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# AGGREGATES TYPES ON PROPERTIES OF CONCRETE

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## ABSTRACT

This study revealed the substitute for conventional materials used in the production of concrete. It involves the use of various aggregates like laterite and quarry dust to replace conventional river sand fine aggregate. The full replacement of granite as coarse aggregate in concrete with less utilized local materials like bush gravel and limestone was employed. Samples of concrete cubes were made using replacement cements of laterite and quarry dust and samples of cubes made by using limestone and gravel instead of granite. The quality of laterite and quarry dust as replacement varied from 0%, 25%, 50%, and 75%, 0% being the control; while granite was fully replaced to ascertain qualities of concrete using a whole new material. A total of 68 cubes of standard 150 mm x 150mm x 150mm were cast from the various batches and cured in a water tank at ambient temperature. The samples were cured for specified periods of 3 days, 7 days, 14 days and 28days Workability test (slump test) was carried out to determine optimum water content noted at 0.5 water/cement ratio for strength. It was observed that the weight of the specimen decreased as the percentage of replacement for both laterite and quarry dust increased. Bulk density of concrete reduced as replacement percentage for sand increased; for coarse aggregates gravel gave the highest value of 2479kg/m$^3$. Compressive strength test and flexural test were carried out for the samples (cubes and beams respectively), and it was observed that compressive strength for all sample batches increased as curing age increased. Furthermore, observations showed for both laterite and quarry dust replacement that compressive strength increased as percentage replacement increased up to 25%. Thereafter, it decreased. Limestone gave a better strength overall than granite and gravel as full replacement of coarse aggregate with a value of 14.47N/m$m^2$.

**Keywords:-** *Comparative Analysis Effects various Aggregates Properties Concrete*

## INTRODUCTION

In recent times, studies have been carried out to determine the usefulness of laterite, excess quarry dust mined from aggregates and other relatively abundant mineral materials in various countries of the world, and other abundant man-made by products similar in physical properties to such abundant element suchas construction waste like crushed sand-Crete blocks and other materials of abundance in the country. Furthermore, Nigeria is a country in the tropics where its climate ranges from semi-arid in the north to humid in the south (Adewumi, 2019). Soils such as laterite are abundant in Nigeria, and are being utilized heavily in Nigerian construction industry(Yaragal *et al*.,2019). Laterite has its use in almost all aspect of civil, Laterite was used extensively in the construction of embankments for roads and earth dams as indicated by (Makasa, 2004). Also, with the high level of waste generated, countries have put up policies to reduce waste generated with recycling and reuse of these waste materials. A lot of waste is generated in construction process or in the remodeling or demolition of structures. In this sense, reuse of construction waste is paramount for both the environment and also as an aid to reduce cost of constituents used for concrete production.

The aim of this paper is to create awareness of the usefulness of abundant materials and even materials termed '**wastes**' and impact of aggregates on the properties of concrete, the use of other un-popular coarse aggregate and even the mix ratios of these mineral combinations and to compare the values gotten from using various aggregates to a control, re-evaluate from previous publications the optimum percentage of these supplementary materials, re-analyze their effects on concrete and finally compare these fine aggregate materials using other standard coarse aggregates usually employed in Nigeria.

## MATERIALS AND METHODS

The materials used in this in this study are water, fine aggregate and quarry dust. The samples of concrete cubes were made by weighing the materials with standard. Equipment in the laboratory, and the curing of those cubes inside water tanks was carried out for all the cubes. A specific number of Tests were carried out, with results were later analysed.

## Test on Fine aggregates

Sieve analysis and physical properties

The study, as one of the main objectives, was to determine the physical and mechanical properties of all fine and coarse aggregates to be used in course of experimentation. The results are shown below in the tables. The table shows the sieve analysis of the fine aggregates used, which included the conventional sand and laterite, and also the result as well for the coarse materials. The results from the graph plotted revealed the fines are well graded

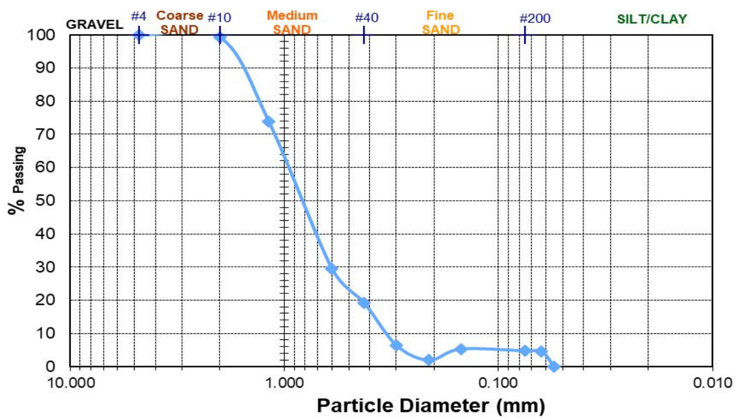


Figure 4.1: sieve analysis for fine aggregate (sand)

