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AN EXPERIMENTAL INVESTIGATION OF MODIFIED CONCRETE USING FLY ASH AND STONE DUST

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Abstract- Construction activity in India during the last decade has more than doubled. Concrete has been the most preferred construction material for over five decades. It is being increasingly used day by day all over the world due to its versatility, mouldability, high compressive strength and many more advantages. The problem of how to meet the increasing demand and cost of concrete in sustainable manner is a challenge in the field of civil engineering and environmental studies. Alternative materials generally used are mainly the industrial wastes which are facing the problems of safe disposal and cause environment hazards. Fly-ash and Stone dust are such industrial wastes in huge quantity facing the safe disposal. Fly-ash is a product developed as industrial waste during the production of electricity in Thermal Power Plants, where coal is prime material. Due to its highly puzzolonic and cementatious properties, Fly ash can be used in much larger amount as cement replacement material in concrete than practiced as of today. Stone dust is a byproduct generated from quarrying activities involved in the production of crushed coarse aggregate in crusher and stone quarries. River sand is becoming a very scarce material. The sand mining from our rivers have become objectionably excessive in view of both economy and environment. Stone dust can be used as an alternative to natural sand and its effects on the strength and workability of the concretes need to be investigated. Unfortunately limited research has been conducted to explore the potential utilization of stone dust in concrete mixture. In view of the above, present investigation is an attempt towards the assessment of suitability use of Fly-ash and stone dust in concrete production.

Keywords: Fly-Ash, Stone dust,Puzzolonic, Mouldability, Hydartion, Landfills

I. INTRODUCTION

Concrete is a composite material that consists essentially of a binding medium within which are embedded particles of fragments of aggregates. In hydraulic cement concrete, the binder is formed from a mixture of cement and water. Concrete is the most widely used construction material, commonly made by mixing cement, sand, crushed stones and water. Its annual total consumption around the globe is around twenty billion tones, which is equivalent to two tones for every living human being. Fly ash is defined in cement concrete technology as Finely divided residue resulting from combustion of powdered coal, which is transported from the fire box through the boiler by flue gases‘. Fly ash is the most commonly and abundantly available artificial pozzolana. It is the non-combustible mineral portion of coal generated on coal combustion in thermal power plants. It is a powdery substance obtained from dust collectors in electrical power plants. The importance and use of fly ash in concrete has grown so much that it has almost become a common ingredient in concrete, particularly for making high performance concrete.

The majority of fly ash produced from thermal power stations in India is disposed in landfills, ponds or rejected in river systems, which may cause serious environmental problems for future generations. Some of the other waste materials that are being utilized are bottom ash, blast furnace slag etc. Out of all these materials fly ash is the material that is abundantly available and cheaper. Due to worldwide usage of aggregates, the consequential problems of this process are considered globally. Stone Dust which is generally considered as a waste material in stone crushers causes an environmental load due to its disposal problem. Hence the use of Stone Dust in concrete as fine aggregate will reduce not only the demand of natural sand but also the environmental burden. Moreover the incorporation of Stone Dust will considerably reduce the production cost of concrete. In brief the successful utilization of Stone Dust will turn waste material into a valuable resource. Unfortunately limited research has been conducted to explore the potential utilization of Stone Dust in concrete mixtures.

In the present work, studies are carried out to understand the strength characteristics of Fly Ash-Stone Dust (FASD) concrete having same properties. In the second part, experimental studies are carried out to understand the flexural behaviour of fly ash-stone dust beams in comparison to normal concrete (M0) having same properties. For both parts of the experimental work, the grade of concrete used is M20. The present study is planned mainly for the following reasons; To increase the confidence level of the structural designer and user by carrying out investigation where in fly ash- stone dust concrete is employed as a structural material. To increase the proportion of use of fly ash and stone dust in concrete as alternative materials in place of cement and fine aggregate to take care of both economy and environmental factors.

To educate the customer and people involved in construction activities towards using more & more alternative materials in place of conventional materials in constructions through which they can make great contribution to mankind by avoiding pollution and saving nature to their coming generation.

