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An Experimental Study on Strength and Durability of Concrete with Addition of Cow Dung Ash and Glass fibre

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Abstract — *In civil engineering constructions cement is the main binding material for concrete preparation. The production and consumption of cement in construction field are increasing day by day. It may cause more environmental problem due to emission of huge amount of pollutant gases to the atmosphere. Many cementitious materials are used as partial replacement of cement. This will reduce the necessity for cement production, thus reducing the environmental effects. This research paper presents the results on the study by using Cow Dung Ash as a partial replacement of cement in the production of concrete. This replacement was designed to study the effects of adding Cow Dung Ash (CDA) in various percentages by weight (6%, 8%, 10% .12% and 14%) of cement and curing for the periods of 7, 14, and 28 days before testing for the Compressive strengths. In this paper cement replacement levels were selected to study the effects of CDA on compressive strength, acid and chloride resistance in concretes. The M25 mix design for the proposed concrete mix is done. The present investigation has also shown that an addition of 0.5% glass fibre to concrete makes it stronger and more durable. Results showed that 8% replacement of cement by cow dung ash produces a considerable increase in compressive strength. From durability tests, it is observed that the CDA concrete with glass fibre has the ability to resist acid attack and chloride attack.*

Keywords- *Cow dung ash, Glass fibre, Cement, Compressive strength, Durability.*

I. INTRODUCTION

Concrete is the most widely used man made construction material in civil engineering. The consumption of cement in concrete industries has been increasing day by day to fulfil the needs of infrastructure .Governments and organizations are working together to find solutions for a greener future, while prospective zero carbon sustainable cities are already underway. The huge production of cement poses environmental problems due to emission of different gaseous pollutants. Emissions of poisonous gases like carbon dioxide, nitrogen dioxide etc by cement production companies have depleted the natural environment. Therefore there is a need to search for supplementary cementitious materials for utilization as partial substitute for cement. Several researchers have used different materials like rice husk ash, saw dust ash, fly ash, GGBS, as partial replacement of cement in concrete.

II. SCOPE OF THE STUDY

The study helps to examine the effectiveness of using CDA as partial replacement of cement and to study strength parameters and durability of concrete with CDA. There is necessity of consumption of the waste material for manufacturing of sustainable concrete for construction. These materials are locally available and they can also reduce the cost of producing concrete. The cement industry is held responsible for some of the carbon-dioxide emission which contributes to the global warming. The production of 1 tonne of ordinary Portland cement emits approximately 1 tonne of carbon-dioxide into the atmosphere. To overcome these problems, in this paper, the role of CDA used as supplementary cementitious material is discussed.

III. OBJECTIVE OF THE STUDY

- To investigate and compare the strength of concrete with CDA to that of normal concrete.
- To compare the durability property of normal concrete and concrete with CDA.

IV. METHODOLOGY

This study was mainly divided into a number of works. The properties of materials were tested in the laboratory as per IS specifications and by using the results mix design was done. The sizes of specimens were suitably chosen and reinforcement details were worked out. The specimens were cast and tested after 28 days of curing to determine the strength. The methodology is represented in the form of a flow diagram as shown in Fig .1.

