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Comparative Analysis of Compressive Strength of Concrete Made With River Sharp Sand and Quarry Dust At: 0, 30, 50, 70 And 100% Replacements.

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ABSTRACT: *Abuja, the federal capital city of Nigeria has witnessed a sustained boom in construction activities in the past twenty five (25 years) with concrete and sandcrete blocks being the most common materials in use. As a result of this, the demand for sharp sand skyrocketed, which also pushed up the cost of the material. The need to source for alternative fine aggregate became apparent, hence the utilization of quarry dust either as a substitute or as partial replacement for river sharp sand as fine aggregate in concrete. The methodology used was the inductive method where the constituent materials were obtained and taken to the Laboratory of Building Department of Federal University of Technology, Minna for preparation and casting of Concrete cubes which were cured and crushed at various ages. Results showed that 50% replacement gave the best compressive strength at 28 days which was 30.73N/mm^2. This result is 8.2% above the control which posted 28.21N/mm^2 at 28 days. 100% replacement also gave 27.4N/mm^2 which is just 2.87% below the control. For a concrete grade of 20, it can be concluded that 50% and 100% replacements of sand with quarry dust can effectively be used. The study recommends that where river sharp sand is not available or its supply is inadequate, it can effectively be substituted with 50% or 100% quarry dust as fine aggregate in structural concrete and quality of material will not be compromised.*

KEY WORDS: *Quarry dust, Replacement, River Sharp Sand, Concrete.*

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I. INTRODUCTION:

Concrete is a mixture of cement (binder) with inert materials (aggregates) which are sand and gravel or chippings. (Shetty, 2005).

The aggregates amount to about three – quarter of the volume of normal weight of concrete and they are cheaper than cement and provide a considerable better durability in concrete than the ordinary cement paste (Neville, 2011).

Increase in construction activities in Abuja metropolis has made the demand for sharp sand to sky rocket, thereby causing the shortage of the material and also a significant increase in its cost. Particularly during the rains, river sharp sand is usually very difficult to come by. The need to source for alternative materials for the replacement of sharp sand (fine aggregate) has become imperative. Fine aggregate are sizes not larger than 5mm, while the coarse aggregates are sizes of at least 5mm and above (Neville, 2011

As a result of the difficulty in obtaining sharp sand with its attendant high cost, attention has shifted to the use of quarry dust as replacement for sharp sand as fine aggregate in concrete and mortar.

Quarry dust is a byproduct of the crushing process which is a concentrated material to use as fine aggregates for concreting purposes (Shyam and Hanumantha, 2016).

Biswaprakash and Mahendra (2018) posits that quarry dust is the residue of particles in the size range of 0 – 4.75mm obtained as a byproduct in the later stages of crushing of igneous rock, sedimentary rock or gravel. It is produced in natural stone processing plants. It is currently used in road highway construction as a surface finishing material. It is also used in manufacture of hollow blocks and light weight concrete blocks.

Arulraj et al., (2013) asserts that fine aggregate which is material with aggregate size not larger than 5mm is an essential component of concrete and that the most commonly used is the natural river sand with its global consumption very high due to its extensive use in concrete.

Anzar (2015) also agreed that the most commonly used fine aggregate is sand derived from river banks. River sand has been the most popular choice for the fine aggregate component of concrete in the past, but over use of the material has led to environmental concerns and also an increase in its cost. This has led to the search for an alternative fine aggregate.

Jimoh and Awe (2007) gave that properties of aggregates affect concrete strength and these properties include: size, surface, texture, types, etc. To buttress this, Shetty (2005) posits that angular and rough aggregate particles increase internal friction in concrete. Shetty (2005) added that the internal friction increases concrete strength while voids lead to decrease in strength. This is a simple indication that aggregates types and sizes influence the strength of concrete significantly. Jimoh and Awe (2007) concluded after their work that the use of combination of quarry dust and granite aggregates in concrete produced higher strength than concrete containing sand and gravel. For a combination of artificial and natural aggregates, the concrete having sand and granite is stronger than the corresponding one with quarry dust and gravel. Also, as sizes of coarse aggregate increases, concrete strength decreases whether the aggregate is natural or artificial. The rate of decrease in strength with change in aggregate size is highest in concrete with quarry dust and granite and lowest in concrete having combination of sand and gravel.

