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# AN EXPERIMENTAL INVESTIGATION ON CERAMIC COARSE AGGREGATE WITH THE PARTIAL REPLACEMENT OF NATURAL COARSE AGGREGATE IN M20 MIX

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**ABSTRACT**

*During the design of a concrete structure it becomes complicated with the increase of dead load, also extra columns and beams are designed to counteract that dead load itself, if that dead load is reduced then that extra columns and beams can be utilized to bear the live loads alone such that the structure becomes economical and also structure can be utilized to its best. Keeping reduction of weight of concrete without losing much strength in point of view when the materials used in concrete are analyzed, it is found that ceramic aggregates can be a better option with the replacement of natural coarse aggregate. An Experimental Investigation is done with the replacement of ceramic coarse aggregate with natural coarse aggregate to find out the optimum replacement of ceramic aggregate and also to find the feasibility of usage of ceramic waste in concrete is studied in terms of Slump value, compaction factor, Compressive strength and weight change.*

***Keywords:*** **Electrical Ceramic waste, Reduction of Concrete weight, Replacement material for coarse aggregate.**

## I. INTRODUCTION

About 19 Billions of Electrical ceramic waste was expected to be generated in India by 2025, the disposal of ceramic waste is quiet complex process since it causes leaching and end up by polluting the environment so to counteract this problem the present experimental investigation is carried out and also by using the ceramic waste as resource in concrete it is capable of reducing the dead load of concrete without losing much strength, Besides that it will be even economical. The Electrical ceramic waste produced from a substation at Tirupati were procured and crushed as ceramic coarse aggregate.

Initially, the materials properties are determined experimentally for cement, Fine aggregate, Natural Coarse aggregate, and ceramic coarse aggregate. Normal M25 mix concrete is prepared as per IS 10262:2009 with stipulated water cement ratio and concrete cubes of size 15cm x 15cm x 15cm are prepared and hardened with various replacements of natural coarse aggregate with ceramic aggregate by 0, 20, 40, 60, 80 and 100% and all

the remaining parameters are maintained constant. At last compressive strength, Workability in terms of the slump and weight loss due to the addition of ceramic aggregate were determined and concluded, which elevates the feasibility of usage of ceramic aggregate concrete leading to concrete property enhancement and maintaining environmental safety.

## II.MATERIAL PROPERTIES USED IN CONCRETE

### 2.1 Cement

Locally available OPC 53 Grade cement (Ultra Tech) was used for a preparation of concrete specimens. The various values obtained from the test conducted on cement were tabulated in Table 1

**Table.1. Physical Properties of Cement**

| S.No | Physical Property | Value |
|---|---|---|
| 1 | Normal Consistency | 30% |
| 2 | Specific Gravity | 3.10 |
| 3 | Initial Setting Time | 91 Min |
| 4 | Final Setting Time | 330 Min |
| 5 | Fineness Modulus | 4 |

### 2.2 Natural Aggregate

The Natural sand is retrieved from the river beds of Swarnamuki which flows in Near Tirupati City and Coarse Aggregate is obtained from the locally available quarry at Tirupati Rural. The Physical Properties of Natural aggregates both fine and coarse are shown in Table 2 and their gradation values are tabulated in Table 3.

**Table 2. Physical Properties of Fine, Coarse Aggregates and Ceramic Coarse Aggregate**

| SI. No | Property | Fine Aggregate | Natural Coarse aggregate | Ceramic waste Aggregate (Insulator bush) |
|---|---|---|---|---|
| 1 | Specific Gravity | 2.62 | 2.68 | 2.50 |
| 2 | Water absorption in % | 2 | 0.12 | 0.18 |
| 3 | Impact value in % | - | 19.2 | 24 |
| 4 | Crushing value in % | - | 16.3 | 19 |
| 5 | Abrasion value in % | - | 20.28 | 21.6 |
| 6 | Fines modulus | 3.1 | - | - |

### 2.3 Ceramic Coarse Aggregate

Insulator Bushes grabbed from an Electrical substation at Tirupati City and they are crushed by a jaw Crusher in Chandragiri quarry. Chemical composition of ceramic Paste were analyzed and shown in Table 3

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X-Ray Diffraction in a Philips diffract-o-meter PW3040 with CuKa radiation using a secondary Monochrometer was used to determine the micro level compounds and nominal conditions of 40Kv, 30ma in range of $10^{o}$ – $90^{o}$ With steps of 0.05 were employed.

