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Suitability of Quarry Dust as Fine Aggregates in Concrete: A Case of Ndolela Quarry in Iringa Tanzania

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Abstract:
The main objective of this research was to test the suitability of using the quarry dust as fine aggregates in concrete. The study wanted to investigate the properties of fresh and hardened concrete that contains quarry dust as fine aggregates. The quarry dust to be investigated was collected from Ndolela quarry site, found at Isimani village in Iringa region Tanzania. The area constitutes plenty of quarry dust lying idle and the soil found in the same area is clay, the soil that is not suitable for construction. First the properties of the quarry dust such as bulk and gross density, fineness modulus and gradation were determined. Thereafter the concrete mix with sand only as fine aggregates (control concrete mix) was prepared and their properties compared with three different concrete mixes containing quarry dust as fine aggregates. The first, second and third mix had sand replaced by 25%, 50% and 75% respectively. The resulting concrete cubes were tested at seven days and twenty-eight days. The concrete cubes with sand replaced with quarry dust by 75% showed excellent results in compressive strength aspect. Both seven day old cubes and twenty-eight day old cubes posted best compressive strength result for 75% sand replacement. Cubes with 25% and 50% sand replacement performed poorly compared to the control mix cubes. The workability of fresh concrete with quarry dust was slightly low compared to the control mix. However, this is does not rule out the quarry dust as fine aggregates; as the results still lied within the desired medium workability range of 30-80mm. From the results of tests on fresh and hardened concrete; it was found that the quarry dust is suitable to be used as fine aggregates in concrete manufacture.

Keywords: *Quarry dust, Fine Aggregate, Concrete, Iringa, Tanzania*

1. Introduction

Concrete is the most widely used construction material in the world, and its popularity can be attributed to two aspects. First, concrete is used for many different structures, such as dams, pavements, building frames, or bridges, much more than any other construction material. Second, the amount of concrete used is much more than any other material. Its worldwide production exceeds that of steel by a factor of 10 in tonnage and by more than a factor of 30 in volume. The applications of concrete in the fields of infrastructure, habitation, and transportation have greatly promoted the development of civilization, economic progress, stability, and quality of life, (Li, 2011). Conventional materials that are used in the concrete manufacture are; the coarse aggregates, fine aggregates, cement and water. Building materials often constitute the single largest input to housing construction in most developing country cities particularly in Africa. It is estimated that the cost of building materials alone can take up to 70 per cent of a standard low-income formal housing unit (Erguden, 2001).

Rising construction costs and the need to reduce environmental degradation through the depletion of aggregate deposits to make construction sustainable, has necessitated research into the use of alternative materials, especially locally available ones which can be used as conventional ones in concrete production. There have been investigations about the use of steel slag, a waste product of blast furnace, in the process of iron extraction used as fine aggregates. The concrete cubes made with the steel slag as fine aggregate were subjected to a number of tests such as Slump test, Compressive strength test, Split tensile strength test and Modulus of rupture tests. After passing those tests, they dared to even recommend for the approval of the material for use in concrete as material for fine aggregates (Kothai & Malathy, 2014). Other investigations on suitable components of concrete apart from conventional one includes; partial replacements of cement with Class-F fly ash, this study was done in India. Richer mix and higher compressive strength has been obtained from the experimented partial replacement of cement with fly ash, (Tensing, 2010).

In Tanzania, a study on alternative components for lightweight concrete was conducted using waste materials as coarse aggregates. The study was conducted in Kilwa and the waste materials used were coconut shell, sisal fibres, and PET plastic due to their abundance in the area. In preparation for mixing, coconut shells were crushed into aggregate no larger than 19mm, sisal fibres were cut into pieces no longer than 9.4mm, and PET plastic was shredded into 6.25mm inch-wide strips no longer than 6 inches. Replicate samples were mixed and then cured for 28 days before they were tested for compressive strength, unit weight, and absorption. The resulting data were compared to ASTM Standards for lightweight concrete masonry units to determine their adequacy. Based on these results, there is potential for coconut shell to be used as coarse aggregate in lightweight concrete. Sisal fiber was unsuccessful in producing the appropriate compressive strength. However, the reduction in spalling of the hardened concrete and the induction of air in the mixes incorporating sisal fiber suggests that it has the potential to improve other characteristics of lightweight concrete. Concrete mixes using PET plastic as aggregate resulted in adequate compressive strengths, but were too dense to be considered 'lightweight' concrete, (Rust, 2014).

According to past research, quarrying of limestone and dolomite typically produces 20-25% fines and sandstone/grit stone up to 35% fines (University of Leeds as cited in (Wilson, 2007)). This means for every 100m^3 of aggregates produced daily; there are 35m^3 of quarry dust produced and will only be left idle. The situation is not unique in Tanzania as with road construction projects which were going on in Iringa-Dodoma road and Iringa-Mbeya road, quarrying sites closes while leaving large quantity of quarry dust unutilized. This is due to the fact that, their aim was to produce coarse aggregates for road construction, leaving quarry dust less or not utilized at all.