Joseph, et al (2012) worked on compressive strength of concrete using lateritic sand and quarry dust as fine aggregate and concluded that the combination of laterite and quarry dust to replace the conventional river sand in the production of concrete for the construction industry in Nigeria and other tropical countries of the World results in structures with reasonable structural characteristics and should be encouraged where there is comparative cost advantage.

There is also the problem of river sharp sand coming with excessive silt and is usually not graded properly, but quarry dust does not possess any silt in it and can be produced to meet desired gradation and fineness. The only challenge with the dust is that, it is a by - product and is sometimes too fine.

Oyekan and Kamiyo (2008) replaced sharp sand with granite fines between 5% and 30% in the production of blocks and the results indicated that the inclusion of granite fines in the sand and cement mixture gave a very significant effect on the compressive strength of the blocks. The best compressive strength value was obtained at 15% granite fine content in the mixture.

Sahul and sekar (2009) studied the use of quarry rock dust and marble sludge powder as possible substitutes for natural sand in concrete and found out that the compressive and split tensile strength and the durability of the concrete were good when the fine aggregate was replaced with 50% marble sludge powder and 50% quarry rock dust and the resistance of concrete to sulphate attack was enhanced greatly.
This study aims at determining a suitable mix proportion for the combination of river sharp sand and granite dust using compressive strength as the measuring tool. In view of this, trial replacements are carried out at: 0%, 30%, 50%, 70% and 100%.

Method:

The study carried out experiment on concrete with 100% river sharp sand as the control, then replaced sand with quarry dust at the following percentages: 30%, 50%, 70% and 100%. Each of these combinations were mixed with a uniform 20mm coarse aggregate and added to cement (Dangote cement grade 42.5) and mixed with 0.6% water. The mix ratio was the 1:2:4 concrete mix for the preparation of the concrete cubes. The cubes were cured by immersion and crushed at 3, 7, 14 and 28 days and the result was recorded.

Materials:

The materials used for this experiment include:

River Sharp Sand:

This was obtained from tipper drivers who get the material from rivers and water beds within and around Abuja city. This particular sharp sand was obtained from usuma dam area of FCT. It was obtained in its natural state and used unwashed
The specific gravity of the sand was found to be 2.55

Quarry Dust:

The material was obtained from a quarry at Deidei village off Zuba – Kubwa express way. It was purchased directly from the quarry operators who sale the material in cubic meters or in tons which was measured from the hip on their site.
The specific gravity of the quarry dust was found to be 2.50

Chippings (Coarse Aggregate):

This material was also obtained from the same quarry site with the stone dust at Deidei village off Zuba – Kubwa express way. It was equally purchased directly from the quarry operators who sale the material in cubic meters or in tons.
The specific gravity of the coarse aggregate was found to be 2.71

Cement:
The Dangote 42.5R was used for the experiment. It was obtained from the local dealers who sale the material around. Care was taken to ensure that the material was of a recent supply so that quality was not compromised.

Water:
Normal domestic pipe borne water was used for both the mix and also for the curing of the cubes. The water had no impurities and so suitable for the experiment.

Preparation of the Specimen:
The concrete was batched by weighing the different material constituents based on the mix ratio of 1:2:4. The materials were thoroughly mixed before adding the required quantity of water which was 0.6 of water/ cement ratio. The fresh concrete mix was filled into the moulds of 100mm x 100mm in layers of 50mm and tapped with the compacting rod 35 times as required. The concrete was then trowelled off to smoothen the surface. It was then covered with soaked sack for 24 hours after which it was demoulded and immersed in water for curing. The total number of cubes casted was 80 (eighty).
Crushing of the cured cubes was carried out after 3 days, 7 days, 14 days and 28 days using the compressive strength testing machine.
The highest load at which the cube is crushed is recorded and used to compute the compressive strength which is ratio of the highest load to the cross sectional area of the sample expressed in N/mm^2.

