66		2544.77	

Table 6: Result of compressive strength and densities of concrete in 28 days.

Types of cement	No of cylinders	Weight (g)	Area (mm^2)	Force (kN)	Compressive strength (MPa)	Average (MPa)	Density kg/m^3	average density kg/m^3
Noni sand	S1	8350.6	22500	495.45	22.02	**21.50**	2539.41	**2503.87**
	S2	8216.9	22500	462.24	20.98		2468.33	
Oku sand	S1	7885	22500	228.15	10.14	**10.22**	2442.99	**2431.17**
	S2	8339	22500	231.75	10.30		2419.35	
Mbo-Nso sand	S1	8425.8	22500	427.05	18.98	**19.35**	2513.72	**2541.70**
	S2	8588.6	22500	443.47	19.71		2569.67	

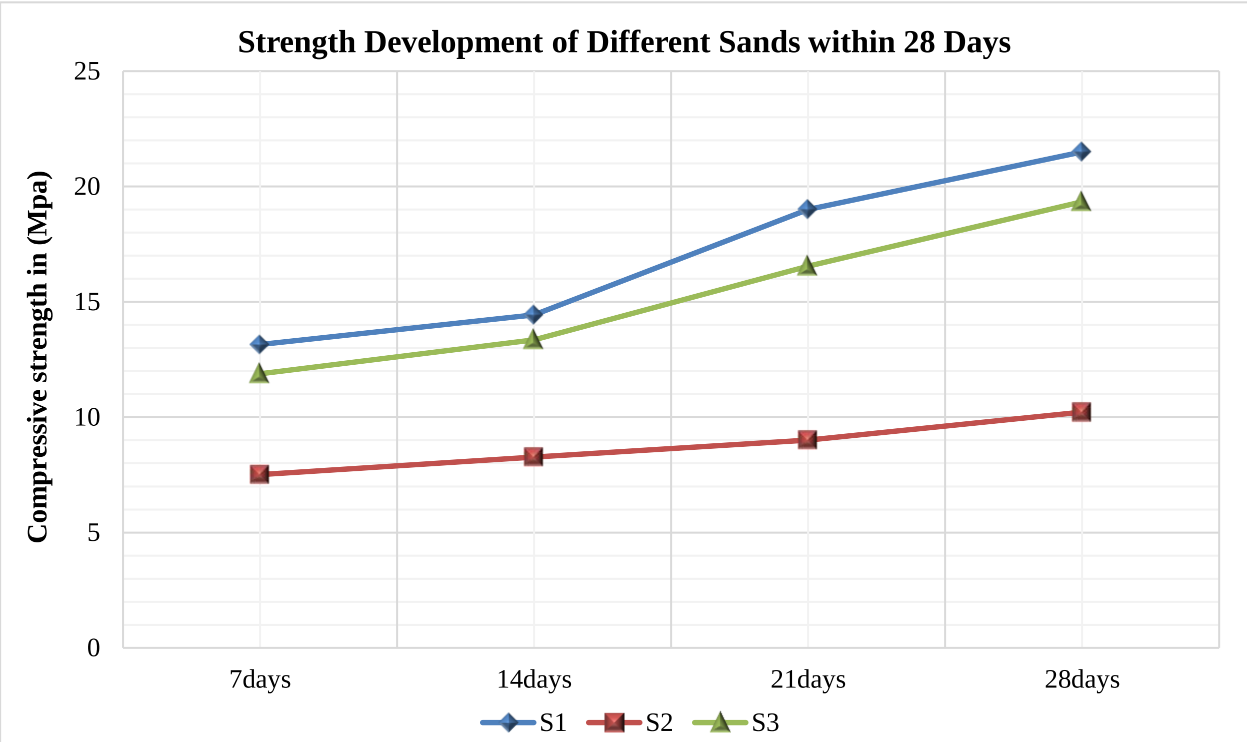

Figure 2: comparative chart of the compressive strength development of concrete made with the three different sands within 7 - 28 days

Density of concrete:

The densities of concrete specimens produced with the three different sands in this study are illustrated on the following Figure 3.