In the meantime, there are building construction sites going on in the vicinity of the quarry site and the soil found around the area under the study is clay soil which is unqualified for construction purpose. This situation has prompted a desire to carry out a research on suitability of quarry dust to be used as fine aggregates in concrete. This is because currently, the ability of quarries to sell fines into the construction market is hampered by lack of product specifications. The lack of clear guidance and assurance on its suitability to be incorporated in the concrete manufacture has been the problem. This study will focus on testing the suitability of quarry dust as fine aggregates in the concrete manufacture by identifying an optimal mix proportion between sand and quarry dust in concrete, assessing workability properties of quarry dust as fine aggregates and testing compressive strength properties of concrete containing quarry dust as fine aggregates.

2. Methods and Materials

2.1. Material Preparation and Sample Collection

Prior to subjecting the materials to tests and concrete mix design; each material to be used was prepared on their respective required manner. The samples were selected from well prepared materials.

2.1.1. Quarry Dust

The quarry dust was collected from Ndolela quarry site situated at Ismani village in Iringa region. It was stored in plastic buckets to ease its transportation and brought to Dar es Salaam via a bus. Upon reaching to the city, the quarry dust was transported to the laboratory. In the laboratory, it was air-dried and then sieved to remove materials greater than 4.75mm and those less than 75micron. The purpose was to simulate the properties of sand as the objective of the study is to test its suitability as fine aggregates in concrete.

Figure 1: Particles Less Than 75micron Removed

2.1.2. Sand

The sand was bought from a dealer at River Side, upon inquiry; the dealer said the sand was from Mpiji. The sand was transported in a car to the laboratory in plastic sacks. Since the sand was wet, it was air dried. The sample from dried sand was obtained using a riffle box.

Figure 1: Wet Sand Being Air-Dried

2.1.3. Coarse Aggregates

These were bought from the same dealer where sand was purchased, but unlike sand; the coarse aggregates were from Lugoba. Like sand, the coarse aggregates were air dried upon reaching the laboratory. The dried aggregates were spread into a round shape and then divided into four quarters using a spade. Two opposite quarters were then collected to be used as a sample.

2.1.4. Cement

The cement to be used will be Ordinary Portland Cement (OPC) class 42.5, purchased in their manufacturer's bags.

2.1.5. Water

Portable water wasbeing used in all operation that required water. Such activities include mixing and curing of concrete, densities determination and water absorption test.

2.2. Material Testing

2.2.1. Sieve Analysis

Prior to testing, the materials were sieved so as to assess their gradation properties. The standard sieves used for sand and quarry dust were 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, 0.15mm and 0.075mm. Whereas for coarse aggregates were 35.7mm, 19mm, 9.5mm, 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, 0.15mm and 0.075mm.The sieves were arranged in ascending order with the smallest sieve at the bottom and the largest at the top.

The percentage retained in each sieve was calculated using the ratio between cumulative weights retained in sieve and total weight of a sample. The fineness modulus for quarry dust calculated was 4.01

