# INVESTIGATIONS IN TO THE USE OF STONE DUST AND CERAMIC SCRAP AS AGGREGATE REPLACEMENT IN CONCRETE

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**Abstract**

*The study was conducted to investigate into the use of stone dust and ceramic scraps aggregate replacement in concrete.The methodology adapted was to compare 2 specimens of cube and beam.Three concrete cubes of 150mmx150mmx150mmsize were tested to determine compressive strength and another three beams of 100mmx100mmx400mm were tested to determine the flexural strength. These Samples were tested after curing for 28days. In the fine aggregate, the maximum mass detained was in sieve of 2.36mm with 100g and the 150 microns with the least mass of 7.41g were used. The coarse aggregate the maximum mass detained in sieved of 40mm with mass of 100g and the 2.36mm with the least mass of 5.10g were used. The experimental test results recorded show that strength of concrete hasincrease at same point due to usage of stone dust as fine aggregatewhile the ceramic scraps subjected as coarse aggregate recorded in reducing strength. The stone dust can be used as conventional fine aggregate. And ceramic scrap can be partially used to replace conventional coarse aggregates up to 20% without affecting its structural significance.*

***Keywords:*** *Stone dust, ceramic scraps, compressive strength, concrete replacement, flexural strength, fine aggregate, coarse aggregate*

## 1.0 INTRODUCTION

For years, construction industries have been making some progress in the utilization of waste materials in concrete. Some of the waste products are fly ash, rice husk, saw dust, discarded tires, e-waste, glass, bagasse ash, stone dust and ceramic. Proper use of waste products provides viable economy and healthy environment. Each waste product has its specific effect on properties of fresh and hardens concrete. The use of waste products in concrete not only makes it economical but also solves some of the disposal problems. Major components of concrete are aggregates which are usually availablein natural form. Fine Aggregate used in concrete is usually river sand available locally or at nearby location (Singh, Srivastava, & Agarwal, 2015). However,they added that the demand for river sand in the construction industry has consequently increased due to the extensive use of concrete resulting in the reduction of sand sources and increase in price. The large-scale depletion of natural sand sources creates also the environmental problem such as erosion and failure of river banks, lowering of river beds, saline water intrusion into the land.

The use of crushed ceramic aggregate can be used to produce lightweight concrete, without affecting strength (Veera. 2010). For this reason, the paper tends to identify another of aggregate as stone dust and ceramic scraps to replace the sand in concrete industry.

## 2.0 LITERATURE REVIEW

Prakash &Hanumatha (2016) Stated that quarry dust is a byproduct of the crushing process which isa concentrated material to use as aggregates for concretingpurpose, especially as fine aggregates. In quarrying activities,the rock has been crushed into various sizes; during theprocess, the dust generated is called quarry dust and it is formed as waste. So it becomes as a useless material andalso results in air pollution. Therefore, quarry dust shouldbe used in construction works, which will reduce the costof construction and the construction material would besaved and the natural resources can be used properly. Mostof the developing countries are under pressure to replacefine aggregate in concrete by an alternate material also tosome extent or totally without compromising the quality ofconcrete.

**According to Merriam–Webster's dictionary (2017) Define**ceramic as relating to the manufacture of any product (such as earthenware, porcelain, or brick) made essentially from a nonmetallic mineral (such as clay) by firing at a high temperature, alsoof or relating to such a product.

The development of concrete properties was observed by substitution of crushed stone coarse aggregate with crushed wasted ceramic aggregate and sand fine aggregate with quarry dust aggregate. Compressive strength was unchanged when ceramic wastes and quarry dust are used partially to replace conventional crushed stone coarse aggregate and sand fine aggregate. To reduce the amount of ceramic waste and quarry dust deposited in landfill or anywhere and helps the natural resources (Mustapha et. al, 2014).

According to Richmond-Recycling (2018). Stone dust is the finest of the types of crushed stone. Although it is made from the same type of stone as the other two types, it is crushed into a powder. When used by itself stone dust forms a hard surface that is water resistant.

