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COMPARING THE FLEXURAL STRENGTH OF CONCRETE MADE WITH RIVER SAND WITH THAT MADE WITH QUARRY DUST AS FINE AGGREGATE

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Abstract

This work focuses on the 100% replacement of river sand with quarry dust in the production of concrete. Two types of concrete were produced (concrete made with river sand and that made with quarry dust as fine aggregate), the concretes produces were cast into beams and cured for 28 days. The flexural strengths of the concrete beams cast was determine at 28 day strength. At 28 days target strength the maximum flexural strength of concrete made with river sand as fine aggregate is 5.375111N/mm^2 and minimum flexural strength is 2.2155N/mm^2, for the concrete made with quarry dust as fine aggregate the maximum flexural strength is 2.567 N/mm^2. The maximum value of 2.567 N/mm^2 for concrete made with quarry dust as fine aggregate is higher than the minimum value of 2.2155N/mm^2 for concrete made with river sand as fine aggregate. With this result it shows that quarry dust is a good substitute to river sand in the production of concrete.

Keywords: Concrete; River Sand; Quarry Dust; Flexural Strength.

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1. Introduction

In recent times African countries especially Nigeria has embarked on massive infrastructural development which involves construction of highways, airport runways, parking lots and playgrounds. All these aforementioned structures cannot be constructed without taken into consideration their flexural strengths which is the value of their resistant to failure in bending, and a measure of their resistance to deformation under a given load (Kala 2013). Concrete plays an important role in the construction of these structures. River sand which is one of the constituents in the production of concrete is becoming very scarce and very expensive. Hence the need to find an alternative to river sand in the production of concrete to reduce the cost of construction and the difficulties encountered in sourcing for river sand. Quarry dust which is a waste material in the quarry industries was used here to replace river sand completely in the production of concrete;

quarry dust has been in used as fine aggregate in the production of concrete (Ilangovana *et al* 2006 and Safiuddin et al, 2012). Comparison is made here between concrete made with river sand and that made with quarry dust based on their flexural strengths.

2. Material and Methods

Material

The chief materials used here are quarry dust, river sand, cement, water and coarse aggregate. The quarry dust used in this study was obtained from a quarry site at Umuoghara in Ezza North Local Goverment Area Ebonyi State, the river sand used was obtained from Otanmiri in Owerri West Local Goverment Area Imo State both in Nigeria. The cement used was Dangote Portland cement, and the water used was from the tape at the Federal Polytechnic Nekede Owerri.

Methods

The specific gravities and bulk densities of river sand, quarry dust, coarse aggregate and cement used were determined and is as shown in Table 1. Particle size grading was carried out using sieve analysis method on the river sand and quarry dust respectively. Using the river sand and quarry dust as fine aggregates respectively, two type of concretes beams were produced based on prescribed mixes shown in Table 2 and 3 : one with river sand as fine aggregate and the other with quarry dust as fine aggregate. The specimens are prepared in accordance with the concrete batch procedure, the concretes are placed in the moulds, and the concrete was consolidated with a mechanical vibrating table (ASTM C78 and BS 1881). Care was taken not to over vibrate the concrete in the moulds since this will cause segregation. After removal from the mould beams, the beams were placed in a curing tank for curing to take place for 28 days. After 28 days the specimens were carried to the universal testing machine while the specimen was still moist from the curing room. The load was applied without shock at a rate of 200m/s. The ultimate loads on each specimen were then recorded, and also the exact location of fracture, and the type of failure on each specimen was also noted. If the failure occurs more than 5% of the length, 2.25 cm, outside the middle third of the beam in the tension surface, the results for such specimen was discarded. The cross section at each end was measured after the test and the average height and depth of each specimen was recorded (Irving 2010). The method adopted in this experiment was simple beam with “Third – Point Loading”. The flexural strength of each specimen was determined using

$$FS = FL/BD^2$$

Where

$FS =$ flexural strength; $L =$ length of the specimen; $B =$ breath of the specimen

$D =$ depth of the specimen

The results are tabulated as shown in fig 1, 2 and 3, and table 1, 2 and 3.