II. RESULTS:

Results of the compressive strength of the cubes are recorded according to the various percentage replacements:

Table 1.1 Compressive Strength at 0% Replacement (Control)

S/No	Age (days)	Compressive strength (N/mm^2)
1	3	7.32
2	7	13.28
3	14	20.33
4	28	28.21

Source: Researcher's Laboratory work 2019

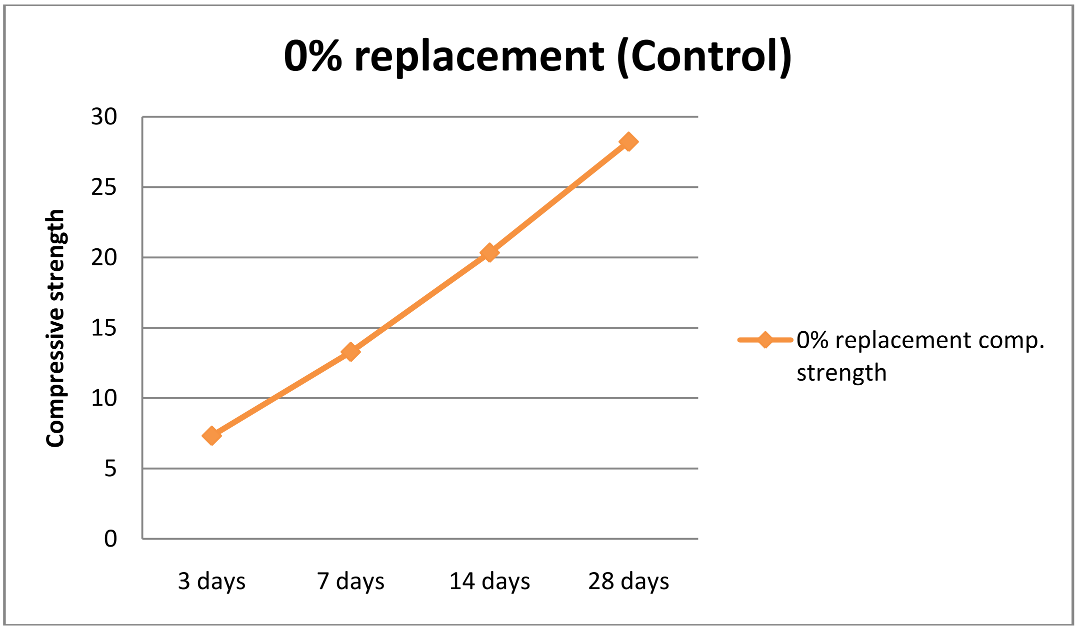

Figure 1:Graph of 0% Replacement.
Source: Researcher's Laboratory work 2019.

The graph in figure 1 explains the result of the compressive strength given in table 1.1. The graph shows a continues steady rise in compressive strength with age. The graph shows that the more the days the more the strength of the material.

Table 1.2 Compressive Strength at 30% Replacement

S/No	Age (days)	Compressive strength (N/mm^2)
1	3	7.94
2	7	19.79
3	14	20.50
4	28	21.28

Source: Researcher's Laboratory work 2019

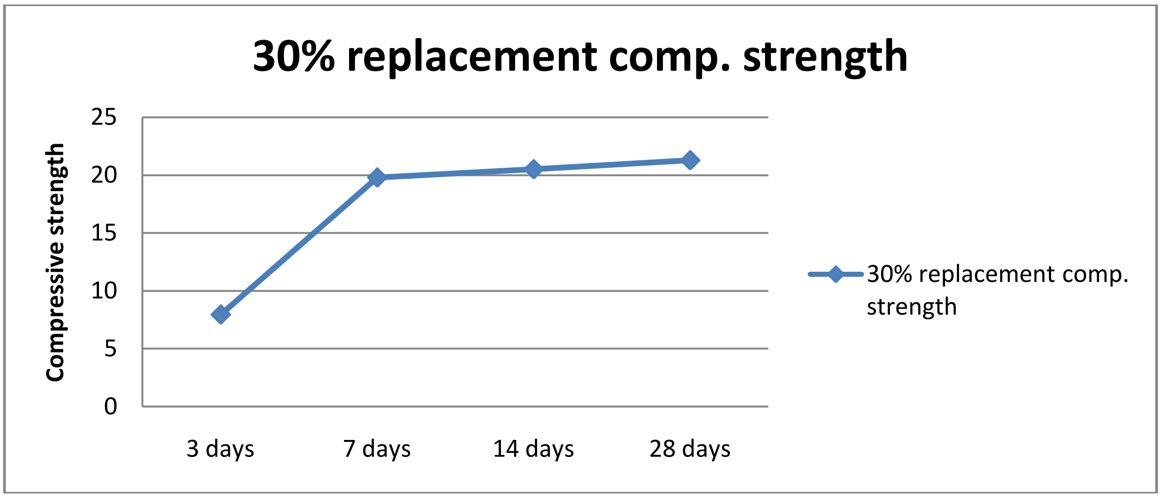

Figure 2 Graph of 30% Replacement
Source: Researcher's laboratory work 2019

The graph in figure 2 gives the result of the compressive strength in table 1.2. The graph shows that there is a sharp rise in early strength and after 7 days, the strength development became extremely slow up to 28 days.

