Partial Replacement of Cement by Fly Ash & Aggregate by Glass Pieces

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Abstract: Concrete is the most important engineering material and the addition of some other materials may change the properties of concrete. Mineral additions which are also known as mineral admixtures have been used with cements for many years. In the present study, an attempt has been made to investigate the strength parameters of concrete made with partial replacement of cement with 10%, 20% and 30% of Class F fly ash and fine aggregate was replaced with 10%, 20% and 30% of crushed cullet glass aggregate. The main parameter investigated in this study is M30 grade concrete with partial replacement of cement by 10%, 20% and 30% of Class F fly ash and fine aggregate was replaced with 10%, 20% and 30% of crushed cullet glass aggregate. On experimental investigation, it was found from the compression test results Mix no.15 having 30% fly ash 20% glass aggregate replacement shows the highest compressive strength and Mix no.15 and Mix no.3 having 20% glass aggregate replacement gives the highest tensile strength.

I. GENERAL

In this study cement was replaced with 10%, 20% and 30% of Class F fly ash and fine aggregate was replaced with 10%, 20% and 30% of crushed cullet glass aggregate in various combinations to arrive at the most suitable mix. In this study we have experimented with various percentages of glass aggregates and fly ash to arrive at the most accurate replacement level.

A huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced by using natural sand obtained from the riverbeds as fine aggregate. However, due to the increased use of concrete in almost all types of construction works, the demand of natural or river sand has increased. To meet this demand of construction industry, excessive quarrying of sand from river beds is taking place causing depletion of sand resources. One of the cheapest and the easiest ways of getting substitute for natural sand is by crushing natural stone to get artificial sand of desired size and grade.

Total of 144 numbers of cubical specimens of size 150mm × 150mm × 150mm, and 144 number of cylinders of size 150mmX300mm were casted and tested for the compressive strength and tensile strength at the age of 3,7 and 28 days.

1.1 CLASSIFICATION OF CONCRETE

Concrete of Grade M30 is considered for this project. As per our Indian standard IS 456: 2000 concretes are grouped as ordinary concrete, standard concrete and high strength concrete as given in Table 1.1

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Name of Group of Concrete</th>
<th>Grade Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ordinary Concrete</td>
<td>M10 to M20</td>
</tr>
<tr>
<td>2</td>
<td>Standard Concrete</td>
<td>M25 to M55</td>
</tr>
<tr>
<td>3</td>
<td>High Strength Concrete</td>
<td>M60 to M80</td>
</tr>
</tbody>
</table>

Note: M refers to mix and the number to specified compressive strength of 150mm size cube test 28 days expressed in N/mm²

1.2. PROPERTIES OF MATERIAL USED

1.2.1 Fly Ash:
Fly ash is also known as flue-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Fly ash is one of the by-products of the combustion of coal in electric power generating plants.
1.2.2 Crushed Glass Aggregate:
Crushed bottle glass if properly sized show properties similar to that of sand due to its high silica content. But the main problem faced in the use of this glass aggregate in the production of concrete is the adverse effect of Alkali Silica Reaction (ASR). It is caused due to the reaction of alkali present in the concrete and silicon dioxide present in the glass. ASR causes expansion of concrete thereby causing formation of micro cracks. In this study we have experimented with various percentages of glass aggregates and fly ash to arrive at the most accurate replacement level.

II. METHODOLOGY

- Literature Review
- Procurement of Materials
- Properties of Materials
- Mix Design
- Casting of Specimens
- Results Analysis
- Report Submission

Fig: 2. Methodology
III. RESULTS AND DISCUSSION

3.1 COMPRESSIVE TEST ON CUBES

3.1.1 Scope

According to IS 516:1959, compression test was carried out on a standard 150x150x150mm cubic specimens. All the cubes were tested in surface dried condition for each mix combination, three cubes were tested at the age of 3, 7 and 28 days using compression testing machine of 2000 ton capacity. The loading was continued till the specimen reaches its ultimate load. The ultimate load divided by the the specimen is equal to ultimate compressive strength, cross sectional area of dividing the maximum load attained during the test by the cross-sectional area of the specimen.

3.1.2 Summary of test method

This test method consists of applying a compressive axil load to moulded cubes at rate which is within a prescribed range until failure occurs. The compressive strength of the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

3.1.3 Results

![Fig 3.1 Compression Testing Machine](image1)

![Fig 3.1.2 Compressive Test](image2)

![Fig 3.1.4 compressive Strength of cube at 3 days](image3)
3.2 SPLIT TENSILE STRENGTH

3.2.1 Scope
This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens, such as molded cylinders and drilled cores. The values stated in inch-pound units are to be regarded as the standard. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determines the applicability of regulatory limitations period to use.