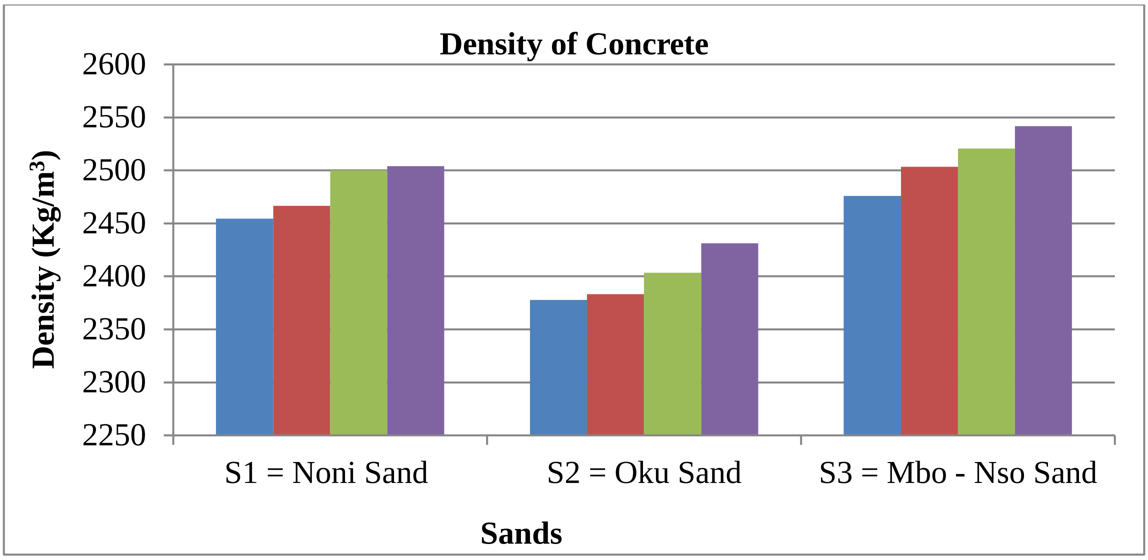

Figure 3: Comparative chart of densities of the three sands.

Comparing the densities of concrete produced with the three sands use for this study, we observed from Figure 3 that all the samples have witnessed an increase in density with increase in age. Mbo-Nso sand was having the highest density of **2541.7 kg/m^3** followed by Noni sand with **2503.87 kg/m^3** while Oku sand had the least density of **2431.17 kg/m^3** within 28 days.

3.2. Discussions

According to the findings of Khatib and Bayomy (2005), increase in water demand of these sands means they will have a reduced strength from what was designed. This therefore points out that Noni and Mbo-Nso sands will produce concrete with relatively higher strength compared to Oku sand. From their slump values, we find that Oku sand tends to absorb more water on formulation with everything else constant, which is why it is the least plastic. This also indicate that the grains have small pore spaces, which will result to denser concrete produced and hence better strength. This is evident by the densities of the concrete formulated with these different sands shown on Figure 3. Mbo-Nso sand will produce concrete of higher quality, strength and durability followed by the Noni sand and then the Oku sand in line with the observation of Neville and Brooks (2010).

The sands produce concrete with densities in line with the ACI (201-08) recommendations, though concrete with Oku sand has a slightly lower density. These sands will produce concrete of high quality, durability, density, and resistance, for greater load bearing in line with the outline from ACI 211.1-91 (2001). The sand from Oku will produce concrete of lighter weight, so we expect reduced durability, overall strength and quality similar to the observations of Neville and Brooks (2010).

Grouping from recommended qualities indicate that Noni sand is best fit for structural bearing, closely followed by Mbo-Nso (Deshpande, 1965), for flooring and block works. Though identification showed Mbo-Nso to have a tendency of producing higher strength concrete, it has a slightly reduced strength, which may result from various factors such as chemical composition (Yaceinthe et al., 2020), impurities like clay, silt, and organic matter, (BS EN 13139. BS EN 12620). Resistance properties indicate that the Oku should not even be applied for structural applications due to its low strength output.

4. CONCLUSION

The purpose of this research was to investigate some physical and mechanical properties of concrete made with three different sands in Bui Division, Northwest region of Cameroon. This is to avoid the use of substandard sand in Bui Division that might lead to the collapse of concrete structures in the area. Experiments were carried out on three mixtures made up of sands from the three sources in Bui and the coarse aggregate was from a quarry site in mankon Bamenda. The study made use of cement of the same strength **(32.5R)** of **CIMAF** brand, the same water/cement ratio **(0.6)** and a batching of **(1:2:4)** to determine the properties of concrete produced with these sands and their effects on the finished concrete. Based on these findings, the following conclusions were made.