3. Results and Discussion

Table 1: Physical properties of the materials used.

	River sand	Quarry dust	Coarse aggregate	Cement
Specific gravity	2.66	2.55	2.60	3.08
Bulk density (Mg/m^3)	1.593	1.48	1.41	1.105

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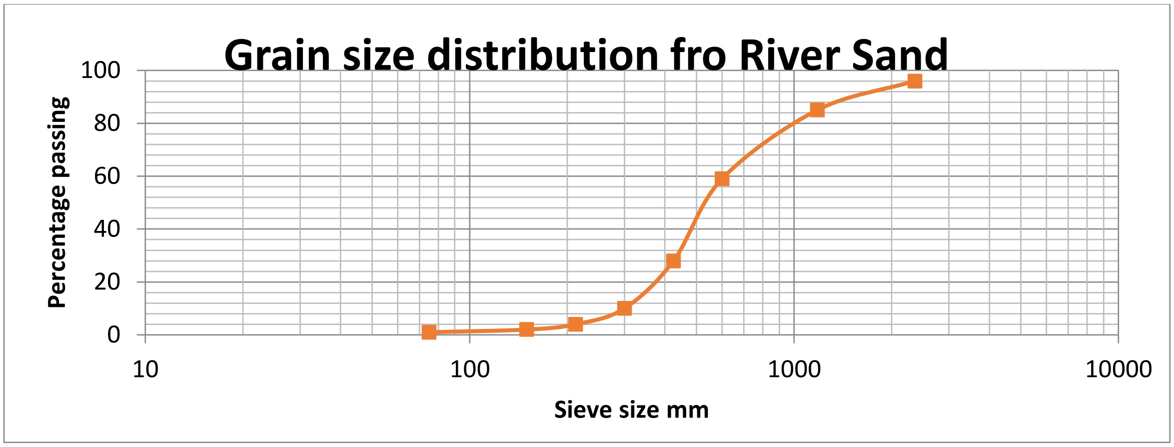

Figure 1: Percentage passing against sieve sizes (River sand)

Effective size $D_{10} = 300\mu m$, $D_{30} = 440\mu m$, $D_{60} = 600\mu m$
The coefficient of uniformity C_c

$$C_c = \frac{D_{60}}{D_{10}} = \frac{600}{300} = 2$$

The coefficient of coverture C_u

$$C_u = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{440^2}{600 \times 300} = 1.08$$

From the curve 95% of the soil is made of sand which have 25% coarse sand, 65% medium sand and 5% fine sand. From the values of C_c and C_u the soil is well graded; the soil is sand that is well graded.

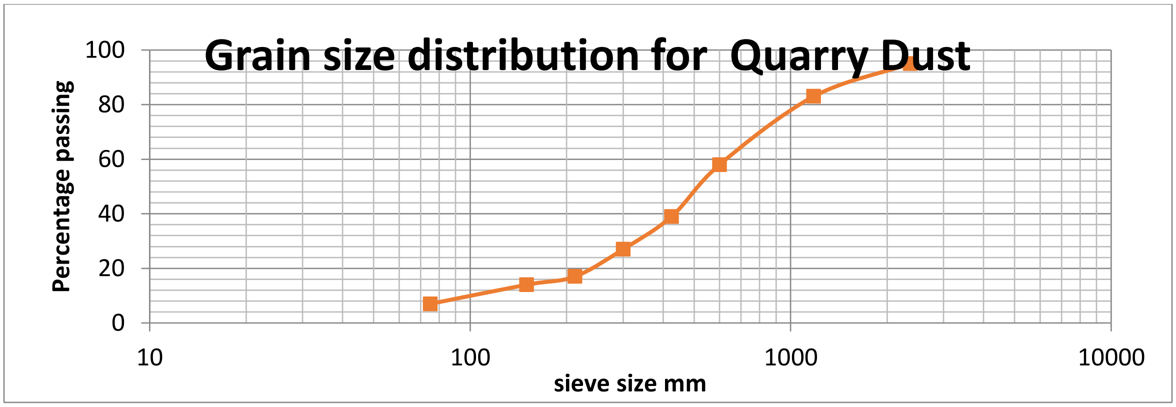

Figure 2: Percentage passing against sieve sizes (quarry dust)

