

EXPERIMENTAL INVESTIGATION OF COMPRESSIVE STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CONSTITUENTS

Durgalakshmi.K.M¹, Krishnachandran.V.N²

¹Department of Civil Engineering, Kerala Technological University, Palakkad, Kerala

²Department of Civil Engineering, Kerala Technological University, Palakkad, Kerala

Abstract

Undoubtedly concrete is the most versatile and widely used construction material. It is the material of choice with strength, performance and durability. This study aims at utilization and to ascertain the suitability of saw dust ash as a partial replacement of cement, glass powder as a partial replacement of fine aggregate and rubber tyre pieces as a partial replacement of coarse aggregate in normal M30 grade concrete. Initially, all trial combinations were casted by replacing binder, fine aggregate and coarse aggregate at a varying rate of 2 to 10 %. The replacement percentage of binder giving maximum strength is chosen and is fixed accordingly for further studies. Thereafter, the percentage of coarse aggregate and fine aggregate were changed from 2 to 8% to arrive at an optimum mix having maximum compressive strength. The strength performance of these concrete with normal concrete mix is investigated and findings are reported.

Keywords – Rubber Tyre Pieces, Saw Dust Ash, Waste- Glass Powder

1. INTRODUCTION

Concrete is by far the most versatile and most widely used construction material worldwide. It can be engineered to satisfy a wide range of performance specifications, unlike other building materials, such as natural stone or steel, which generally have to be used as they are. The properties of concrete depend not only on the various constituent materials but also on the way they are proportioned and mixed, as well as on the methods of placing and curing the composite.

Waste recycling can provide an opportunity to collect and dispose it in an environmental and economical way and it can be also converted into a resource. The utilization of industrial waste or secondary materials has encouraged the production of cement and concrete in construction field. Over recent decades, intensive research studies have been carried out to explore all possible reuse methods. Further investigations are needed to clarify for instance which are the possibilities and means to maximize concrete performance.

2. METHODOLOGY

The work is done with the following process:-

• Collection of materials

Basic materials such as cement, sand, and gravel required for the concrete are to be collected. Cement used in the work was PPC (Portland Pozzolana Cement). Fine-aggregate used was M sand and coarse aggregate used was natural gravel. Also the waste materials such as saw dust, waste glass and waste rubber tyre required for the work were collected from different sources.

• Recycling (preparation) of waste materials

The collected waste materials were recycled into convenient form required for the work.

• Material testing

The basic tests for all the materials were carried out and it was done for recycled waste materials also.

• Mix design

After the obtained result from material testing, mix design was carried out.

Control mix design and casting was carried out.

• Casting of samples

Required numbers of cubes samples were casted and cured properly.

• Testing of samples

Compressive strength and light weight character were tested.

• Interpretation of results

2.1 Material Collection and Preparation

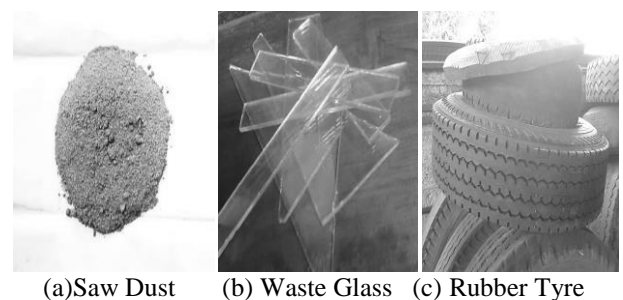


Fig.1

Saw dust used in this project which was obtained from nearby timber milling factory is air-dried and then calcinated

into ashes by burning process. The saw dust ash was sieved through 150µ and those passing the sieve were used for this work.

Glass powder is used as a substitute material for sand in concrete. Before adding in the concrete, the glass was powdered to desired size. It was crushed using Compression Testing Machine and then sieved through 1.18mm IS sieve.

Rubber aggregate is prepared by manual cutting and sieved through 20mm IS sieve. The reason for it is that they can give the required shape and size which is similar to the common natural gravel.



(a)Saw Dust Ash (b) Glass Powder (c) Rubber Tyre Pieces

Fig.2

2.2 Material Testing

The relevant tests to identify the properties of the aggregates were carried out manually.

The properties of all the materials were tested in the laboratory to check whether the sample can be used in the production of concrete. The result obtained from the laboratory is compared with the conventional materials.