- That out of the three cases of sands studied in this work, Noni sand is the best sand for concrete production in Bui Division with a compressive strength of **21.5 MPa** which falls within the acceptable range of **20 MPa** to **25 MPa** in the Northwest region of Cameroon.
- That Mbo-Nso sand with a compressive strength of **19.35 MPa** after 28 days can be improved upon by adding admixtures which can enhance its compressive Strength.
- That Oku sand having a 28-day compressive strength of **10.22 MPa** far less than the expected and acceptable compressive strength should not be used for concrete production of any kind in the area.
- That this work did not cover some of the mechanical properties of concrete such as split tensile strength of concrete, flexural tensile strength of concrete and modulus of elasticity for concretes made with these three sands.
- That concrete designers in Bui Division must first embark on the thorough study of the concrete materials especially sands and carry out laboratory investigation to ascertain their suitability for concrete production.

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Conflict of Interest

The authors of this article declare that there are no known conflicts of interest that could have appeared to influence the work reported in this paper. All the standards and ethics of scientific writing have been respected.

REFERENCES

[1] Ajagde W.O., Tijani, M. A. and O. A. Agbede (2018). Compressive strength of concrete made from aggregates of different sources. Departments of civil Engineering, university of Ibadan, Nigeria, Departments of civil engineering, Adeleke university Ede, Nigeria.

[2] ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens (1998). ASTM International.

[3] ASTM C90 Standard Specification for Loadbearing Concrete Masonry Units. (2012). ASTM International.

[4] Deshpande R. S., 1965: “Materials of Construction” P: 95, United Book Corporation, Poona

[5] Donza, H., Cabrera, O. and Irassar, E.F. (2002). High-strength concrete with different fine aggregates.

[6] H. N. Ngugi, R. N Mutuku, and Z. A. Garity, (2014). Effects of sand quality on bond strength of concrete: A case study in Nairobi city county and its environs, Kenya, university of Agriculture and Technology, Juja, Kenya.

[7] H.O. Ozioko and E.E. Ohazurike, (2020); Effects of fine aggregates types on the compressive strength of concrete; department of civil engineering. Micheal OkaraUniversity of agriculture, Umudike Abia state-Nigeria.

[8] Khatib, J.M., and Bayomy, F.M., (2005). Effect of mixing water content on properties of self-compacting concrete. Construction and Building Materials, vol.19, no.9, pp.679-686.

[9] Madhav P. K., & Er. Buddhi R. J., (2017). Construction sand, quality and supply management in infrastructure project (Vol. 4). Pokhara, Gandaki, Nepal: International Journal of Advances in Engineering & Scientific Research.

[10] Neville, A.M., and Brooks, J.J., (2010). Concrete technology. Pearson education.

[11] Praveen, S. (2015). Strength Properties of Self-Compacting Concrete with Steel Fibers. Civil Engineering International Journal [CEIJ] TM, 1.

[12] S. Rahman (2020). Analysis on compressive Strength of concrete using different sources of fine aggregates. Department of civil engineering, Port city International university, Chattogram, Bangladesh.

[13] Tetsopgang, S., Bongsiyisi, B. B., Dinayen, L. S., & Nkenglefac., T. D. (2020, April). Geotechnical assessment of sand for civil engineering in western Cameroon. The Extractive Journal Society, 7(2), 497-504.

[14] Wagih, A.M.; El-Karmoty, H.Z.; Ebid, M.; Okba, S.H. Recycled construction and demolition concrete waste as aggregate for structural concrete. HBRC J. 2013, 9, 193–200. [Google Scholar] [CrossRef] [Green Version

[15] Yaceinthe Djepaze II, Bertin Pagna Kagonbé, Achille Madi Balo, Elie Kamseu, and Guy Edgar Ntamack (2020). Influence of the Fineness Modulus of Sand on The Compressive Strength of Its Corresponding Mortar: A Mathematical Model Proposal. Science and Technology Publishing (SCI & TECH). Vol. 4 Issue 7. ISSN: 2632-1017

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