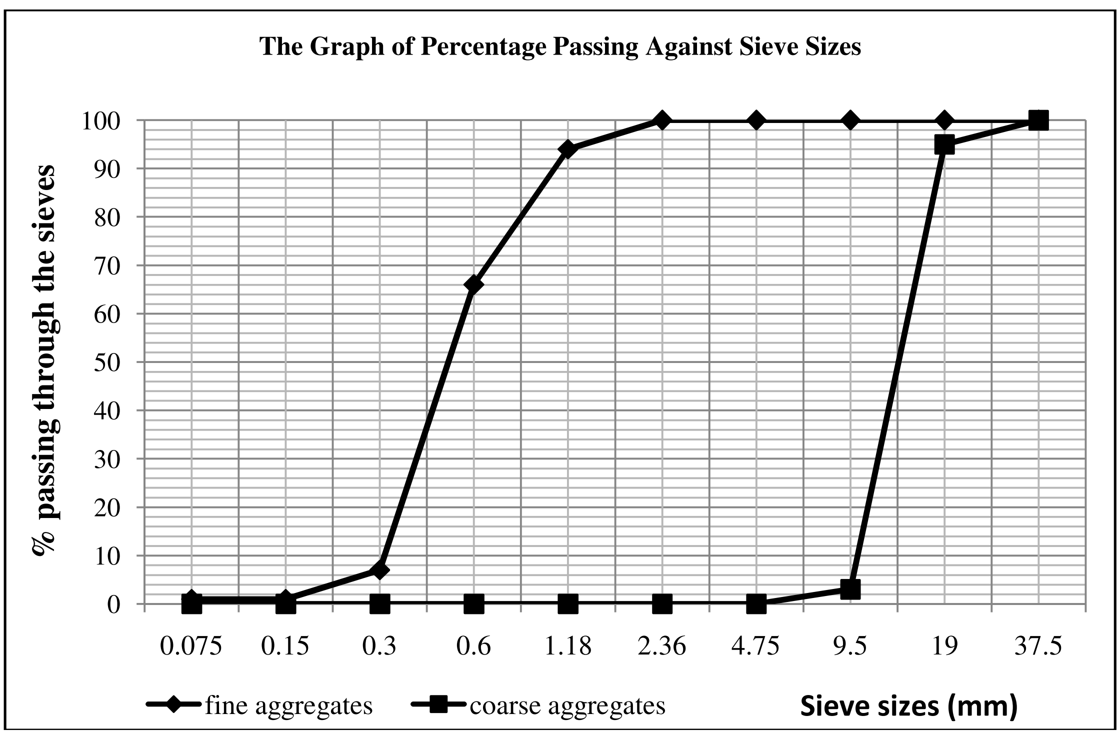

Figure 3: Grading Curve for Fine Aggregates and Coarse Aggregates

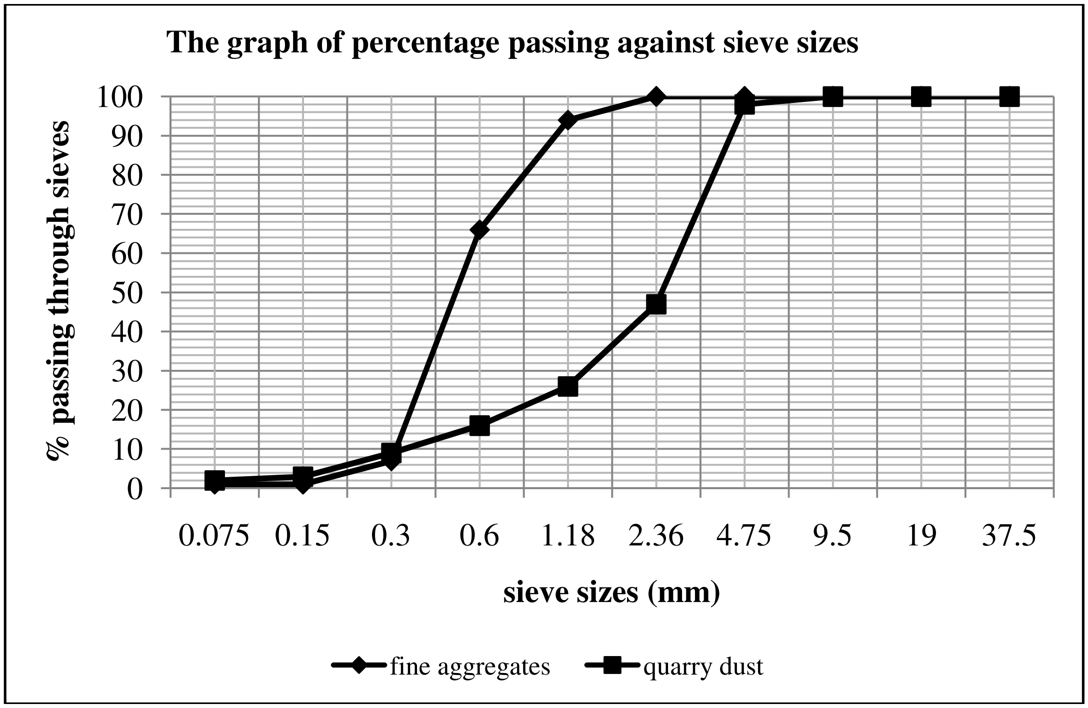

Figure 4: Grading Curve for Fine Aggregates and Quarry Dust

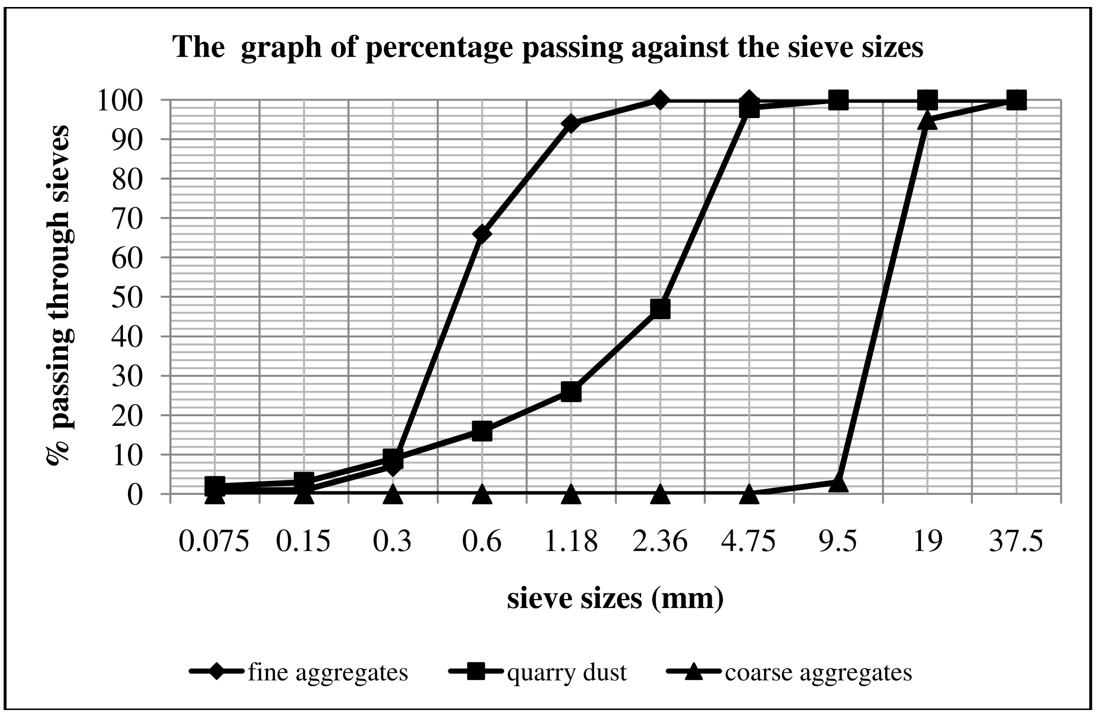

Figure 5: Grading Curve for Fine Aggregates, Quarry Dust and Coarse Aggregates

2.2.2. Determination of Gross density and Bulk density

2.2.2.1. Gross density and Bulk density of Sand

For the bulk density, the sand was filled into a metal container whose weight and volume were known. The sand was filled to the brim, levelled using a metal rod and weighed. For the gross density; water was filled into a measuring cylinder and the volume of water was noted as V_1. The dry sample of sand was weighed and filled into the measuring cylinder. The reading on a cylinder was then taken as V_2. The results were recorded as stipulated in Table 1 and Table 2.

2.2.2.2. Gross density and Bulk density of Coarse Aggregates

Just as it was the case with the sand, the coarse aggregates were filled into a metal container whose weight and volume were known. The aggregates were filled to the brim, levelled using a metal rod and weighed. The data were collected and the bulk density was calculated. For the gross density; water was filled into a measuring cylinder and the volume of water was noted as V_1. The dry sample of coarse aggregates was weighed and filled into the measuring cylinder. The reading on a cylinder was then taken as V_2. The results were recorded as stipulated in Table 1 and Table 2.

2.2.2.3. Gross density and Bulk density of Quarry dust

Similar procedure was used as it was for the case of sand and coarse aggregates. The determination of gross density and bulky density for quarry dust followed similar fashion described above as it was for the sand and coarse aggregates. The results were recorded as stipulated in Table 1 and Table 2.

