PARTIAL REPLACEMENT OF OPC WITH FLY ASH IN CONCRETE

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Abstract- Fly Ash is a by-product at thermal power stations, also referred to as residues of fine particles that rise with flue gases. An industrial by-product could also be inferior to the traditional materials used construction applications, but, the lower the cost of those inferior materials make it an attractive alternative if adequate performance can be achieved. The purpose of this study is to evaluate the chemical and physical effectiveness of self-cementing fly ashes derived from thermal power stations for construction applications with combined standards. Using laboratory testing specimens, suitable types of Fly Ashes namely: Kendal Dump Ash, Durapozz and Pozzfill, were tested to the specified standards to gauge e the potential properties. All three Fly Ashes have been classified as a Class F Fly Ash, which needs a cementing agent for reactions to take place and for early strength gains in the early stages of the reaction processes. The Fly Ashes conformed to the combination of standards and have shown that the proper reactions will take place and can continue over period of time. The utilization of fly ash is accepted worldwide due to saving in cement, consuming industrial waste and making durable materials, especially due to improvement within the quality fly ash products.

Keywords : - Thermal power station , Cementing , Durable material.

Introduction

Fly ash is residue of the non-combustible mineral portion of coal. When coal is consumed in the power-plant. ,it's first ground to the fineness of powder. Into the power-plants boiler, the carbon is consumed, leaving molten particles rich in silica alumina and calcium. These particles solidify as microscopic, glassy spheres that are collected from the power-plants exhaust before. Fly ashes undergo pozzolanic reaction with lime created by hydration of cement and water to form calcium silicate hydrate like cement. In additionally, some fly ashes may possess enough lime to be self-cementing in additionally to the pozzolanic reaction with lime from cement hydration. Through pozzolanic activity, fly ash combines with free lime to provide an equivalent cementitious compound formed by the hydration of Portland cement. Due to this series of ash is a fine powder recovered from gases created by coal-fired electric power generation. Power -plants produce around millions of tons of fly ash annually, which is usually dumped in landfills. Fly ash is a cheaper replacement for Portland cement utilized in concrete, while it actually improves strength, and ease of pumping of the concrete. Fly ash is also used as an ingredient in brick, block, paving and structural landfills.

Literature Review

ARUN KUMAR, A. S. SANTHI, G. MOHANGANESH et-al. (March, 2012), In their paper on "Various Utilization of Fly Ash and its Properties on Concrete" explained about several utilization of fly ash and its properties over conventional concrete according to the current studies stressing the advantages of fly ash. The use of fly ash is one of the measures from low-level applications such as a landfill to high-strength concrete due to its engineering characteristics. The physical and chemical properties of fly ash increase most of the properties of concrete as long-term availability. Fly ash is also utilized in non- engineering applications such as in agriculture as soil amendments, ceramics and in glass manufacturing, etc. Fly ash should be termed as a resource material considering its beneficial effects and it should be used more in the cement and concrete industry. Successful application of this waste will have great advantages and minimize the land getting used for disposal of this waste. This review paper can help the researchers in starting a study of fly ash without limitation of national standards for paving the way for a replacement revolution in fly ash utilization resulting in a greener society and also for sustainable development.

While, Alvin Harison , Vikas Srivastava and ArpanHerbert et-al. (January 2014),explained about compressive strength in their paper "Effect of FlyAsh on Compressive Strength of Portland Pozzolana Cement Concrete" They proved that Compressive strength of fly ash concrete up to 30% replacement level is more or equal to referral concrete at 28 and 56 days Optimum replacement level of fly ash is 20%. It was observed that at 28 and 56 d in 20% replacement of PPC by fly ash, the strength marginally increased from 1.9% to 3.28%. It was also observed that up to 30% replacement of PPC by fly ash, the strength is almost equal to referral concrete at 56 d. PPC gains strength after the 56 d curing because of slow hydration process.

