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Empirical Linear Model for Compressive Strenght of Sand-Quarry Dust Cubes and Blocks

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Abstract:
This empirical study presents the results of the investigation carried out on the relationship between compressive strength of sand-quarry block and their corresponding cube strength, using quarry dust as partial replacement of 3 different river sand samples of fineness modulus of 2.38, 2.55 ,and 3.02 with varying percentage replacements of 0%,10%,20%,30%,40%,50% to 100%. A total of 99 cubes of 100 × 100 × 100mm size and 99 blocks of 450 × 225 × 255mm size were produced with a mix ratio of 1:6 and 1:6 respectively. Three(3) cubes and 3 hollow blocks for each replacement and a total 33 cubes and 33 blocks for each river sand, were crushed to obtain the compressive strength of 28day curing respectively. It was found out that the sandcrete cubes possess higher strength than the hollow blocks in all the replacements and with all the 3 river sands used. Three(3) correlation models were developed using linear regression equation for the prediction of both the cube and block strength for each river sand respectively. From the regression analysis, the correlation equations derived were: $y = 3.06x – 0.112$, $y = 2.668x + 0.839$ and $y = 3.04x – 0.026$, where y is the cube strength and x is the block strength. From the equations derived, a unit increase in the block strength will result to an increase in the cube strength and vice versa. This shows that the correlation equation between the cube strength and the block strength are directly proportional. It is, therefore recommended that the possibility of relating the sandcrete cube strength to that of hollow block and vice versa seems feasible and effective.
***Key Word**: Fineness modulus, river sand, Quarry dust, compressive strength, quarry dust-sandcrete block, quarry dust sandcrete cube, percentage replacement, mix ratio.*

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I. Introduction

Nowadays, the world has been in revolution in the utilisation of sand-quarry dust blocks as a building material in construction industries. A lot of researches has proven that wider scale efforts are required in the course of testing the strength of these sandcrete blocks which proves to be very cumbersome[10]. This has led to the development of different cube –block strength relationship with respect to the partial replacements and the fineness modulus of the river sand type[7].

Also, a lot of researches have also been performed in order to picture the actual variation of the compression strength of both sand-quarry dust cubes and blocks respectively with respect to different partial replacements[9].

Finally, efforts have been put in place in past to reduce the usage of river sand as a concrete material[2]. This is to ensure that higher percentage replacement is achieved using several other cheap alternative bye-products due to overuse of the material(river sand) and the excessive depletion of securable river sand deposits[3]. Thus, it is economically and ecologically beneficial to obtain cheap, environmental-friendly substitutes for cement and river sand such as bye-products[4]. Quarry dust has been presented as an alternative to river sand to enhance the structural properties of sandcrete elements[6]. Quarry dust as a concrete material have been employed into several structural utility in the construction sector such as pavement, teraxo flooring, light weight aggregates, brick and tiles[8].

In this study, the focus will give more research on the relationship between sandcrete cube and that of hollow block and also the variational changes on compressive strength of sandcrete cube and block with different percentage alternative replacements. However, for this study, quarry dust will partially alternate river sand.

II. Material And Methods

Materials

The preparation of materials is very important as the materials need to be kept under a dry condition and air dried.

Constituent materials, the ratio of blend, mode of batching and casting are vital determinants of the structural properties of sandcrete blocks. The constituent materials employed in this research work are thus presented below:

Cement

Ordinary Portland Cement was utilize, from the Dangote Cement Company, Ewekoro in Ogun State of Nigeria with properties conforming to british standard.

Water

Potable water that was free from impurities. The water was a bore-hole water sourced within the school vicinity.

Sand

The river sand utilized were free from clay, silt, acidic substances and toxic impurities. The sands were sourced from Otamiri river, located at Umuchima, Ihiagwa community in Owerri west local government in Imo State, Nigeria.

The three(3) grades of river sands used in this research work had a specific gravity of 2.5 and 2.72 & 2.8 respectively ; bulk density of 0.92g/ml, 0.95g/ml and 0.98g/ml respectively; fineness modulus of 2.38, 2.55 and 3.02 ; the percentage water absorption were 2.17%, 2.10 and 2.04% and mean moisture content of 0.90%. The coefficient of uniformity of the sand was 2.95.

