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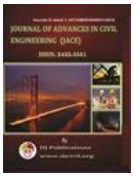

RESEARCH ARTICLE

# A Study on Behaviour of Concrete Using Ceramic Waste

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## ABSTRACT

The objective of this study is to analyze the strength of concrete along with ceramic waste as coarse aggregate. Moreover disposal of solid waste is the major problem in the recent scenario. About 15% to 30% of ceramic production from industries quit as waste, which is not yet undergoing in the recycle method. In this work an trial has been done for finding the suitability of the ceramic industrial wastes as a feasible replacement for conventional crushed stone coarse aggregate. Trial mixes are performed to achieve a concrete of M20.The project work deals with the resolution of strength of concrete using various percentage of ceramic waste material i.e., broken ceramic waste by partially replacing coarse aggregate with 5%, 10%, 15%, 20%, 25% of ceramic waste. Various tests are conducted for materials such as, specific gravity test, water absorption test, crushing test, impact test, sieve analysis, consistency test before casting cubes, cylinders and beams. The comparative behaviour of concrete is studied by conducting laboratory tests on concrete cubes, cylinders and plain beams for conventional concrete and concrete casted with ceramic waste as coarse aggregate.
**Keywords**: Coarse aggregate, Ceramic waste, Gravity test, Sieve analysis, Recycle.

## 1. INTRODUCTION

Concrete is a widely known and using substance and it mainly comprised of a binder and a mineral filler. It plays a vital role in civil engineering construction. Admixtures are sometimes added to change the properties of cement such as to increase or decrease the rate of setting or to increase the strength. The components of concrete are fine aggregate, coarse aggregate and binding material. Sudden surge in construction bustle carried out to terrible scarcity of conventional construction substance. It is traditional that crushed stone is being used as a coarse aggregate in concrete. To achieve economy, it is proposed to replace coarse aggregate by ceramic waste [1.] A relatively better strength is anticipated when coarse aggregate is partially replaced by ceramic waste. It is proposed that attempts are to be made to replace the coarse aggregate with ceramic waste without losing it workability and strength of concrete.

### 1.1. Ceramic waste

One of the alternatives for coarse aggregate is ceramic material. It has good potential use in areas where crushed stone is costly. Only few researchers reported the use of ceramic waste as coarse aggregate. This research discusses the physical features of crushed ceramic waste and the compressive strength of the concrete which is made up of certain amount of coarse aggregate replaced by ceramic waste. Calcium carbonate $CaCo_3$ is nature substance which provides hardness and strength to things for example rocks. When it reacts with hydrochloric acid, carbon dioxide gas is produced. Ceramic material has about 7% calcium carbonate which readily reacts with hydrochloric acid and produces calcium dioxide [2]. Ceramic waste is generally obtained from two main sources.

- From ceramic industry, this ceramic waste also denoted as non-hazardous industrial waste.
- Ceramic waste is related with construction and demolition bustle.

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Figure 1.Ceramic coarse aggregate

### 1.2. Scope

Nowadays 30 % of ceramic production is left as waste, so reuse the ceramic materials for concrete to reduce landfills. The ceramics are easily available material from the industries. The ceramic materials are broken into 20 mm size and used for partial replacement of coarse aggregate.

### 1.3. Objectives

- To introduce ceramic waste as aggregate as a new material into the concrete.
- To increase the strength of concrete using ceramic material.
- To solve the environmental problem of disposal of ceramic waste.
- To reduce the cost of construction of concrete by partially replacing coarse aggregate by ceramic waste.

## 2. SOURCES AND PROPERTIES OF MATERIALS

In this study, materials used for preparing concrete are tested before casting the specimens.

### 2.1. Cement

For the present investigation RAMCO brand PPC cement is used. Various tests are conducted on cement and their values are tabulated in Table 1.

Table 1.Tests on cement

| Description of test | Values |
|---|---|
| Specific gravity | 3.15 |
| Consistency | 31% |
| Initial setting time | 30 min |
| Final setting time | 450 min |

### 2.2. Fine aggregate

For this present investigation, locally available Thamirabharani river sand is selected as fine aggregate. Next the sand is washed and sieved for removing the unwanted deleterious substance and further it is tested as per the standards given in BIS: 2386 – 1968 and their values are tabulated in Table 2.

