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Case study on manufacturing of concrete from ready mix concrete plant and cost analysis on flyash blended concerete

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Abstract— This paper summarizes the results of various physical properties conducted on the aggregates, cement, fly ash, concrete and the effect of replacement of cement by fly ash (15%, 20% and 30%) on the compressive strength to provide sound concrete for the purpose of utilization in various civil engineering constructions like buildings, dams, bridges etc. Our study includes the mix designs of fly ash blended concrete and compressive strength test on concrete cubes to know the performance of the concrete.
It is the material of choice where strength, durability, impermeability, fire resistance and abrasion resistance are required. Several design mixes were prepared, cured and tested for compressive strength properties. The results are analysed and compared with standard concrete and conclusions made on how best the flyash can be utilized to give optimum results. The results indicate that, as the total replacement level of OPC in concrete using blend of OPC + FA increases, the strength with respect to control mix increases up to certain replacement level and thereafter decrease. If the cement content of control mixes at same w/c ratio, then higher percentage of OPC can be replaced with FA to get 28 days strength comparable to the control mix. The use of fly ash concrete brings about a substantial saving in cement consumption and overall construction cost.

Index Terms— Concrete, Fly Ash, aggregates, Super Plasticizer, durability and Compressive Strength

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1 INTRODUCTION

This paper is based on techno-economic analysis for the compressive strength of flyash concrete

Fly Ash is an industrial waste and a residual material of energy production burning the pulverised coal, which has been found to have numerous advantages for use in concrete industry. For several years it has been used in varying proportions and compositions in concrete. Reached indicates that there are still additional benefits to be gained if the concrete industry can further optimize its use in concrete.

In the last millennium concrete has demanding requirements both in terms of technical performance and economy while greatly varying from architectural masterpiece to the simplest of utilities. Concrete is a material with which any shape can be cast and with equal strength or rather more strength than the conventional building stones. The main important material used in making concrete is cement, sand, crushed stone and water. Concrete is the key material used in various types of construction, from the flooring of a hut to a multi-storied high rise structures. Concrete is one of the versatile heterogeneous materials. With the advent of concrete civil engineering has touched highest peak of technology.

In order to usher modernization and development of the construction industry, industrialization of concrete is necessary .RMC is one such technology. Ready mix concrete is a type of concrete that is manufactured in a factory or in a batching plant, according to asset recipe, and then delivered to a worksite, by truck mounted transit mixers. This results in a precise mixture, allowing specialty concrete mixtures to be developed and implemented on construction sites.

The first ready mix factory was built in the 1930s, but the industry did not begin to expand significantly until the 1960s, and it has continued to grow since then. Ready mix concrete is sometimes preferred over on-site concrete mixing because of the precision of the mixture and reduced worksite confusion. Ready mix concrete is sold by volume usually expressed in cubic meters.

In this experimental investigation, an attempt has been made to study the techno-economic analysis for the compressive strength of flyash concrete. The flyash is produced from thermal power plants nearby. Using the experimental data, a column section is designed. The relative cost of column section designed with OPC as well as various proportions of flyash is estimated and compared. It is observed that flyash can be safely and economically used. This also provides an environmental friendly method of flyash disposal.

1.2 LAYOUT EQUIPMENTS OF READY MIX CONCRETE PLANT

A. Aggregate delivery; B. Aggregate receiving hopper; C. Aggregate storage; D. Conveyor Belt; E. Cementitious Material

ISSN 2229-5518

storage; F. Weigh Hopper; G. Cement Delivery; H. Mixer; I. Admixture; J. Ready Mix Truck with returned concrete; K. Recycled water; L. Reclaimed Aggregates; M. Pump; N. Water storage; O. Concrete loaded on Ready Mix Truck; P. Control Room

1.3 RMC PLANT:

Ready mixed concrete refers to concrete that is batched for delivery from a central mixing plant instead of being mixed on the job site. Each batch of ready-mixed concrete is tailor-made according to the specifications of the contractor or concrete mix design and is delivered to the site in green or plastic condition, usually in the cylindrical trucks often known as "Transit mixers".

Concrete constituents occupy a large space for storage at construction site. Further, the builder has to spend a lot of time and effort to source these materials and test their quality before use. Ready Mixed Concrete (RMC) suppliers take care to collect and store all these materials and supply the required quantity of concrete at the specified time and place so that construction can proceed smoothly. Metropolitan Cities are hard-pressed for Storage Space. Therefore, RMC greatly relieves the space problem.

RMC is a specialized material in which the cement aggregates and other ingredients are weigh-batched at a plant in a central mixer or truck mixer, before delivery to the construction site in a condition ready for placing by the builder. Thus, `fresh' concrete is manufactured in a plant away from the construction site and transported within the requisite journey time.