	Course Aggregates		**Fine Aggregates (Sand)**		**Quarry Dust**	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Mass of an empty container gmsM_1	3122	3122	3122	3122	3122	3122
Mass of a container + dry sand gmsM_2	7658	7635	7500	7510	8091	8058
Mass of dry sand (B-A) g	4536	4513	4378	4388	4969	4936
Volume of container V (cm^3)	3000	3000	3000	3000	3000	3000
Bulk Density$(M_2-M_1)/V$ g/cm^3	1.512	1.5043	1.459	1.463	1.656	1.645
Average Bulk Density g/cm^3	1.508		1.461		1.6505	

Table 1: Summary of Determination of Bulky Density of Course aggregates, fine aggregates and quarry dust

Variable	**Course Aggregates**		**Fine Aggregates (Sand)**		**Quarry Dust**	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Mass of an empty container in grams (M_1)	3122	3122	3122	3122	3122	3122
Mass of a container + Materials in grams (M_2)	3754	3968	3434	3429	3742	3696
Mass of Quarry dust(M_2-M_1) in grams	632	846	312	307	620	574
Volume of container before filling materials in $cm^3(V_1)$	520	390	580	410	515	600
Volume after filling materials in cm^3 (V_2)	745	690	700	530	740	810
Gross Density $(M_2-M_1)/(V_2-V_1)$ in g/cm^3	**2.809**	**2.82**	**2.6**	**2.558**	**2.756**	**2.73**
Average Gross Density in g/cm^3	**2.815**		**2.579**		**2.743**	

Table 2: Summary of Determination of Gross Density of Course aggregates, fine aggregates and quarry dust

2.2.3. Determination of Water absorption

Water absorption for course aggregates was determined using the method listed underneath. Table 3 shows the moisture absorption for course aggregates determined.

- Small sample of Coarse aggregates were weighed;
- Coarse aggregates were soaked into a measuring cylinder filled with water,
- Soaked aggregates are left overnight
- Next day the coarse aggregates are removed from water;
- Aggregates are rubbed with a dry cloth to make them saturated surface dry (SSD)Plate
- Sample was reweighed;
- Moisture absorption determined.

