International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 08 | Aug 2019 www.irjet.net p-ISSN: 2395-0072

BEHAVIOURIAL STUDY OF THE CONCRETE ON PARTIAL REPLACEMENT OF CEMENT BY FLY ASH

Ankesh S.B[1], Bharat G.K[2], Bibek Malla[3], Chethan Gowda G.D[4], Devaraja H.V[5]

[1]Assistant Professor, Department of Civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, India
[2,3,4,5]B.E. Students, Department of Civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, India

---

Abstract - *The infrastructures are developing day by day so demand is more for concrete. The construction activity is readily depend on concrete directly or indirectly. Hence heavy releases of carbon dioxide gas in cement manufacturing process, destruction of environment taking place. To overcome these problems, partially use of industrial waste in place of cement are necessary in the production of concrete. In this study an attempt has been made with a M_{20} mix proportion. Experimental study is conducted to evaluate the strength characteristics of hardened concrete. Properties of concrete have been assessed by partially replacing cement with Fly-Ash. The cement has been replaced by Fly-Ash in the range of 0%, 10%, 20% and 30% by weight of cement. Concrete cubes were casted and tested after 7 days, 14 days and 28 days of curing for compressive strength and compared the results with the control cube specimens. The optimum mix of Fly ash is determined.*

Key Words: Industrial waste, Fly ash (FA), Compressive strength, Split tensile strength.

1. INTRODUCTION

Fly ash is a by-product of burning pulverized coal in an electrical generating station. Specifically, it is the unburned residue that is carried away from the burning zone in the boiler by the flue gases and then collected by either mechanical or electrostatic separators.

Fly ash is a pozzolanic material. It is a finely-divided amorphous alumino-silicate with varying amounts of calcium, which when mixed with Portland cement and water, will react with the calcium hydroxide released by the hydration of Portland cement to produce various calcium-silicate hydrates (C-S-H) and calcium-aluminate hydrates. Some fly ashes with higher amounts of calcium will also display cementitious behavior by reacting with water to produce hydrates in the absence of a source of calcium hydroxide. These pozzolanic reactions are beneficial to the concrete in that they increase the quantity of the cementitious binder phase (C-S-H) and, to a lesser extent, calcium-aluminate hydrates, improving the long-term strength and reducing the permeability of the system. Both of these mechanisms enhance the durability of the concrete.

1.1 BENEFITS OF FLY ASH WHEN USED IN CONCRETE

1. Produce various set times.
2. Increase durability.
3. Reduce alkali silica reactivity.
4. Increase ease of pumping and improve flow – ability.
5. Reduce segregation and slump loss.
6. Reduce water demand.
7. Cold weather resistance.
8. Higher strength gains.
9. Can be used as a admixture.
10. Reduces cost.
11. Increases the modulus of elasticity of concrete when concrete of same strength with and without fly ash are compared.
12. Improved sulphate resistance.
13. Can substitute for Portland cement.
14. Considered a non-shrink material.

1.2 OBJECTIVE

To study the suitability of the fly ash, as the use of fly ash in concrete retains or improves the strength properties of concrete.

1.3 SCOPE OF WORK

Following procedure to be done for this word

-Preliminary tests conducted on materials to find out physical properties

-Materials are mixed in proper proportion and moulded in a cylinders and cubes.

-M20 cement concrete and with replacement of cement by 10%, 20%, 30% by fly ash.

-These various specimens of concrete are to be tested at 7days, 14 days and 28 days for compressive strength and tensile strength.

-Analysis of test result

2. LITERATURE REVIEW

Dr SuhasV. Patil, Suryakant C. Nawl&et.all (2013), studied industrial applications of fly ash. It is used as a substituent of cement and in tiles it can be substituted up to 50%...It is used in Cement industry for structural fills, in concrete, in Portland concrete in fly ash roads, for bricks, mosaic tiles, light weight aggregates. In chemical industry it is used as filler in Jute cloth industry, removal of phenol and its derivative etc.,

P.S.Joanna, Jessy Rooby & et.all, studied the behavior of concrete with 50% fly ash. It obtains good compressive strength with superior durability properties. 60% Fly ash produces self-compacting concrete Ultimate moment capacity of fly ash concrete beam is 16% less OPC concrete at 28 days but it increases by 23% at 75^{th} day. The deflections are within allowable limit under design load IS 456:2000. 50% fly as beams showed displacement ductility in the range 4 to 6 which is adequate for members subjected to large displacement such as sudden forces caused by earthquake. Therefore, results suggested that concrete with 50% fly ash replacement for cement could be used for RC beams.