Tapeshwar Kalra 1&Ravi Rana 2 et-al. (April 2015), focused on rate of strength gain in their paper "FLY ASH CONCRETE" Fly ash concrete is most important building material for slower strength gainat early ages as major problem in making fly ash concrete very popular in the Indian construction industry which is only focused on short term strength gain. A detailed mix design procedure along with conformation of results for designing fly ash concrete to achieve required strength at 28 days is needed. It is must to shift contractors focus on economical and durable fly ash concrete even if higher days of curing are required.

A.J.Patel1 , Dr.V.M.Patel2, Dr.M.A.Patel3 et- al. (November 2015), in their paper on "PARTIAL REPLACEMENT OF CEMENT IN CONCRETE
"suggested to reduce or reuse some material in field of concrete production which is at its top now-days then it largely impact environment and leads to pollution free and soothing surrounding.

Similarly, Jayanta Chakraborty1 , Sulagno Banerjee2et-al. (August 2016), suggested that compressive strength of concrete mixes decrease with increase presence of Fly Ash in their paper "Replacement of Cement by Fly Ash in Concrete" The optimum limit of mixing of Fly Ash was suggested to be 45 % and more than that may not be safe for different concrete mixes. Generally with the increase of fly ash there is steep increase in strength from 7 to 28 days which is indicative that early strength of concrete is reduced with increase in proportion of fly ash. Above all the variation in early strength is more than that of in later strength. Hence the fact remains that Fly Ash has an adverse effect on early strength of concrete. Depending upon the percentage of FlyAsh as well as time of curing sometimes mixes of higher strength can be economical than that of mix of lower strength.

Jyoti1 , Praveen Kumar et-al. (Apr 2017), inferred in their paper "Partial Replacement of Cement with Fly Ash for Concrete Pavement" that Having fly ash in a concrete mix as a replacement of cement or fine aggregate increases its compressive strength due to the pozzolanic activity of the ash. The compressive strength of a fly ash concrete keeps increasing over a longtime because fly ash retards the hydration process of cement, whereas ordinary concrete reaches its maximum compressive strength after around 28 days. Regardless of the replacement level for all the mixes, inclusion of fly ash improves the workability of a concrete due to the fineness sand spherical shape of its particles. Thus the water requirement gets reduced by incorporation of fly ash as partial replacement in concrete. Fly ash concrete will have lower compressive strength than conventional concrete at early age; however it achieves higher ultimate strength than can be achieved with conventional concrete.

Mr. Anurag Verma1 , Ms. Disha Srivastava2 ,Mr. Neelesh Kumar Singh3 et-al. (May 2017) discussed the various effects of flyash in their paper " Flyash and Effect" Use of flyash reduces the voids and cracks formation and corrosion. Flyash increases workability, durability and minimizes the water demand. Flyash reduces the overall cost by 10-30% of that of concrete when 50% of cement is replaced and 46% cost reduction when 65% cement is replaced. The setting time is generally increased by approx.2 hours by adding flyash to it. The development of compressive strength, flexural strength is slow however it holds pace in later days from 7 to 28 days and from 28 to 56 days, 91,182 and 365 days. With increase in content of fly ash, air content increases whereas unit weight decreases. With increase in content of flyash, air content increases and unit weight decreases. Flyash content increases workability and drainage characteristics. There isa limitation in addition of flyash content in concrete so that workability is maintained. Up to 55% cement can be easily replaced by fly ash if used along with polyester fibers. Self- Compacting Concrete can also be developed for 55% replacement of cement by fly ash. With increase in fly ash content, so rptivity and shrinkage of concrete also decreases. For HVFA concrete, admixtures help to obtain higher strength for negligible change on cost.

Anesh Chaurasiya1, Ahsan Rabbani et-al. (November, 2017), "Experimental Study on Use of Fly Ash in Concrete" specifically explains that fly ash is a great replacement for low-grade cement like M20. It can be elaborated that at 25% of replacement of cement by fly ash there is a significant increase in strength of concrete. Mixing of fly ash in concrete can save the coal and thermal industry disposal cost and produce a "greener" concrete for construction. With the use of mineral admixture, the cost is greatly reduced due to non-use of mechanical vibrators plus viscosity modifying admixtures also avoided. The strength of concrete decreases with increases in percentage of fly ash initially and again increases as the percentage of fly ash increases.