Mass of empty container M_1gms	3122
Mass of container + dry sample M_2gms	3585
Mass of dry sample W (M_1-M_2) gms	463
Mass after soaking overnight M_3	463
Initial reading before soaking dry sample cm^3	560
Initial reading after soaking V2 cm^3	720
Final reading after soaking overnight V3 cm^3	720
Volume of water absorbed V3-V2 cm^3	0
Moisture absorption $\frac{M_3-W}{W}X100$ %	0

Table 3: Moisture Absorption Determination for Coarse Aggregates

2.2.4. Determination of Aggregate Crushing Value

This test was performed so as to determine the crushing strength of the coarse aggregates. The sample of coarse aggregates used was that which passed the 14mm sieve but retained in 10mm sieve. The sample was oven dried at a temperature of 105°C for two hours prior to test. The oven dried sample was cooled to room temperature and then filled in a cylindrical mould in three layers. Each layer was tamped 25 strokes with a 16mm metal rod. After a third layer is compacted a metal plunger was placed on the top of the cylindrical mould. The whole assembly was then placed in the compression testing machine and subjected to a load of 400kN over the gross area of the plunger, the load being increased gradually over a period of 10 minutes.

After releasing the load, the aggregate was removed and sieved in the 2.36 mm sieve. The mass of aggregates retained as well as the mass of the aggregates passing was weighed and recorded, see Table 4. The ratio of the mass of aggregates passing to the total mass removed from the cylindrical mould is the Aggregate Crushing Value (ACV) of the aggregates.The aggregate crushing value test was determined in accordance with British Standard Institution(1990).

	TEST 1	TEST 2
Weight of sample (10-14mm) gms A	3057	2918
Weight retained on 2.36mm sieve gms B	2493	2372
Weight passing on 2.36mm sieve gms C	563	545
Difference A - (B + C) gms	1	1
Aggregate crushing value (C/A) %	18.4	18.7
Average Aggregate Crushing Value (ACV) %	18.55	

Table 4: Test Results for Aggregate Crushing Value

(British Standard Institution, 1990) shows that the ACV starts from 16% to 25%, meaning the higher the ACV, the lower the aggregate strength. Test results showed the ACV of 18%, which was a good indication that the aggregates could be used for structural concrete.

2.2.5. Determination of Aggregate Impact Value

The aim of this test was to determine the resistance of coarse aggregates to failure by impact. The sample of coarse aggregates used was that which passed the 14mm sieve but retained in 10mm sieve. The sample was oven dried for four hours prior to test. The oven dried sample was then filled into a small cylindrical mould in three layers; each layer was tamped with a metal rod 25 times. The mould was then placed into a machine. The impact was then provided by a standard hammer falling 15 times under its own weight upon the aggregates in a cylindrical mould. This results into the fragmentation similar to that produced by the plunger in the crushing value test.After 15 blows, the aggregate was removed and sieved in the 2.36 mm sieve. The mass of aggregates retained as well as the mass of the aggregates passing was weighed and recorded and tabulated in the table, see Table 5. The ratio of the mass of aggregates passing to the total mass removed from the cylindrical mould is the Aggregate Crushing Value of the aggregates.

	TEST 1	TEST 2
Weight of sample (10-14mm) gms A	313	336
Weight retained on 2.36mm sieve gms B	250	268
Weight passing on 2.36mm sieve gms C	63	68
Difference A - (B + C) gms	0	0
Aggregate crushing value (C/A) %	20.1	20.3
Average Aggregate Impact Value (AIV) %	20.2	

Table 5: Test Result for Aggregate Impact Value

(British Standard Institution, 1992) states that aggregates with AIV of 25% and 30% can be used in heavy duty concrete floor finish and pavement wearing surfaces respectively. Now, since the test results were below these values (20.2%), and then the aggregates can be used for structural concrete construction purposes.

2.2.6. Concrete Mix Design

The aim was to produce a concrete of a desired strength of 25N/mm^2 at 28 days. The mix was designed to meet three basic requirements of sufficient compressive strength, sufficient workability, and sufficient density. Concrete constituents were Ordinary Portland Cement, Natural coarse aggregates, Natural fine aggregates, Tape water, and Quarry dust.

Three (3) trial concrete cubes were cast, cured in water for three days and then tested for compressive strength, where the results are stipulated in Table 6. Specifications states that for Ordinary Portland Cement within three days of curing, a cube must have attained 35% of the minimum desired strength. Now, minimum desired strength was 25N/mm^2; so, its 35% is 0.35*25=8.75N/mm^2

Age (days)	Size of a cube (mm)			Cube Weight(g)	Ultimate Load(kN)	Gross density	Compressive Strength (N/mm^2)
	Length	Width	Height				
3	10	10	10	2506	120	2.506	12
3	10	10	10	2436	85	2.436	8.5
3	10	10	10	2403	80	2.403	8

Table 6: Trial Concrete Cubes Results

From the above summary; the average compressive strength is (12+8.5+8)/3 =9.5N/mm^2. The average value is higher than 35% of the desired minimum strength; therefore, the concrete mix design was found to besatisfactory.