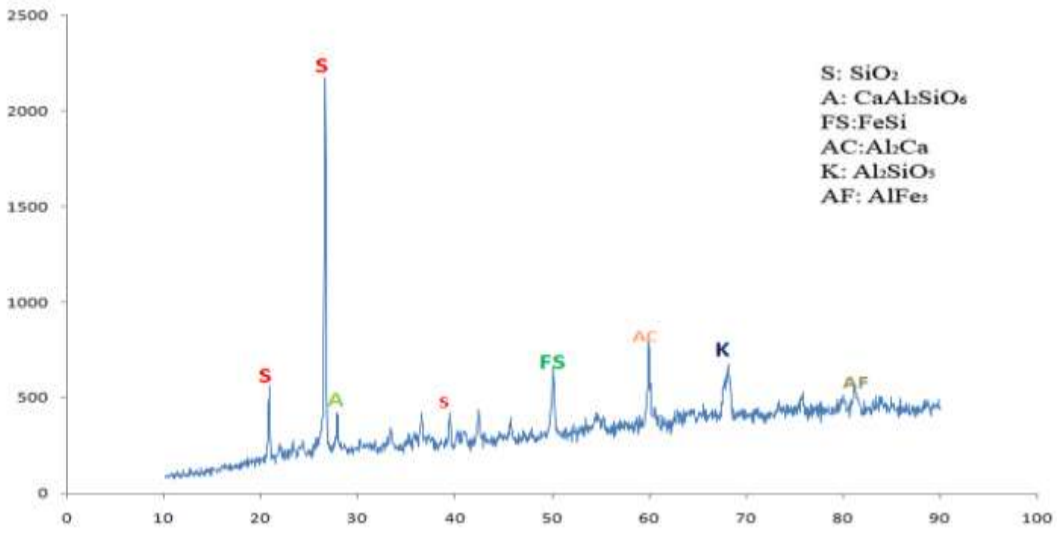


**Table 4: Chemical Properties of Ceramic Paste**

| S.No | Material | Percentage |
|---|---|---|
| 1 | $Si\ O_2$ | 68.83 |
| 2 | $Al_2\ O_3$ | 20.62 |
| 3 | $Fe_2\ O_3$ | 5.31 |
| 4 | $Cao$ | 2.01 |
| 5 | $Na_2O$ | 2.06 |
| 6 | $K_2O$ | 1.92 |
| 7 | $Mgo$ | 0.65 |
| 8 | $TiO_2$ | 0.862 |
| 9 | $Mno$ | 0.083 |
| 10 | $P_2O_5$ | 0.026 |
| 11 | $SO_3$ | 0.08 |
| 12 | $L.O.I$ | 0.52 |

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### 2.4 Mix Proportions and Test Specimens

The present Investigation studies the partial replacement of natural coarse aggregate with ceramic coarse aggregate as 0, 20, 40, 60, 80 and 100%. Design mix has been prepared as 0.45:1:1.5:3 and cubes were cast for evaluating the strength of ceramic concrete. Water cement ratio, binder material, and fine aggregate are maintained constant only coarse aggregate is varied and replaced with ceramic coarse aggregate were shown in Table 5

**Table 5. Materials calculated for various mixes**

| Materials (kg) | Replacement of C.A by Ceramic Aggregate | | | | | |
|---|---|---|---|---|---|---|
| | 0% | 20% | 40% | 60% | 80% | 100% |
| Cement | 10 | 10 | 10 | 10 | 10 | 10 |
| Fine aggregate | 15.3 | 15.3 | 15.3 | 15.3 | 15.3 | 15.3 |
| Natural crushed aggregate | 28.8 | 23.04 | 17.28 | 11.52 | 5.76 | 0 |
| Ceramic aggregate | 0 | 5.76 | 11.52 | 17.28 | 23.04 | 28.8 |

6 Concrete cubes of size 15cm x 15cm x 15cm are prepared to test, each 3 cubes for 7 days and 28 days after curing. 12 cubes for 7days and another 12 cubes for 28days so in total 36 Cubes were cast and tested for compressive strength and weight loss.

## III.RESULTS AND DISCUSSION

Results have been classified into three categories ie; workability, the compressive strength of concrete cubes for 7days and 28days, weight decrement of concrete.