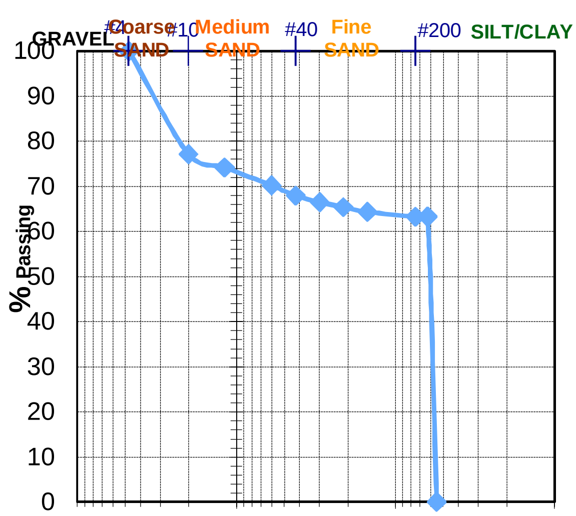


Figure 4.2: sieve analysis for fine aggregate (laterite)

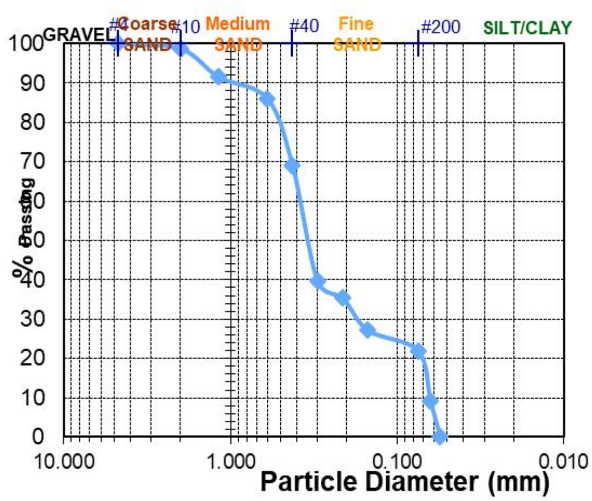


Figure 4.3: sieve analysis for quarry dust

The figure above showed the grading curve obtained for the fine aggregates. The result of particle size of fine aggregates used include: sand which ranged from 0.055 to 2mm with a specific gravity of 2.62 highlighted in the table- in appendix. Uniformity coefficient of sand was found to be 3.06 and coefficient of curvature 1.02, and sand is can be said to be well graded with particles passing the 4.75m sieve and retained on 75µ sieve. Quarry dust gave a fineness modulus of 2.92 with the sieve analysis and other properties tabulated below.

Table 4.1: Specific gravity and water absorption

| ` | Limestone | Granite/CA | FA | Laterite | Stone dust | Gravel |
|---|---|---|---|---|---|---|
| Mass Of Bottle + sample +Water (M3) | 524.5 | 534 | 90 | 83.5 | 78 | 1097 |
| Mass Of Bottle + sample (M2) | 275 | 271.5 | 46.5 | 36.5 | 30.5 | 453.5 |
| Mass Of Bottle Full Of Water Only (M4) | 421 | 427 | 73 | ` | 73 | 767.5 |
| Mass Of Bottle (M1) | 103 | 105.5 | 19 | 19.5 | 20 | 35.5 |
| Mass Of Water Used (M3-M2) | 249.5 | 262.5 | 43.5 | 47 | 47.5 | 643.5 |
| Mass Of sample Used (M2-M1) | 172 | 166 | 27.5 | 17 | 10.5 | 418 |
| Volume Of sample (M4-M1)-(M3-M2) | 68.5 | 59 | 10.5 | 12.5 | 5.5 | 88.5 |
| Gs=(M2-M1)/(M4-M1)-(M3-M2) | 2.51 | 2.81 | 2.62 | 1.36 | 1.91 | 4.72 |

## 4.2 Test on coarse aggregate

Table 4.2: Sieve analysis

| Sieve Number | Diameter (mm) | Mass of Sieve (g) | Mass of Sieve & Coarse Soil (g) | Coarse Soil Retained (g) | Coarse Soil Retained (%) | Coarse Soil Passing (%) |
|---|---|---|---|---|---|---|
| | 25.000 | 574 | 574 | 0.0 | 0.00 | 100.00 |
| | 20.000 | 570 | 580.5 | 10.5 | 1.05 | 98.95 |
| | 13.200 | 561.5 | 998.5 | 437.0 | 43.70 | 56.30 |
| | 5.000 | 521.5 | 1074 | 552.5 | 55.25 | 1.05 |
| | 2.000 | 525.5 | 525.5 | 0.0 | 0.00 | 0.00 |
| | 1.180 | 494.0 | 494.0 | 0.0 | 0.00 | 0.00 |
| | 0.600 | 477.0 | 477.0 | 0.0 | 0.00 | 0.00 |
| | 0.425 | 454.0 | 454.0 | 0.0 | 0.00 | 0.00 |
| | 0.300 | 449.0 | 449.0 | 0.0 | 0.00 | 0.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 0.212 | 420.0 | 420.0 | 0.0 | 0.00 | 0.00 |
| | 0.150 | 402.0 | 402.0 | 0.0 | 0.00 | 0.00 |
| | 0.075 | 367.0 | 367.0 | 0.0 | 0.00 | 0.00 |
| | 0.063 | 381.5 | 381.5 | 0.0 | 0.00 | 0.00 |
| Pan | | 389.0 | 389.0 | 0.0 | 0.00 | 0.00 |
| | | | | **1000.0** | **100.00** | |