Effective size $D_{10} = 100\mu m$, $D_{30} = 340\mu m$, $D_{60} = 630\mu m$
The coefficient of uniformity C_c

$$C_c = \frac{D_{60}}{D_{10}} = \frac{630}{100} = 6.3$$

The coefficient of coverture C_u

$$C_u = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{340^2}{630 \times 100} = 1.83$$

From the curve 15%of silt, 77% of sand and 8% of gravel is present in the quarry dust. From the values of C_c and C_u the soil is well graded. The soil is well graded with mixed particles having more of sand.

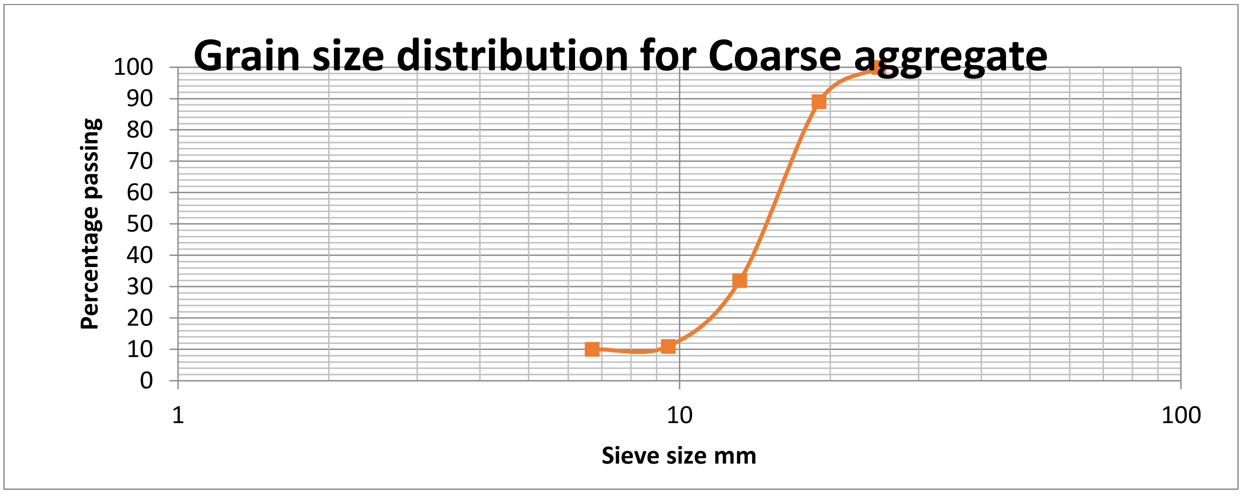

Figure 3: Percentage passing against sieve sizes (Coarse aggregate)

Effective size $D_{10} = 6.5$, $D_{30} = 14\ mm$, $D_{60} = 17\ mm$
The coefficient of uniformity C_c

$$C_c = \frac{D_{60}}{D_{10}} = \frac{17}{6.5} = 2.65$$

The coefficient of coverture C_u

$$C_u = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{14^2}{17 \times 6.5} = 1.77$$

From the curve 100% of the soil is gravel, with 93% medium gravel and 7% coarse gravel. From the values of C_c and C_u the soil is uniformly graded; the soil is a uniformly graded gravel.

The physical properties of aggregates and cement

The values of specific gravities and bulk densities for the aggregate are shown in Table 1. The corresponding values for cement are also as shown in Table 1. Specific gravity value for river sand (2.66) was higher than those for quarry dust and coarse aggregate which were 2.55 and 2.60 respectively. The grading curve for river sand and quarry dust are shown in Fig 1.