Table 2.Tests on fine aggregate

| Description of test | Values |
|---|---|
| Specific gravity | 2.665 |
| Fineness modulus | 2.88 |
| Zone of sand | II |
| Water absorption | 1.55% |

### 2.3. Coarse aggregate

In this examination, the crushed hard blue granite angular coarse aggregate with sieve size of 20 mm conforming to standards IS: 383 - 1970 is utilized. Ceramics are also used as coarse aggregates. Test conducted and their values are depicts in Table 3.

Table 3.Tests on coarse aggregate

| Description of test | Values |
|---|---|
| Specific gravity | 2.695 |
| Water absorption | 1.70% |
| Crushing value | 28.35% |
| Impact value | 32.15% |

### 2.4. Ceramic aggregate

The ceramic materials are taken from the ceramic industry and which is broken into a size of 20mm and which is sieved by using IS sieve [3-6]. Various tests are conducted on ceramic aggregate and their values are tabulated in Table 4.

Table 4.Tests on ceramic aggregate

| Description of test | Values |
|---|---|
| Specific gravity | 2.49 |
| Water absorption | 1.38% |
| Crushing value | 21.39% |
| Impact value | 24% |

## 3. EXPERIMENTAL INVESTIGATIONS

Several tests are conducted on the material for preparing concrete and these tests are carried out based on bureau of Indian standards.

### 3.1. Compressive strength

Compressive strength test is conducted by using compression testing machine. The strength of the concrete cube after 7 days, 14 days and 28 days are shown in Tables 5 and 6.

Table 5. Days compressive strength

| Sl. No | w/c ratio | % of ceramic added | Average strength in n/mm² |
|---|---|---|---|
| 1 | 0.50 | 0 | 24.03 |
| 2 | 0.50 | 5 | 24.27 |
| 3 | 0.50 | 10 | 25.43 |
| 4 | 0.50 | 15 | 26.45 |
| 5 | 0.50 | 20 | 27.90 |
| 6 | 0.50 | 25 | 27.03 |

From the result of 7 days compressive strength, it is noted that the variation in compressive strength is from 24.03 N/mm² to 27.03 N/mm². The maximum strength of 27.90 N/mm² is attained at 20 % replacement of ceramic waste. Even though, it is identified that there is a reduction in strength at 25 % replacement, when the strength overcomes the target mean strength.

Table 6.14 days compressive strength

| Sl. No | w/c ratio | % of ceramic added | Average strength in N/mm² |
|---|---|---|---|
| 1 | 0.50 | 0 | 30.81 |
| 2 | 0.50 | 5 | 30.95 |
| 3 | 0.50 | 10 | 32.26 |
| 4 | 0.50 | 15 | 33.57 |
| 5 | 0.50 | 20 | 34.29 |
| 6 | 0.50 | 25 | 34.00 |

On observing results of compressive strength on 14 days, it shown that the difference in compressive strength is from 30.81 N/mm² to 34.00 N/mm² and 34.29 N/mm² is the highest strength obtained at 20 % replacement of ceramic waste. Yet it depicts the minimization in strength at 25 % replacement, when the strength overwhelms the target mean strength.

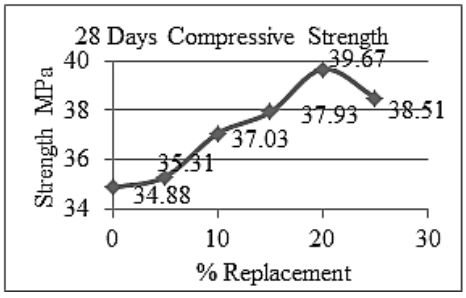


Figure 2.28 days compressive strength

Figure 2 depicts the compressive strength for 28 days test. From the Figure 2, it is noted that the variation in compressive strength is from 34.88 N/mm² to 38.51 N/mm². The topmost strength of 28 days compressive strength is 39.67 N/mm² which is achieved at 20 % replacement of ceramic waste. But also it shows reduction in strength at 25 % replacement, the strength overcomes the target mean strength.

### 3.2. Split tensile strength

Compression testing machine is utilized for testing tensile strength. Table 7 shows the tensile strength of the concrete cylinder after 7days.

Table 7.7 days split tensile strength

| Sl. No | w/c ratio | % of ceramic added | Average strength in N/mm² |
|---|---|---|---|
| 1 | 0.50 | 0 | 1.80 |
| 2 | 0.50 | 5 | 1.89 |
| 3 | 0.50 | 10 | 1.98 |
| 4 | 0.50 | 15 | 2.22 |
| 5 | 0.50 | 20 | 2.45 |
| 6 | 0.50 | 25 | 2.40 |

On observing results of tensile strength on 7 days, it shown that the difference in tensile strength is from 1.80 N/mm² to 2.40 N/mm² and 2.45N/mm² is the highest strength obtained at 20 % replacement of ceramic waste. Yet it depicts the minimization in strength at 25 % replacement, when the strength overwhelms the target mean strength.