1.4 CODE STIPULATION

The most important parameter is the time that gets elapsed from the instance of adding water to the placement of concrete. Normally, the concrete has to be placed in about 90 -120 minutes or before the rotating drum of transit mixer has made about 300 revolutions. Indian Standard 4926:2003 permits concrete to be discharged from the truck mixer within 120 minutes after loading. It also permits a longer period if suitable retarding admixtures are used.

1.5 ADVANTAGES OF RMC

1. The quality of concrete will be superior over the site-mixed concrete.
2. The considerable wastage of materials on site due to poor storage conditions and repeated shifting of the mixer location.
3. Obtaining RMC at the site can reduce supervision and labour costis prevented.
4. This greatly helps in controlling the water to cement ratio (w/c) which results in correct strength and durability.

2 MATREIALS

2.1 CEMENT

Cements having calcium silicates as major constituents are called Portland cement. Cements in which the major constituents are ingredients other than calcium silicates are called non-Portland cement. When making concrete the cement paste acts as a binding medium which adheres to the intermixed sand and stone particles. This binds the mass together which becomes very hard.

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Cement used in the laboratory investigations was ordinary Portland cement of 53grade. The properties of cement used in the investigation are presented. The chemical properties are tabulated in table 1, and the physical properties are tabulated in table 2.

Table 1. Chemical properties of cement

Component	Percentage
Si02	17-25
AL2O3	4-8
Fe2O3	0.5-0.6
CaO	61-63
MgO	0.1-4
SO3	1.3-3

Table 2. Properties of Cement:

Property		OPC 53
Standard Consistency (%)		27.3
Specific Surface (m²/kg)		334
Setting Time	Initial	210
	Final	280
Soundness Test	Le chatelier (mm)	0.5
	Auto clave (%)	Nil
Compressive Strength	3 days	30.0
	7 days	43.0
	28 days	52.0

2.2 FLY ASH

Fly ash for this study is taken from NTPC thermal plant in Visakhapatnam. This fly ash conforms to the requirements of

IS: 3812 Part 1. Generally fly ash quality is assessed on the basis of some of the key parameters like pozzolanic activity, material retained on 45 micron sieve, loss on ignition and other chemical parameters. Various tests were done to find out the physical and chemical properties of flyash which is illustrated in this table. Fly ash used in this project is a by-product of steel plant.

Parameter	Observed value	Permissible value as per IS 3812-2003
Specific surface value	340-360 m²/kg	>250 m²/kg
Particle retained on 45 micron sieve	29.1%	<35%
Compressive strength at 28 days	43.76-48.38 N/mm²	>39-43 N/mm²
Soundness	0.015 to 0.019	<8%
Silica + alumina + iron oxide	87-91%	>70%
Silica	57-60%	35%
Sulphur as SO3	0.25-0.32%	<0.3%
MgO	0.25-0.33%	<0.5%
Loss on ignition available alkalis as Na2O	0.15 to 0.03%	1.5%
Chlorides	0.16-0.04%	0.05%

It can be seen that all parameters are within permissible limits.

2.3 WATER

Water distributes the cement evenly, so that every particle of the aggregate is coated with it.it reacts chemically with the ingredients of cement, the reaction called hydration o cement and brings about the setting and hardening of cement. After also lubricates the ix and gives it the workability required to place and compact properly. Water used in the concrete should be free from impurities.

2.4 ADMIXTURES

Admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes and are added to the concrete at the time of batching/mixing. The common types of admixtures are accelerators, retarders, plasticizers, super plasticizers etc.

a. Super plasticizers(high rate water reducers)
b. Plasticizers(water reducers)

a. Super Plasticizers (water reducers):

The use of super Plasticizers(high range water reducers) permit the reduction of water to the extend up to 30% without reducing the workability in contrast to the possible reduction up to 15% in case of plasticizers.

b. Plasticizers (water reducers):

This is used for right workability which is essence of good concrete. The high range water reducing and retarding super-plasticizer conforming to IS 9103 CRYSO Pvt. Ltd.,was used. The base of admixture used in this study was sulphonated naphthalene formaldehyde and water reduction of admixture. The admixtures used are the best when compared to the other brands. Varaplast and chyso delta were the admixtures used in the study.

VARAPLAST SP 123

Varaplast 123 is a chlorine free, super plasticizing admixture based on selected synthetic polymers. It is supplied as a brown solution which is instantly dispersible in water. Itcan provide very high level of water reduction and hence major increase in strength can be obtained coupled with good retention of workability to aid placement.

CHRYSO PLAST DELTA

Increases the workability of concrete for a constant water content, Increases concrete's density and compressive strength, Optimizing cement content in order to obtain a given compressive strength, Enhancing concrete pumpability.

2.5 FINE AGGREGATES

The locally available river sand conforming to the requirements of IS: 383was used as fine aggregate in the present investigation. The river sand was washed and screened, to eliminate deleterious materials and over size particles. The specific gravity is 2.63.The sand is free from clayey matter, salt and organic impurities.

