An Experimental Study on Strength Properties of Concrete on Addition of Cow Dung Ash and Glass Fibre

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Abstract - *The consumption of cement in concrete industries increasing day by day. Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. The most important part of concrete is the cement. Use of cement alone as a binder material produces large heat of hydration since the production of this raw material emits huge amount of CO_2. The carbon dioxide emission from cement is very harmful to the environmental changes. The concrete industry is looking for supplementary cementitious material with the objective of reducing the carbon dioxide emission which is harmful to environment. The effective way of reducing CO_2 emission from the cement industry is to use the industrial by products or use of supplementary cementing material such as ground granulated blast furnaces slag (GGBS), fly ash, silica fume and metakaolin. In this present experimental work an attempt is made to replace cement by Cow dung ash (CDA) to overcome these problems. The cement has been replaced by CDA in the range of 6%, 8%, 10%, 12% and14% by weight of cement for M25 grade mix. It was tested for compressive strength and split tensile strength at the age of 7, 14 and 28 days and compared with those of conventional concrete. Results showed that 8% replacement of cement by cow dung ash makes a considerable increase in compressive strength and split tensile strength. The present investigation has shown that an addition of 0.5% glass fibre to concrete makes it stronger and more durable.*

Key Words: Concrete, Cow Dung Ash (CDA), Glass fibre, Compressive strength, Split tensile strength, Cement.

1. INTRODUCTION

There is need for affordable building materials in providing adequate housing for the teaming populace of the world. The cost of conventional building materials continues to increase as the majority of the population continues to fall below the poverty line. Thus, it is necessary to use a supplementary local material as alternative for the construction of low-cost buildings in both rural and urban areas. A huge amount of concrete is consumed by the construction industry. The production of Portland cement is not only costly and energy intensive, but it also produces large amounts of carbon emission. The production of cement poses environmental problems due to emission of gaseous pollutants. The emissions of poisonous gases like CO_2, NO etc by cement production companies have depleted the natural environment. They have caused environmental pollution and global warming due to the depletion of ozone layer. Some industrial wastes have been studied for use as supplementary cementing materials such as fly ash, silica fume, metakaolin etc. The disposal and management of waste material is a potential challenge. Sustainable materials are currently widely considered and investigated in construction engineering research. Some examples of sustainable research are the use of recycled concrete aggregates, coal fly ash, ground clay brick and pervious paver block system. Further, substantial research work has been conducted on fibre-reinforced concrete which is a concrete primarily made of a mix of hydraulic cement, aggregates, water and reinforcing fibres. Cow dung is the undigested residue of plant matter which comes from cows gut. In cow dung nitrogen, calcium, carbon, potassium, and phosphorus have a high content. About 10-15 kg cow dung is produced by a cow in a day, which contains about 28% water in fresh state. 34% of cow dung becomes ash when it is burnt. In the present study, cement was replaced by cow dung ash by 6%, 8%, 10%, 12% and 14%.

2. SCOPE AND OBJECTIVES OF THE STUDY

The main scopes of the study are,

- To examine the effectiveness of using CDA as partial replacement of cement by studying strength parameters.
- To study the necessity of consumption of the waste material for manufacturing of sustainable concrete for construction. To use locally available material and to reduce the cost of producing concrete.
- To overcome the problems faced by cement industries to a little extent.

The experimental investigation was proposed to work out the suitability of addition of cow dung ash as partial replacement of ordinary Portland cement in concrete with the following objective.

- To investigate the compressive strength and split tensile strength of concrete with CDA to that of normal concrete.
- To prepare high strength, eco-friendly and cost effective concrete

3. MATERIALS USED

The material used in this study included ordinary Portland cement, fine aggregate, coarse aggregate, water, chemical admixture and glass fibre.

3.1 Cement

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.

3.2 Fine aggregate

Fine aggregates are basically sands. Fine aggregates are the materials that pass through 4.75 mm IS sieve. Manufactured sand (M sand) was used as fine aggregate. The tests such as specific gravity and gradation were carried out to determine the physical properties of fine aggregate.

3.3 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.

3.4 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.

3.5 Cow dung ash

The cow dung is exposed to sunlight to dry in order to have dung cakes which is then subjected to burning after it is dried to have the cow dung ash which is obtained in black colour.Fig-1 shows the obtained cow dung ash.

Fig-1:Cow Dun Ash

3.6 Glass fibre

The glass fibre is used to reinforce cement and to limit crack propagation in mortar and concrete.Fig-2 shows the glass fibre. Traditional concrete mixes are prone to plastic shrinkage during setting phase and this can lead to crazing and cracking. The fibres add strength and flexibility to the concrete resulting in a strong yet light-weight end product. Fibres have high tensile strength to withstand stress. Different percentages of fibre used are 0%, 0.5%, 1%, 1.5% and 2%.The maximum strength obtained at 0.5% addition. So the optimum fibre content is 0.5%.

