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Experimental Investigation on concrete with replacement of Fine Aggregates by Foundry Sand and Cement by Cow dung ash

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ABSTRACT: Concrete is the most important engineering material and the addition of some other material may change the properties of concrete. This research is carried out to produce a low cost and eco-friendly concrete. Studies have been carried out to investigate the possibility of utilization a broad range of material of partial replacement of fine aggregate and cement in production of concrete. Here the partial replacement of fine aggregate by waste foundry sand in the percentage of 5%,15%,25% and cement by cow dung ash with constant percentage of 10% is used. The tests were carried out to determine the mechanical properties of concrete. The main aim of this study is to make economical and eco-friendly concrete.

KEYWORDS: Concrete, foundry sand, cow dung ash, Compressive strength, Split tensile strength.

I. INTRODUCTION

Now-a-days construction sector is exploring on a large scale in construction of modern infrastructures and industrialization. It also involves new techniques for rapid and comfort works on the field. Concrete as a building material plays an important role in the sector. The natural resources are also in the verge of extinct. These problems forces us to recover the natural resources and to find an alternative option for it. In order to overcome this, foundry sand which is the by-product of metal casting industries is used in concrete preparation. This environmentally hazardous material being abundant is used as an alternative in the concrete production process thus reducing the stress on environment.

Metal casting industries use foundry sand that is uniformly sized and that contains high quality silica. It is bonded to form a mould for casting of ferrous and non-ferrous metal. Sand that is finer than normal sand is used in metal casting process. The burnt sand after the metal casting process is reused several times but when it cannot be used further it is removed from foundry sand as a partial replacement of fine aggregate in concrete leads to production of economic, light weight and high strength concrete.

The cement industry has one of the highest carbon footprints which makes traditional concrete unsuitable in the future. Thus cow dung ash that has relatively high carbon to the nitrogen ratio is used as an alternative to the cement. Cow dung is basically the rejects of the herbivorous matter which is acted upon by the symbiotic bacteria residing within the animal's rumen. Cow dung comprises of organic material including fibrous material that passed through the cow's digestive system. Exact chemical composition is mainly composed of carbon, nitrogen, oxygen, phosphorous, hydrogen, etc., some urea, mucus, as well as cellulose, lignin and hemicelluloses. These rejects are collected and are allowed to try in the sunlight. It is then burned to get the ash which is then partially replaced in the concrete production process to improve workability and durability or may act as an additional binder.

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II. LITERATURE REVIEW

The literature review was carried out to find out the various researchers conducted in partial replacement of fine aggregate and cement with the similar type of materials. The behaviour of the concrete has been found out. The available literatures collected on this topic are as follows.

Jitender Kumar Dhaka and Surendra Roy suggests that utilization of CDA in concrete production will not only save the cement used in concrete industry but will also protect the environment by controlling the emission of CO from the cement industry as well as providing a technique for the usage of CDA in the civil engineering field.

Mahima Ganeshan , Dr. Sreevidya V. , Salim.P.M concluded that this paper mainly targets on making of commercially available solid masonry blocks to high strength so that it can be used in load bearing structures and replacement of fine aggregate in these blocks with waste foundry sand. It was inferred that about 20 to 30 percent of replacement of fine aggregate to waste foundry sand gave good results for all practical purposes. This study also aims to encourage industries to start commercial production of concrete products using waste foundry sand. For 100% replacement efflorescence was noted which may be due to heavy salts present in waste foundry sand. Hence 100% replacement is not advisable as it may be harmful for connected R.C.C works like footings, columns, beams and slabs.

Ojedokun. O.Y, Adeniran. A. A, Raheem. S.B and Aderinto. J describes that the initial and final setting time increases as the percentage of Cow Dung Ash is added, has an advantage that offers lightness of weight and low thermal conductivity. Cow Dung Ash requires more quantity of water as the percentage increases in the concrete therefore it has a serious limitation that must be understood before it is put to use. CDA is recommended for use only when a ten percentage of CDA is added. While the concrete is suitable for use on certain floor and wall that will not be subjected to heavy load or structures that are of temporary use.