LITERATURE REVIEW

1. Jaafar M.S (2002)1: Investigated the effect of using fine stone dust as cement replacement on the mechanical properties as well as durability characteristics in high strength concrete. The concrete obtained by this mix was cured by autoclaving.

2. Nagaraj T.S and Zahida Banu (1996)2: Investigated the effect of rock dust as fine aggregate on the strength and workability aspects of concrete mixes. It was also examined in this investigation as to how the strength data of the trial mix itself included the synergetic roles of these variables, thus enabling further reproportioning to obtain desired levels of workability and strength.

II. EXPERIMENTAL INVESTIGATION

1 BINDING MATERIAL (CEMENTITIOUS MATERIALS)

A) CEMENT: In the present work, ordinary Portland cement of 53 grade Birla Super conforming to IS 12269:1987 has been used. The physical properties of cement obtained on conducting appropriate test as per IS 269/4831 and the requirements as per 4031 -1968.

B) FLY ASH: Fly ash was collected and brought from Raichur Thermal Power Station. Physical and chemical properties of this fly ash are obtained by testing the sample based on standards methods of testing with reference to IS:3812 (Part 1 & 2) : 2003 and IS:1727 – 1967

TABLE 1. PHYSICAL PROPERTIES OF FLY ASH

S.NO	TEST CONDUCTED	RESULTS	REQUIREMENTS AS PER IS:3812 : 2003	
			PART 1	PART 2
1.	Specific Gravity	2.07	---	---
2.	Fineness – Specific surface in m^2/kg by Blaine's Air-Permeability method, min.	408.0	320	200
3.	Lime reactivity – Average Compressive Strength in N/mm^2, min.	4.7	4.5	--
4.	Comparative Compressive Strength at 28 days, percent, (min)	92.0	Not less than 80% of the strength corresponding to plain cement mortar cubes	--

TABLE 2. CHEMICAL PROPERTIES OF FLY ASH

S. NO	TEST CONDUCTED	RESULTS	REQUIREMENTS AS PER IS: 3812 : 2003			
			PART 1		PART 2	
			SILICEOUS PULVERIZED FUEL ASH	CALCAREOUS PULVERIZED FUEL ASH	SILICEOUS PULVERIZED FUEL ASH	CALCAREOS PULVERIZED FUEL ASH
1.	Silicon dioxide (SiO_2) plus aluminum oxide (Al_2O_3) + iron oxide (Fe_2O_3) minimum	91.29	70.0%	50.0%	70.0%	50.0%
2.	Silicon dioxide (SiO_2) minimum	58.49	35.0%	25.0%	35.0%	25.0%
3.	Magnesium oxide (MgO), maximum	0.94	5.0%	5.0%	5.0%	5.0%
4.	Total sulphur as sulphur trioxide (SO_3), maximum	0.20	3.0%	3.0%	5.0%	5.0%
5.	Loss on ignition, maximum	0.85	5.0%	5.0%	5.0%	5.0%

C) FINE AGGREGATES:

NATURAL SAND:
Locally available clean river sand obtained from Kavery river bed near Kanakapura Taluka is used. The physical properties of sand obtained on conducting sieve analysis and specific gravity tests and sieve analysis carried out for natural sand is given in table 3

TABLE 3. PHYSICAL PROPERTIES OF SAND

S NO	PROPERTY	TEST RESULT
1	Specific gravity	2.66
2	Water absorption	1.4 %

D) STONE DUST:
Locally available stone dust obtained from the stone crusher near Bidadi is used. . The physical properties of stone dust obtained on conducting sieve analysis and specific gravity tests and Sieve analysis carried out for stone dust and the results are given in table 4

TABLE 4. PHYSICAL PROPERTIES OF STONE DUST

S NO	PROPERTY	TEST RESULT
1	Specific gravity	2.63
2	Water absorption	0.6 %
3	a)Dry rodded bulk density	1807 Kg/m^3
	b)Loose bulk density	1628 kg/m^3
4	Fineness modulus	2.72

E) COARSE AGGREGATE:
The granite metal jelly 20mm and down size received from stone crusher near Bidadi. Coarse aggregate crushed granite of 20 mm maximum size and retained on IS 4.75 sieves have been used as coarse aggregate. The sieve analysis of coarse aggregates conforms to the specifications of IS 383: 1970 for graded aggregates and specific gravity are given in table 5

TABLE 5: PHYSICAL PROPERTIES OF CA

SL NO	PROPERTY	TEST RESULT
1	Specific gravity	2.66
2	Water absorption	0.4 %

REMARKS: Sample conforms to the requirements of single size aggregate as per IS:383-1970
F) WATER: Clean potable water is used for mixing and curing of concrete with a pH value of 6.94.