Table 1.3 Compressive Strength at 50% Replacement

S/No	Age (days)	Compressive strength (N/mm^2)
1	3	8.87
2	7	19.83
3	14	23.40
4	28	30.73

Source: Researcher's Laboratory work 2019

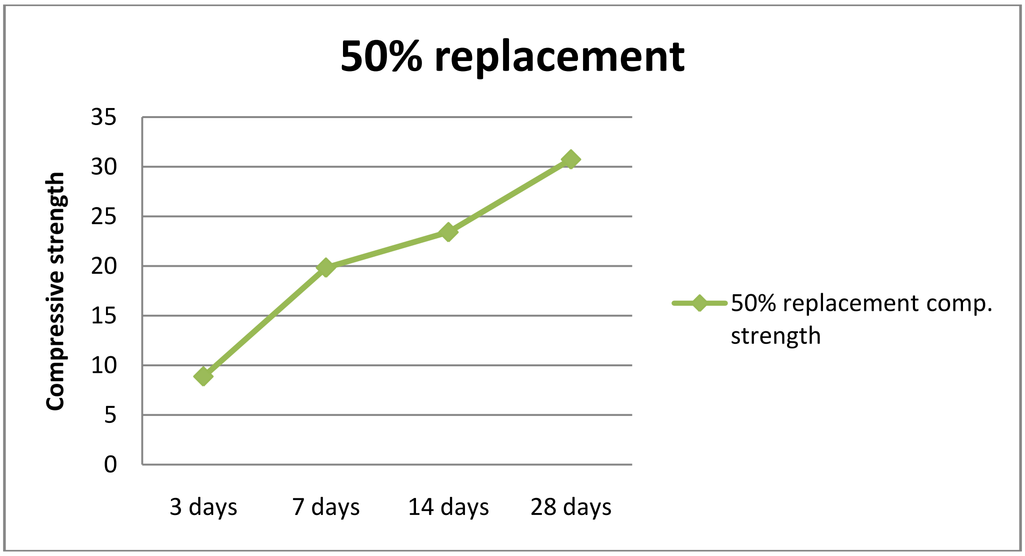

Figure 3: Graph of 50% Replacement
Source: Researcher's Laboratory work 2019

The graph in figure 3 gives the result of the compressive strength in table 1.3. The graph shows a sharp rise in early strength up to 7 days, then a slower strength development up to 14 days, after which a sharp rise from 14 days up to 28 days.

Table 1.4 Compressive Strength at 70% Replacement

S/No	Age (days)	Compressive strength (N/mm^2)
1	3	7.06
2	7	19.33
3	14	17.95
4	28	17.15