Quarry dust has been proposed as an alternative to river sand that gives additional benef it to concrete. Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete **(Chandana, Katakam,Teja& Roam2013).**

## 3.0 MATERIALS AND METHOD

### 3.1 Materials used

### 3.1.1 Cement

The cement for the whole work was Sokoto ordinary cement procured in a single consignment and properly stored. The properties of cement (IS: 12269, 1987) used in the investigation are presented in Table 3.1

**Table 3.1**
Properties of cement

| SI. NO | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **Property** | Specific gravity | Fineness | Initial setting time | Final setting time | Stranded consistency | Compressive strength |
| **Value** | 3.00 | 97.80 | 67 min | 8 hrs. | 30% | 54.27N/MM2 |

### 3.1.2 Fine Aggregate

a) Sand: River sand was used as fine aggregate at Mafara River, talatamafara. The specific gravity of sand was 2.61and fineness modulus of fineness was 2.52

b) Stone dust: Stone dust is selected as raw materials from local quarry at sadogusau road were used as fine aggregate. The specific gravity of stone dust was 2.62 and fineness modulus was 2.68

### 3.1.3 Coarse Aggregate

a) Conventional Coarse Aggregate: Machine crushed granite obtained from a local Quarry at Sado Gusau road was used as coarse aggregate. the specific gravity 2.66 and fineness modulus 2.22.

b) Ceramic Scrap: The ceramic scrap was obtained from a local ceramic insulator industry. The ceramic insulators are initially broken into pieces with hammer into required size. The properties of Conventional aggregate and crushed insulator ceramic scrap are shown in Table 3.2. And the sieve analysis data of fine and coarse aggregate data is presented in Table 3.3

**Table 3.2**

Properties of coarse aggregate

| Materials | Properties |
|---|---|
| **Conventional coarse aggregate** | Specific gravity = 2.69 |
| | Fineness modulus = 6.80 |
| | Impact value = 15 .60 |
| | Crush value = 20 |
| **Ceramic scrap** | Specific gravity = 2.48 |
| | Fineness modulus = 7. 02 |
| | Impact value = 18.71 |
| | Crush value = 23.65 |

**Table 3.3**

**Details of Sieve analysis of fine and coarse aggregate**

| SI. NO | Sieve Designation | Percentage Passing | | | |
|---|---|---|---|---|---|
| | | Fine aggregate | | Coarse aggregate | |
| | | Natural Sand | Stone Dust | Natural Aggregate | Ceramic Scrap |
| **1** | 14 5mm | --- | --- | 100 | 100 |
| **2** | 10mm | --- | --- | 94.25 | 87.35 |
| **3** | 4.78mm | 100 | 100 | 10.41 | 9.88 |
| **4** | 2.36mm | 100 | 100 | 5.10 | 1.30 |
| **5** | 1.15mm | 98.60 | 48.22 | 0 | 0 |
| **6** | 600 | 57.30 | 10.6 | --- | --- |
| **7** | 300 | 22.81 | 5.3 | --- | --- |
| **8** | 150 | 7.41 | 2.1 | --- | --- |

### 3.1.4 Preparation of Specimens

The quantities of the constituents of the concrete were obtained from the Indian Standard Mix Design method (IS: 10262- 2009). The variation of strength of hardened concrete using stone dust as fine aggregate (partial replacement) is studied by casting cubes, cylinders and beams. The concrete was prepared in the laboratory using hand mixing. The cement, fine aggregate and coarse aggregate were first mixed in dry state to obtain uniform color and calculated amount of water obtained from workability test was added and the whole concrete was mixed for six minutes in wet state.

Meanwhile the molds are screwed tightly to avoid leakage; Oil was applied on inner surface of the molds. The cast specimens were removed from molds after 24 hours and the specimens were immersed in a clean water tank. After curing the specimens for a period of 28 days, the specimens were removed from the water tank and allowed to dry under shade.

## 3.2 Methods

### 3.2.1 Test

For each batch of concrete three cubes of 150mm x 150mm x 150mm size were tested to determine compressive strength. Another three beams of 100mm x 100mm x 400mm were tested to determine the flexure strength.

