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Destructive And Non-Destructive Evaluation Of Replacement Of Cement By Flyash, (M40)Gr Of Concrete

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ABSTRACT

The aim of this paper is to study the behavior of M-40 grade of concrete having mix proportion of 1:1.83:2.65 with w/c of 0.41 and to determine the compressive strength of the flyash concrete made with 0, 5, 10, 15, 20, 25, 30% [1]of cement replacement was evaluated in terms of its relation with compressive strength and workability test. Compression was made between ordinary Portland cement and flyash concrete. In this work the mechanical properties of fly ash based concrete which includes compressive strength and Non destructive testing method like Rebound Hammer [2]tests will be examined and analyzed based on the different mix proportions of cement with (0, 5, 10, 15, 20, 25, 30%) Fly ash Test result [3]indicated the strength of concrete having cement replacement up to 30 % of flyash was comparable to the normal concrete mix without flyash. In the investigation, conventional concrete and flyash based on concrete cubes of 150x150x150mm sizes[4] were used for testing the compressive strength. The cubes are tested in compressive testing machine of capacity *2000kn. Compressive strength[5] of concrete mix made with and without fly ash With different percentages determined at 7,28 days of curing. The results confirm that flyash concrete is a promising material for long term strength development. This due to fact that early age strength of flyash was lowers as compared to strength of control concrete.*

Keywords: *Flyash, Compressive strength, Specific Gravity, Density, Cement concrete, Rebound Hammer.*

I. INTRODUCTION

In today's world the main emphasis is on green and sustainable development. Concrete is now the most widely used construction material as it can be cast to any form and shape at site very easily. Cement concrete has established itself as the most preferred material.. Cement industry is one of the major contributors to pollution by releasing carbon dioxide. One ton of OPC[2] production produces approximately one ton of Carbon dioxide. So by partially replacing cement with pozzolonic material such as fly ash, the cement industry can serve both the purposes of meeting the demands of construction industry and at the same time providing a green and clean environment. Fly ash is difficult to decompose so using flyash is a major step towards sustainable development. Flyash[3] does not have cementisious property by itself which is responsible for strength generation. But in presence of water it reacts with free lime obtained from cement and form hydrated products (C_2S and C_3S) which helps in attaining the strength and also improving the durability. As the flyash is very fine in structure, it fills more voids and provides superior pore structure and thereby improves its strength at later stages due to reduced permeability.

Fly ash is the fine powder produced as a product from the combustion of pulverized coal. The disposal is one of the main reason of fly ash. As dumping of fly ash as a waste material may cause severe environmental problems. The quantity of fly ash produced from the thermal power stations in India is approximately 80 millions tons per year. But its percentage of utilization is less than 10%. Mainly more amount of fly ash produced is class F type. Fly as is generally used as a replacement of cement, as an admixture in concrete, and manufacturing cement. By using fly ash as an admixture in concrete instead of dumping it as a waste material can be great beneficial for the lowering the water demand of concrete for similar workability which also reduces bleeding and lowers the evolution of heat.

The concrete containing fly ash as partial replacement of cement possesses problems on delayed early strength. But concrete containing fly ash as partial replacement of fine aggregate will possess no delayed early strength, and the stages are follows;

Stage I: Procurement of materials and its testing
Stage II: Moulding of specimens and curing
Stage III: Testing of specimen

II. Materials

Low calcium, Class F [5]dry fly ash, conforming to IS 3812(part 1:2003)[8], is obtained from Kothagudem Thermal power station, Bhadradri Kothagudem Dist, Telangana, India .. Specific gravity of fly ash 2.175. Chemical composition details are shown in Table 1. Natural river sand was used as fine aggregate. The bulk specific gravity in oven dry condition and water absorption of the sand as per IS 2386 (Part III, 1963)[10] were 2.45 and 1% respectively. The gradation of the sand was determined by sieve analysis as per IS 383 (1970)[9]. Fineness modulus of sand was found to be 2.50. Crushed granite stone aggregate of size 12 mm and 10 mm were used as coarse aggregate. The bulk specific gravity in oven dry condition and water absorption of the coarse aggregate 12 mm and 10mm as per IS 2386[10] (Part III, 1963) were 2.35 and 0.28% respectively. Super Plasticizer Conplast Sp-430 was used to obtain the desired workability. Potable water was used in the experimental work for preparation of alkaline solution.