Table 2 Flexural strength of concrete made with Quarry Dust.

S/N	Mix ratio	Point of observation	Average strength (KN)	Average Flexural strength (N/mm^2)
1	0.6:1:1.5:3	S_1	16.155	2.393333
2	0.5:1:1.75:4	S_2	14.694	2.176889
3	0.55:1:2:3	S_3	17.325	2.566667
4	0.56:1:2:5	S_4	15.024	2.225778
5	0.575:1:1.75:3	S_{12}	15.951	2.363111

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6	0.55:1:1.625:3.5	S_{13}	14.79	2.191111
7	0.58:1:1.75:4	S_{14}	16.545	2.451111
8	0.53:1:1.875:4.5	S_{23}	17.76	2.631111
9	0.555:1:2:4	S_{24}	15.921	2.358667
10	0.525:1:1.875:3.5	S_{24}	16.665	2.468889

Note: the cube strength in N/mm^2 is derived from dividing the force by $(F \times L)/(b \times d^2)$

Table 3: Flexural strength of concrete made with River sand.

S/N	Mix ratio	Point of observation	Average strength (KN)	Average Flexural strength (N/mm^2)
1	0.6:1:1.5:3	Q_1	24.978	3.700444
2	0.5:1:1.75:4	Q_2	35.367	5.239556
3	0.55:1:2:3	Q_3	36.282	5.375111
4	0.56:1:2:5	Q_4	27.831	4.123111
5	0.575:1:1.75:3	Q_{12}	33.732	4.997333
6	0.55:1:1.625:3.5	Q_{13}	33.114	4.905778
7	0.58:1:1.75:4	Q_{14}	17.784	2.634667
8	0.53:1:1.875:4.5	Q_{23}	14.955	2.215556
9	0.555:1:2:4	Q_{24}	18.036	2.672
10	0.525:1:1.875:3.5	Q_{24}	20.787	3.079556

Note: the cube strength in N/mm^2 is derived from dividing the force by $(F \times L)/(b \times d^2)$