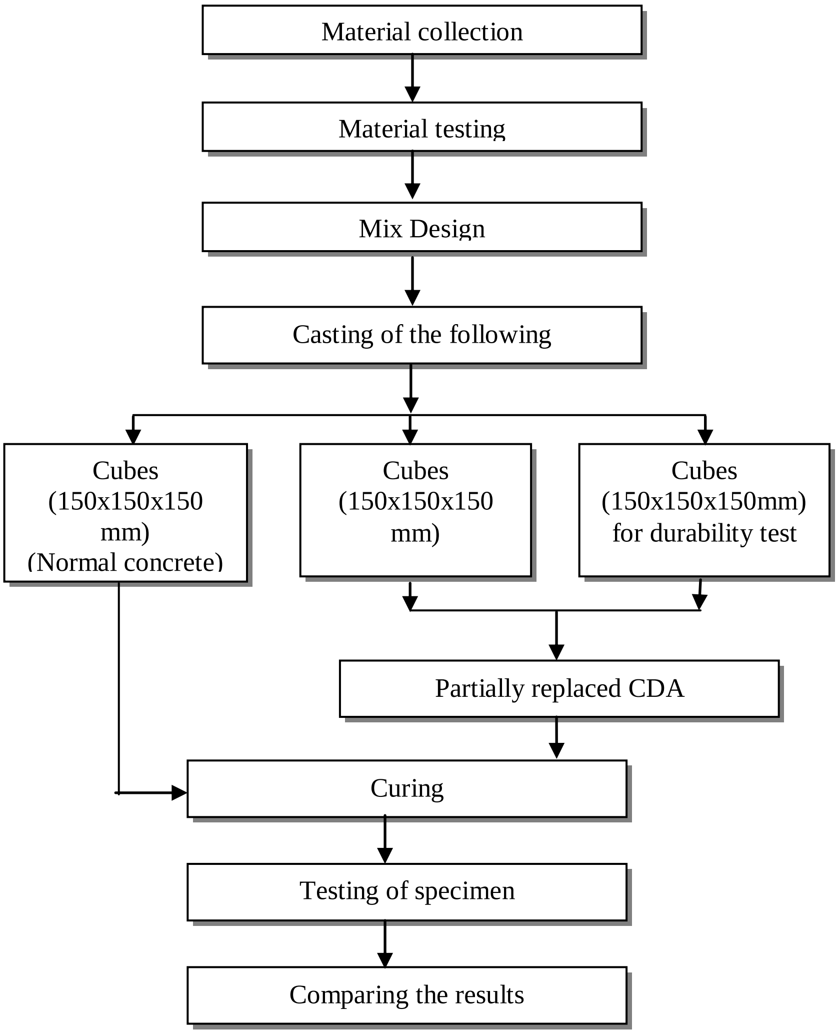

Fig.1 Methodology

4.1. Material collection

The materials used in concrete cubes and cylinders are cement, sand as fine aggregate, stone chips as coarse aggregate and water. The necessary properties and specifications of these materials were determined in the laboratory as per the specified code. In this study, cow dung ash was used for preparing concrete specimens by replacing different cement percentage and the fixed optimum percentage of 0.5 of glass fibre.

A. Ordinary Portland cement

The Bureau of Indian standard has graded the Ordinary Portland cement in to three grades, namely 33 grades, 43 grades and 53 grades. Ordinary Portland cement 53 grade was used throughout the study. The standard consistency, setting time and specific gravity were tested in the laboratory. All the tests were carried out in accordance with procedure laid down in IS 12269 – 1987.

B. Fine aggregate

Fine aggregates are basically sands obtained from the land or the marine environment. Fine aggregates are the materials that pass through 4.75 mm IS sieve. Manufactured sand (M sand) was used as fine aggregate. Manufactured sand is a substitute of river sand for construction purposes sand produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The tests such as specific gravity and gradation were carried out to determine the physical properties of fine aggregate.

C. Coarse aggregate

Locally available crushed stone aggregate of 20 mm size was used throughout the experimental study. The tests such as specific gravity and gradation were carried out to determine the physical properties of coarse aggregate. The coarse aggregate is chosen by shape as per IS 2386(Part I) 1963, surface texture characteristics of aggregate is classified as in IS 383-1970.

D. Water

This is the least expensive but most important ingredient of concrete. The water which is used for making concrete should be clean and free from harmful impurities such as oil, alkali, acid, etc. Potable water was used for the experiment.

E. Chemical admixture

To impart additional workability a super plasticizer CERAPLAST 300 was used.

F. Cow dung ash

The cow dung is exposed to sunlight to dry in order to have dung cakes which are then subjected to burning to have the cow dung ash which is obtained in black colour. Fig.2 shows cow dung ash.

Fig.2 Cow dung ash

G. Glass fibre

Glass fibre is a monofilament glass fibre with Engineering Properties. Glass fibre improves quality, durability and service life of structure. Glass fibre is very useful for prevention of plastic shrinkage crack. Glass Fibre is very useful for concrete, mortars, roads, industrial flooring, cement and concrete articles, precast works, and crack prevention.Fig.3 shows glass fibre.