Omoniyi. T, Duna. S and Mohammed. A reports on an investigation into the use of cow dung ash (CDA) as supplementary cementitious material in concrete. Cement was replaced with cow dung ash upto 30% at 5% interval. The workability of concrete decreased as the CDA content increases. CDA has pozzolanic traits and thus classified as pozzolana. Compressive strength of CDA/OPC blended concrete decreases as CDA content increases and increases with curing age. The use of CDA in concrete retards its setting times and hence can be used as a set retarder for concreting in hot weather.

Pavithra. V says that the consumption of cement in concrete industries has been increasing day by day to fulfill the pressing needs of infrastructure due to growing population, industrialization and urbanization. The production of cement possess environmental problems due to emission of gaseous pollutants. Among the various mixes it was observed at the age of 28 days the maximum strength should be attained at 20% of soil with 10% of cow dung ash. The concrete preparation is for eco-friendly and cost effective

Pathariya Saraswati. C, Rana Jayakrushna. K, Shah Palas. A, Mehta Jay. G concluded that the aim of this research is to know the behavior and mechanical properties of concrete after addition of industrial waste in different proportions by tests like compressive strength and split tensile. This paper demonstrates the use of waste foundry sand as a partial replacement for the fine aggregate in concrete. An experimental investigation is carried out on a concrete containing waste foundry sand in the range of 0%, 20%, 40% and 60% by weight for M25 grade concrete(PPC). Material was produced, tested and compared with conventional concrete in terms of workability and strength.

Smit M. Kacha, Abhay V.Nakum , Ankur C.Bhogayata says that the experiments conducted for the properties like strength and durability. It was observed the results have shown positive changes and improvements in strength and durability properties of the conventional cementitious concrete due to the addition or replacement of fine sand with used foundry sand in different proportions. Finally it could be concluded that the usage of 30-40% of foundry sand in concrete will increase the compressive and tensile strength up to 20% whereas not much change in modulus of

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elasticity. It could also be noted that the effects of concrete containing foundry sand shall be differs as the foundry sand changes its characteristics according to its manufacturing process and source.

III. MATERIALS USED

Foundry sand

Most of the metal industries prefer sand casting system. In this system mould made of uniform sized, clean, high silica sand is used. After casting process foundries recycle and reused the sand several times but after sometime it is discarded from the foundries known as waste foundry sand. The application of waste foundry sand to various engineering sector can solve the problem sand is clean, uniformly sized, high quality silica sand is bounded to form moulds for ferrous (iron and steel) and non-ferrous (copper, aluminium, brass) metals. Type of foundry sand depends on the casting process in foundries. Foundry sand is generally of following types: Green sand, chemically bounded sand and black sand. Additive in sand depends on metal casting. Use of waste foundry sand as full partial replacement by fine aggregate helps to achieve different properties of behavior of concrete.

Fig 1: Foundry Sand

Fig 2: Cow dung ash

Ordinary portland cement and cow dung ash

The experimental program was planned to quantify the consistency and compressive Strength of mortar and concrete using cow dung ash as replacement of cement. Cement replacement at various percentages levels were used in this investigation to observe the effects of different cow dung ash levels in cement to find the compressive strength of mortar and concrete at various ages of curing. Table-1 shows the chemical analysis of cement and cow dung ash. It is found that that the loss of ignition is almost equal for both cement and cow dung ash. Also observed that the silica percentage is at higher value in the cow dung ash and alumina is slightly higher than the cement values.

Table 1: Chemical analysis of ordinary portland cement and cow dung ash

Chemical compound	OPC(53 Grade)	Cow dung ash
Loss of ignition(L.O.I)	4.83	4.25
SiO2	18.78	79.22
Al2O3	2.87	5.62
Fe2O3	4.03	2.98
CaO	54.66	3.71
MgO	3.46	1.88
SO3	1.13	0.19
Insoluble Residue (IR)	9.69	1.65

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Coarse aggregate

The aggregate having size more than 4.75mm size is termed as coarse aggregate. The graded coarse aggregate is described by its nominal size. i.e 40mm,20mm,etc., 80mm size is the maximum size that could be conveniently used for making concrete. In this study coarse aggregate is conformed to IS: 383.The Flakiness and Elongation Index were maintained well below 15%.