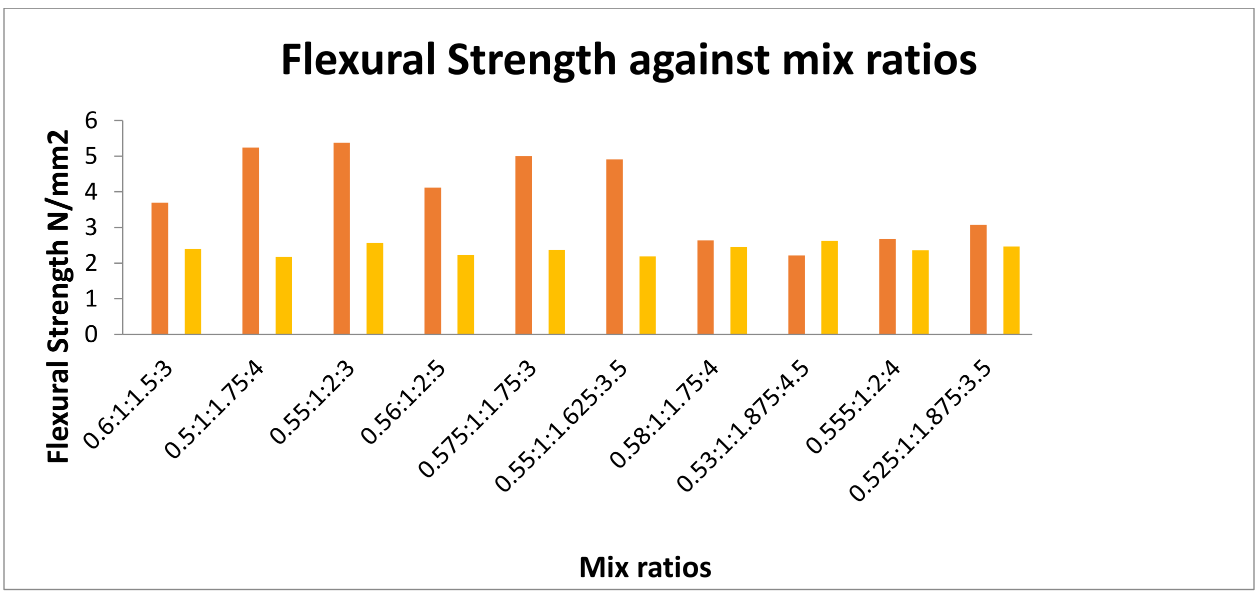

Figure 3: flexural strengths against mix ratios

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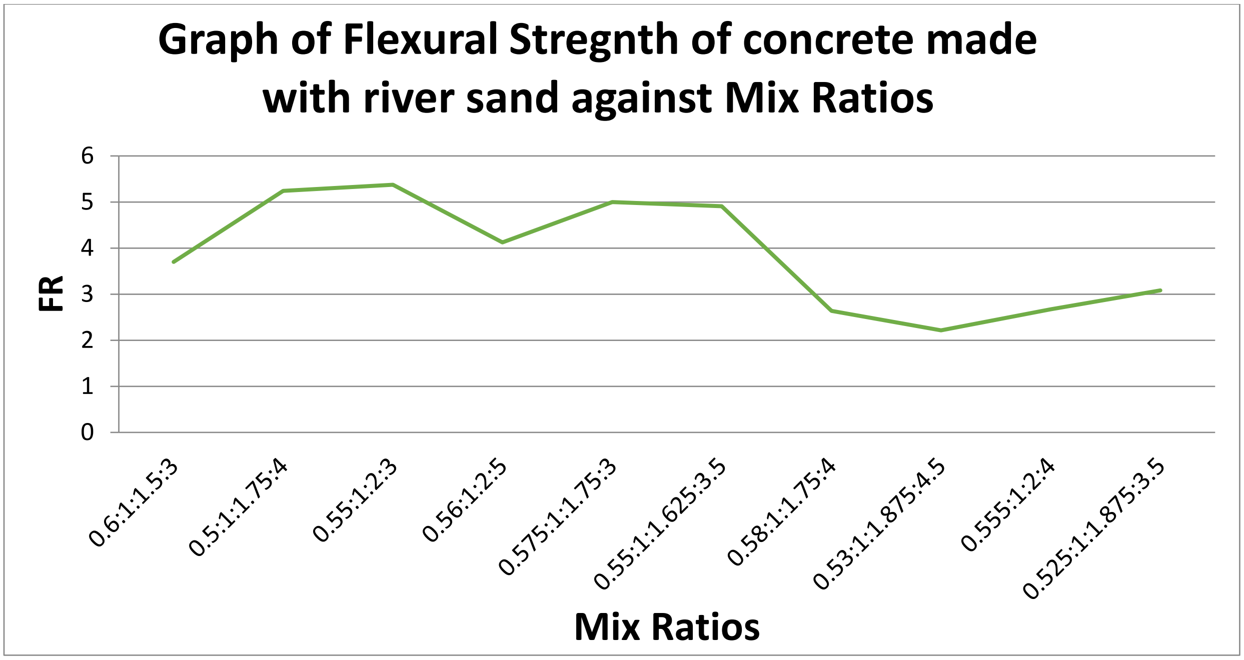

Figure 4: Graph of flexural strength of concrete made with river sand against mix ratios