### 3.2.2 Mixed Selection

The grade of concrete adopted for investigation was M25. The mix proportion of concrete for laboratory investigations was arrived by designing as per British standard method. The final mix used was 1:2: 4 with water cement ratio of 0.45. The details of mix designations and specimens used in experimental programme are given in Table 3.4.

**Table 3.4**

**Detail of mixed Designation and specimens**

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**Table 3.4**

**Detail of mixed Designation and specimens**

| Sieve Designation | Percentage Passing | | | | Number of Specimens | |
|---|---|---|---|---|---|---|
| | Fine aggregate | | Coarse aggregate | | Cubes | Beams |
| | Natural Sand | Stone Dust | Natural Aggregate | Ceramic Scrap | | |
| **M 1** | 100% | 0% | 100% | 0% | 3 | 3 |
| **M 2** | 100% | 0% | 80% | 20% | 3 | 3 |
| **M 3** | 80% | 20% | 80% | 20% | 3 | 3 |
| **M 4** | 60% | 40% | 80% | 20% | 3 | 3 |
| **M5** | 40% | 60% | 80% | 20% | 3 | 3 |
| **M 6** | 20% | 80% | 80% | 20% | 3 | 3 |
| **M 7** | 10% | 100% | 80% | 20% | 3 | 3 |

**4.0 RESULTS AND DISCUSSION**

It can be observed from Table 3.4, inthe fine aggregate, the maximum mass detained was in sieve 2.36mm with 100g and the 150 microns with the least mass of 7.41g were used. The coarse aggregate the maximum mass detained in sieved 40mm with mass of 100g and the 2.36mm with the least mass of 5.10g were used. The observation shows the stone dust can be used as conventional fine aggregate. While ceramic scrap can be used in place of coarse aggregate. The Samples were tested and analyzed after curing for 28days.

The experimental test results are presented in Table 4.1. It can be observed from the Table 5that the strength of concrete has increased at some point due to usage of stone dust as fine aggregate. While the strength is reducing due to usage of ceramic scrap as coarse aggregate. Hence in concrete with ceramic scrap as coarse aggregate up to 20%, conventional fine aggregate can be replaced partially by stone dust up to 40%. The experimental test results show in table 4.1.

**Table 4.1**

Experimental test results

| Mix designation | M1 | M2 | M3 | M4 | M5 | M6 | M7 |
|---|---|---|---|---|---|---|---|
| **Compressive strength** | 25.45 | 23.65 | 24.13 | 21.27 | 18.41 | 16.17 | 15.31 |
| **Flexural strength** | 6.12 | 7.83 | 8.61 | 9.12 | 7.83 | 6.41 | 6.01 |

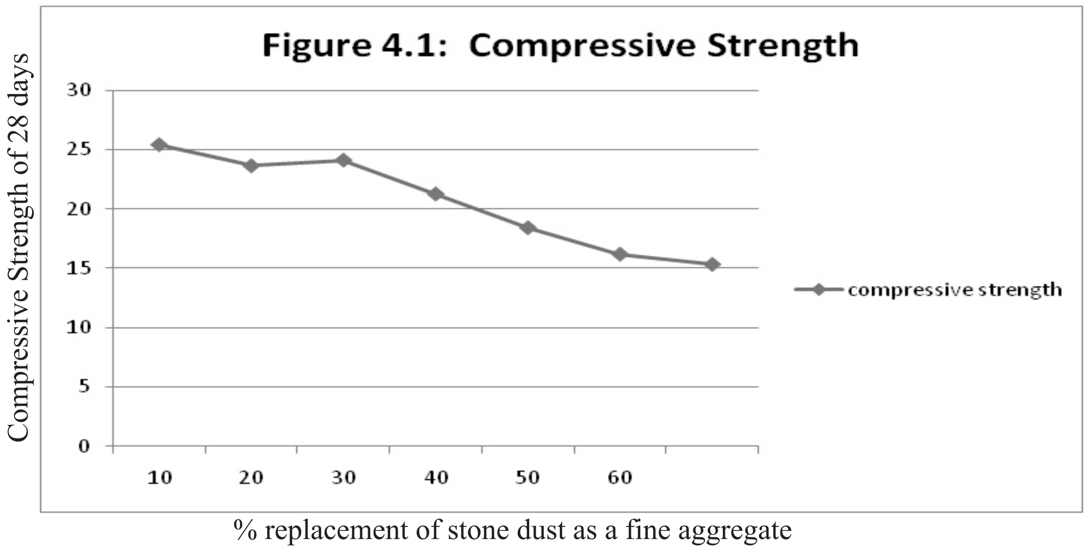

Figure 4.1; shown the variation of compressive strength with percentage replacement of stone dust with 20% ceramic scrap as coarse aggregate.