II. EXPERIMENTAL PROGRAM

1. STRENGTH BEHAVIOUR OF MODIFIED CONCRETE.

1. To study the compressive strength behaviour of M20 grade fly ash-stone dust concrete in which natural sand is replaced by stone dust in three levels and 10% cement replaced by fly ash, cube specimens of size 150mmx150mmx150 are prepared. Twenty (20) cubes each are tested for 28days and 56days. Compressive strength of modified concrete is compared with normal concrete.

2. To determine the flexural strength behaviour of M20 grade fly ash-stone dust concrete in which natural sand is replaced by stone dust in three levels and 10% cement replaced by fly ash, prism specimens of size 100mm x 100mm x 500mm are prepared. Three prisms each are tested for the strength at 28days and 56days.
Flexural strength of fly ash-stone dust concrete is compared with normal concrete.

2. MIX PROPORTIONS

For the present work concrete of grade M20 is adopted. For this mix design of normal concrete (without fly ash and stone dust) is obtained as per standard procedure as out lined in IS: 10262-1982.

Typical mix design calculation of normal concrete is shown in appendix. Details of mix proportions obtained are given in Table 6 for Normal concrete, Fly ash concrete with 10% of Cement replaced by fly ash for different replacement levels of stone dust. Typical detailed calculation of mix design as per standard procedure as out lined in IS: 10262-1982 is given in APPENDIX

2.1 MIXING PROCEDURE

The fly ash and cement were first dry mixed in a pan thoroughly so that a uniform mix of fly ash and cement is obtained. Fine and coarse aggregates were added together. Then one third of the water is added. The mixture of fly ash and cement was then added. The concrete was mixed with all ingredients with addition of remaining quantity of water as per water binder ratio obtained by mix design.

TABLE 6. MIX PROPORTION DETAILS

MIX DESCRIPTION	M-0	M-1	M-2	M-3
Fly Ash(%)	0	10%	10%	10%
Stone dust(%)	0	50%	80%	100%
Cement content(kg/m^3)	400	360	360	360
Fly ash (kg/m^3)	0	40	40	40
Stone dust (kg/m^3)	0	286.63	458.61	573.27
Water (kg/m^3)	180	208	208	208
Water cement ratio	0.45	0.52	0.52	0.52
Fine aggregate(kg/m^3)	573.27	286.63	114.66	0
Coarse agreegate(kg/m^3)	1213.61	1213.61	1213.61	1213.61

3. WORKABILITY OF CONCRETE

The workability of concrete is defined as the ease with which concrete can be mixed, handled, placed and compacted. The factors which affect the workability of concrete are water content, mix proportion, size and shape of aggregates surface texture of aggregates, grading of aggregates and use of admixtures.

Workability of concrete is a complex property. Numerous

The compacting factor (CF) = (weight of partially compacted concrete) divided by (weight of fully compacted concrete).

4. COMPRESSIVE STRENGTH TEST

Casting of cube specimens for compression test: The steel cube moulds were coated with mould oil on their inner surfaces and were placed on Plate. Concrete was poured in to the moulds in three layers each layer being compacted using mechanical vibrator. The top surface was finished using trowel. After 24 hours concrete cubes were demoulded and the specimens were kept for curing under water.

Testing of cube specimens for Compressive Strength of concrete: At each desired curing periods specimens were taken out of water and kept for surface drying. The cubes were tested in 2000kN capacity compressive testing machine loaded at constant rate of loading at 145kg/cm2/min as per standard procedure explained in IS: 516-1959(1999) to get the compression strength of concrete.