Beglarigale, F. Ghajeri&et.all (2014), studied the Permeability Characteristics of Concrete Incorporating fly ash strength loss due to fly ash incorporation at 28-day is more pronounced in the case of stronger concretes. Effective curing procedures should be applied.A good relationship between compressive strength and ultrasonic pulse velocity was achieved but the result of ultrasonic test is not indicative for permeability characteristics, replacement of cement by fly ash increased the resistivity values. Reduced electrical conductivity can be a measure in terms of reinforcement corrosion and incorporation of FA decreased the air permeability of concrete mixture as well as capillary or total water absorption.

Saurabh Attarde, Sagar Marathe&et.all, studied utilization of fly ash in construction industries for environmental managementFly ash in bricks: These bricks have been invented in India producing bricks without coal. It can be produced in variety of strengths and size.Fly ash in road construction: Fly ash has application in roads, railways, dam, and embankments. It is a good structural fill for low lying areas. It has been used in embankments of roads and highway bridges. Example, Okhla fly over bridge in Delhi utilizing 4800 tons of fly ash. Construction of approach embankment of Nizamuddin Bridge in Delhi using 150000 tons of fly ash. Local soils replaced by fly ash for backfill, one of fly ash highest use. Reduce in CO_2, PM emission and embodied energy. Reduction in resource use, reuse of industrial by product, sustainability achieved through efficient design and enhanced durability

Nagabhushana (2015), studied on properties of concrete with different levels of replacement of cement by fly ash. The object is to study the strength properties of M_{20}, grade of concrete with various levels of replacement of cement by fly ash and to arrive at optimum. The replacement levels selected for the study are 0%, 10%, 20% & 30% of cement by weight. For M_{20} grade, workability is achieved without super plasticizer. For M_{20} grade of concrete, the 28 days compressive strength is increased by 8% when compared to normal concrete with 35% replacement of cement. At 50% replacement of cement by fly ash, there is decrease in strength. The increase in split tensile strength at 35% replacement is 14%. The increase in flexural strength at 35% replacement is 8% when compared to normal concrete. For M_{35} grade of concrete the 28 days compressive strength is increased by 7% when compared to normal concrete at 35% replacement of cement. The increase in split tensile strength is 12%. The increase in flexural strength is 28% with respect to normal concrete. From the result of this study, it can be concluded that cement replacement by fly ash is 4 useful in lower grades of concrete such as M_{20} and M_{35}. Useful in lower grades of concrete such as M_{20} and M_{35}.

Er.Amit Kumar Ahirwar, Prof. Rajesh Joshi&et.all, studied laboratory analysis of fly ash mix cement concrete for rigid pavement: The workability of concrete decreases with the increase in fly ash, the particles of Fly ash reduces the amount of water required to produce a given slump.

The compressive strength and flexural strength increases with the increase of fly ash in concrete up to 30% replacement with cement in conventional mix, however the compressive strength increases more as compared to flexural strength, the values are acceptable as per IRC.

Integration of fly ash in concrete increased the cohesiveness of the mix, prohibited segregation and resulted in reduced bleeding. Higher percentages of fly ash can cause a change in color of the mix.

Incorporation of fly ash in concrete can save the coal & thermal industry disposal costs and produce a greener Concrete for construction.

R.D Padhye, N.S Deo (2016), studied cement replacement by fly ash in concrete. The compressive strength of the concrete mixes decreases with the increase in fly ash. The fly ash can be replaced up to maximum of 40%, and replacement above 40%may be may not be safe for different concrete mixes. In general, with the increase in fly ash there is a steep increase in strength from 7 to 28 days indicating that the early strength of the concrete is reduced with the increase in fly ash. Also, the variation in early strength is more than the variation in later strength. Thus, the fly ash has an adverse effect on the early strength of the concrete.