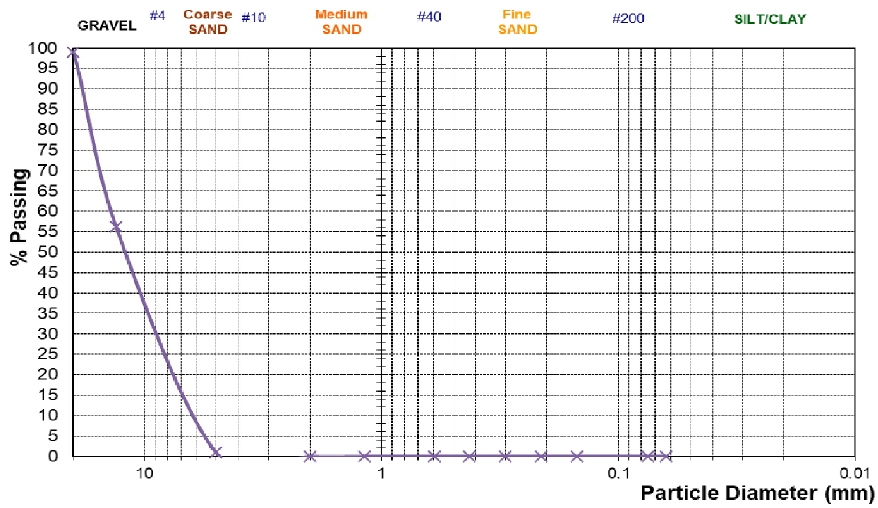


Figure 4.4: sieve analysis for coarse aggregate

The table 4.4 below, shows the values of the various test carried out on the coarse aggregate. It also specifies its compliance to predetermined requirement according to the standard, thereby making it suitable for use in various construction works.

## Aggregate Impact Value

The result of the aggregate impact value test for gravel and granite is 23.9 and 19.8 respectively. This means impact value fall within desirable region. BS 822 [11] prescribed a maximum value of 45% for non-wearing surfaces. This value is inversely related to the toughness of aggregate, meaning a higher value connotes a lower toughness.

## Aggregate Crushing Value

The test result for gravel and granite used are 38.8 and 29.8 respectively, which lies within expected value of 45% for ordinary cement used. For further emphasis there is indirect relationship between this value gotten and compressive strength of concrete.

Table 4.3: test carried out on coarse aggregate

| Test carried out | Obtained Test Results (GRANITE) | Obtained Test Results (GRAVEL) | Standard Test Values |
|---|---|---|---|
| Aggregate Impact Test | 19.8% | 23.9 | 30% maximum |
| Aggregate Crushing Test | 29.8% | 38.8 | 45% maximum |
| Los Angeles Abrasion Test | 33.8 | 34.8 | 60% maximum |
| Flakiness Index | 24.8% | 23.0 | 30% maximum |
| Elongation Index | 25.2% | 34.9 | 30% maximum |
| Density | 1500.20kg/m^3 | 1650 kg/$m^3$) | |
| Specific Gravity | 2.81 | 2.98 | 3 Maximum |

**Test on Limestone**

Below are the sieve analysis and particle distribution for the limestone used in preparation of the unconventional concrete in the table. The values gotten are detailed in the table- found in the appendix.

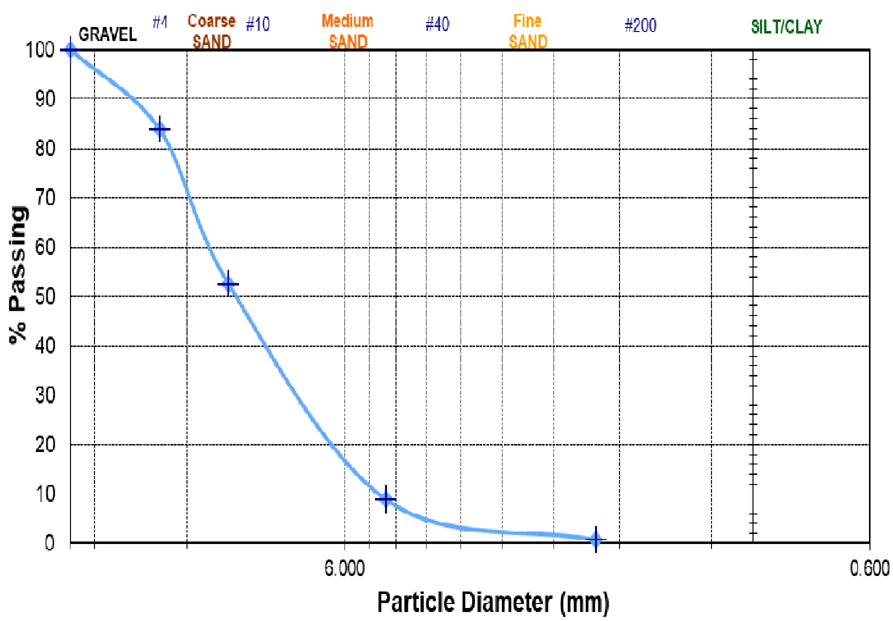


Figure 4.5: sieve analysis for limestone

From the graph plotted, the values of D10, D30 and D60 on the fine aggregate curve was traced to be 4.5, 6.15 and 6.9 respectively. The Uniformity coefficient was found to be 1.52 and coefficient of curvature was 1.22 from the above figure. From ASTMD-2487 soil classification, it can be said that the Coarse aggregate is a well graded sample because $1 \leq Cc \leq 3$. The table shows the various results of test carried out on limestone.

Table 4.4: test carried out on coarse aggregate (limestone)

| Test carried out | Obtained Test Results | Standard Test Values |
|---|---|---|
| Aggregate Impact Test | 32.7% | 30% maximum |
| Aggregate Crushing Test | 44.2% | 45% maximum |
| Los Angeles Abrasion Test | 47.2% | 60% maximum |
| Flakiness Index | 21.6 | 30% maximum |
| Elongation Index | 20.7 | 30% maximum |
| Density | 1500.20kg/m^3 | |
| Specific Gravity | 2.51 | 3 Maximum |

The table also specifies its compliance to predetermined requirement according to the standard, thereby making it suitable for use in various construction works.