5. FLEXURAL STRENGTH TEST

Casting of prism specimens for Flexural Strength of concrete**:** The prisms moulds were coated with mould oil on their inner surfaces and were placed on Plate. Concrete was poured in to the moulds in two layers, each layer being vibrated using mechanical vibrator. The top surface was finished using trowel. After 24 hours concrete prisms were demoulded and the specimens were kept for curing under water.

Testing of Prism specimens for Flexural Strength of concrete: At each desired curing period specimens were taken out of water and kept for surface drying. The prisms were tested in 100 KN capacity flexure testing machine under two point loading spaced at 133 mm for specimens of 100mm x 100mm x 500mm long loaded at constant rate of loading at 140kg/cm2/min as per the standards procedure explained in IS:516-1969(1999) to get the flexural strength of concrete.

6. CURING

The physical properties of concrete depend to a large extent on the degree of hydration of the cement and the resultant microstructure of hydrated cement. It is necessary to create conditions of temperature and humidity during a relatively short period immediately after placing and compaction of concrete, favourable to the setting and hardening of concrete. The process of creation of a favourable environment is termed as curing. The cube specimens or beam specimens are kept in water for 28 days and 56 days of curing before conducting the tests.

IV. RESULTS

The test results and discussions on workability, compressive strength and flexural strength (Strength parameters) of Fly ash-stone dust concrete (where 10% cement is replaced by Fly ash and different replacement levels of sand by stone dust) and normal concrete (M0).The test results of fly ash-stone dust concrete are compared with normal concrete for different curing periods.

Properties of M20 Grade Fly ash-Stone dust concrete

Properties of fly ash-stone dust concrete where 10% cement is replaced by fly ash and sand replaced by different replacement levels of stone dust at 50%, 80% and 100% are compared with normal concrete (M0) with no fly ash and no stone dust.

1. Workability

The workability is measured by using compaction factor, slump test and vee bee consistometer test. The test results with constant water/binder ratio for fly ash-stone dust concrete and normal concrete are given in Table 7. The graph between percentage replacements of sand by stone dust against all workability tests of concretes it is observed that for 50 and 80 percentage replacement of stone dust with sand has the better workability whereas 100 percent replacement of sand with stone dust decreases the workability. This is mainly due to more absorption of water when 100 percent of sand is replaced with stone dust.

TABLE 7. DETAILS OF WORKABILITY RESULTS

MIX DESIGNATION	FLY ASH (%)	STONE DUST (%)	COMPACTION FACTOR	SLUMP VALUE (MM)	VEE – BEE CONSISTOMETER (IN SECONDS)
M_0	0	0	90	50	12
M_1	10	50	85	42	18
M_2	10	80	83	37	21
M_3	10	100	78	30	21

2. Density of concrete:

The test results of densities of M20 grade 28 and 56 days curing and densities of modified concrete with different fly ash and stone dust percentage for 28 and 56 days curing periods are given in Table 8. The density of concrete on standard 150 mm cube is calculated using the formula D = M/V kg/m3M=is the mass of concrete in kg V=is the volume of concrete in mm3D= is the density of cube specimen in kg/m3

TABLE 8: TEST RESULTS OF DENSITIES OF CONCRETE

MIX DESIGNATION	FLY ASH(%)	STONE DUST(%)	AVG. DENSITIES OF CONCRETE	
			28 DAYS	56 DAYS
M0	0	0	2452.77	2458.36
M1	10	50	2505.12	2513.45
M2	10	80	2512.53	2516.44
M3	10	100	2523.11	2529.73

3. Compressive Strength of concrete:

The compressive strength of concrete on standard 150 mm cube is calculated using the formula f = P/A N/mm2 Where f... is compressive strength of concrete in N/mm2P... is ultimate load resisted by concrete in Newton‘s A... is cross sectional area of cube specimen in mm2. The test results of compressive strength of normal M-20 concrete and modified concrete is been showed in table 9

TABLE 9: TEST RESULTS OF COMPRESSIVE STRENGTH OF CONCRETE

MIX DESIGNATION	FLY ASH (%)	STONE DUST (%)	AVG. COMPRESSIVE STRENGTH N/MM^2	
			28 DAYS	56 DAYS
M0	0	0	50.81	56.92
M1	10	50	48.31	55.03
M2	10	80	48.00	56.92
M3	10	100	49.20	57.49