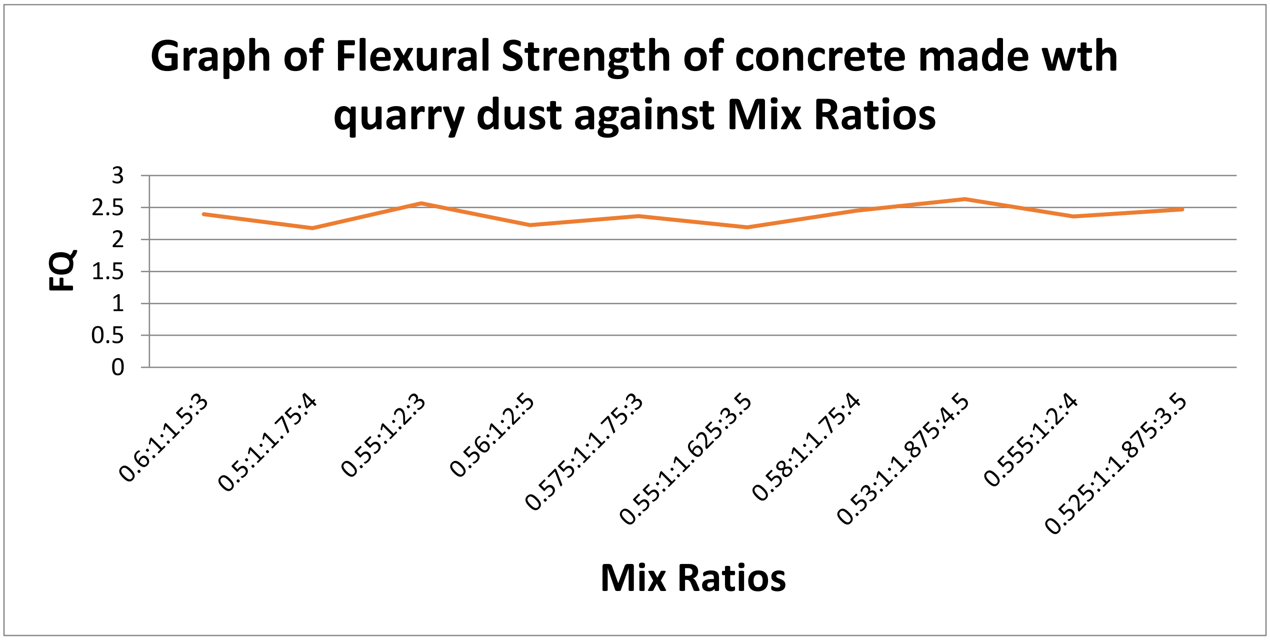

Figure 5: Graph of flexural strength of concrete made with quarry dust against mix ratios

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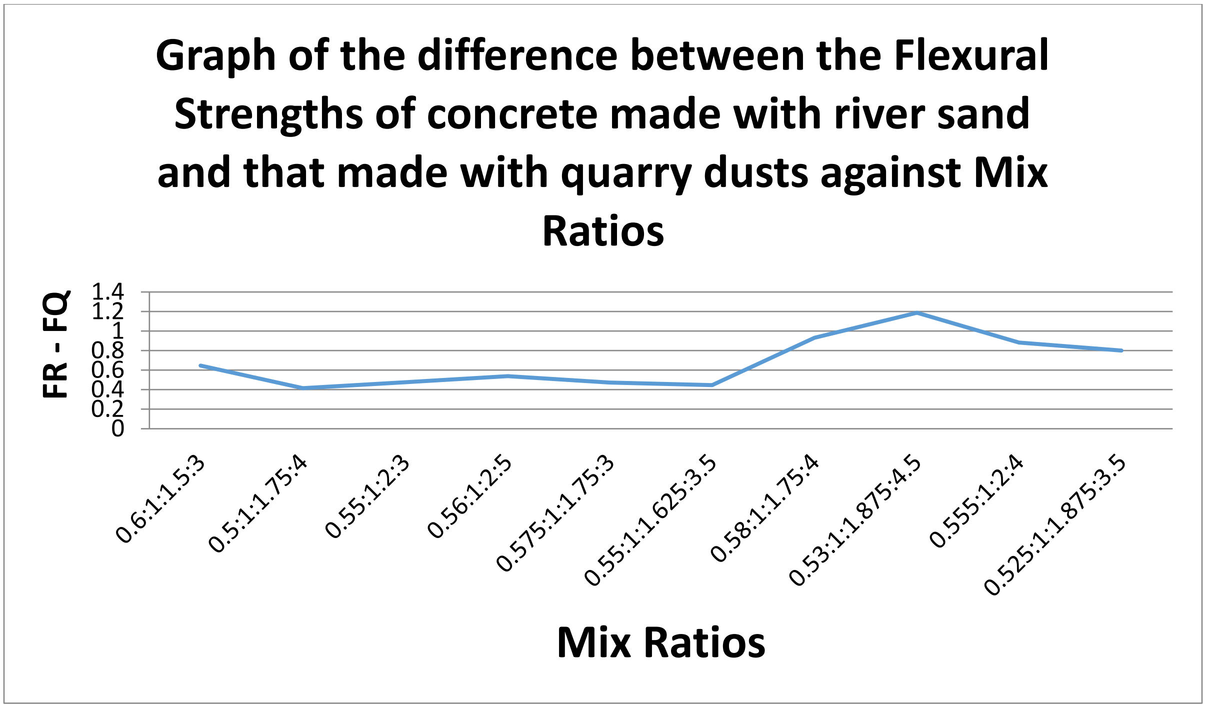