**Test on Concrete**

Test on fresh concrete (slump test)

The result of the slump test are presented in the table below using a W/C value of 0.6 to make concrete more workable. The figure 4.5 showed the gravel concrete produced the highest value of true slump due to its non-uniform gradation, presence of impurities i.e. silt

Table 4.5: slump values for various replacement of sand

| S. NO | % of replacement | slump value (mm) (quarry dust) | slump value(mm) (laterite) | Type of slump |
|---|---|---|---|---|
| 1 | 0 | 10 | 10 | True slump |
| 2 | 25 | 60 | 30 | True slump |
| 3 | 50 | 20 | 40 | True slump |
| 4 | 75 | 50 | 60 | True slump |

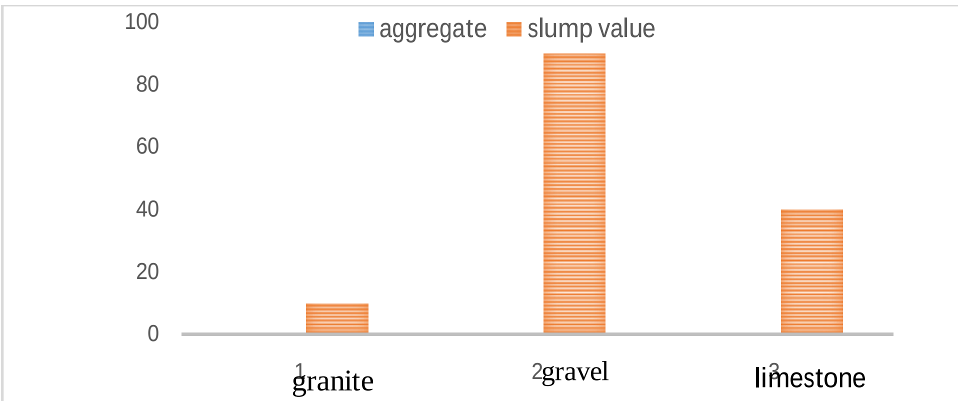


Figure 4.6: slump value for 100% coarse aggregates utilized

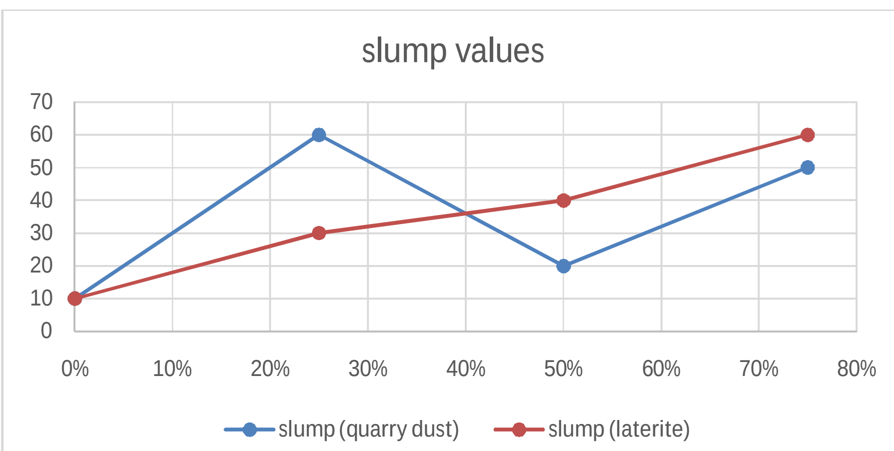


Figure 4.7: slump values for replacement of sand

**Effect of Sand Replacement Inclusion on Weight**

It was observed that the weight of the specimen decreased as the percentage of replacement for both laterite and quarry dust increased. At the 3 days curing phase, weight gradually decreased with higher replacement values. At 0% replacement laterite value the weight was 7.86kg, at 25% the weight was found to be 7.5kg, at 50% the weight was found to be 7.03kg indicating a 6.2% reduction in weight, and at 75% it was 6.7kg; while for the quarry dust the 25% weight was found to be 7.5kg, 50% was 7.03 and 75% was 6.83kg

## Bulk Density of Concrete

Table 4.6: bulk density of concrete using laterite as replacement for sand

| S.NO | WEIGHT OF CUBE (kg) | VOLUME ($m^3$) | DENSITY (kg/$m^3$) | AVERAGE DENSITY ((kg/$m^3$) |
|---|---|---|---|---|
| **M30 REPLACEMENT** | | | | |
| 1 | 7.4 | 0.003375 | 2192.59 | |
| 2 | 8.3 | 0.003375 | 2459.14 | 2330.82 |
| 3 | 7.9 | 0.003375 | 2340.74 | |
| **25% REPLACEMENT LATERITE** | | | | |
| 1 | 7.3 | 0.003375 | 2162.96 | |
| 2 | 6.9 | 0.003375 | 2044.44 | 2222.22 |
| 3 | 8.3 | 0.003375 | 2459.25 | |
| **50% REPLACEMENT LATERITE** | | | | |
| 1 | 6.7 | 0.003375 | 1985.19 | |
| 2 | 7.3 | 0.003375 | 2162.96 | 2083.95 |
| 3 | 7.1 | 0.003375 | 2103.7 | |
| **75% REPLACEMENT LATERITE** | | | | |
| 1 | 6.2 | 0.003375 | 1837.04 | |
| 2 | 7.0 | 0.003375 | 2074.07 | 1985.18 |
| 3 | 6.9 | 0.003375 | 2044.44 | |