4. Flexural strength of concrete

The bearing surfaces of the supporting and loading rollers are wiped clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers (38 mm dia.).The specimen is then placed in the machine in such a manner that the load is applied to the uppermost surface as cast in the mould along two lines spaced at 13.3 cm apart (Two Point Method). The load is increased until the specimen fails, and the maximum load applied to the specimen during the test is recorded. The flexural strength of the specimen shall be expressed as the modulus of rupture fb, which, if „a" equals the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/cm2 as follows: Flexural strength, $\mathbf{f_f = P\,L\,/b\,d^2}$ N/mm^2

The test results of flexural strength of normal M-20 concrete and modified concrete is been showed in table 10.

TABLE 10 : TEST RESULTS OF FLEXURAL STRENGTH OF CONCRETE

MIX DESIGNATION	FLY ASH (%)	STONE DUST (%)	AVG. FLEXURAL STRENGTH N/MM^2	
			28 DAYS	56 DAYS
M0	0	0	3.5	3.9
M1	10	50	3.45	3.8
M2	10	80	3.32	3.65
M3	10	100	3.4	3.78

V. DISSCUSSIONS

From the above investigations and analysis of the results the following discussions are drawn The density of M20 concrete for both 28 days and 56 days is higher than the other proportions. The compressive strength and flexural strength for both 28 days and 56 days for M20 concrete is higher than the other proportions. The compressive strength for M1 concrete is 48.31 N/mm2 and 55.03 N/mm2 for 28 days & 56 days respectively. This is lower than M2 and M3. This is mainly because of increasing percentage of stone dust. The flexural strength for M1 concrete is 3.45 N/mm2 and 3.8 N/mm2. This is higher than M2 and M3. The higher strength may be attributed to the content of stone dust. The compressive strength for M2 concrete is 48 mpa and 56.92 mpa for 28 days & 56 days respectively. The flexural strength for M2 concrete is 3.32 mpa and 3.65 mpa.the decrease in strength with respect to M1 can be attributed to increase in the percentage of stone dust. The compressive strength for M3 concrete is 49.20 mpa and 57.49 mpa for 28 days & 56 days respectively. The flexural strength for M3 concrete is 3.4 and 3.78 mpa.as the percentage of stone dust is increased, the strength has decreased. The density increases with increase in Stone dust percentage. The compressive strength of cement mortar with 10% fly ash would be 25.42 N/mm2 and 26. 52 N/mm2 for 28 and 56 days respectively.

VI. CONCLUSIONS

The strength parameters of M20 grade Fly ash-stone dust concrete with constant 10% of cement replaced by fly ash and fine aggregate natural sand replaced by stone dust at different levels namely 50, 80 and 100% with curing periods of 28 and 56 days for compressive strength and Flexural strength. The conclusions pertaining to comparison of strength parameters of fly ash-stone dust concrete are listed below. Stone dust is a very good replacement of river sand, which is in short supply currently. The inclusion of stone dust has desirable effect on concrete mechanical properties which is comparable to normal concrete. The addition of stone dust causes a loss in slump; though such loss in slump can be significantly reduce by the addition of fly ash. The use of stone dust to partial replace of sand in concrete production will require a higher water-cement ratio. The rate of strength development in fly ash-stone dust concrete is less at early ages this may be due to delayed pozzolonic activity, however at later ages strength development increases. So this requires longer curing periods compared to normal concrete. From the above results, it can be concluded that fly ash and stone dust can be effectively used in concrete.

SCOPE OF FURTHER STUDIES:

Concrete using higher percentages of fly ash can be studied. Further investigations on the mechanical properties such as stress-strain properties & durability of such concretes can be carried out. Behavior of concrete containing stone dust and fly ash to marine environment can also be studied. Investigations to study shrinkage and bond properties of fly ash-stone dust concrete Characterization study on fly ash and stone dust collecting the samples from different sources so that they can be standardized for better application as alternate material.

VII. REFERENCES

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