Abhash Kumar Prajapati, Dinesh Sen (2017), analyzed the properties of the concrete with fly ash.

Standard consistency increased as amount of fly ash increased in cement fly ash mix, that means less water quantity need to make cement fly ash mix paste, fly ash takes longer time to settle down as compare to ordinary Portland cement. Cement paste settle down in 45 to 50 minute. On other hand as amount of fly ash increased its settling time also increased, In slump test, Fly ash cement concrete has more workability as compare to normal cement concrete, Fly ash-cement concrete cube absorbs more water, compressive strength is approximately same as normal cement concrete. As amount of fly ash increased, as compressive strength decreased. Replacement of fly ash with cement in concrete up to 35%-45% is safe to use in road construction.

Rishabh Joshi (2017), studied the effect on compressive strength of concrete by partial replacement of cement with fly ash. The average compressive strength of cubes at the age of 7 days and 28 days were found as 13.86 N/mm^2 and 20.58 N/mm^2 for normal concrete with no fly ash and it reduced to 10.11 N/mm^2 and 16.35 N/mm^2 when 30 % of cement was replaced with fly ash. The decrease in compressive strength of concrete after 28 days of curing was found to be 21%, when 30% of cement was replaced with fly ash. The compressive strength of concrete decreases with increase in fly ash content. The reduction in compressive strength of concrete at the age of 28 days was found to be 4.57%, 12.20% and 20.55% for 10%, 20% and 30% replacement of cement with fly ash. The workability of concrete improves with the increase in fly ash content.

Dr.S.SenthilSelvan (2017), studied performance of high volume fly ash concrete compressive strength. The results show that the compressive strength of high volume fly ash concrete at 28 days is lower when compared to the compressive strength of conventional concrete specimens. There is an increase of compressive strength to the specimens made of high volume fly ash concrete at 90 days of curing. Increase in compressive strength of high volume fly ash concrete is slower. At 90 days of curing, compressive strength of high volume fly ash concrete is higher than the conventional concrete. Cubes made of 55% replacement of cement with fly ash gives the best compressive strength value.

Flexure Strength: Flexure strength test values are obtained at 28 days and 56 days of curing Table 2 shows the results obtained by center point loading on prisms. Specimens made of 55% replacement of cement with fly ash concrete gives best values at 56 days of curing.

Impact Strength: Specimens made of 55% and 65% replacement of cement with fly ash shows good results when compared to conventional concrete at 56 days of curing. The optimum replacement level of cement with fly ash is 55%. Flexure strength test gives higher values for specimens with 55% replacement of cement with fly ash concrete.

Michael Thomas, studied about optimizing the use of fly ash.

Compressive strength: Long-term strength development is improved when fly ash is used and at some age the strength of the fly ash concrete will equal that of the Portland cement concrete so long as sufficient curing is provided. .The ultimate strength achieved by the concrete increases with increasing fly ash content, at least with replacement levels up to 50%.Creep: The creep of HVFA concrete tends to be lower than Portland cement concrete of the same strength and this has been attributed to the presence of unreacted fly ash (Sivasundaram 1991). It is also likely that the very low water and paste contents attainable in HVFA concrete (and concurrently high aggregate content) play an important role in reducing the creep of concrete with high levels of fly ash. In well-cured and properly-proportioned fly ash concrete, where a reduction in the mixing water content is made to take advantage of the reduced water.

3. MATERIALS AND METHODOLOGY

3.1. MATERIALS USED

1. Cement: Ordinary Portland Cement (OPC) of 53 grade (Birla Super) confirming to (IS 8112 -1989) was used. To find the quality of cement, few tests have been conducted in the Laboratory. The results have been tabulated in table.1.