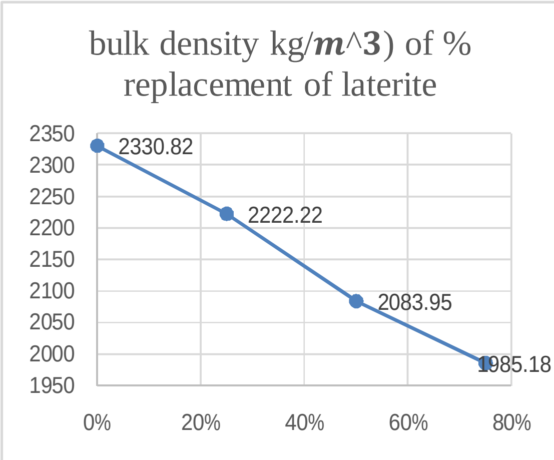


Figure 4.8: density of concrete using laterite as replacement

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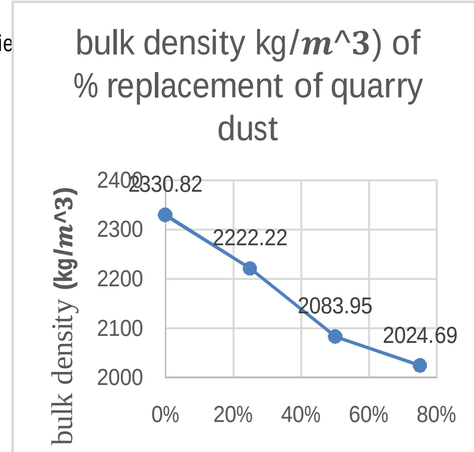


Figure 4.9: density of concrete using quarry dust as replacement for sand

Table 4.7: bulk density of concrete using quarry dust as replacement for sand

| S.NO | WEIGHT OF CUBE (KG) | VOLUME ($m^3$) | DENSITY(kg/$m^3$) | AVERAGE DENSITY (kg/$m^3$) |
|---|---|---|---|---|
| **GRANITE** | | | | |
| 1 | 7.4 | 0.003375 | 2192.59 | |
| 2 | 8.3 | 0.003375 | 2459.14 | 2330.82 |
| 3 | 7.9 | 0.003375 | 2340.74 | |
| **25% REPLACEMENT QUARRY DUST** | | | | |
| 1 | 7.3 | 0.003375 | 2162.96 | |
| 2 | 6.9 | 0.003375 | 2044.44 | 2222.22 |
| 3 | 8.3 | 0.003375 | 2459.25 | |
| **50% REPLACEMENT QUARRY DUST** | | | | |
| 1 | 6.7 | 0.003375 | 1985.19 | |
| 2 | 7.3 | 0.003375 | 2162.96 | 2083.95 |
| 3 | 7.1 | 0.003375 | 2103.7 | |
| **75% REPLACEMENT QUARRY DUST** | | | | |
| 1 | 7.2 | 0.003375 | 2133.33 | |
| 2 | 6.9 | 0.003375 | 2044.44 | 2024.69 |
| 3 | 6.4 | 0.003375 | 1896.3 | |

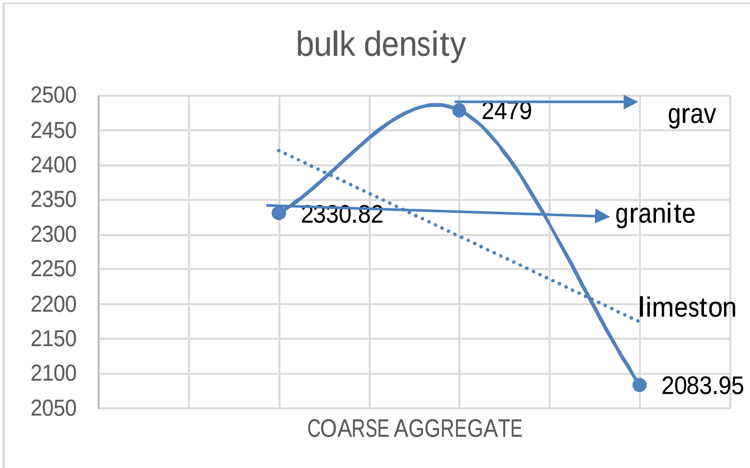


Figure 4.10: density of concrete using quarry dust as replacement for sand
A downward slope was noted for the bulk density graph, for both laterite and quarry dust indicating that the control (river sand) had a higher value in comparison to replacement samples. For coarse aggregate replacement, granite gave the highest value for bulk density owing to its particle size and gradation.