Table-2: Properties of coarse aggregate

Properties	Values
Specific gravity	2.81
Fineness modules	6.4
Size	Passing through 20mmsieve & retained in 16mm sieve
Bulk density	1674 kg/m3

Fig 3: Coarse Aggregate

Fig 4: Fine Aggregate

Fine aggregate

Generally the fine aggregate shall consist of natural sand, manufacture sand, etc., The fine aggregate for concrete should be sieved and should be free from aggregate are as per IS 383-1970 reactive materials that cause expansion of concrete. Physical properties of fine aggregate are as per IS 383-1970.

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Table-3: Properties of fine aggregate

Properties	Values
Specific gravity	2.67
Fineness modules	2.85
Size	Passing through 4.75mm sieve
Bulk density	1721 kg/m^3

Water

Water plays an important role as it contributes in chemical reaction with cement. Water is used for mixing as well as for curing purpose also it should be clean and free from salts, acids, alkalis and other harmful materials. Generally, ordinary water is used for mixing concrete.

IV. EXPERIMENTAL PROCEDURE

Testing plays an important role in controlling the quality of cement concrete work. Systematic testing of the raw material, the fresh concrete and the hardened concrete is an inseparable part of any quality control program for concrete which helps to achieve higher efficiency of the material used and greater assurance of the performance of the concrete in regard to both strength and durability. The quantities of cement, foundry sand, cow dung ash and water for batch shall be determined by weight to an accuracy of 1.1% of total weight of batch. The concrete shall be mixed by hand or preferably in a laboratory batch mixer, in such an manner so as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10% excess after moulding the desired number of test specimen.

Hand mixing

The concrete batch shall be mixed on a water tight, non-absorbent platform with a shovel, trowel or similar suitable implement, using the following procedure. The cement, fine aggregate, cow dung ash and foundry sand shall be mixed dry until the mixture is thoroughly blended and is uniform in color.

The coarse aggregate shall then be added and mixed with the cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch, and water shall be added and the entire batch is mixed until the concrete appears to be homogeneous and has the desired consistency. If repeated mixing is necessary, because of addition of water in increments while adjusting the consisting, the batch shall be discarded and a fresh batch made without interrupting the mixing to make trial consisting tests.

Concrete mixed with foundry sand and cow dung ash were casted in the concrete moulds. In the meanwhile, the mould is assembled and its inner sides are coated with grease or oil. After proper mixing, the concrete is then placed in the mould and compacted, simultaneously. Manual placing and compacting type procedure is adopted, since the scale of concreting was small. Damping rod are used to compact the concrete in the mould. Proper compaction is done to completely eliminate the air bubbles.

After allowing the concrete to set for 24 hours in the mould, i.e., the final setting time, it is taken out of the mould. Concrete strength is influenced by its moisture level during the hardening process. So, it must be kept damp during the several days. It requires to set and harden and this process is called curing. We adopted immersion curing type procedure. The set concrete specimen is then immersed in a tank of water to avoid dehydration during the hardening period.

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V. MATERIALS TEST RESULT

Compressive Strength

Compressive strength was tested in compressive testing machine .Cube specimens of size 150mm x 150mm x 150mm were adopted for the test. Compressive strength was tested after 3,7 and 28 days of curing. The results of the tests are tabulated below.

The testing machine of any reliable type of sufficient capacity for the test and capable of applying load. The testing machine shall be equipped with two steel bearing platens with hardened faces. One of the platens shall be fitted with a wall seating in the form of portion of the sphere, the centre of which coincide with the central point of the face of the platens .The other compression platen shall be plain rigid block. The movable portion of the spherically seated compression platen shall be healed on the spherical seat, but the design shall be such that the bearing face can be rotated freely and tilted small angles in any direction.

Table-4: Test results of Compressive strength

Type of Mix (Cube specimen)	Age of curing	Compressive strength(N/mm^2)
Control specimen	3	11.1
	7	15.78
	28	22.2
5% of Foundry sand	3	12.22
	7	16.8
	28	24.98
15% of Foundry sand	3	13.33
	7	17.33
	28	26.22
25% of Foundry sand	3	12.44
	7	16.22
	28	25.47

Split tensile strength of concrete

The specimen from the water is removed after specified curing time and wipe out excess water from the surface. The bearing surface of the specimen is cleaned. The specimen is placed in the machine in such a manner that the load shall be applied to the opposite sides of the cylinder casted. This specimen is aligned centrally on the base plate of the machine. This is applied of on the specimen gradually without shock and continuously at the rate 140 kg/cm /minute till the specimen fails. The maximum load carried by the specimen is noted.