The sand is tested for various properties like specific gravity, bulk density etc., in accordance with Indian Standard 2386-1963(28). The properties of fine aggregate used in the investigation are presented in Table 3.

Table 3.Properties of Fine Sand

I.S sieve	Weight retained	cumulative weight retained	% of cumulative weight retained	% of passed	I.S limits % of passed sample
4.75	0.022	0.022	2.2	97.8	90-100
2.36	0.194	0.216	21.6	78.4	75-100
1.18	0.161	0.3765	37.7	62.4	55-90
600µ	0.123	0.499	49.9	50.1	35-59
300 µ	0.209	0.642	70.2	29.8	8-30
150 µ	00.141	0.849	85.9	15.1	0-20
75 µ	0.106	0.955	95.5	4.5	-
Pan	0.045	1.00	100	0	-

2.6 COARSE AGGREGATE

Machine crushed angular granite aggregate confined to Indian Standard: 383-1970from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for

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its various properties. The properties of crushed coarse aggregate are shown in Table 4 and Table 5.

3 TESTS ON AGGREGATE

3.1 TESTS ON AGGREGATES

Flakiness Index, elongation index, aggregate impact value test, sieve analysis, specific gravity test.

Flakiness index	10.520%
Elongation index	12.405%
Aggregate impact value test	24.7%

Sieve analysis of fine aggregate, 12.5mm coarse aggregate and 20mm coarse aggregate are done.

Table 4 12.5mm COARSE AGGREGATE:

I.S sieve	Weight retained	cumulative weight retained	% of cumulative weight retained	% of passed	I.S limits % of passed sample
16	0	0	0	100	100
12.5	0.050	0.050	1	99	75-100
10	1.07	1.12	22.4	77.6	0-40
4.75	3.75	4.91	98.2	1.8	0-15
Pan	0.09	5.00	100	0	0

Table 5.20 mm COARSE AGGREGATE

I.S sieve	Weight retained	cumulative weight retained	% of cumulative weight retained	% of passed	I.S limits % of passed sample
40	0	0	0	100	100
20	0.28	0.28	14	86	85-100
10	1.157	1.437	71.85	28.15	0-20
4.75	0.539	1.976	98.8	1.2	0-15
Pan	0.024	2	100	0	0

3.2 COMPRESSIVE STRENGTH OF CONCRETE

In this test sample of concrete is filled in the mould of size 15cm x 15cm x 15cm and top of mould is strike off. A total number of 18 cubes were casted. Flyash is added in place of cement in concrete in 6 different percentages starting from 0%, and raised the mixing of fly ash upto 25%, at an interval of 5%. The specimens are covered with the wet gunny bags for 24 hours. Then after sample is removed and kept for curing in curing tank. At the end of curing period sample is removed and tested immediately. The testing is done under Universal Testing Machine model no. UTM 40, Yama Engineers Kolhapur make. The load is applied smoothly and gradually. The crushing loads are noted and average compressive strength for all the specimens is determined.

4 MIX DESIGN

4.1 MIX DESIGN

This standard provides the guidelines for proportioning concrete mixes as per the requirements using the concrete making materials including other supplementary materials identified for this purpose. The proportioning is carried out to achieve specified characteristics at specified age, workability of fresh concrete and durability requirements. This standard is applicable for ordinary and standard concrete grades only.

Mix design for M20 grade concrete was performed by using IS method. As per the design, the mix proportion obtained is presented in the Table 6.

Data for the mix M20 grade

Grade designation	M20
Type of cement	OPC-53G
Maximum normal size of aggregate	20mm
Minimum cement content	300kg/m3
Maximum w/c ratio	0.5
Workability	100mm
Exposure condition	Moderate
Method of concrete placing	Pumping
Degree of supervision	Good
Type of aggregate	Ground aggregate crushed
Chemical admixture type	Type is super plasticizer
Specific gravity of cement	3.15
Specific gravity of flyash	2.0

Table 6.Mix proportions for concrete of M20 grade

MATERIALS	OPC	OPC + 15% FLY-ASH	OPC + 20% FLY-ASH	OPC + 30% FLY-ASH
Water to cement ratio	0.50	0.50	0.50	0.50
Cement (kg/m³)	330.00	280.50	265.00	230.00
Fine aggregate (kg/m³)	725.98	696.01	694.19	730.95
Coarse aggregate (kg/m³)	1244.33	1295.92	1292.88	1304.69
Water (l)	165.00	165.00	165.00	140.00
Admixture (ml)	77.88	1265.14	945.25	1093.21

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4.2 CASTING OF TEST SPECIMENS

The Concrete Cubes (control specimens) of size 15cm x 15cm x 15cm were cast by using above proportion of materials for OPC. Similarly 3 fly ash concrete cubes each were cast obtained from cement fly ash proportions for different days of curing. The specimens were demoulded after 1 day and immersed in water for 7, 14, 28, days for curing. During fresh state of concrete, Workability of concretes were measured .The mix shall be carefully observed for freedom from segregation, bleeding and its finishing properties.