Quarry Dust

Quary dusts otherwise known as granite fines were obtained from the asphalt company quarry site located at Lokpakwu in Okigwe Local government in Imo State of Nigeria. The specific gravity of the granite fines was 2.5; bulk density of 0.76g/ml; percentage water absorption of 2.63% ; fineness modulus of 3.46 and the mean moisture content was 0.32%. The coefficient of uniformity of the granite fines was 10.7.

Cube Mould and Hollow Block Mould

The cube mould used for the mould of the cubes is a metallic mould with a size of 100× 100× 100mm. The hollow block mould also has a size of 450× 225×225mm[1].

Laboratory Testing Of Materials:

Laboratory analysis were performed on the constituent materials, they include: particle size distribution, bulk density, specific gravity, and water absorption percentage. The river sands were categorized according to their fineness modulus.

Methodology

Sandcrete Cube Production

A total of 99 sandcrete cube samples with size of 100mm × 100 × 100mm were produced for this research work using a partial replacement of quarry dust of 0% , 10% , 20% , 30% ,40%,50% to 100% . The mix ratio used is 1:6 and water - cement ratio of 0.5 and 0.6 respectively. The procedure for the production of the cube samples are as follows:

Step 1 -Weigh the air dried quarry dust, cement, water and sand using a weight balance according to the specified mix ratios of 1:6

Step 2 -Batch each material by weight according to the mix ratio to give about 3 cubes for each percentage replacement.

Step 3 -Mix all the weighed materials in a container.

Step 4 -Sprinkle the measured water on the mixed materials using a trowel until the desired uniform mixture is attained. Then weigh the mixed mortar.

Step 5 -Prepare the cube mould by cleaning and wiping it with grease.

Step 6 -Pour the weighed mixture and compress and compact it into the mould using a rammer for about 14times until the mixture attains its maximum compaction into the mould.

Step 7 -Let the cube stay in the mould for about 24hrs and demould it carefully, to be cured for 28days emersing them in a curing tank.

Step 8 -The same procedure were repeated for the other replacement of 0%,10%, 20%, 30%, 40% to 100% respectively.

Sandcrete Hollow Block Production

A total of 33 vibrated hollow block samples with size of 450 × 225 ×150were produced for this research work with the use of the vibrating machine using a partial replacement of quarry dust of 0% , !0% ,

20% , 30% , to 100% . The standard mix ratio used is 1:6 for cement and aggregate respectively. The aggregates were batched according to the to mix ratio by weighing the materials on a weigh scale and then taken to the machine for moulding.
After the blocks were demoulded, the blocks were placed on wooden platforms in separate rows. The blocks are then cured by sprinkling water on it for 28 days.

Compressive Strength Test
The Compressive strength of the cubes and blocks were carried out using the universal testing machine with a load rate of 0.3kN/second. The test was performed as follows:
Step 1 - The sandcrete cubes were removed from the curing tank for about 24hrs prior to the test.
Step 2 - The cubes and blocks were weighed and recorded.
Step 3 - Set the pallete base of the machine and place the cubes or block on it.
Step 4 - Ensure that the position of cubes and blocks are centralized to avoid error in the test.
Step 5 - Put on the machine for crushing and switch it off as soon as the machine indicates its maximum capacity.
Step 6 - Take the readings
Step 7 - Release the machine to remove the crushed cube or block and get it ready for the next crushing and ensure that the particles of the previous crush were all removed.

III. Result

The results of this study are presented on Table 1a to Table 5c and Figure 1 to Figure 3. Table 1a and Table 1b shows Mix proportion for sandcrete hollow block

Table 1a: Mix proportion for sandcrete hollow block.