2.2.7. Design Quantities of Each Mix Components Materials

This study involved four (4) different concrete mixes namely;

- The first concrete mix with 0% quarry dust and 100% sand (W0); the control mix;
- The second concrete mix with 25% quarry dust and 75% sand (W25);
- The third concrete mix with 50% quarry dust and 50% sand (W50);
- The fourth concrete mix with 75% quarry dust and 25% sand (W75).

Each mix required six (6) cubes for compressive strength test at 7days and 28days. Table 7 presents the proportion of quantities for each concrete mix type.

Concrete Mix type	Number of cubes	Cement (kg)	Fine aggregates		Coarse Aggregates (kg)	Water
			Quarry dust	Sand		
W0	6	3.28	0	5.98	10.19	2
W25	6	3.28	1.495	4.485	10.19	2
W50	6	3.28	2.99	2.99	10.19	2
W75	6	3.28	4.485	1.495	10.19	2
TOTAL	24	13.12	8.97	14.95	40.76	8

Table 7: Quantities for Concrete Mix Type

The method of batching for quantities of materials required was Weight Batching Method except for water that was measured using a measuring cylinder.

2.2.7.1. Mixing

After batching, concrete was mixed using Hand Mixing method. This was because; the quantity to be mixed was low as such Machine mixing would have led to the loss of large portion of the concrete. The concrete was thoroughly mixed to ensure that all ingredients are coated with cement paste and all ingredients form a uniform mass.

2.2.7.2. Casting of Concrete cubes

After mixing, the concrete was cast into 100mm cubes steel moulds. Prior to casting moulds were smeared with oil to ensure the concrete does not stick to them during striking. After casting, moulds were placed on the vibrating table so as to drive out entrapped air.

Figure 6: Fresh Cast, Vibrated Concrete Cubes

2.2.7.3. Curing of Concrete cubes

Concrete remained in their moulds for an overnight period and the next morning moulds were removed. The aim was for cubes to gain the shape as well as developing early strength. Concrete cubes were cured in water for their respective desired time of 3days, 7days and 28 days respectively.

2.2.8. Testing Concrete Properties

Concrete was tested while fresh and in the hardened state. Equipments used for testing of fresh concrete properties were; a slump cone with a top diameter of 100mm, bottom diameter of 200mm and height of 300mm; a metal rod with hemispherical tip for stroking; and a ruler. For hardened concrete, the Compression Machine was used.

2.2.8.1. Measurement with Fresh Concrete

Immediately after mixing the concrete was tested for workability properties. The test was carried out for each type of concrete mix, W0, W25, W50 and W75. The slump cone was filled in three layers of approximate volume. Each layer receiving twenty-five (25) strokes of a metal rod with a hemispherical end. After compaction, the cone was lifted slowly and set aside leaving an unsupported concrete. The difference in levels between the height of the mould and the highest point of the unsupported concrete was recorded. The results were as tabulated in the Table 8. The slump goal was 30-80mm, which is the slump for medium workability.

Concrete Mix	**Targeted Workability**	**Fine Aggregates content (%)**		**Slump mm**
		Sand	Quarry Dust	
W0	Medium	100	0	70
W25	Medium	75	25	60
W50	Medium	50	50	55
W75	Medium	25	75	40

Table 8: Summary for the Results of Fresh Concrete Test

2.2.8.2. Measurement with Hardened Concrete

After 7 days and 28 days of curing in water, three (3) samples of each mix type were subjected to compressive strength test. Before testing, the cubes were left in air for half hour so as to wipe off surface water. The samples were weighed and their dimensions recorded. The cubes were put under compression machine and loaded gradually until ultimate load was attained, see Figure 7 & 8

Figure 7: Concrete Cube Loading

Figure 8: Concrete Cube Immediately After Failure

3. Discussion of Results

In the course of carrying out this study, a number of methods and tests were carried out which provided the basis to discussion of results. The following findings were deduced:

3.1. Properties of Quarry dust

Quarry dust has shown the following properties that qualifies it to be used as fine aggregates

<u>3.1.1. Size</u>

From the sieve analysis, the maximum particle size, *D* was 4 mm while the minimum, *d* was 0.075mm. Now *D/d* gives us 53.33; Clause 4.2 of BS EN 12620 states that aggregates can only be declared as fine aggregates if the ratio D/d is greater to 1.4, which has been the case for the quarry dust.

3.1.2. Grading

Figure 10 shows the grading curve for quarry dust, and Figure 9 shows the graph extracted from BS EN 12620 which recommends the region in which coarse and fine aggregates should fall. From comparison between the two figures above; it can be confidently stated that quarry dust approximately falls within the recommended region for fine aggregates.