Table -1 Material Testing Results comparison with Cement and Saw Dust Ash

Material Properties	Results (Cement)	Results (SDA)	Permissible Limit According to IS 1489: 1991
Fineness	1.7%	5%	5%
Specific Gravity	2.85	2.71	Around 2.9
Standard Consistency	32%		Not < 30mins
Initial Setting Time	90min		
Soundness	1mm		Not>16mm
Compressive Strength	20.7N/mm ²		22 N/mm ²

Table -2: Material Testing Results comparison with Coarse Aggregate and Rubber Tyre Pieces

Material Properties	Results (Cement)	Results (SDA)	Permissible Limit According to IS:383 1970
Bulk Density	1.662	0.674	1.52 to 1.68
Void Ratio	0.796	0.837	Not > 1
Specific Gravity	2.93	1.2	2.5 to 3
Water Absorption	0.4%	0.4%	Not >0.6%

Table 3: Material Testing Results comparison with Fine Aggregate and Glass Powder

Material Properties	Results (Cement)	Results (SDA)	Permissible Limit According to IS:383 1970
Sieve Analysis	Zone II	Zone II	
Bulking	38.89% (for 8% moisture)	53.85% for 8% moisture	10% moisture
Bulk Density	1.441	1.351	1.52 -1.68
Void Ratio	0.846	0.574	Not > 1
Specific Gravity	2.66	2.13	2.5 to2.9
Water Absorption	2.6%	1.6%	Not>4%

2.3 Mix Design

By selecting the right mix proportion of concrete, the concrete workability can be achieved. The mix design was according to IS : 10262 – 1982 guidelines for M30 mix including replacements are designed for the investigation.

Table 4: Mix Design Results

Design Parameters	Results for M30
Target mean strength	38.25 N/mm ²
Water cement Ratio	0.45
Water Content	186 litres
Cement Content	413.333 kg/m ³
Fine aggregate content	604.283 kg/m ³
Coarse aggregate content	1235.9 kg/m ³
Mix Ratio	1 : 1.46 : 2.99

2.4 Casting

The cubes are of size 15 X 15 X 15 cm were casted by replacing cement, fine aggregate and coarse aggregate with saw dust ash, glass powder and rubber tyre pieces respectively by 2,4,6,8 and 10% to fix the maximum replaceable percentage.



Fig.3 Cube Specimens

2.5 Testing

Compressive strength and light weight character of all the samples was determined after curing of 7days. Light weight character was measured for concrete before curing itself. The average dry weight of concrete cube specimens containing replacement was compared with average dry weight of normal M30 concrete cube specimens and the percentage decrease in dry weight was measured.



Fig.4 Compressive Strength Test Set up



Fig.5 Measuring of weight

After the initial test results maximum replaceable percentage was obtained and it is chosen as the replacement percentage for binder for further trials. Then samples were casted with coarse aggregate and fine aggregate percentages were changed from 2 to 8%.

3. RESULTS

The compressive strength for initial trials was obtained as increasing up to a replacement of 4% and then decreasing.