% Replacement	0%	10%	20%	30%	40%	50%
Ratio	0.45:1:6	0.45:1:6	0.55:1:6	0.6:1:6	0.7:1:6	0.75:1:6
Water	1.57kg	1.57kg	1.88kg	2.05kg	2.36kg	2.52kg
Cement	3.50kg	3.50kg	3.44kg	3.44kg	3.38kg	3.35kgkg
Aggregate	20.94kg	20.94kg	20.66kg	20.53kg	20.26kg	20.13kg
Sand	20.94kg	18.85kg	16.53kg	14.37kg	12.16kg	10.07kg
Quarry dust	0.00kg	2.10kg	4.13kg	6.16kg	8.10kg	10.07kg

Table 1b: Mix proportion for sandcrete hollow block

% replacement	60%	70%	80%	90%	100%
Ratio	0.8:1:6	0.9:1:6	0.95:1:6	1:1:6	1.05:1:6
Water	2.67kg	2.96kg	3.11kg	3.25kg	3.39kg
Cement	3.33kg	3.29kg	3.27kg	3.25kg	3.23kg
Aggregate	20.00kg	19.75kg	19.62kg	19.5kg	19.38kg
Sand	8.00kg	5.93kg	3.92kg	1.95kg	0.00kg
Quarry dust	12.00kg	13.83kg	15.70kg	17.55kg	19.38kg

Table 2a and Table 2b shows Mix proportion for Sandcrete cubes

Table 2a: Mix proportion for Sandcrete cubes

% Replacement	0%	10%	20%	30%	40%	50%
Ratio	0.5:1:6	0.5:1:6	0.5:1:6	0.55:1:6	0.55:1:6	0.55:1:6
Water	0.16kg	0.16kg	0.16kg	0.18kg	0.18kg	0.18kg
Cement	0.33kg	0.33kg	0.33kg	0.33kg	0.33kg	0.33kg

Aggregate	2.00kg	2.00kg	2.00kg	1.98kg	1.98kg	1.98kg
Sand	2.00kg	1.80kg	1.60kg	1.39kg	1.18kg	0.99kg
Quarry dust	0.00kg	0.20kg	0.40kg	0.59kg	0.79kg	0.99kg

Table 2b: Mix proportion for Sandcrete cubes

% replacement	**60%**	**70%**	**80%**	**90%**	**100%**
Ratio	0.55:1:6	0.6:1:6	0.6:1:6	0.6:1:6	0.6:1:6
Water	0.18kg	0.20kg	0.20kg	0.20kg	0.20kg
Cement	0.33kg	0.33kg	0.33kg	0.33kg	0.33kg
Aggregate	1.98kg	2.00kg	2.00kg	2.00kg	2.00kg
Sand	0.76kg	0.60kg	0.40kg	0.2kg	2.00kg
Quarry dust	1.18kg	1.40kg	1.60kg	1.80kg	2.00kg

Table 3a, Table 3b and Table 3c shows Compressive Strength Result of Sandcrete Cubes with river sand of fineness modulus of 2.38, 2.55 & 3.02 respectively

Table 3a: 28th day Compressive Strength Result of Sandcrete Cubes with river sand of 2.38 fineness modulus

% Replacement	**Average Weight(kg)**	**Average failure Load(N)**	**Area(mm^2)**	**Compressive Strength(N/mm^2)**
0%	2.35	68666.67	10000.00	6.86
10%	2.40	78666.66	10000.00	7.86
20%	2.40	64666.66	10000.00	6.46
30%	2.40	51333.33	10000.00	5.13
40%	2.40	78666.66	10000.00	7.86
50%	2.40	59333.33	10000.00	5.93
60%	2.38	55333.33	10000.00	5.53
70%	2.35	69333.33	10000.00	6.93
80%	2.35	64333.33	10000.00	6.43
90%	2.35	84000.00	10000.00	8.40
100%	2.38	67333.33	10000.00	6.73

Table 3b: 28th day Compressive Strength Result of Sandcrete Cubes with river sand of 2.55 fineness modulus