Table-1: Lab test result on cement

SL NO	Experiment	Value
1	Specific gravity	3.16
2	Fineness	4.5%
3	Standard consistency	33%
4	Initial setting time	60 min

2. Fine aggregate: The locally available natural river sand belonging to zone-1 and passing through 4.75mm sieve of IS 383-1970 was used for the project work. The results have been tabulated in table.2

Table-2: Test result on Fine Aggregate

SL NO	EXPERIMENT	RESULTS
1	Sieve analysis	Fineness =3.19
2	Specific Gravity	2.55
3	Moisture Content	1.8%

3. Coarse aggregate: The coarse aggregate comprising 20mm & 12.5mm in saturated surface dry condition were used. The coarse aggregate used as 20 mm graded aggregate as per IS: 383 -1970 specification. The results have been tabulated in table.3

Table-3: Test result on Coarse Aggregate

SL NO	EXPERIMENT	RESULTS
1	Sieve analysis	Fineness modulus =6.42
2	Specific gravity	2.64
3	Water absorption	0.35 %

4. Fly Ash: The fly ash is mainly two classes one is class F & class C in this experimental work we used class F fly ash. Fly ash is blended in cement at the rate of 10-30% by weight of cement in steps of 10%.fly ash used is brought from Jindal Steel Plant, Bellary, Karnataka.

5. Water: Water is a vital element of concrete as it effectively took an interest in chemical response with cement, clean versatile water which is accessible in our college is utilized. The water used for casting and curing should satisfy as per IS 456-2000.

3.2 METHODOLOGY

Preliminary Tests: These were performed on the fine aggregates, coarse aggregates and cement to confirm their suitability for concrete making.

Mix Design: Mix design: The M_{20} grade concrete is adopted for the present work. Detailed mix proportion is obtained as per code IS: 10262-2009. As $20N/mm^2$ was target strength. Nominal mix design of 1:2:4 was adopted.

Batching: The materials were weigh batched using electronic weighing machine.

Mixing: Mixing was done in a lab concrete mixer. The mixing was done as per the standard for min 3 min.

Preparation of moulds: Before casting the specimens, all cube and cylinder moulds were cleaned, screwed tightly and oil was applied to all surfaces to prevent adhesion of concrete during casting.

Compaction: Placing of concrete in oiled mould was done in three layers for cubical mould and five layers for cylindrical mould, each layer tamped at least 25 times with the tamping rod.

Curing: After 24 hours, all the casted specimen were demoulded from the moulds and marked (To identify the casting batch) and immediately put into the curing tank for a period of 7, 14 and 28 days for different specimens. The specimens were not allowed to become dry during the curing period.

Testing: Specimen was taken out from the curing tank after 7, 14 and 28 days to perform various test. Three numbers of specimens in each sample were tested and average value was calculated for cubes. One specimen was tested for split tensile test for various proportions of fly ash at 7 and 28 days. Specimens were tested on compression testing machine. Compressive strength test and split tensile test are carried out and results are noted and graphs are plotted

Table-4: Mix proportions for 5 cubical moulds

Fly ash %	Cement kg	Fly ash kg	Fine kg	Coarse kg	Water ltrs
0	8.250	0	12.875	24.750	3.55
10	7.425	0.825	12.875	24.750	3.55
20	6.600	1.650	12.875	24.750	3.55
30	5.775	2.475	12.875	24.750	3.55

The mix proportions are calculated by measuring area of cubical moulds.

4. RESULTS

4.1 COMPRESSIVE STRENGTH TEST

The Compressive strength results of 7 days, 21 days and 28days are tabulated for different replacement ratios for M_{20} Grade concrete mix.

Table-5: 7 days compressive strength

Fly ash (%)	Compressive Strength (N/mm^2)	Average (N/mm^2)
0	26.68 28.25 29.2	28.27
10	26.42 25.02 22.93	25.79
20	20.93 20.66 20.80	20.79
30	18.74 19.18 19.35	19.09