A. Fuzail Hashmi, and Moin ul Haq et-al. (September, 2018), distinguishes about flyash in their paper on "Indian based fly ash & international based fly ash" It elaborates that the Indian fly ash are mostly of class F which is a low lime fly ash characterized by a relatively higher concentration of SiO2 and Al2O3 and lower contents of Fe2O3 whereas international fly ash are mostly of class C which is a high lime fly ash, generally spherical in shape and range in size from 2 µm to 10 µm consist mostly of silicon dioxide (SiO2), aluminum oxide (Al2O3) and iron oxide (Fe2O3). High volume of fly ash in the concrete result in the reduction of drying shrinkage in the concrete. High volume fly ash concrete (up to 40% cement replacement) showed better abrasion resistant particularly at high compressive strength. The inclusion of high volumefly ash in the concrete increases the porosity and the percentage of water absorption, but decreases the permeability. Both the porosity and water absorption increased with increasing fly ash content. The compressive strength of high volume fly ash concrete is low at initial ages but with the passage of time i.e. beyond 28 days, it gains satisfactory or better compressive strength as compare to normal concrete. High volume fly ash concrete achieve satisfactory tensile strength as compare to normal concrete with the passage of time. However, the flexural strength of all mixes decreases as the percent replacement of fly ash increases.

RESEARCH OBJECTIVES

Thus as concluded from above literature review we can research further more in direction of partially replacing cement, sand and aggregate up to most optimum level we can by reusing or introducing waste material as its option. From studying all these research paper it is clear that positive and favorable results are obtained if further research work and study is carried out in this field. And by using locally available wastes like glass waste, marble dust powder, ceramic waste, quarry dust, GGBS, Fly ash, RHA, CKD, BSFC, Silica fume, silt ,clay, sewage sludge ash and different sludge etc. as partial substitution atplace of concrete ingredients, it may prove more economical than traditional concrete and question of damping of such waste produced by different industries is also get solved. This waste also create air pollution and land pollution by damping and also causes water pollution so by using this material in concrete we can save our atmosphere and land. Ultimate goal is to produce economical and eco-friendly concrete with all desired properties and strength which one obtains by regular concrete ingredients.

Materials and Methodology

Cement In this work, Portland pozzolana cement (PPC) obtained from single batch was used throughout the investigation. The properties of PPC are given in table.

Table .1

Properties of 53 Grade Ordinary Portland Cement (OPC)

Sr. No.	Physical Properties of Cement	Result	Requirements as per IS: 8112-1989
1	Specific Gravity	3.15	3.10 – 3.15
2	Standard Consistency(%)	29%	30 – 35 (%)
3	Initial Setting Time	35 min	30 minutes
4	Final Setting Time	180 min	600 minutes
5	7 days Compressive Strength	38.50 N/mm^2	43 N/mm^2
6	28 days Compressive Strength	52.31 N/mm^2	53 N/mm^2

Fine Aggregate

The fine aggregate was locally available river sand which was passed through 4.75 mm sieve the fineness modulus, specific gravity and moisture content 2.83, 2.23 and 2.0% respectively.

Coarse Aggregate

The coarse aggregate was locally available having two different sizes, one fraction was passing through 20mm sieve and its fineness modulus was 7.5, and another fraction passing through 10mm sieve and its fineness modulus was 6.8. The specific gravity and water absorption of coarse aggregate was 0.8 and
2.66 respectively for both the fractions.

Flyash- In the present work the fly ash is obtained from the NTPC, TANDA AMBEDKAR NAGAR, U.P (INDIA), Kanti.
Thermal Power Plant Station (located in Kanti, Muzaffarpur, Bihar (INDIA)). The physical andchemical properties of the fly ash was tested and the result is shown below ash is a fine powder by product from industrial plants using pulverized coal or lignite as fuel. It is the most widely used pozzolana siliceous or alumina siliceous in nature in a finely divided form. They are spherical shaped "balls'' finer than cement particles A. Sources of fly ash Fly ash is powder recovered from the gases of coal fired electricity production Inexpensive replacement of Portland Cement Improves strength, segregation and ease of pumping the concrete.