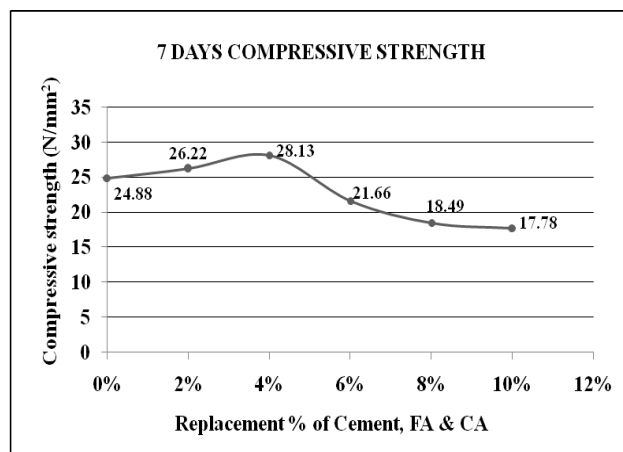


Fig.6 Seven Days Compressive Strength without varying aggregate content

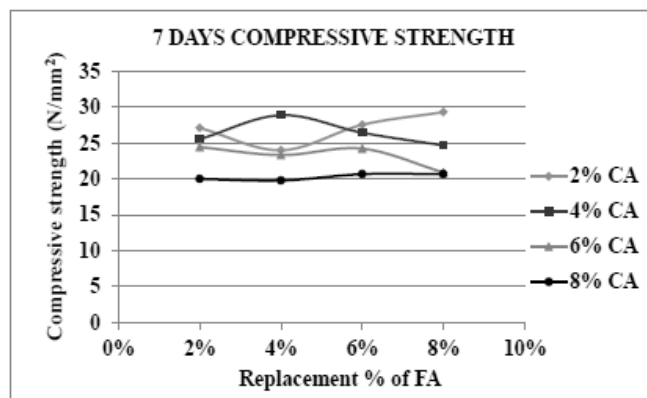


Fig.7 Seven Days Compressive Strength without varying aggregate content

The % decrease in weight for initial trials was obtained as decreasing from 0% to 10% of replacement.

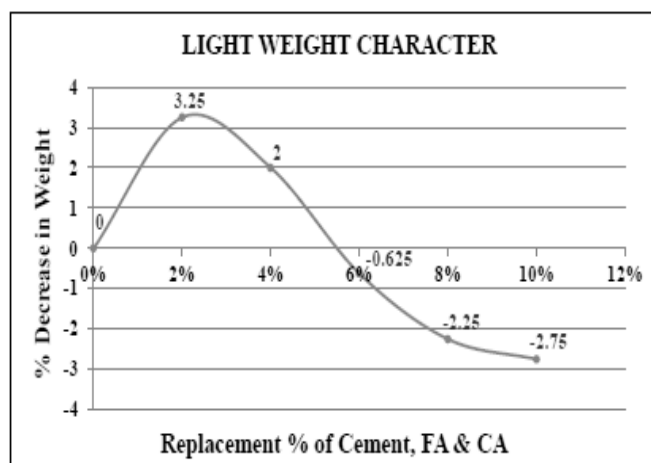


Fig.8 Light Weight Character without varying aggregate content

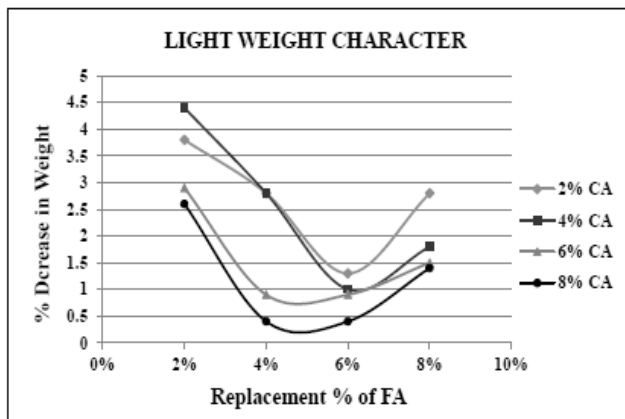


Fig.9: Light Weight Character with varying Aggregate Content

4. DISCUSSION

From the initial trial combinations by replacing binder, fine aggregate and coarse aggregate at a rate of 2 to 10 %, maximum compressive strength was obtained for a replacement of 4%. The significant increase in strength of concrete can be due to the pozzolanic reaction of Saw Dust Ash and the cementitious products formed as a result of hydration of cement. Compressive strength was found to increase with the addition of waste glass powder due to the angular nature of the glass particles facilitating increased bonding with the cement paste.

In case of compressive strength a maximum value was obtained at a replacement of cement with 4% SDA, FA with 8% glass powder and CA with 2% rubber tyre pieces. The minimum percentage of rubber tyre pieces will not affect the bonding of concrete mix and also provide minimum voids and vacuum in the matrix. Along with this, the maximum percentage of glass powder increases the bonding by the angular structure of its particle and hence strength will also be enhanced. Waste glass contain high silica content (SiO_2) i.e. 72% and high compressive strength. Waste glass powder also reacts with alkalis in cement (pozzolanic reaction) and cementitious product that help contribute to the strength development.

5. CONCLUSION

By fixing the percentage of replacing binder at 4% and then varying the replacement percentage of fine aggregate and coarse aggregate from 2 to 8%, an optimum mix ratio with a maximum strength was obtained as 4:8:2, viz. with a replacement of cement with 4% of SDA, fine aggregate with 8% of glass powder and coarse aggregate with 2% of rubber tyre pieces. This appears to be a best mix for achieving maximum strength for M30 grade concrete.

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