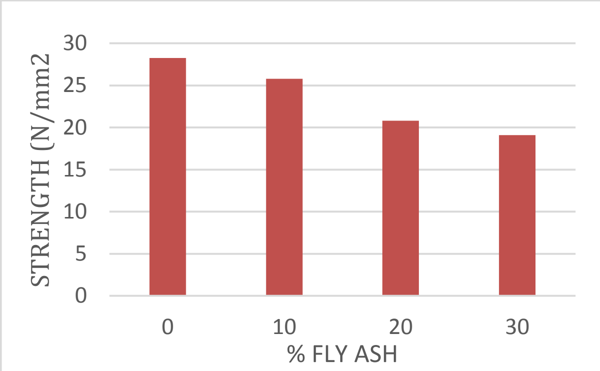

Chart-1: 7 days compressive strength

Table-6: 14 days compressive strength

Fly ash (%)	Compressive Strength (N/mm²)	Average (N/mm²)
0	32.44 30.61 29.50	30.37
10	28.08 27.38 27.73	27.23
20	24.32 24.85 24.94	24.70
30	18.74 19.18 19.35	19.09

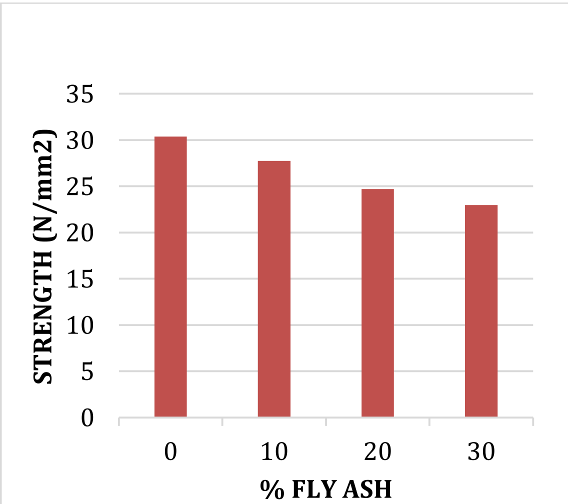

Chart-2: 14 days compressive strength

Table-7: 28 days compressive strength

Fly ash (%)	Compressive Strength (N/mm²)	Average (N/mm²)
0	36.01 34.8	35.45
10	32.18 31.22 33.31	32.24
20	30.52 31.45 30.52	30.34
30	24.41 25.51 24.41	24.87

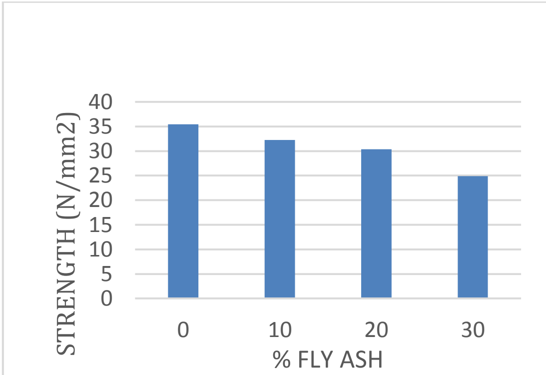

Chart-3: 28 days compressive strength

4.2 SPLIT TENSILE TEST

Table-8: 7 days tensile strength

%replacement of fly ash	Trial 1 (N/mm²)
0	2.16
10	2.83
20	1.44
30	1.52

Table-9: 28 days tensile strength

%replacement of fly ash	Trial 1 (N/mm²)
0	2.99
10	3.33
20	2.77
30	2.55

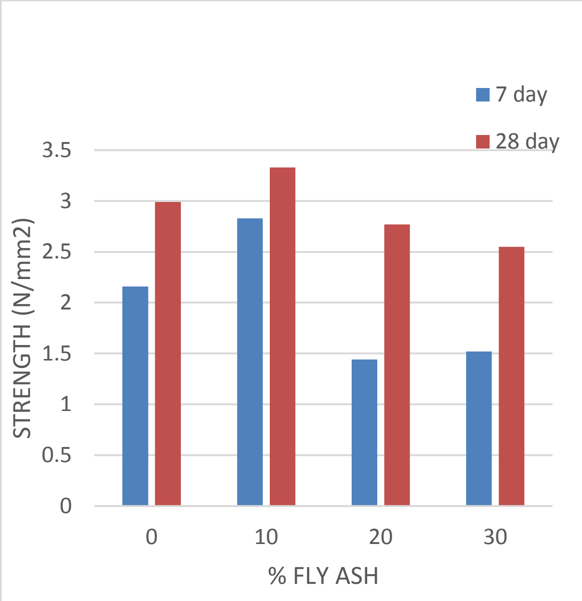

Chart-4: 7 and 28 days tensile strength

5. BRIEF ESTIMATE OF COST SAVINGS

Quantity of cement/m^3=383Kg=7.66 bags, Rs400/bag (50Kg)