Classification Of Fly-Ash In Material Use-

Two classes of fly ash are define by ASTM C618 :
The classification is based on the chemical composition of FA i.e. the sum of silica , alumina and iron oxide percentages in the FA
Class F fly ash if ($SiO_2+Al_2O_3+Fe_2O_3$) > 70%
Class C fly ash if 70% > ($SiO_2+Al_2O_3+Fe_2O_3$) > 50%

Fig.1- Classification of Fly ash

Table .2

Differences between PPC & Fly Ash

Physical Properties		
	PPC	Fly Ash
Specific Gravity	2.72	2.10
Mean grain size(μm)	23	20

Test Methods

The Steel mould of size 150 x 150 x 150 mm is well tighten and oiled thoroughly. then tested in 7, 14, 28 days

Compressive strength

Compressive strength is defined as the ratio of the load per unit area. Compressive strength is estimated by dividing the maximum load by the original cross-sectional area ofa specimen in a compression test. The compressive strength of different

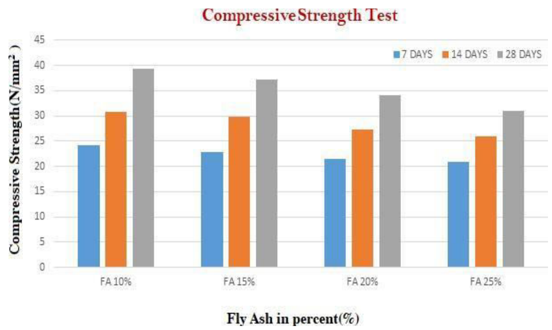
specimens for same concrete mix is different, so average compressive strength of three specimen sample was used for strength calculation. Compressive strength of referral concrete as well as concrete made using fly ash as partial replacement of PPC is shown in table below.

Compressive Strength Formula

Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross- sectional Area

Procedure: Compressive Strength Test of Concrete Cubes
For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical molds of size 15cm x 15cm x 15cm are commonly used.
This concrete is poured in the mold and appropriately tempered so as not to have any voids. After 24 hours, molds are removed, and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by placing cement paste and spreading smoothly on the whole area of the specimen.These specimens are tested by compression testing machine after seven days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.



Apparatus for Concrete Cube Test
Compression testing machine

Precautions for Tests
The water for curing should be tested every 7 days and the temperature of the water must be at 27+-2oC.

Calculations of Compressive Strength
Size of the cube =15cmx15cmx15cm

Area of the specimen (calculated from the mean size of the specimen)=225 cm2 Characteristic compressive strength(f ck)at 7 days =17 MPA

Expected maximum load =fck x area x f.s = 5.2 tons
Range to be selected is = 32
Similar calculation should be done for 28 day compressive strength

Maximum load applied =5 tones = 44.45KN

Compressive strength = (Load in N/ Area in mm2)= 34 N/mm2

Table .3
Compressive strength with % of fly ash and days

S.NO.	Mix Design ation	Compre ssive	Strength(N /mm²)	
		7 Days	**14 Days**	**28 Days**
2	**FA 15%**	**22.75**	**29.80**	**37.20**
3	**FA 20%**	**21.40**	**27.34**	**34.14**
4	**FA 25%**	**20.90**	**25.85**	**31.05**

Water absorption test

The 100mm dia x 50 mm height cylinder after casting were immersed in water for 90 days curing. These specimens were as the dry weight (W1) of the cylinder. After that the specimen was kept in hot water at 85°c for 3.5 hours. Then Figure 1 and figure 2 shows the setup of oven and setup of hot water curing respectively. % water absorption = [(W2 – W1) / W1] x 100