Fig.3 Glass fibre

4.2. Material testing

A.Specific gravity test

The specific gravity is normally defined as the ratio between the weight of a given volume of material and weight of an equal volume of water. Specific gravity of cement, fine aggregate and coarse aggregate are tested.Fig.4 shows specific gravity test on cement, fine aggregate and coarse aggregate.

a) b) c)

Fig.4 Specific gravity test on a) cement b) Fine aggregate c) Coarse aggregate

B. Fineness of cement

Fineness test was conducted on cement using 90 micron sieve. Fineness is an important property of cement which affects the rate of hydration of cement. Finer cement offers a greater surface area for hydration and hence faster the development of strength. The test was conducted by sieving 100 gm of cement through IS 90 micron sieve continuously up to 15 minutes.Fig.5 shows fineness of cement.

Fig.5 Fineness of cement

B. Sieve analysis

Sieve analysis is done as per IS 2386 (Part I)-1963. The first step involves arranging the IS sieves in the order of4.75mm-2.36mm-1.18mm-600µ-300µ-150µ-75µ.1kg of fine aggregate is taken and placed on the top most sieve. Sieving is done for fifteen minutes and weight retained on each IS sieve is found. Using the above values, fineness modulus is calculated.Fig.6 shows sieve analysis of fine aggregate.

Fig.6 Sieve analysis of fine aggregate

C.Consistency of cement

Consistency test is done to determine the standard water requirement for setting time. The test was done under standard condition as mention in IS: 4031-1988.Fig.7 shows consistency test on cement.

Fig.7 Consistency test on cement

4.3. Mix design

Mix design is a process of selecting suitable ingredients and determining their relative proportions with the objective of producing concrete having certain minimum workability, strength and durability. Mix design was done as per IS 10262 – 2009.

4.4. Preparation of specimen

The specimens were prepared by using M25 grade concrete. The compressive strength is determined after 28 days of curing. Concrete cubes of size 150×150×150 mm were cast as normal concrete and CDA concrete. At each interval, concrete was compacted giving 25 blows by a compaction rod. Then the top surface of the cube was finished using a trowel. After that, the moulds were left for drying for 24 hours. At the end of 24 hours, the cubes were removed from the moulds and were submerged in water tanks for curing. After 7, 14 and 28 days of curing compression test were carried out using compression testing machine. The optimum percentage of cow dung ash is determined from this result. The cube specimens were cast for durability test also. After 28 days of water curing the specimen was immersed into chloride solution and acid solution upto 50 days for durability test.Fig.8 shows stages of preparation of concrete cubes.

a) *b)* *c)*

Fig.8 Stages of preparation of concrete a) mixing b) casting c) curing

4.5. Test on concrete

4.5.1. Compressive strength test

Compressive strength of concrete is a measure of its ability to resist static load.7, 14 and 28 day compressive strength tests were conducted on three specimens having size (150x150x150 mm) and the average strength was taken as the cube compressive strength of concrete. The optimum percentage of glass fibre was determined by conducting compression test on cubes with different percentages of glass fibre. Cubes were made with partially replaced CDA at various percentages such as 6%, 8%, 10%, 12%, 14% and optimum percentage of glass fibre. The tests were conducted by using compression testing machine. From the results of the compression tests, the optimum percentage of CDA to be added is determined as the one which renders the maximum compressive strength. Fig.8 shows compression test of the cube specimen.

Fig.8 Compressive strength test

4.5.2. Durability test

Durability study of concrete is very important for controlling the quality of any concrete. The main purpose of durability study on concrete is to record the durability performance of the concrete under different environment condition. The main tests carried out to determine durability of high performance concrete are acid attack test and chloride attack test. Both ordinary portland cement concrete and CDA concrete cubes of size 150mm x 150mm x 150mm were cast to test durability against acid and chloride.

A. Acid resistance

The concrete cube specimens of various concrete mixtures of size 150x150x150mm were cast and after 28 days of water curing, the specimens were removed from the curing tank and allowed to dry for one day. The weights of concrete cube specimen were taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water for 50 days after 28 days of curing. Hydrochloric acid (HCl) with pH of about 2 at 5% weight of water was added to water in which the concrete cubes were stored. After 50 days of immersion, the concrete cubes were taken out of acid water. Then, the specimens were tested for compressive strength. The resistance of concrete to acid attack was found by the percentage loss of weight of specimen and the percentage loss of compressive strength on immersing concrete cubes in acid water.Fig.9shows the cube specimen immersed in 5% HCl solution.