Fig-2: Glass Fibre

3.7 Chemical admixture

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

4. METHODOLOGY

4.1 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-3: Specific gravity test on a) cement b) fine aggregate c) coarse aggregate

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 as shown in FIG-4. 1kgs of fine aggregate is taken and placed on the top most sieves. Sieving is done for fifteen minutes and weight retained on each IS sieve is found.

Fig-4: Sieve analysis on fine aggregate

c) Fineness of cement
Fineness test 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 test.

Fig-5: Fineness test

d) Consistency of cement
Ordinary Portland cement of grade 53 was used in the casting of the specimens. Consistency limit 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-5 shows consistency test.

Fig-6: Consistency test

d) Bulk Density, Void Ratio and Porosity of Fine and Coarse Aggregate
Bulk density is the density of dry aggregate. This is required to determine the amount of aggregate in concrete mix. Container having 3L capacity, tamping rod and weighing balance were used for determining the bulk density, void ratio and porosity of aggregate.

Fig-7:Test on aggregate

e) Initial and final setting time
Vicat apparatus with 1mm square needle was used for initial setting time test and another needle with annular attachment was used for final setting time test of Ordinary Portland cement. In this test 400 gm of cement was mixed with 0.85 times the percentage of water as determined in the consistency test. The time required to penetrate the needle to a depth of 5 mm from the bottom of the mould was noted as initial setting time and the time required to make an impression on the test block was noted as final setting time.Fig-8 shows initial and final setting time testing apparatus.

(a) (b)

Fig-8: Initial and final setting time test (a) Apparatus (b) Plunger

4.2 Mix design

Mix design is calculated as per IS 10262:2009 specifications. The concrete mix of M25 grade concrete is adopted with a water cement ratio of 0.5.

4.3 Preparation of specimen

The cube moulds of size 150mmx150mmx150mm and cylinders mould of size 150mm diameter and 300mm length were filled with the mix. The cubes were tamped by tamping rod for around 25 times and the surfaces of moulds were levelled properly. The specimens were kept for 24 hours; de- moulded and then set for curing.Fig-9 shows stages of preparation of specimen. The curing was allowed until the date of testing i.e., for 7th, 14th, and 28th. Then after the days of curing, the cube specimens were taken out and tested under testing machine.

(a)

(b)

Fig-9: Stages of preparation of specimen (a) Mixing (b) Casting

4.4 Curing

The curing was allowed until the date of testing i.e., for 7th, 14th, and 28th. Then after the days of curing, the cube specimens were taken out and tested under testing machine.Fig-10 shows curing of specimen.

Fig-10:Curing

4.5 Workability test

Slump test and compaction factor test were conducted on fresh concrete to determine the workability of concrete as per IS 456 – 2000.Workability testing apparatus as shown in Fig-11.

(a) (b)

Fig-11: Workability test (a)Slump cone test (b) Compaction factor test

4.6 Compressive strength test

Compressive strength of concrete is a measure of its ability to resist static load. 7, 14 and 28 day compressive strength test were conducted on three specimens having size 150x150 mm and the average strength was taken as the cube compressive strength of concrete.Fig-12 shows the compression testing machine. 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. The cube specimen was taken out from the curing tank after specified curing time and were allowed for dry and the weight of each specimen as well as measure the dimension of the specimen were noted. The specimens were placed in the machine such that load shall be applied to the opposite sides of the specimen, and the specimens were aligned centrally on the base plate of the machine. The movable portion was rotated gently by hand so that it touches the top surface of the specimen. The load was applied gradually till the specimens failed and the maximum load at failure of specimen were recorded. The compressive strength of the specimen was calculated by dividing the failure load by the cross-sectional area of the specimen.

Fig-12:Compression testing machine

4.7 Split tensile strength test

Tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. The usefulness of the splitting cylinder test for assessing the tensile strength of concrete in the laboratory is widely accepted and the usefulness of the above test for control purposes in the field is under investigation. The standard has been prepared with a view to unifying the testing procedure for this type of test for tensile strength of concrete. The load at which splitting of specimen takes place is recorded. The compression testing machine was used for testing splitting tensile strength of the concrete cylinders.