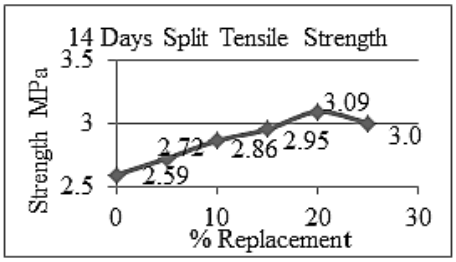


Figure 3.14 days split tensile strength

Figure 3 depicts the tensile strength for 14 days. From the Figure 3, it is noticed that the difference in tensile strength is from 2.59 N/mm² to 3.00 N/mm². The topmost strength of 14 days tensile strength is 3.09 N/mm² which is achieved at 20 % replacement of ceramic waste. But also it shows reduction in strength at 25 % replacement, the strength overcomes the target mean strength.

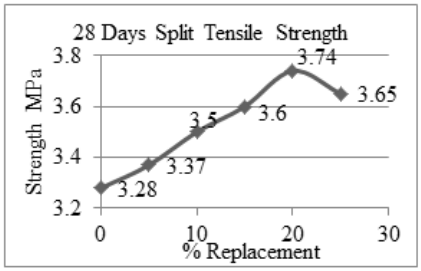


Figure 4.28 days split tensile strength

Figure 4 shows the 28 days split tensile strength. From the result of 28 days tensile strength, it is noted that the variation in compressive strength is from 3.28 N/mm² to 3.65 N/mm². The maximum strength of 3.74 N/mm$^2$ is attained at 20 % replacement of ceramic waste. Even though, it is identified that there is a reduction in strength at 25 % replacement, when the strength overcomes the target mean strength.

### 3.3. Flexural strength

The flexural strength test was conducted by using universal testing machine [7-9]. Figure 5 depicts the flexural strength for 7 days. From the Figure 5, it is noticed that the difference in flexural strength is from 1.58 N/mm² to 1.84 N/mm². The topmost strength of 7 days flexural strength is 1.88 N/mm² which is achieved at 20 % replacement of ceramic waste.

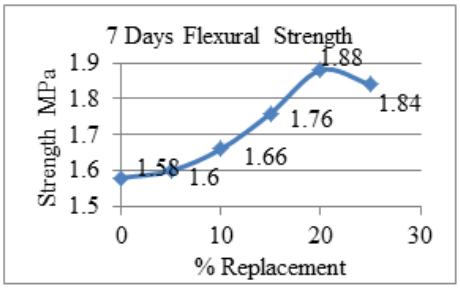


Figure 5.7 days flexural strength

Table 8 shows the 14 days flexural strength.

Table 8.14 days flexural strength

| Sl. No | W/c Ratio | % of Ceramic added | Average strength in N/mm² |
|---|---|---|---|
| 1 | 0.50 | 0 | 1.91 |
| 2 | 0.50 | 5 | 2.09 |
| 3 | 0.50 | 10 | 2.39 |
| 4 | 0.50 | 15 | 2.56 |
| 5 | 0.50 | 20 | 2.65 |
| 6 | 0.50 | 25 | 2.58 |

From the result of 14 days flexural strength, it is noted that the variation in flexural strength is from 1.91 N/mm² to 2.58 N/mm². The maximum strength of 2.65 N/mm² is attained at 20 % replacement of ceramic waste.

Flexural strength of concrete beam is tabulated in Table 9. From the 28 days flexural strength outcomes, it is experimental that the variation in flexural strength is from 2.80 N/mm² to 3.24 N/mm². The highest strength of 3.32 N/mm² is gained at 20 % replacement of ceramic waste. Yet, there is a reduction in strength at 25 % replacement, when the strength overcomes the target mean strength is observed 7, 14 and 28 days flexural strength test.