## Water Absorption

Table 4.8: Water absorption test results after 28 days (laterite)

| **Batch** | Block no | Dry mass (kg) | Wet mass (kg) | Water absorbed (%) | Average water absorbed (%) |
|---|---|---|---|---|---|
| | 1 | 8.370 | 8.4075 | 1.2 | |
| control | 2 | 8655.5 | 8.762 | 1.1 | 1.15 |
| | 1 | 7.662 | 7.967 | 3.98 | |
| 25 % | 2 | 7.200 | 7.503 | 4.2 | 4.09 |
| | 1 | 5.5025 | 5.601 | 1.8 | |
| 50 % | 2 | 6.201 | 6.311 | 1.77 | 1.79 |
| | 1 | 7.325 | 7.409 | 1.15 | |
| 75 % | 2 | 6989.5 | 7.072 | 1.19 | 1.17 |

Table 4.9: Water absorption test results after 28 days (quarry dust)

| **Batch** | Block no | Dry mass (kg) | Wet mass (kg) | Water absorbed (%) | Average water absorbed (%) |
|---|---|---|---|---|---|
| | 1 | 8.370 | 8.4075 | 1.2 | |
| control | 2 | 8655.5 | 8.762 | 1.1 | 1.15 |
| | 1 | 7.440 | 7.5315 | 1.2 | |
| 25 % | 2 | 7.695 | 7.790 | 1.23 | 1.22 |
| | 1 | 7.464 | 7.539 | 1.0 | |
| 50 % | 2 | 7.112 | 7.187 | 1.05 | 1.03 |
| | 1 | 6.801 | 6.866 | 0.95 | |
| 75 % | 2 | 7.001 | 7.067 | 0.94 | 0.95 |

Table 4.10: Water absorption test results after 28 days

| **Batch** | Block no | Dry mass (kg) | Wet mass (kg) | Water absorbed (%) | Average water absorbed (%) |
|---|---|---|---|---|---|
| | 1 | 8.370 | 8.4075 | 1.2 | |
| GRANITE | 2 | 8655.5 | 8.762 | 1.1 | 1.15 |
| | 1 | 9.952 | 10.048 | 0.96 | |
| GRAVEL | 2 | 8.322 | 8.418 | 1.15 | 1.06 |
| | 1 | 7.205 | 7.275 | 0.97 | |
| LIMESTONE | 2 | 7.779 | 7.874 | 1.2 | 1.09 |

## Compressive Strength

The grade of concrete, type of aggregate used, age of curing are variables in this investigation. This test is done to determine the cube strength of concrete mix prepared. The test is conducted on 3days, 7days, 14days and 28days, with the details of the compressive strength of M15 gradesshown in the Table 4.8. The compressive strength values of percentage replacement of sand 0%, 25%, 50% and 75% laterite and quarry dust are listed in details.

Table 4.11: Compressive Strength using laterite as Replacement for sand

| % Replacement Laterite | mix ratio | 3 days | 7days | 14 days | 28 days |
|---|---|---|---|---|---|
| | | compressive **(N/m$m^2$)** | | strength | |
| 0 | 1: 2: 4 | 5.14 | 8.45 | 11.70 | 13.01 |
| 25 | 1: 2: 4 | 5.23 | 8.29 | 11.45 | 12.94 |
| 50 | 1: 2: 4 | 4.74 | 7.71 | 10.67 | 11.86 |
| 75 | 1: 2: 4 | 4.41 | 7.16 | 9.92 | 11.02 |

Table 4.12: compressive strength using quarry dust as replacement for sand

| % Replacement Laterite | mix ratio | 3 days | 7days | 14 days | 28 days |
|---|---|---|---|---|---|
| | | compressive (**N/mm$^2$**) | | strength | |
| 0 | 1: 2: 4 | 5.14 | 8.45 | 11.70 | 13.01 |
| 25 | 1: 2: 4 | 5.09 | 8.19 | 11.04 | 12.75 |
| 50 | 1: 2: 4 | 4.84 | 7.86 | 10.88 | 12.09 |
| 75 | 1: 2: 4 | 4.65 | 7.56 | 10.47 | 11.63 |

Table 4.13: compressive strength of concrete utilizing various coarse aggregate

| Coarse aggregate | mix ratio | 3 days | 7days | 14 days | 28 days |
|---|---|---|---|---|---|
| | | compressive (**N/mm$^2$**) | | strength | |
| GRANITE | 1: 2: 4 | 5.14 | 8.45 | 11.70 | 13.01 |
| GRAVEL | 1: 2: 4 | 4.57 | 7.38 | 10.04 | 11.19 |
| LIMESTONE | 1: 2: 4 | 5.69 | 9.36 | 13.02 | 14.47 |

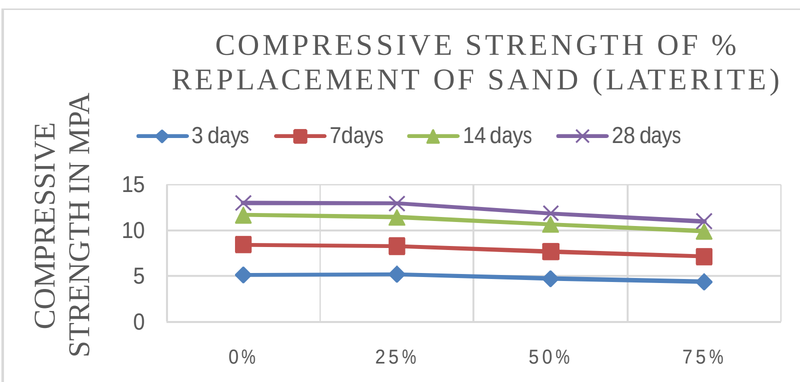


Figure 4.11: compressive strength of concrete using laterite as partial replacement of sand