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Table-5: Split tensile strength of concrete

Type of Mix (Cylindrical specimen)	Age of curing	Tensile strength(N/mm^2)
Control specimen	3	1.42
	7	1.84
	28	2.31
5% of Foundry sand	3	1.6
	7	2.01
	28	2.5
15% of Foundry sand	3	1.79
	7	2.19
	28	2.90
25% of Foundry sand	3	1.56
	7	1.98
	28	2.76

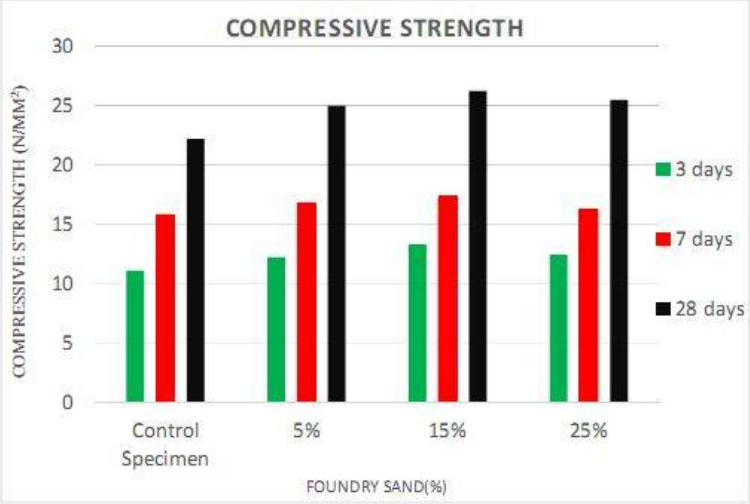

Fig 5: Graph showing compressive strength details

The above graph is drawn taking various percentages of foundry sand such as 5%,15%,25% by replacing fine aggregate in concrete, cement by cow dung ash with constant percentage of 10% in abscissa and compressive strength in ordinate. The maximum compressive strength is obtained in 15% replacement of fine aggregate by foundry sand and 10% replacement of cement by cow dung ash.

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Fig 6: Graph showing split tensile strength details

The split tensile of concrete is shown in the above graph taking various percentages of foundry sand such as 5%,15%,25% by replacing fine aggregate in concrete, cement by cow dung ash with constant percentage of 10% in abscissa and tensile strength in ordinate. The maximum split tensile strength is obtained in 15% replacement of fine aggregate by foundry sand and 10% replacement of cement by cow dung ash.

VI. RESULTS AND DISCUSSIONS

From the results of the two experiments i.e., the compression test, split tensile test of the concrete shows us the good result in terms of both engineering and economic wise. By the addition of 10% Cow Dung Ash and 15% foundry sand as a partial replacement of cement and fine aggregate in the cement concrete we get the strength as 26.22 N/mm for 28 day test. Thus the foundry sand and cow dung ash replacement in the concrete will be a good and effective process. By the rate analysis of the concrete also shows that the use of foundry sand and cow dung ash is economical than the ordinary concrete. The foundry sand and cow dung ash rates are very much lower than the other replacement materials. Hence the use of foundry sand and cow dung ash in the cement concrete will be more useful for the producers and also for the environment by reduction in the use of river sand and cement by decreasing the environment pollutions.

VII. CONCLUSION

Among the various mixes it was observed at the age of 28 days the maximum strength attained at 15% of foundry sand with 10% of cow dung ash. Use of cow dung ash in higher proportion reduces the strength and hence, a constant value of 10% is maintained throughout the project. This concrete preparation is eco-friendly and cost effective. The degree of workability of concrete was normal with the addition of Cow Dung Ash and Foundry sand for M20 grade concrete. The main advantage being reduction of environmentally hazardous material and increasing the strength of concrete to a considerable percentage.

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