] Total=Rs 7.66*400= Rs 3064

Rate per bag of fly ash =Rs.200

Rate per kg= Rs200/50= Rs 4

3.10% of 383Kg=38.3 kg

Cost of 38.3 kg cement, 38.3 kg xRs.8=Rs 306.4

Cost of 38.3 kg fly ash, 38.3 kg x Rs4= Rs 153.2

Cost saved = Rs 153.2 per cum

Case Study:

Generally for a 40x50 site house construction cost (Ground + 2, 4 BHK) up to 3100 Sq. built up area requires 1480 bags of cement.

Total cost of cement 53 grade Birla Super= Rs 400 x 1480 = Rs 592000

With 10 % replacement, total bags of cement required = 1332

Total bags of fly ash = 148

Total cost with replacement = Rs 400x1332 + Rs 200x148 = Rs562400

Total cost saved = Rs 592000- Rs 562400 = Rs 65600

Note: However, transport &logistics have not been considered since rice husk ash is abundantly available at countryside & may be used.

6. CONCLUSIONS

Based on the limited study carried out on the strength behaviour of fly ash, the following conclusions are drawn

Compared to the concrete with completely OPC, the strength gained is less. The reasons might be the quality of fly ash, and may also depend upon the degradation during the storage of the fly ash.

At all the cement replacement levels of fly ash; there is gradual increase in compressive strength from reaching the designed characteristic strength.

Samples with 10%, 20% and 30% content of fly ash replacing the cement have been tested. 10% of replacement of cement content with fly ash gives safe and economic results. And it is recommended not to add more than 20% as the strength gain is less compared to others.

The technical and economic advantages of incorporating fly ash in concrete should be exploited by the construction industry.

We would also like to suggest the concerned authorities to regulate the handling of the fly ash as it was evident from dealer that the fly ash handling is unmanaged and unregulated handling.

7. REFERENCES

1) "IS: 10262: 2009", Indian Standard Concrete Mix Proportioning-Guidelines, Bureau of Indian Standards, New Delhi, 2009.
2) "IS: 456:2000", Indian Standard Plain and Reinforced Concrete-Code of Practice (Fourth Revision), Bureau of Indian Standards, New Delhi, 2000.
3) "IS :4031 (Part 4)- 1988", Indian Standard Methods Of Physical Test For Hydraulic Cement-Part 4, Bureau of Indian Standards, New Delhi,1988.
4) AmarnathYerramala, Rama Chandrudu C, Bhaskar Desai V (2012), "Influence of fly ash replacement on strength properties of cement mortar", International Journal of Engineering Science and Technology (IJEST), Volume 4 , No 8.
5) Dr SuhasV.Patil, Suryakant C. Nawle, Sunil J. Kulkarni (2013), "Industrial Applications of fly ash: A review", International Journal of Science, Engineering and Technology Research, Volume 2, Issue 9.
6) P.S.Joanna, Jessy Rooby, Angelina Prabhavathy, R.Preetha, C.Sivathanu Pillai(2013), "Behaviour

of reinforced concrete beams with 50 percentage fly ash", International Joural of Civil Engineering "and Technology (IJCIET), Volume 4, Issue 2, pp36-48.

7) SaurabhAttarde, Sagar Marathe, AvickSil. (2014), "Utilization of fly ash in construction industries for environment management", Int. J. Environmental Sciences, Volume 3(2): pp 117-121.
8) A. Beglarigale, F. Ghajeri, H. Yigtir, H. Yazici. (2014), "Permeability Characterization Of concrete incorporating fly ash", 11th International Congress in Advances in Civil Engineering, ACE 2014.
9) Er.Amit Kumar Ahirwar, Prof. Rajesh Joshi, Er.KapilSoni (2015), "Laboratory analysis of fly ash mix cement concrete for rigid pavement", Int. Journal of Engineering Research and Applications, Volume 5, Issue 2, pp 86-91.