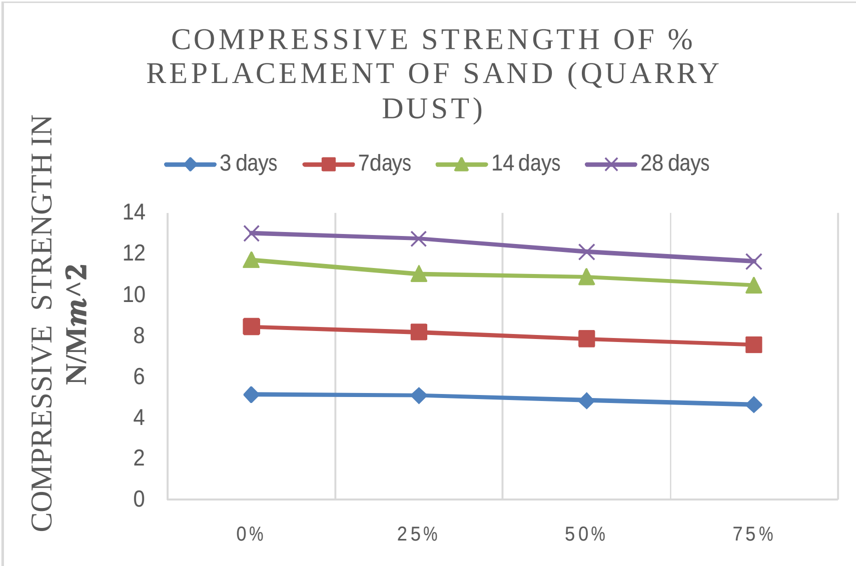


Figure 4.12: compressive strength Using quarry dust as partial replacement of sand

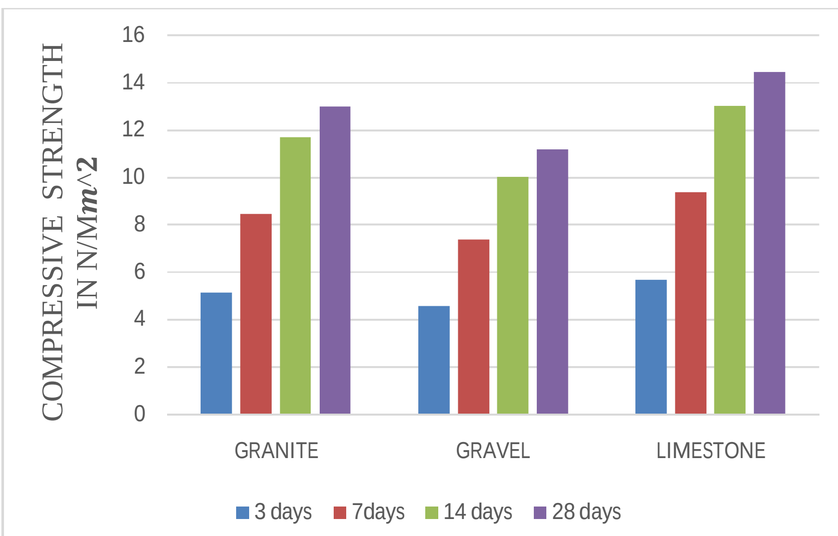


Figure 4.13: compressive strength of concrete cube samples using different coarse aggregate and variation with curing age

The compressive strength of control sample surpassed all the replacement samples produced using laterite for the various replacement. It had a strength value of 6.84 N/m$m^2$ while the most suitable replacement using laterite produced 5.29 N/m$m^2$, which is a 29.3% difference.

In all samples produced using laterite replacement, the control exhibited a more superior value and higher compressive strength, but observations show the 25% to 50% is an acceptable replacement value, for use in conventional construction work. The same could be said about the samples produced using quarry dust, the control is produced a superior strength for the experiments carried out. For the fine aggregate replacement, 75% of quarry dust proved to be the minimum compressive strength. There was an obvious increase in strength with increase in curing days for all samples.

## Flexural Strength

The table 4.11 shows the details of the flexural strength of the different replacement for sand and types of coarse aggregate used for the concrete; at 3, 7, 14 and 28days for concrete grade M15.

Table 4.14: flexural strength of concrete using laterite as replacement for sand

| % Replacement Laterite | mix ratio | 3 days | 7days | 14 days | 28 days |
|---|---|---|---|---|---|
| | | Flexural strength **(N/m$m^2$)** | | | |
| 0 | 1: 2: 4 | 1.79 | 2.29 | 2.7 | 2.85 |
| 25 | 1: 2: 4 | 1.82 | 2.27 | 2.67 | 2.84 |
| 50 | 1: 2: 4 | 1.72 | 2.19 | 2.58 | 2.72 |
| 75 | 1: 2: 4 | 1.66 | 2.11 | 2.49 | 2.62 |

Table 4.15: flexural strength of concrete using quarry dust as replacement for sand

| % Replacement Laterite | mix ratio | 3 days | 7days | 14 days | 28 days |
|---|---|---|---|---|---|
| | | Flexural strength **(N/m$m^2$)** | | | |
| 0 | 1: 2: 4 | 1.79 | 2.29 | 2.7 | 2.85 |
| 25 | 1: 2: 4 | 1.78 | 2.26 | 2.62 | 2.82 |
| 50 | 1: 2: 4 | 1.74 | 2.21 | 2.59 | 2.74 |
| 75 | 1: 2: 4 | 1.7 | 2.17 | 2.55 | 2.69 |