Table 9.28 days flexural strength

| Sl. No | w/c ratio | % of ceramic added | Average strength in N/mm² |
|---|---|---|---|
| 1 | 0.50 | 0 | 2.80 |
| 2 | 0.50 | 5 | 2.92 |
| 3 | 0.50 | 10 | 3.01 |
| 4 | 0.50 | 15 | 3.18 |
| 5 | 0.50 | 20 | 3.32 |
| 6 | 0.50 | 25 | 3.24 |

## 4. RESULTS AND DISCUSSION

Compressive strength for 7 days differs from 24.03 N/mm² to 27.03 N/mm². The maximum strength of 27.90 N/mm² is attained at 20 % replacement of ceramic waste. For 14 days it differs from 30.81 N/mm² to 34 N/mm². The maximum strength of 34.29 N/mm² is achieved at 20 % replacement of ceramic waste. For 28 days it varies from 34.88N/mm² to 38.50 N/mm². The maximum strength of 39.67 N/mm² is acquired at 20 % replacement of ceramic waste. Figure 5 outlined the comparisons of compressive strengths for 7, 14 and 28 days.

Figure 6 portrays the comparisons of tensile strengths for 7, 14 and 28 days. Split Tensile strength for 7 days varies from 1.80N/mm² to 2.40 N/mm². The maximum strength of 2.45 N/mm² is acquired at 20% replacement of ceramic waste. For 14 days it varies from 2.59 N/mm² to 3.00 N/mm². The maximum strength of 3.09 N/mm² is gained at 20 % replacement of ceramic waste. For 28 days it varies from 3.28 N/mm² to 3.65 N/mm². The maximum strength of 3.74 N/mm² is attained at 20 % replacement of ceramic waste.

Figure 7 exposes the comparisons of flexural strengths for 7, 14 and 28 days. The 7 days flexural strength varies from 1.58 N/mm²

to 1.84 N/mm². The maximum strength of 1.88 N/mm² is obtained at 20 % replacement of ceramic waste. The 14 days flexural strength varies from 1.91N/mm² to 2.58 N/mm². The maximum strength of 2.65N/mm² is obtained at 20 % replacement of ceramic waste. The 28 days flexural strength varies from 2.80 N/mm² to 3.24 N/mm². The maximum strength of 3.32 N/mm² is obtained at 20 % replacement of ceramic waste.

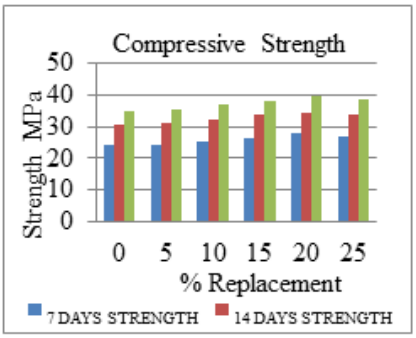


Figure 5.Comparisons of compressive strengths

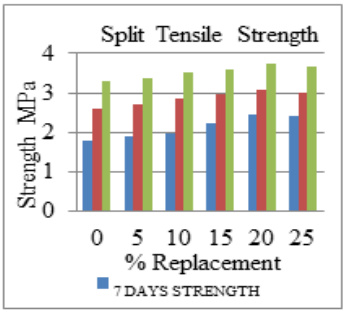


Figure 6.Comparisons of split tensile strengths

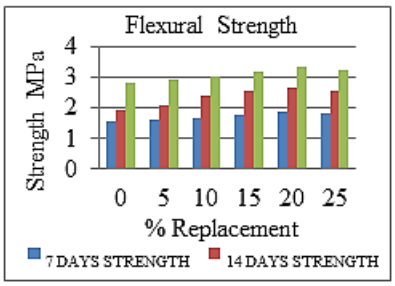


Figure 7.Comparison of flexural strengths

## 5. CONCLUSION

From the experimental study it is observed that replacement of ceramic waste by 20 % of coarse aggregate gives better results than conventional concrete. Comparing the compressive strength, noted that the strength of concrete is replaced by 20 % ceramic aggregate is 39.67 N/mm² and that for conventional concrete is 34.88 N/mm². So there is a rise in 12 % of compressive strength of concrete than conventional concrete. Comparing the split tensile strength, found that the tensile strength of concrete is replaced by 20% ceramic aggregate is 3.28 N/mm² and that for conventional concrete is 3.74 N/mm². So there is an improvement in 12 % of compressive strength of concrete than conventional concrete. Comparing the flexural strength, identified that the strength of concrete is replaced by 20 % ceramic aggregate is 2.80 N/mm² and that for conventional concrete is 3.32 N/mm². So there is a growth in 15 % of compressive strength of concrete than conventional concrete. Though the strength decreases in 25 % it satisfies the target mean strength.

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