Fig.9 Cube specimens immersed in 5% HCl

B. Chloride resistance

Sodium chloride (NaCl) solution with 5% concentration was used as the standard exposure solution for all tests. The specimens were immersed in the sodium chloride solution in a plastic container and the volume proportion of chloride solution to specimens was maintained as four to one. The change in mass and change in compressive strength were observed. Fig.9shows the cube specimen immersed in 5% NaCl solution.

Fig.10 Cube specimens immersed in 5% NaCl solution

V. RESULTS

5.1 Test on ordinary Portland cement

Table.1 Test results of ordinary Portland cement

Sl.No	Physical properties	Result
1	Fineness	1.133%
2	Specific Gravity	3.15
3	Consistency	29%

5.2 Test on aggregate

Table.2 Test results of aggregate

Sl.No	Physical property	Result
1	Specific gravity of fine aggregate	2.6
2	Specific gravity of coarse aggregate	2.68

5.3 Compressive strength test

Table.3 Obtained compressive strength

Sl.No	Percentage of CDA	Percentage of glass fibre	Compressive strength after 7days (N/mm^2)	Compressive strength after 14 days (N/mm^2)	Compressive strength after 28 days (N/mm^2)
1	0%	0%	20.74	25.18	30.66
2	6%	0.5%	21.62	26.92	31.55
3	8%		23.70	28.4	32.44
4	10%		20.29	24.14	27.55
5	12%		19.25	22.22	25.33
6	14%		18.07	20.14	22.07

5.4 Durability test

Durability study of concrete is very important for controlling the quality of any concrete. The main purpose of durability study on concrete is to record the durability performance of the concrete under different environmental conditions. The main tests carried out to determine durability of high performance concrete are acid resistance test and chloride resistance test. Both ordinary Portland cement concrete and CDA concrete cubes of size 150mm x 150mm x 150mm were cast to test durability against acid and chloride.

5.4.1 Acid resistance

Fig.11 shows percentage mass loss of concrete due to acid attack. The loss in mass of the CDA concrete specimen was 0.98% after 50 days. In the case of the OPC concrete specimens, the loss in mass was about 1.42% after 50 days of immersion. Fig.12 shows loss of compressive strength in concrete. The loss in compressive strength of the CDA concrete specimens soaked in the HCl solution was 1.33% after 50 days of immersion. In the case of the OPC concrete specimens, the loss in compressive strength was about 2.142% after 50 days of immersion.