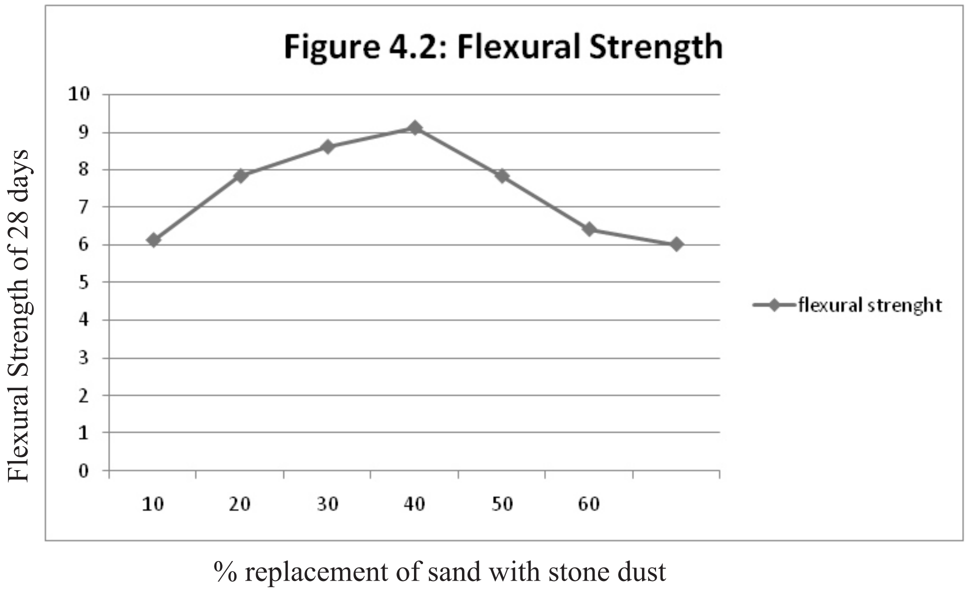


**Figure 4.2; shown the variation of flexural strength with percentage replacement of stone dust along with 20% ceramic scrap as coarse aggregate**

## 5.0 CONCLUSIONS

**The following conclusions are drawn:**

1. The investigations carried out reveals that Stone dust can be effectively used as fine aggregate in place of conventional river sand in concrete.
2. It is advised on the basis of present study that ceramic waste alone could not be used as a replacement of coarse aggregate because it has an adverse effect on the properties of concrete.
3. On the other hand if it is used along with the stone dust it gives satisfactory results and up to 40 % of replacement of fine aggregate with stone dust the properties of concrete is found to be enhanced and after that it decreases.
4. Ceramic scrap can be partially used to replace conventional coarse aggregates up to 20% without affecting its structural significance.
5. Stone dust has a potential to provide alternative to natural sand and helps in maintaining the environment as well as economical balance. Non-availability of Natural sand at reasonable cost, forces to search for alternative material. Stone dust qualifies itself as a suitable substitute for natural sand at reasonable cost.

6, The compressive and flexural strength of concrete with 40% replacement of natural sand by stone dust along with 20% replacement of coarse aggregate by ceramic waste.

7. The higher strength as compared to 0 % replacement of natural sand by stone dust along with 20% replacement of coarse aggregate by ceramic waste.

8. It is observed that as compare to flexural strength the compressive strength greatly decreased when only ceramic waste is used as a 20% replacement of coarse aggregate (i.e.at 0% stone dust and 20 % ceramic waste).

9. It is observed that the optimum percentage for replacement of stone dust with fine aggregate along with 20% replacement of coarse aggregate by ceramic waste is almost 40% for both cubes and beams.

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