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Experimental Investigation of Compressive Strength of Concrete Using Waste Materials

Durgalakshmi.K.M[1], Krishnachandran.V.N[2]

[1]*PG Student, Department of Civil Engineering, Sreepathy Institute of Management And Technology, Vavanoor, India*
[2]*Assistant Professor, Department of Civil Engineering, Sreepathy Institute of Management And Technology, Vavanoor, India*

Abstract - *Concrete is a composite material that consists essentially of a binding medium, such as a mixture of Portland cement and water, within which are embedded particles or fragments of aggregate, usually a combination of fine and coarse aggregate. This study aims at utilization and to ascertain the suitability of saw dust ash as a partial replacement of cement, glass powder as fine aggregate and rubber tyre pieces as coarse aggregate in normal concrete. Initially, all trial combinations were casted by replacing binder, fine aggregate and coarse aggregate at a rate of 2 to 10 %. The replacement giving more strength is chosen and the binder is fixed accordingly for further trials. Thereafter coarse aggregate and fine aggregate percentages were changed from 2 to 8% to arrive at an optimum mix having maximum compressive strength. The strength performance of these concrete with conventional concrete is to be investigated so as to report the findings.*

Key Words: Glass Powder, Recycling, Rubber Tyre Pieces, Saw Dust Ash

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.6

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. MATERIALS USED

Cement used in the work was PPC (Portland Pozzolana Cement). Fine- aggregate used was Manufactured Sand (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.

2.1 Saw Dust Ash (SDA)

Saw dust used in this project was of type Irul wood which obtained from nearby timber milling factory is air-dried and then calcinated into ashes by burning process. The burnt ash is then allowed to cool under environmental conditions and then collected into a safe container for material testing. The ash was sieved through 150µ and those passing the sieve were used for this work.

2.2 Glass Powder

Plain broken windows glass was used for replacement which was supplied from windows glass market. Glass powder is used as a substitute material for sand in concrete. Before adding in the concrete, the glass was powdered to desired size.

2.3 Rubber Tyre Pieces

For uniformity of the concrete production and convenience, all the tires collected are that of bus. The reason for choosing it is that they can give the required shape and size which is similar to the common natural gravel. For this study, rubber aggregate is prepared by manual cutting and sieved through 20mm IS sieve. Rubber tyre aggregates are supposed to be dipped in aqueous solution of Sodium Hydroxide (NaOH) for 20 minutes in order to enhance its strength property. It is supposed to be done just before casting the specimens.

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

Fig -1

3. MATERIAL PROPERTIES

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.

The material properties of Saw Dust Ash were tested in the laboratory to check whether the sample is a pozzolan material and can be used in the production of concrete.

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& IS:383 1970
Fineness	1.7%	5%	5%
Specific Gravity	2.85	2.71	Around 2.9
Standard Consistency	32%		
Initial Setting Time	90min		Not < 30mins
Soundness	1mm		Not >16mm
Compressive Strength	20.7 N/mm^2		22 N/mm^2

In general, aggregates should be hard and strong, free of undesirable impurities, and chemically stable. The relevant tests to identify the properties of the aggregates were carried out manually.

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

Material Properties	Results (Cement)	Results (SDA)	Permissible Limit According to IS 1489 : 1991& 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 8 Material Testing Results comparison with Fine Aggregate and Glass Powder

Material Properties	Results (Cement)	Results (SDA)	Permissible Limit According to IS 1489 : 1991& 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 to 2.9
Water Absorption	2.6%	1.6%	Not >4%

4. MIX DESIGN

The strength and durability of concrete depend on the materials and methods chosen with adequate mixing. By selecting the right mix proportion of concrete, the concrete workability can be achieved. The mix design was according to IS : 10262 - 1982guidelines for M30 mix including replacements are designed for the investigation. The mix design data and results are tabulated below –

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
Materials for 1 cube (15cmx15cmx15cm)	Water = 627 ml Cement =1.395 kg FA = 2.039 kg CA = 4.171 kg

5. CASTING OF SAMPLES

Initially 30 numbers cube samples of M30 mix were casted. 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.

(a) Samples with 2% replacement (b) Samples with 4% replacement

Fig -2

Compressive strength of all the samples was determined after curing of 7 days. The compressive strength was obtained as increasing up to a replacement of 4% and then decreasing.

Fig -3 Compression Test Set up

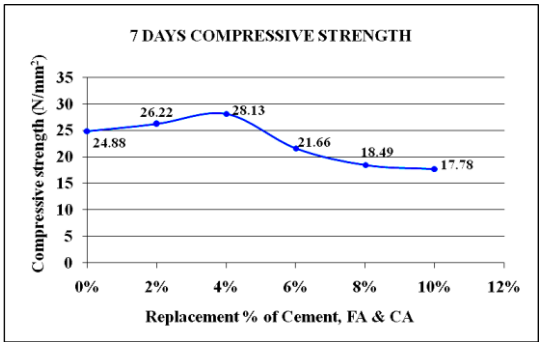

Chart-1 Seven Days Compressive Strength

6.1 Casting with Varying Aggregate Content

After the initial test results maximum replaceable percentage was obtained as 4%. It is chosen and the replacement percentage for binder is fixed as 4% for further trials.

64 numbers of samples were casted with coarse aggregate and fine aggregate percentages were changed from 2 to 8% and binder as 4%.

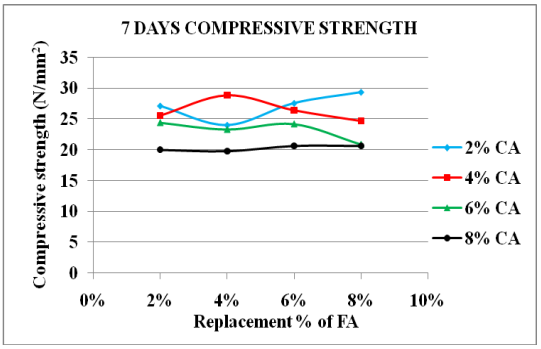

Chart-2 Seven Days Compressive Strength with varying Aggregate Content

7. CONCLUSIONS

From this study, it can conclude that-

- 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 SDA and the cementitious products formed as a result of hydration of cement.
- The reduction in compressive strength with an increase in the proportion of cement replaced will be due to the change in microstructure of the interfacial transition zone and also a change in the

microstructure of the hydrated cement paste composed of the saw dust ash.

- 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.

- Compressive strength decreases by increasing the content of rubber tyre pieces because the weak bonding of cement paste with rubber tyre pieces. With the increase in the voids in concrete with maximum replacement of rubber aggregates also decreases the strength.

- 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 tire pieces. This appears to be a best mix for achieving maximum strength for M30 grade concrete.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.

(a) Bonding (b) Crack formation

Fig -4

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