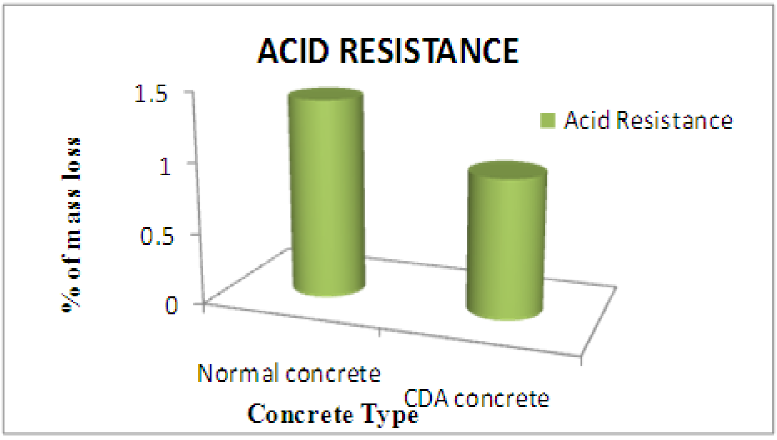

Fig.11 **Percentage mass loss of concrete due to acid resistance**

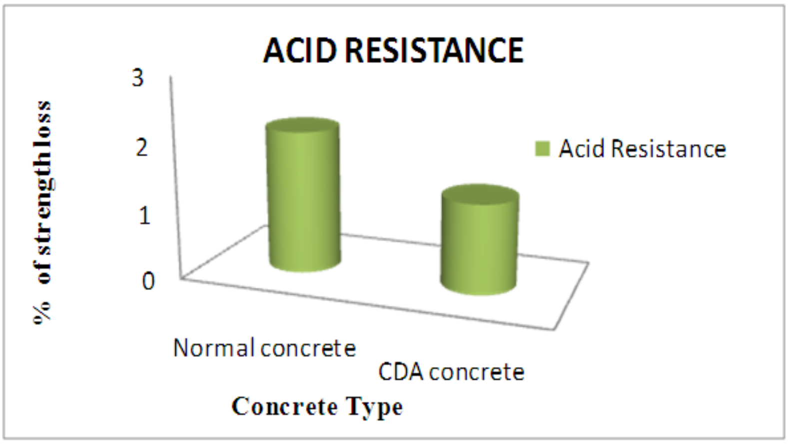

Fig.12 **Percentage strength loss of concrete due to acid resistance**

5.4.2 Chloride resistance

Fig.13 shows percentage mass loss of concrete due to chloride attack. The loss in mass of the CDA concrete specimen was 1.82% after 50 days. In the case of the OPC concrete specimens, the loss in mass was about 1.85% after 50 days of immersion. Fig.14 shows loss of compressive strength of concrete. The loss in compressive strength of the CDA concrete specimens soaked in the sodium chloride solution was 1.428% after 50 days of immersion. In the case of the OPC concrete specimens, the loss in compressive strength was about 2.66% after 50 days of immersion.

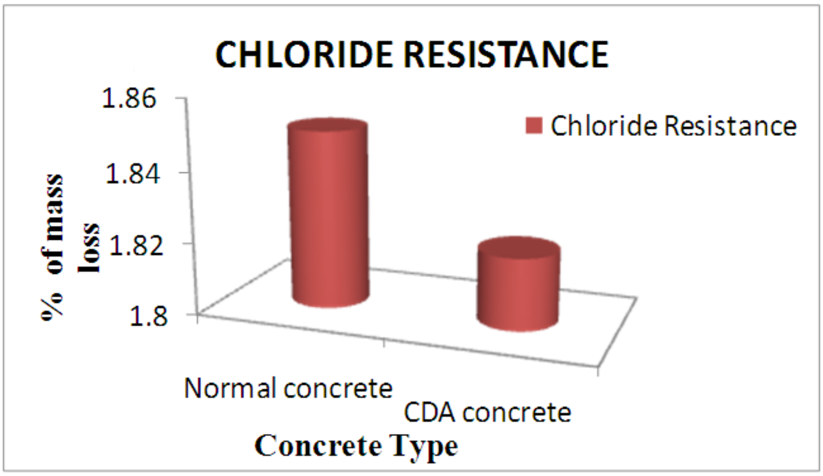

Fig.13 **Percentage mass loss of concrete due to chloride resistance**

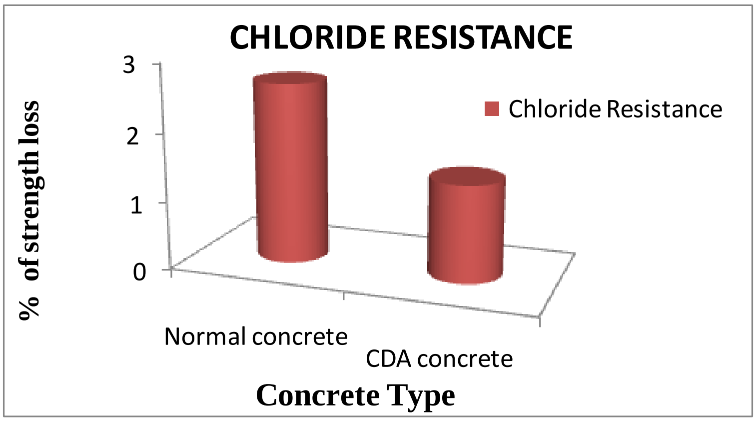

Fig.14 **Percentage strength loss of concrete due to chloride resistance**

VI.CONCLUSIONS

The major conclusions based on the results obtained in the experiments are as follows:

- Maximum compressive strength is attained at 8% CDA and 0.5% of glass fibre, after which strength starts decreasing, thus the optimum content is 8%.
- The replacement of cement with cow dung ash 8% shows maximum strength and it gradually decreases as the CDA percentage increases.
- Compressive strength of concrete increased by 5.8%.
- From durability tests, it is observed that the CDA concrete has ability to resist acid attack and chloride attack compared to normal concrete.

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