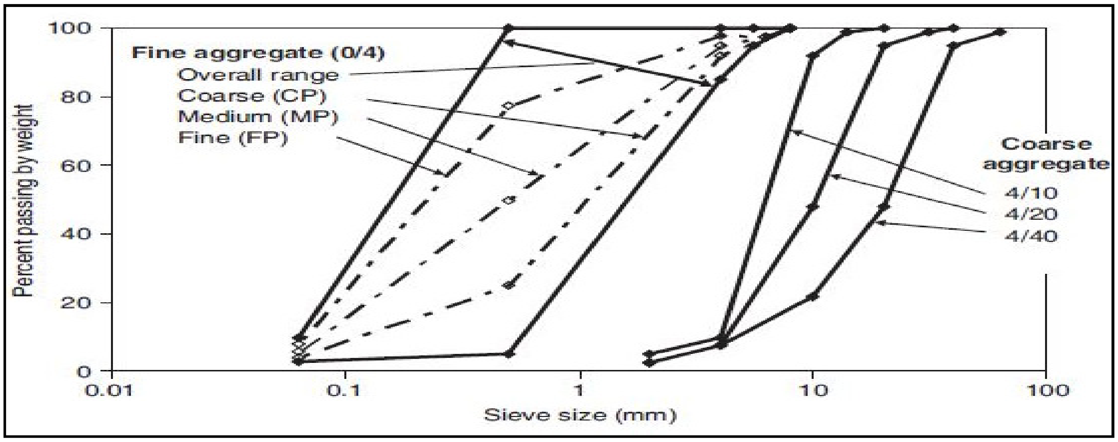

Figure 9: Grading of Aggregates at Mid-Range (SOURCE: BS EN 12620: BSI 2002)

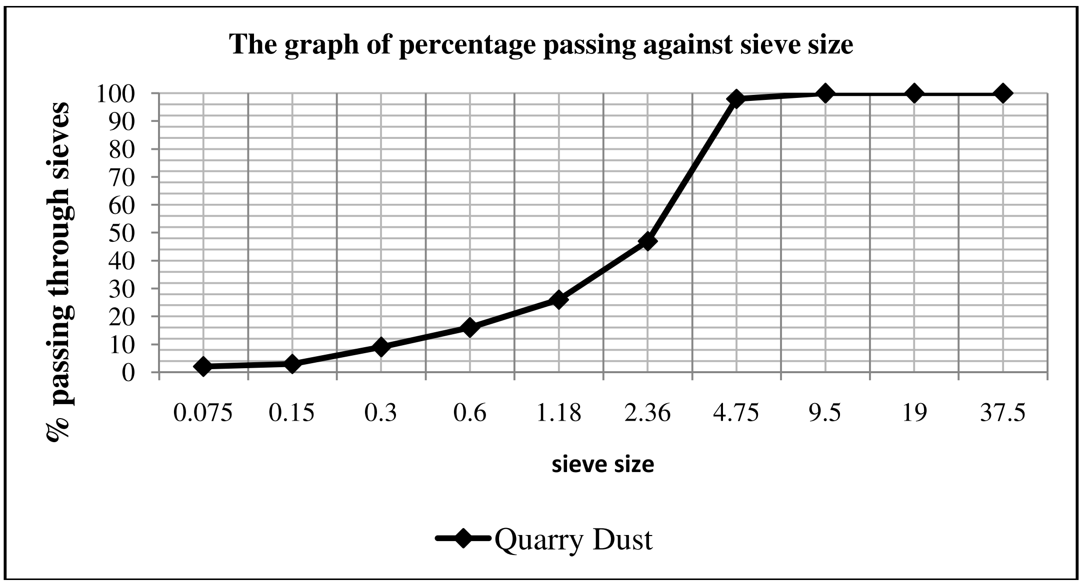

Figure 10: Grading Curve for Quarry Dust

3.1.3. Fineness Modulus

The higher the fineness modulus value the coarser the material and hence the higher the cement paste requirement. Now, for our case the value was 4.01, which was slightly higher than the upper limit of 3.3 for sand. This implied that with quarry dust the cement requirement is minimized.

3.1.4. Physical Properties

The bulk density and gross density of quarry dust are 1.65g/cm^3 and 2.743g/cm^3 respectively; approximately equal those of sand. Meaning it is suitable for the use in normal weight concrete.