Fig-13: Split tensile strength testing machine

5. RESULTS

5.1 Test on cement

Table-1: Properties of cement

Sl.No	Properties	Result
1	Fineness	1.133%
2	Specific gravity	3.15
3	Consistency	29%

5.2 Test on aggregate

Table-2: Properties of aggregate

Sl.NO	Physical properties	Result
1	Specific gravity of fine aggregate	2.6
2	Specific gravity of coarse aggregate	2.68
3	Bulk density of coarse aggregate	1574kg/m³
4	Void ratio of coarse aggregate	0.8
5	Porosity of coarse aggregate	0.445

5.3 Test on fresh concrete

Table-3: Test on fresh concrete

Sl.No	Grade	Percentage of replacement of cement with CDA	Percentage of glass fibre added	Workability test	
				Slump test	Compaction factor test
1		0%	0%	82	0.91
2		6%		81	0.90
3		8%		81	0.90
4	M25	10%	0.5%	77	0.87
5		12%		75	0.84
6		14%		72	0.82

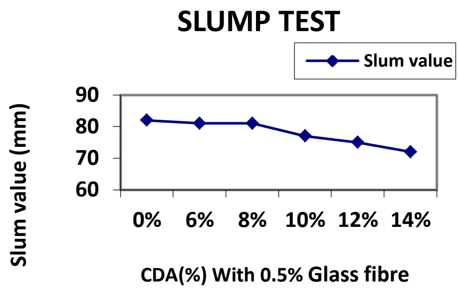

Chart-1: Plot between slum value and various percentage of CDA with 0.5% glass fibre

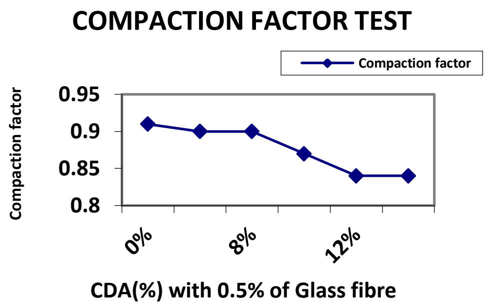

Chart-2: Relationship between compaction factor and various percentage of CDA with 0.5% glass fibre

5.4 Compressive strength test

Table -4: Obtained compressive strength

Percentage of replacement of cement with CDA	Percentage of glass fibre added	Compressive strength after 7 days (N/mm²)	Compressive strength after 14 days (N/mm²)	Compressive strength after 28 days (N/mm²)
0%	0%	20.74	25.18	30.66
6%		21.62	26.92	31.55
8%		23.70	28.44	32.44
10%	0.5%	20.29	24.14	27.55
12%		18.25	22.22	25.33
14%		18.07	20.14	22.07

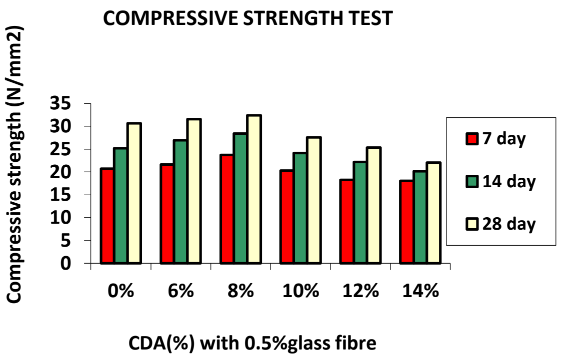

Chart-3: Relationship between compressive strength and various percentage of CDA with 0.5% glass fibre

5.5 Split tensile strength test

Table-5: Obtained split tensile strength

Percentage of replacement of cement with CDA	Percentage of glass fibre added	Split tensile strength after 7 days (N/mm²)	Split tensile strength after 28 days (N/mm²)
0%	0%	2.970	3.112
6%	0.5%	3.041	3.253
8%		3.324	3.748
10%		2.758	3.041
12%		2.475	2.687
14%		2.192	2.546

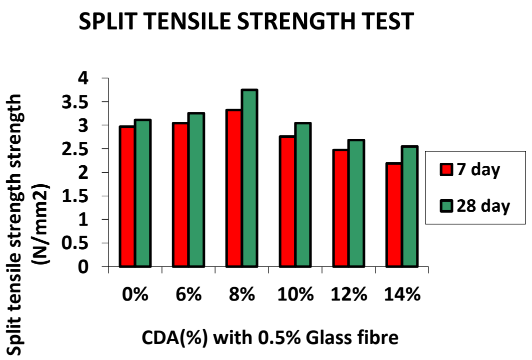

Chart-4: Relationship between Split tensile strength and various percentage of CDA and 0.5% glass fibre

6. CONCLUSION

- The workability of concrete had been found to decrease with increase of cow dung ash and glass fibre.
- The use of a super plasticizer can achieve the desired workability.
- Maximum compressive strength is attained at 8% CDA and 0.5% of glass fibre, after that strength starts decreasing, thus the optimum content is 8%.
- Maximum split tensile strength is attained at 8% CDA and 0.5% of glass fibre, after that, strength starts decreasing, thus the optimum CDA content is 8%.
- The replacement of cement with cow dung ash 8% shows maximum strength and it gradually decreases as the CDA percentage increases.

ACKNOWLEDGEMENT

Thanks are due to all the teaching and nonteaching staff of Civil Engineering Department Sree Narayana Institute of Technology. Above all, we express the gratitude to the almighty **GOD**, without whose blessing we would never have been able to complete this work successfully

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BIOGRAPHIES

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