4.3 WORKABILITY OF CONCRETE

Before casting of the cube the workability of concrete is tested and then cubes are casted. To find out workability of concrete different tests are conducted.

a. Slump Test
b. Compacting Factor Test
c. Flow Test
d. Kelly Ball test
e. Vee Bee Consistometer Test

Out of above all the tests mentioned, slump cone test was performed as a measure of workability of concrete.

5 RESULTS AND DISCUSSION

5.1 COMPRESSIVE STRENGTH

The compressive strength of concrete is one of the most important design parameters required for concrete. This series of test determines the strength attained by concrete hose cement and fine aggregate quantities have been replaced with fly ash varying from 0 to 30.

The test was conducted in 3000kN compression testing machine. The load was applied at the rate approximately 140kg/cm2/min until the failure of the specimen. The maximum load applied to the specimen until failure was recorded and shown in Table 7

The results plotted on the graphs below are the average values of the tested at each age and flyash percentage.

Table 7 Strength comparison:

Mix Proportions For Concrete M20 Grade	7 Days Strength (N/mm²)	28 Days Strength (N/mm²)
100% OPC	39.16	48.38
OPC+FLYASH-15%	35.78	51.84
OPC+FLYASH-20%	33.30	43.76
OPC+FLYASH-30%	20.31	47.24

5.2 COMPRESSIVE STRENGTHVs FLY ASH PERCENTAGE

As more flyash is added to the concrete, a decrease in the rate of strength gain is observed as showed in fig.1.Early strength gain (7days) generally decreases as more flayash is added to concrete. Flyash affects the early strength gain probably due to the curing process. As the concrete is further cured the ultimate desired strength is attained.

Concrete with 20% and 30% Fly ash provided the most optimal results for its compressive strength. This is probably because the fly ash react with the pozzalanas in the hydration process.

5.3 FLY ASH Vs AGE OF CONCRETE

The compressive strength of the flyash concrete increased with an increase of number of days that it was cured. The strength accelerates with the next 7 days then follows a similar trend in strength gain with the rest of the samples.

Cost of the materials are shown approximately

Cement : 300/- per bag
20 mm aggregate : 700/-per metric ton
10 mm aggregate : 450/-per metric ton
M.Sand : 350/-per metric ton
Admixture : average 60/-per Kg (chrysodelta,varaplast)

FOR 1 CU.M of concrete:

Mix	Cost
100% OPC	3160.74
OPC + 15% FLY-ASH	2902.01
OPC + 20% FLY-ASH	2779.34
OPC + 30% FLY-ASH	2679.93

6 CONCLUSIONS

From the results obtained by compression strength tests made on flyash blended concrete of different percentages and OPC, it is observed that by using flyash (cementitious material) which is the byproduct from the industries of power generation (coal), strength attained is greater than OPC which is advantageous.

It is probable that even higher percentile replacements of cement would still be able to provide the same compressive strength as no flyash concrete. However the results of the study do not indicate at which point the continued replacement of cement with flyash would cause the compressive strength to decline below the strength observed from the no flay ash concrete. A 20 to 30% flayash replacement provides the most optimal strength results;more air entrained admixture is required for increasing amounts of flyash used.

Also from the cost analysis made, fly ash replacing cement trails are economical than using plain cement as by products cost is lower than cement. By replacing cement with fly ash (cementitious material) pollution caused in cement production can be reduced to a little extent.

Fly ash is actually a solid waste. So, it is priceless. If it can be used for any purpose then it will be good for both environment and economy. Use of this fly ash as a raw material in Portland cement is an effective means for its management and leads to saving of cement and economy consequently. Hence it is a safe and environmentally consistent method of disposal of flyash. However the rate of strength development is less, Due to lesser rate of strength development, flyash finds specific application in mass concreting e.g. dam construction. It can be concluded that power plant waste is extensively used in concrete as a partial replacement for cement and an admixture. Since a huge quantity of flyash is used in concrete in mass concrete construction and the cost of fly ash is negligible as compared to that of the cement, the use of fly ash concrete brings about a substantial saving in cement consumption and overall construction cost.

Now a days due to increase in constructions, there is an extra demand for the concrete to be supplied. As we are in the stage of scarcity of land to be used for the mixing and storing of the materials, there we prefer ready mix concrete which is prepared to the accurate proportions of materials to be used.

This paper describes preliminary results of an on-goingproject. More research work is being carried out to determine the effects. This flyash would have on the durability and bond strength of concrete.

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