Where,

W1 = Oven dry weight of cylinder in grams

W2 = After 3.5 hours wet weight of cylinder in grams

Table .4

AVERAGE % WATER ABSORPTION

Concrete Mix	% Replacement of Cement by Fly Ash	Dry Wt. in grams (W1)	Wet Wt. in grams (W2)	% Water Absorption
A1	0%	929.67	934.67	0.54
D1	5%	931.23	942.67	1.23
D2	10%	919.42	933.17	1.50
D3	15%	932.33	955.67	2.50

1	**FA 10%**	**24.20**	**30.75**	**39. 29**

D4	20%	870. 33	897. 17	3.10

Results and Discussion

Results of Concrete Cube Test

Average compressive strength of the concrete cube = 17 N/ mm^2 (at 7 days)

Average compressive strength of the concrete cube = 44.45 N/mm^2 (at 28 days

On the basis of the result obtained from the experiment following conclusion can be drawn.

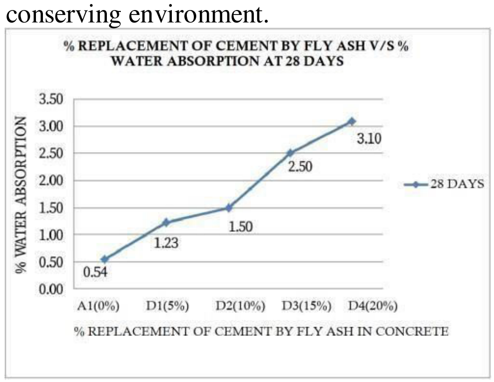
1. The compressive strength of concrete that was partially replaced with fly ash gave nearly similar results when compared to conventional concrete .

2. The compressive strength decreases with increase in percentage of proportion of replaced fly ash

3. The split tensile strength also decreases with increase in percentage of proportion of replaced Fly ash

4. Since the unit weight of fly ash is less so the concrete made from it is a light weight concrete.

5. Recycling of fly ash could aid in conserving environment.



Conclusion

Fly ash thus holds a vast potential for improving the modern day concrete when it comes to qualities in the long terms. In spite of being an industrial waste, it can improve durability and reduce heat of hydration.

The prospects of fly ash are still being underused even today. Thus keeping in mind about environment concerns and its indispensability as a mineral admixture, the values of fly ash should be effectively gamered. The optimum amount of fly ash varies not only with the application, but also with composition and proportions of all the materials in the concrete mixture (especially the fly ash), the conditions during placing (especially temperature), construction practices (for example, finishing and curing) and the exposure conditions. Thus, the optimum fly ash content will vary on a case-by-case basis. Fly ash contents of up to 35% may be suitable for mostelements provided the early-age strength requirements of the project can be met and provided that adequate moist-curing can be ensured. For flatwork, the level may be dictated by finishing requirements. If adequate curing cannot be provided or if the concrete is exposed to freezing and thawing in

Why flyash is not used beyond limit

The maximum percentage of fly ash to replace a part of cement in the high-strength concrete mix to obtain the strength, which is equivalent to the strength of concrete with OPC only is 35%. The strength of concrete with 35% fly ash (86.62 MPa) at age 28- days is slightly higher than that of strength of OPC only (84.09 MPa). The use of fly ash beyond 35% as the replacement of cement gives a strength (78.93 MPa) lower than t hat of OPC only strength.

the presence of deicer salts, the amount of fly ash should be limited (for example, ≤ 35%).

REFERENCES

Concrete technology(theory and practice)- M.S Shetty

https://images.app.goo.gl/6ueXWb3bF523zTRXA

https://allcountypaving.com/about-acp/we-care/#:~:text=Fly%20ash%20is%20comprised%20of,stream%20exiting%20the%20power%20plant

https://www.scribd.com/document/97910100/104-376-1-PB

http://jairjp.com/JANUARY%202014/07%20ALVIN.pdf

http://www.ijirset.com/upload/2015/july/193_61_Effect.pdf

https://www.researchgate.net/publication/236841389_Fly_Ash_abstract_16May_2013

https://www.researchgate.net/publication/309880687_Replacement_of_Cement_by_Fly_Ash_in_Concrete

https://theconstructor.org/concrete/compressive-strength-concrete-cube-test/1561/?amp=1