### 3.1 Workability

Workability can be measured by using slump test and compaction factor test, here in this experimental investigation both those slump test and compaction factor tests have been considered and the results for various mixes obtained are reported in Table 6

**Table.6. Workability in terms of slump test and compaction factor**

| S.No | Type of specimens | Percentage replacement of natural coarse aggregate with ceramic waste aggregate | Slump value in mm | Compaction Factor |
|---|---|---|---|---|
| 1 | NA | 0 | 155 | 0.94 |
| 3 | CA20 | 20 | 150 | 0.94 |
| 4 | CA40 | 40 | 150 | 0.91 |
| 5 | CA60 | 60 | 135 | 0.88 |
| 6 | CA80 | 80 | 122 | 0.85 |
| 7 | CA100 | 100 | 120 | 0.85 |

Workability of concrete depends upon the shape, size, surface texture and water absorption. When ceramic aggregate and natural coarse aggregate are compared, the ceramic aggregate having greater angularity, smoother surface, and higher water absorption capacity. And also from XRD analysis Ceramic aggregate possess higher pozzolanic activities due to which gel pores and cavities could not be filled with sufficient cement paste with reference to 0% replacement. Due to these factors, the workability factors such as Slump value and Compaction factor decreased gradually with increase in replacement of natural coarse aggregate with ceramic waste aggregate.

### 3.2 Compressive Strength:

The compressive strength obtained for various replacements of ceramic coarse aggregate are reported for 7days in Table 7 and 28days in Table 8

**Table 7. Compressive strength of ceramic aggregate concrete for 7days**

| S.No | % of Ceramic | Weight (gm) | Load(KN) | Compressive strength(Mpa) |
|---|---|---|---|---|
| 1 | 0 | 8154 | 825 | 36.67 |
| 2 | 20 | 8013 | 790 | 35.11 |
| 3 | 40 | 7940 | 740 | 32.89 |
| 4 | 60 | 7879 | 653 | 29.04 |
| 5 | 80 | 7798 | 580 | 25.78 |
| 6 | 100 | 7705 | 530 | 23.41 |

**Table 8. Compressive strength of ceramic aggregate concrete for 28days**

| S.No | % of Ceramic | Weight (gm) | Load(KN) | Compressive strength(Mpa) |
|---|---|---|---|---|
| 1 | 0 | 8415 | 975 | 43.33 |
| 2 | 20 | 8395 | 945 | 42.07 |
| 3 | 40 | 8212 | 940 | 41.78 |
| 4 | 60 | 8138 | 930 | 41.33 |
| 5 | 80 | 8004 | 915 | 40.74 |
| 6 | 100 | 7889 | 795 | 35.41 |

Compressive Strength of Concrete obtained from the strength of aggregate, the strength of cement paste and bond strength between cement paste and aggregate. Thought Ceramic coarse aggregate possess higher values of impact value, crushing value and abrasion value than the Natural aggregate. Ceramic aggregate concrete behavior under compression is reduced.

The decrement in compressive strength is due to its brittle nature, poor bonding between the cement paste and coarse aggregate due to its porcelain surface nature.

### 3.3 Weight loss obtained

Since the weight to volume ratio ie; density of natural aggregate is higher than that of ceramic coarse aggregate, reduction in the weight has been observed with the increase of replacement. The percentage of weight of for 7 and 28days have been tabulated in Table 9

**Table 9: Percentage of weight loss of ceramic coarse aggregate when compared to natural Aggregate**

| TYPE OF SPECIMENS | 7-DAYS IN % | 28-DAYS IN % |
|---|---|---|
| CA20 | 1.72 | 0.23 |
| CA40 | 2.62 | 2.41 |
| CA60 | 3.37 | 3.29 |
| CA80 | 4.36 | 4.88 |
| CA100 | 5.50 | 5.50 |

## IV. CONCLUSION

1. The slump value and compaction factor gradually decreased with increase in replacement of coarse aggregate by ceramic aggregate due to smooth surface texture.
2. The decrease in compressive strength of ceramic aggregate concrete was mainly because of its poor bonding with cement and brittle nature of aggregates.
3. Weight loss is obtained with increment of ceramic coarse aggregates due to lower density ceramic aggregates when compared to natural coarse aggregates

## V. FUTURE SCOPE

1. Further investigation can be done to obtain an optimum dosage of ceramic coarse aggregate replaced with natural Coarse aggregate.
2. Since acids are stored in Ceramic vessels, there is a chance that ceramic addition can reduce the acid effect on concrete, so the effect of acid on ceramic aggregate concrete can be studied.
3. In this present Investigation, as the strength is getting reduced due to bonding nature, there is a scope of the study to increase the bond between cement ceramic aggregate.

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