3.2. Effect of Quarry Dust on Compressive Strength

From data presented in Table 10 showing compression test results after 28 day; it was deduced that the introduction of 25% of quarry dust as fine aggregate caused a drop of 7 N/mm^2 by strength when compared to the control mix (W0). The strength was lowered further by 11.66 N/mm^{2}of compressive strength to 34.33N/mm^2 when sand was replaced by 50% of quarry dust. However, there was a remarkable increase in compressive strength when 75% of sand was now replaced with quarry dust. The strength increased to 35N/mm^2,0.67N/mm^2 higher compared to the control mix (W0). The results from 7 days' concrete cubes followed similar trend, as presented in Table 9

Concrete mix	Age	Size of cubes			Weight	Gross density	Ultimate load	Compressive strength
		length	width	height				
	days	*mm*	*mm*	*mm*	*g*	*g/cm³*	*kN*	*N/mm²*
W0	7	100	100	100	2491	2.491	190	19
	7	100	100	100	2509	2.509	200	20
	7	100	100	100	2518	2.518	200	20
Average values					**2506**	**2.506**	**197**	**19.7**
W25	7	100	100	100	2555	2.555	185	18.5
	7	100	100	100	2533	2.533	160	16
	7	100	100	100	2552	2.552	172.5	17.25
Average values					**2547**	**2.547**	**172.5**	**17.25**
W50	7	100	100	100	2528	2.528	175	17.5
	7	100	100	100	2477	2.477	160	16
	7	100	100	100	2337	2.337	145	14.5
Average values					**2447**	**2.447**	**160**	**16**
W75	7	100	100	100	2486	2.486	265	26.5
	7	100	100	100	2493	2.493	225	22.5
	7	100	100	100	2501	2.501	225	22.5
Average values					**2493.33**	**2.4933**	**238.3**	**23.83**

Table 9: Results for Compressive Strength Test for Seven Days Concrete Cubes

Concrete mix	Age	Size of cubes			Weight	Gross density	Ultimate load	Compressive strength
		length	width	height				
	days	*mm*	*mm*	*mm*	*g*	*g/cm³*	*kN*	*N/mm²*
WO	28	100	100	100	2511	2.511	420	42
	28	100	100	100	2496	2.496	290	29
	28	100	100	100	2501	2.501	320	32
Average values					**2502.67**	**2.503**	**343.3**	**34.33**
W25	28	100	100	100	2496	2.496	280	28
	28	100	100	100	2489	2.489	280	28
	28	100	100	100	2516	2.516	260	26
Average values					**2500.33**	**2.5**	**273.33**	**27.33**
W50	28	100	100	100	2301	2.301	200	20
	28	100	100	100	2483	2.483	240	24
	28	100	100	100	2482	2.482	240	24
Average values					**2422**	**2.422**	**226.7**	**22.67**
W75	28	100	100	100	2409	2.409	270	27
	28	100	100	100	2518	2.518	360	36
	28	100	100	100	2540	2.54	420	42
Average values					**2489**	**2.489**	**350**	**35**

Table 10: Results for compressive strength test for twenty-eight days concrete Cubes

3.3. Effects of Quarry Dust on Workability

Test results have shown that, the workability/fluidity of the concrete is decreasing when the replacement percentage of the quarry dust is increasing gradually. This also showed that quarry dust has slightly higher water absorption properties. The reduction in flowability is not detrimental as the slump falls were still within the limits of medium workability of 30-80mm.

4. Conclusion

On the basis of the physical properties; it was found that the bulk and gross densities of quarry dust are approximately equal to those of the river sand, though quarry dust densities were slightly higher. Most particle size of quarry dust are coarser relative to those of the river sand. For the case of 7 days old concrete cubes, the optimal mix proportion between sand and quarry dust lies between 50% and 75%. The replacement of sand by bigger portion to 50% yielded better strength than the control mix. It can be deduced that, the optimal mix proportion can be achieved when the sand is replaced by more than 50%.

The compressive strength for mix type W0, W25, W50 and W75 were19.7 N/mm^2, 17.25 N/mm^2, 16 N/mm^2 and 23.83 N/mm^2 respectively for 7 days' concrete cubes tested. W25 and W50 mix type yielded lower strength than the control mix W0. Only W75 registering better result than the control mix W0.The compressive strength for mix type W0, W25, W50 and W75 were 34.33N/mm^2,27.33 N/mm^2, 22.67 N/mm^2 and 35 N/mm^2 respectively for 28 days' concrete cubes tested. W25 and W50 mix type yielded lower strength than the control mix W0. Only W75 registered better result than the control mix W0 as it was the case for 7 days' results. The introduction of quarry dust lowered the workability. This can be owed to their coarser nature and the rough texture that limits their ability to flow in the mix.

5. Recommendations

From the results gathered on this study it can be recommended to use quarry dust as fine aggregates in concrete manufacture. The recommendation is not limited to the quarry dust from my case study area only, but also from other quarries; though some properties of the quarry dust may vary due to the nature of the parent rock used. The engineering, economic and environmental issues are among things that should be given a serious consideration.

Now, this study which has showed that the replacement of sand by a percentage greater to 50% yields optimal result, it is then recommended further study on partial replacement of sand by quarry dust in concrete production by considering other properties that requires further probing such as modulus of elasticity, creep, permeability, flexural and split tensile strength among other properties of concrete. These areas need advanced investigation so as to be sure that the quarry dust is a perfect substitute for river sand.

6. References

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