% Replacement	**Average Weight(kg)**	**Average failure Load(N)**	**Area(mm^2)**	**Compressive Strength(N/mm^2)**
0%	2.30	16400.00	10000.00	16.40
10%	2.35	111333.33	10000.00	11.13
20%	2.30	143333.33	10000.00	14.33
30%	2.30	120000.00	10000.00	12.00
40%	2.30	132666.66	10000.00	13.26
50%	2.30	99333.33	10000.00	9.93
60%	2.30	74000.00	10000.00	7.40
70%	2.35	79333.33	10000.00	7.90
80%	2.40	88666.67	10000.00	8.86
90%	2.40	70000.00	10000.00	7.00
100%	2.38	67333.33	10000.00	6.73

Table 3c: 28th day Compressive Strength Result of Sandcrete Cubes with river sand of 3.02 fineness modulus

% Replacement	Average Weight(kg)	Average failure Load(N)	Area(mm^2)	Compressive Strength(N/mm^2)
0%	2.20	97333.33	10000.00	9.73
10%	2.25	88000.00	10000.00	8.80
20%	2.26	103333.33	10000.00	10.30
30%	2.25	104000.00	10000.00	10.40
40%	2.30	71333.33	10000.00	7.13
50%	2.25	78000.00	10000.00	7.80
60%	2.36	85333.33	10000.00	8.53
70%	2.3	89333.33	10000.00	8.93
80%	2.35	56000.00	10000.00	5.60
90%	2.35	58000.00	10000.00	5.80
100%	2.38	67333.33	10000.00	6.70

Table 4a, Table 4b and Table 4c shows Compressive Strength Result of Sandcrete Blocks with river sand of fineness modulus of 2.38, 2.55 & 3.02 respectively

Table 4a: 28th day Compressive Strength Result of Sandcrete Blocks with river sand of 2.38 fineness modulus

% Replacement	Average Weight(kg)	Average failure Load(N)	Area(mm^2)	Compressive Strength(N/mm^2)
0%	25.13	143333.30	53200.00	2.69
10%	24.53	110000.00	53200.00	1.99
20%	26.06	158000.00	53200.00	2.97
30%	26.13	122000.00	53200.00	2.29
40%	25.53	135000.00	53200.00	2.53
50%	24.86	141000.00	53200.00	2.65
60%	24.06	123333.00	53200.00	2.32
70%	23.73	131333.33	53200.00	2.47
80%	23.73	128000.00	53200.00	2.73
90%	22.86	82000.00	53200.00	1.54
100%	23.13	120000.00	53200.00	2.26

Table 4b: 28th day Compressive Strength Result of Sandcrete Blocks with river sand of 2.55 fineness modulus

% Replacement	Average Weight(kg)	Average failure Load(N)	Area(mm^2)	Compressive Strength(N/mm^2)
0%	25.20	113000.00	53200.00	2.12
10%	25.53	101000.00	53200.00	1.89
20%	25.33	128000.00	53200.00	2.40
30%	24.80	146000.00	53200.00	2.74
40%	23.67	81000.00	53200.00	1.52
50%	24.27	100666.70	53200.00	1.89
60%	23.60	108666.70	53200.00	2.04
70%	24.27	142666.70	53200.00	2.68
80%	23.73	111333.30	53200.00	2.09
90%	23.47	95000.00	53200.00	1.78
100%	25.87	107000.00	53200.00	2.01

Table 4c: 28th day Compressive Strength Result of Sandcrete Blocks with river sand of 3.02 fineness modulus

% Replacement	Average Weight(kg)	Average failure Load(N)	Area(mm^2)	Compressive Strength(N/mm^2)
0%	2.20	97333.33	10000.00	9.73
10%	2.25	88000.00	10000.00	8.80
20%	2.26	103333.33	10000.00	10.30
30%	2.25	104000.00	10000.00	10.40
40%	2.30	71333.33	10000.00	7.13
50%	2.25	78000.00	10000.00	7.80
60%	2.36	85333.33	10000.00	8.53
70%	2.3	89333.33	10000.00	8.93
80%	2.35	56000.00	10000.00	5.60
90%	2.35	58000.00	10000.00	5.80
100%	2.38	67333.33	10000.00	6.70