Figure 6: Graph of the difference between the flexural strengths of concrete made with river sand and that made with quarry dust against mix ratios

Table 4: Descriptive Statistics: river, quarry

Variable	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
River	10	3.894	1.197	2.216	2.663	3.912	5.058	5.375
Quarry	10	2.3827	0.1536	2.1769	2.2171	2.3782	2.4933	2.6311

Flexural Strength of Concrete

The values of 28-day strength of concrete made from river sand and quarry dust as shown in Table 2 and 3 respectively. Flexural strength values are average of their replicates. Concrete made from river sand had flexural strength values that ranges from 2.215556N/mm^2 to 5.375111N/mm^2 while quarry dust based concrete had flexural strength values that ranges from 2.176889N/mm^2 to 2.631111N/mm^2. The mean values and standard deviation of the flexural strength are 3.894 N/mm^2 and 1.197N/mm^2 as well as 2.3827N/mm^2 and 0.1536N/mm^2 respectively. The mean value of the flexural strength of concrete made from river sand is higher than that of concrete made with quarry dust as fine aggregate. Also the standard deviation of the flexural strength of concrete made from river sand is higher than concrete made with quarry dust as fine aggregate. From the experimental results obtained the relationship between the flexural strength of concrete made with river sand as fine aggregate and that made with quarry dust as fine aggregate is given as

$$f_R = 44.7497e^{-1.02964f_Q}$$

Where
f_R = Flexural strength of concrete made with river sand as fine aggregate
f_Q = Flexural strength of concrete made with quarry dust as fine aggregate

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4. Conclusion

From the results and analysis the following conclusion can be drawn:

- The maximum compressive strength is 5.375N/mm^2 at w/c of 0.55 (mix ratio 1:2:4) for concrete made with river sand and the maximum compressive strength is 2.57 N/mm^2 at w/c of 0.55 (mix ratio 1:2:4) for concrete made with quarry dust as fine aggregate.
- Maximum flexural strength of 2.57 N/mm^2 is achievable at mix ratio of 1:2:4 and w/c of 0.55 for concrete made with quarry dust as fine aggregate which is greater than the minimum value of 2.216N/mm^2 given by concrete made with river sand at mix ratio of 1:1.75:3.5 and w/c of 0.525.
- From the bar chart it can be seen that at mix ratio 1:2.25:4.5 and w/c of 0.55 the flexural strengths of concrete made with river sand and that made with quarry dust are almost equal.
- At mix ratio of 1:2:4 the two concrete have their highest compressive strength of 5.375N/mm^2 and 2.567N/mm^2 respectively at water/cement ratio of 0.55.
- The relationship between the concrete made with river sand and that made with quarry dust was developed.
- From the experimental results and analysis, quarry dust can be use as a replacement to river sand in the production of concrete.

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