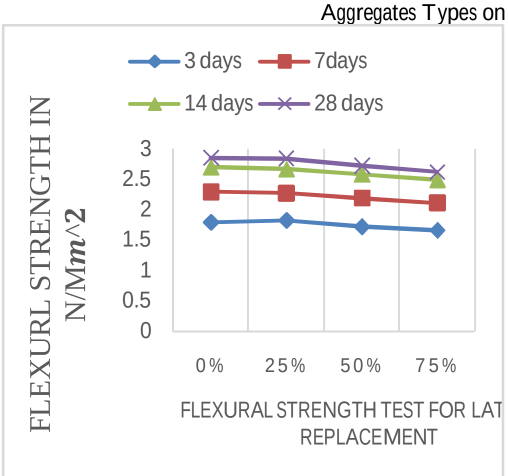


Figure 4.14: flexural strength using laterite as sand replacement

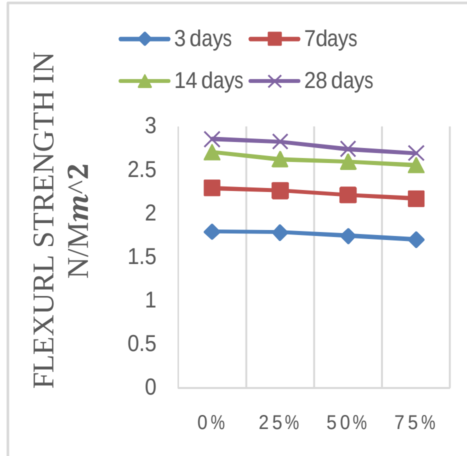


Figure 4.15: flexural strength using quarry dust as sand replacement

Table 4.16: flexural strength of concrete using various coarse aggregate

| Coarse aggregate | mix ratio | 3 days | 7days | 14 days | 28 days |
|---|---|---|---|---|---|
| | | compressive **(N/mm$^2$)** | | strength | |
| GRANITE | 1: 2: 4 | 1.79 | 2.29 | 2.7 | 2.85 |
| GRAVEL | 1: 2: 4 | 1.69 | 2.14 | 2.5 | 2.64 |
| LIMESTONE | 1: 2: 4 | 1.88 | 2.41 | 2.85 | 3.00 |

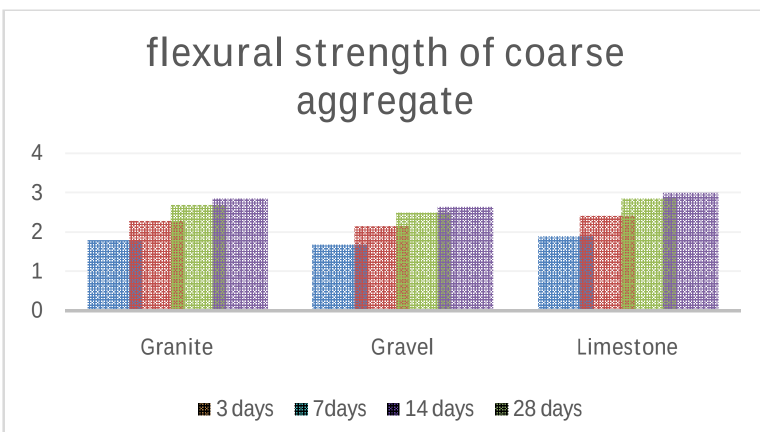


Figure 4.16: flexural strength of concrete cube samples using different coarse aggregate and variation with curing age

# CONCLUSION AND RECOMMENDATION

## Conclusion

Based on the systematic and detailed experimental study conducted on the various combinations used to produce concrete, with the aim of producing concrete of significant strength, M15 grade using locally available material, while still being economical in its approach; the following deductions can be drawn from the study:

1) The bulk density of concrete for all samples were around 2000kg/$m^3$, and the value of density decreased as replacement percentage increased.
2) Compressive strength of control, 25%, 50%, and 75% replacement of sand by laterite was found to be 13.01, 12.94, 11.86 and 11.02 respectively. While for quarry dust at 0%, 25%, 50%, and 75% replacement was noted to be 13.01, 12.75, 12.09, and 11.63 N/m$m^2$**.** For coarse aggregate granite, gravel and limestone gave compressive strength of 13.01, 11.19 and 14.47 after 28 days curing.
3) As the percentage of replacement increased, the workability of concrete increased especially for the Laterized concrete; the quarry dust replacement gave an irregular value as indicated by the slump test.
4) Flexural and compressive strength increased for all samples as curing age increased.
5) Limestone concrete gave the highest strength in comparison to other coarse aggregate used in concrete production.

In conclusion replacing sand with laterite and quarry dust are acceptable up to a replacement percentage of less than 50%, from whence a significant reduction of strength is noted from the investigations carried out, hence for construction work the suitable percentage of replacement especially structural is about 50%.

# RECOMMENDATION

Although this study gives an insight on the effects of partial replacement of sand in concrete a lot of questions cannot be answered with the data at hand.

- It should be noted that partial replacement and not full replacement of sand as coarse aggregate should be welcomed and not feared in construction but done only when similar strength properties have been done on substitute like laterite and quarry dust.

- It is recommended that further investigations should be carried out on the effects of grading of the coarse aggregates used.
- Also, this investigation should be further expanded by combining the alternate coarse aggregate i.e. limestone and gravel with the various replacement materials for sand and note its characteristics.
- The use of granite and sand on conventional concrete cannot be overemphasized in its use in sophisticated construction like high rise buildings.
- Mix ratio was constant in this study, it is advised for further investigations that more mix ratios should be used to verify claims in this investigation.
- Further, a handful of experiments geared towards determining other structural properties of concrete should be added to further validate the claims touted in this study.

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