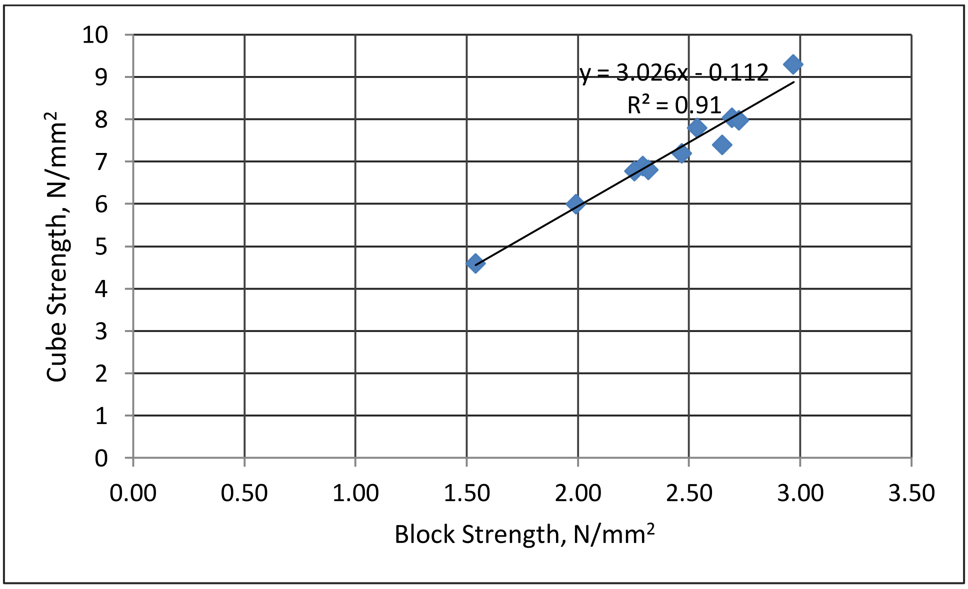

Figure 1: Regression graph for cube and block strength using the river sand of 2.38 fineness modulus

Table 5a : Regression/correlation model for cube and block strength correlation using river sand of 2.38 fineness modulus

variables	Regression coefficient		Regression Fitted
Block strength	3.026	0.91	y = 3.026x - 0.112
intercept	-0.112		

y(cube strength) = 3.026X – 0.112
Where x = block strength

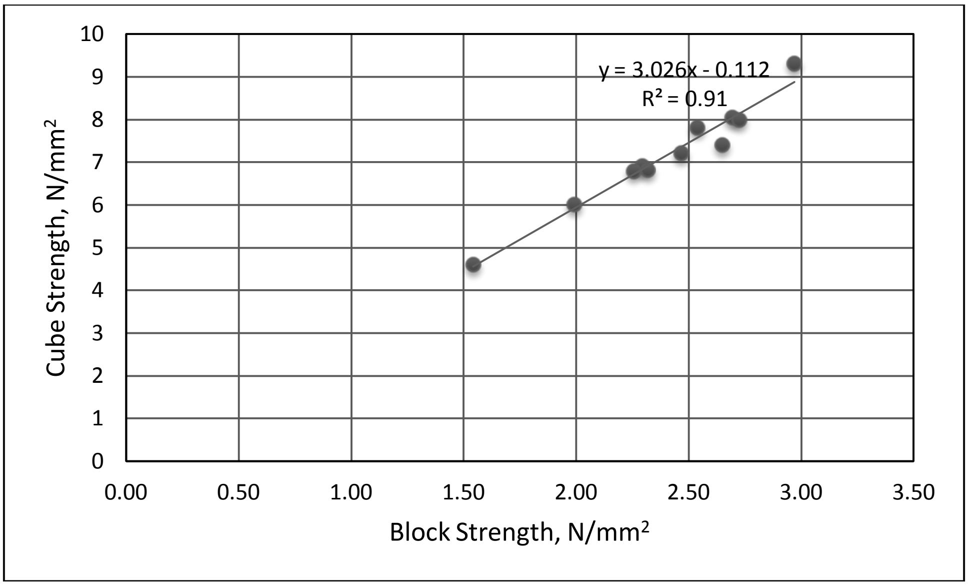

Figure 2: Regression model graph for cube and block strength using the river sand of 2.55 fineness modulus