3.2.2 Summary of Test Method
The cylinders were tested in saturated surface dried condition. For each mix combination, three cylinders were tested at the age of 3, 7 and 28 days using compression testing machine of 2000 tone capacity. The split tensile strength is calculated by using the formula given in IS 5816:1999, splitting tensile strength of concrete - method of tests.

3.2.3 Significance and Use
Splitting tensile strength is simpler to determine the direct tensile strength and splitting tensile strength is used to evaluate the shear resistance provided by concrete in reinforced light weight aggregate concrete members.
3.2.4 Results

3 Days tensile strength (Mpa)

![Graph showing 3 Days tensile strength for different mixes](image)

Fig: 3.2.5 Split Tensile Strength of cylinders in 3 Days

7 Days tensile strength (Mpa)

![Graph showing 7 Days tensile strength for different mixes](image)

Fig: 3.2.6 Split Tensile Strength of cylinders in 7 Days
3.3 RAPID CHLORIDE PENETRATION TEST

3.3.1 Scope

The rapid chloride permeability test (RCPT), as it is commonly called, has been in existence for over 20 years and was standardized by ASTM over 15 years ago.

3.3.2 Significance

By determining how easy it is to force chloride ions into saturated concrete by applying an electrical potential across a test specimen in accordance with AASHTO T277 or ASTM C1202. This is known as the “Coulomb Test” or the “Rapid Chloride Permeability Test (RCPT).” By measuring the penetration depth of chloride ions, after an electric potential has been applied to the specimen in accordance with NORDTEST BUILD 492 (Chloride Migration Coefficient from Non-Steady State Migration Experiments) to determine the “Chloride Migration Coefficient,” which can be used to estimate the chloride diffusion coefficient for service life calculations.

3.3.3 Procedure

The test method involves obtaining a 100 mm (4 in.) diameter core or cylinder sample from the concrete being tested. A 50 mm (2 in.) specimen is cut from the sample. The side of the cylindrical specimen is coated with epoxy, and after the epoxy is dried, it is put in a vacuum chamber for 3 hours.
Table 3.7 chloride permeability based on charge passed (ASTM C1202)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Charge passed (coulombs)</th>
<th>Chloride ion penetrability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt; 4,000</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>2,000-4,000</td>
<td>Moderate</td>
</tr>
<tr>
<td>3</td>
<td>1,000-2,000</td>
<td>Low</td>
</tr>
<tr>
<td>4</td>
<td>100-1,000</td>
<td>Very Low</td>
</tr>
<tr>
<td>5</td>
<td>&lt; 100</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

**IV. XRF ANALYSIS**

X-ray fluorescence techniques is based on the principle that a crystal of a substance has a unique diffraction pattern when a monochromatic X-ray beam falls on a crystal structure it gets reflected by the various crystalline planes. If a crystalline mineral is exposed to X-rays of particular wavelength, the layers of atoms diffract the rays and produce the patterns of peaks which are the characteristics of the mineral. XRF Analysis Report are shown in the form of tables and graphs.

Sand is Very less and Lead Zero than the Natural Sand which results in the Zero Percent Corrosion.

**XRF Analysis Report For different materials**

![Fig: 3.17 XRF Patterns of Natural Sand](image-url)
Fig: 3.18 XRF Patterns of Fly Ash

Fig: 3.19 XRF Patterns of Glass Powder

V. SUMMARY AND CONCLUSIONS

Based on the experimental results, the following conclusions are drawn:

1. It was found from the compression test results Mix no.15 having 30% fly ash 20% glass aggregate replacement shows the highest compressive strength.
2. Mix no.15 and Mix no.3 having 20% glass aggregate replacement gives the highest tensile strength.
3. From the RCPT test it was found that the all the mixes used were moderately resistant to chloride penetration.
4. In this thesis, this type of replacement of cement by Fly ash and fine aggregate by crushed glass aggregate were found to have positive effect on the strength of concrete. Also it will not affect the nature resources. In future we can use this type of replacement even in high-strength concrete.

REFERENCES


A S Rossomagina, D V Saulin, and I S Puzanov, “Prevention of Alkali-Silica Reaction in Glass Aggregate Concrete”, pp-2, Perm State Technical University, Russia.


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