Source: Researcher's Laboratory work 2019

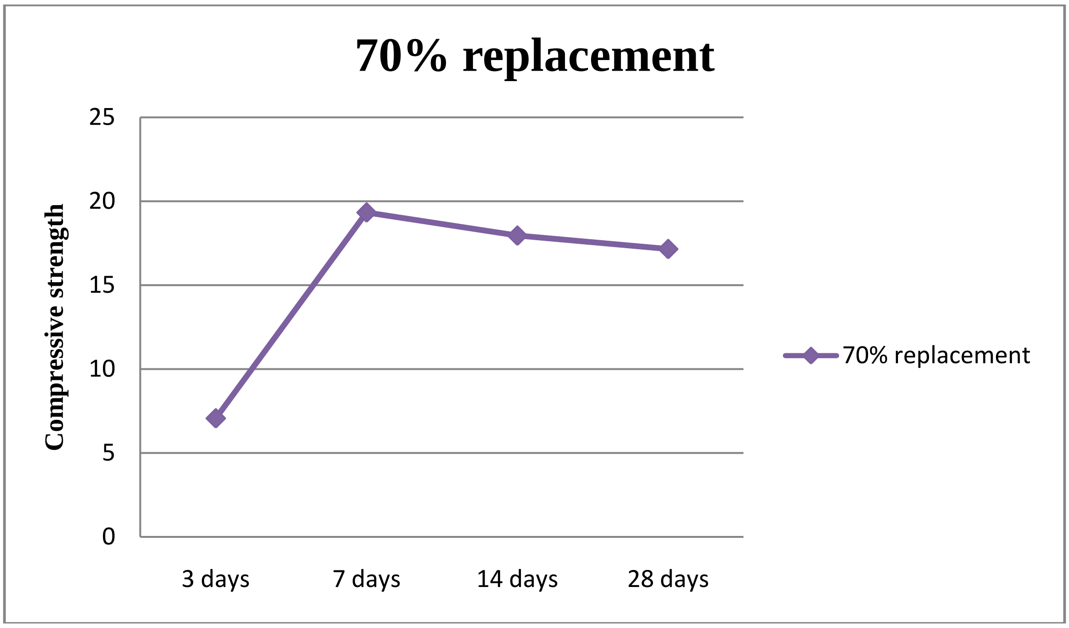

Figure 4: Graph of 70% Replacement
Source: Researcher's Laboratory work 2019

The graph in figure 4 further explains the result of the compressive strength given in table 1.4, where there is a sharp rise in compressive strength which peaked at 7 days, but began to drop steadily up to 28 days giving the worst compressive strength of all the replacement percentages.

Tabe 1.5 Compressive Strength at 100% Replacement

S/No	Age (days)	Compressive strength (N/mm^2)
1	3	7.01
2	7	12.54
3	14	15.23
4	28	27.40

Source: Researcher's Laboratory work 2019

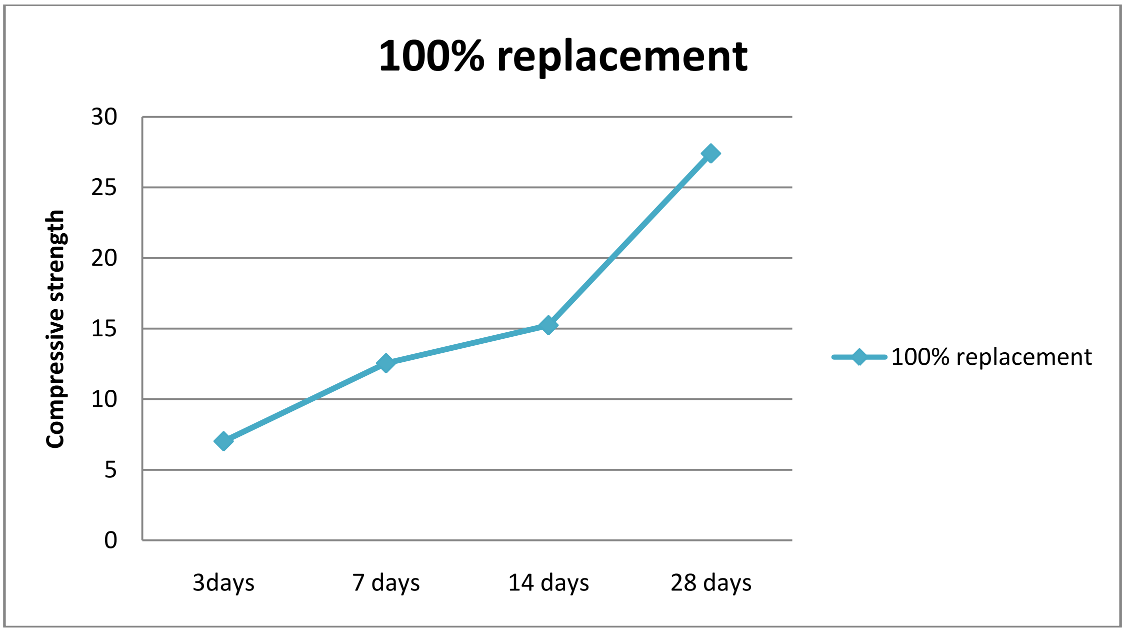

Figure 5: Graph of 100% Replacement
Source: Researcher's Laboratory work 2019

Figure 5 gives the graph of the result of the compressive strength presented in table 1.5. The graph shows that the early strength rose slowly up to 7 days and it further slowed down upto 14 days, but rose sharply from 14 days up to 28 days.