Table 5b : Regression/correlation model for for cube and block strength correlation using river sand of 2.55 fineness modulus

variables	Regression coefficient	R2	Regression Fitted
Block strength	2.668	0.89	y = 2.668x + 0.839
intercept	0.839		

y(cube strength) = 2.668X + 0.839
Where x = block strength

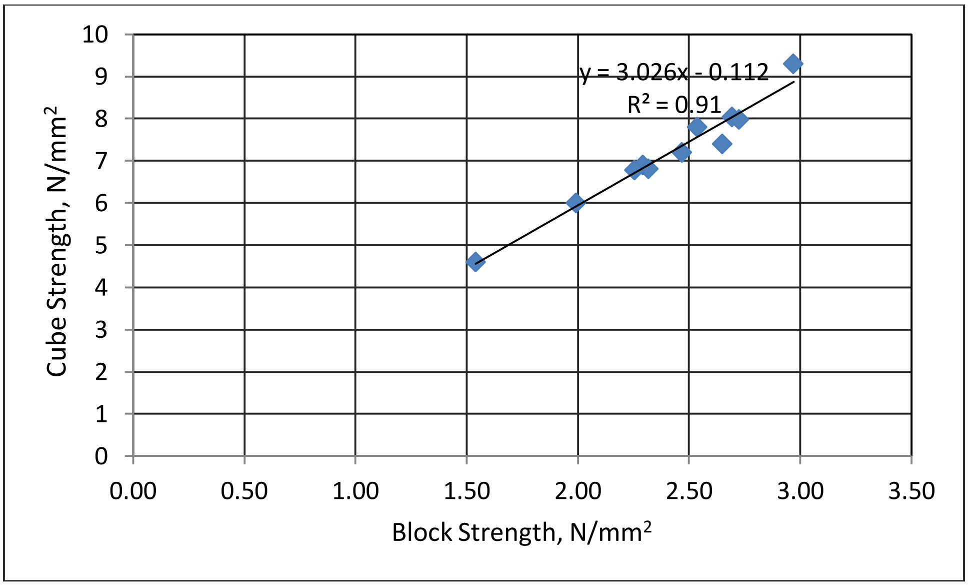

Figure 3: Regression graph for cube and block strength using the river sand of 3.02 fineness modulus

Table. : Regression/correlation model for for cube and block strength correlation using river sand of 3.02 fineness modulus

variables	Regression coefficient	R2	Regression Fitted
Block strength	3.054	0.903	y = 3.054 - 0.026
intercept	0.839		

y(cube strength) = 3.04x – 0.026
Where x = block strength

IV. Discussion

Table 1a to Table 2b showed the mix proportions of the sandcrete cubes and sandcrete blocks respectively using a mix ratio of 1:6 for each. Table 3a and Table 4a showed the results of the strength of sand - quarry cubes and block made with river sand of 2.38 fineness modulus respectively. Table 3b and Table 4b show the results of the strength of cubes and block made with river sand of 2.55 fineness modulus respectively. Table 3c and Table 4c showed the results of the strength of cubes and block made with river sand of 3.02 fineness modulus respectively.

Table 5a to 5c and Figure 1 to 3 showed the Regression/correlation model for cube and block strength correlation using all the river sand respectively. Also, figure 1, figure 2 and figure 3 show the regression /correlation graph and equation for all the river sand respectively. From the result, the correlation equation or model were gotten to be: $y = 3.06x-0.112$, $y = 2.668x + 0.839$ and $y = 3.04x – 0.026$ for the 3 river sand respectively. The correlation coefficient were 0.91, 0.89 and 0.903 for the prediction of the cubes for the 3 river sands respectively. This signifies that the model is accurately in agreement to the experimented result. From the correlation equation above, a unit increase in the block strength will result to an increase in the cube strength and vice versa. This shows that the correlation equation between the cube strength and the block strength are directly proportional.

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