Table 1.6 Combine Table Of All Replacement Percentages Compared With The Control

% replacement	3 Days	7 Days	14 Days	28 Days
0	7.32	13.28	20.33	28.21
30	7.94	19.79	20.5	21.28
50	8.87	19.83	23.4	30.73
70	7.06	19.33	17.95	17.15
100	7.01	12.54	15.23	27.4

Source: Researcher's Laboratory work 2019

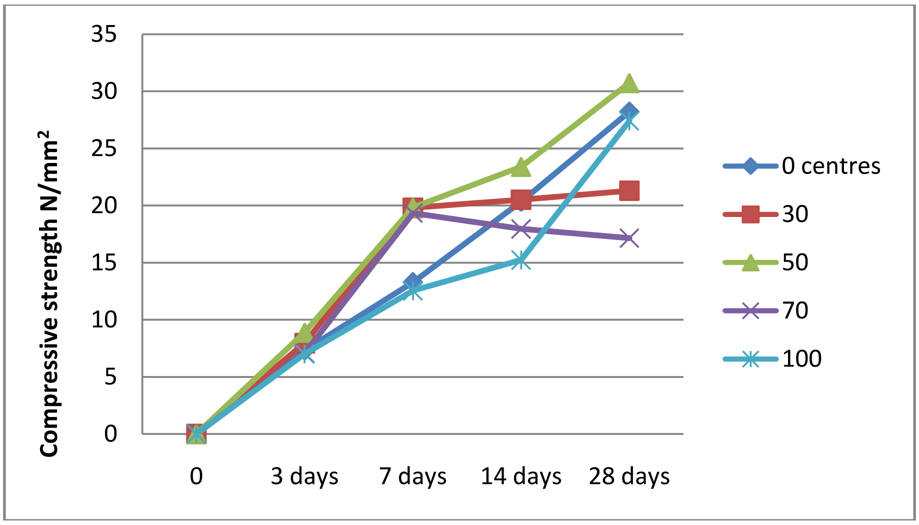

Figure 6: Combined Graph of All Percentage Replacements Source: Researcher's lab work 2019

Analysis of results

From the results, it can be seen that:-

1. At 3 days of age, 50% replacement had the best compressive strength result of 8.87 N/mm^2.

2. At 7 days of age, 50% and 30% replacement still gave the best compressive strength results which were 19.83 and 19.97N/mm^2 respectively. The lowest strength at 7 days was given by 100% replacement with 12.54N/mm^2.
3. At 14 days of age, 50% replacement still gave the highest compressive strength of 23.4Nmm^2 while 30% replacement gave 20.50N/mm^2. The lowest compressive strength was given by 100% replacement which stood at 15.23N/mm^2.
4. At 28 days of age, 50% replacement posted the best compressive strength of 30.73N/mm^2 which was closely followed by 0% replacement (the control) with a compressive strength of 28.21N/mm^2. This was also followed closely by 100% replacement which gave a compressive strength of 27.4N/mm^2. The lowest or poorly performed combination at 28 days was 70% replacement which gave 17.15N/mm^2 followed by 30% with 21.28N/mm^2.

From the results, if 50% replacement can be obtained or achieved, it is highly recommended for structural concrete; going by the early strength results and also the final results for full strength development.

Where quarry dust is unavailable or expensive, river sharp sand should be used for structural concrete – as its compressive strength was found to be good at 28.21N/mm^2 at 28 days.

Quarry dust alone as fine aggregate also gave a result of 27.4N/mm^2 at 28 days.

In essence, which ever material is found to be available or has a reasonable cost benefit compared to the other, it can be used for structural concrete.

Based on these results, the basis for consideration should be availability and the cost benefit. However, where better strength is the focus, 50% replacement of river sharp sand with quarry dust should be utilized.

From the results, it can also be seen that quarry dust alone gave the slowest early strength development up to 7 days of strength with the 3 and 7 days age of the concrete posting the lowest figures of 7.01N/mm^2 and 12.54N/mm^2.

Fastest early strength development was posted by 50% and 30% replacements with 3 and 7 days results showing 8.87 and 7.94N/mm^2 and 19.83 and 19.79N/mm^2 respectively.

III. CONCLUSION

This study concludes that a combination of river sharp sand and quarry dust at 50% each is a good material for fine aggregate in structural concrete. This combination should also be encouraged for sand crete block moulding as both materials complement one another.

IV. RECOMMENDATIONS

This study recommends that, in a situation where river sharp sand is unavailable or inadequate in supply, quarry dust can be used to either replace the sand at 50% or at 100% and quality of concrete will not be compromised.

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