Table .1-showing the chemical composition of Fly ash and GGBS, percentage by mass

A. Materials and Test Results

1.CEMENT
2.FINE AGGREGATE
3.COARSE AGGRETE
4.WATER
5.FLY ASH

***a) CEMENT*:**

Locally available Ordinary Portland Cement of 53 grade of BIRLA Brand confining to ISI standards has been procured, and the following tests have been carried out according 15:8112-1989

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cement is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

S.No.	*Property*	*Value*
1	Fineness of cement	4.52 %
2	Specific gravity	3.05
3	Normal consistency	33 %
4	Setting time i. Initial setting time ii. Final setting time	 40 Mins 6 Hours
5	Compressive strength at i. 3 days ii. 7 days iii. 28 days	 34 N/mm^2 44.8 N/mm^2 59 N/mm^2

Table .2 - Physical properties of cement

Material	SiO2	Al2O3	Fe2O3	SO3	CaO	MgO	Na2O	LOI
Fly ash	60.12	26.63	4.22	0.32	4.1	1.21	0.2	0.85

b) Fine Aggregate:

The locally available Natural river sand conforming to grading zone II of table 4 of IS 383-1970 has been used as Fine aggregate.

The following tests have been carried out per the procedure given in IS 383-1970(2)

1) Specific Gravity
2) Bulk Density
3) Grading

4) Fineness Modulus of Fine Aggregate

Fine aggregates are the structural filler that occupies most of the volume of the concrete mix formulas. Depending on composition, shape, size and

other properties of fine aggregate you can have a significant impact on the output. The role of fine aggregate can be described in few points:

- Fine aggregates provide dimensional stability to the mixture
- The elastic modulus and abrasion resistance of the concrete can be influenced with fine aggregate.
- Fine aggregates quality also influence the mixture proportions and hardening properties

The properties of fine aggregates also have a significant impact on the shrinkage of the concrete.
Table 3 –Properties of Fine Aggregate

S.No.	*Property*	*Value*
1	Specific Gravity	2.62
2	Fineness Modulus	3.87
3	Bulk Density i. Loose ii. Compacted	 14.87 KN/m^3 16.24 KN/m^3
4	Grading	Zone II

Table 3 –Properties of Fine Aggregate

Fig 1:FN

S.No.	*Is Sieve*	*Weight Retained*	*% Of Weight*	*Cumulative % Of Weight*	*% Of Passing*
1	4.75mm	25	2.50	2.50	97.50
2	2.36mm	56	5.60	8.10	91.90
3	1.18mm	169	16.90	25.00	75.00
4	600 µ	278	27.80	52.80	47.20
5	300 µ	375	37.50	90.30	9.70
6	150 µ	82	8.20	98.50	1.50
7	75 µ	10	1.00	99.50	0.50
Fineness Modulus = 3.77				Total = 376.70	

Table 4 – Sieve Analysis of F.A

C) Coarse Aggregate:

Machine Crushed granite confining to IS 383-1970 [23] consisting 20 mm maximum size of aggregates have been obtained from the local quarry. It has been tested for Physical and Mechanical Properties such as Specific Gravity, Sieve Analysis, Bulk Density, Cushing and Impact values and the results have been shown

Table 5 - Properties of C.A

S.No.	*Property*	*Value*
1	Specific Gravity	2.67
2	Bulk Density i. Loose ii. Compacted	 13.259 N/mm^2 15.120 N/mm^2
3	Water Absorption	0.75%
4	Flakiness Index	10.42 %
5	Elongation Index	11.64 %
6	Crushing Value	21.33 %
7	Impact Value	15.550 %

d) WATER:

Potable water has been used in this experimental program for mixing and curing.
Water is a transparent, tasteless, odorless, and nearly colorless chemical substance, which is the main constituent of Earth's hydrosphere, and the

fluids of most living organisms. It is vital for all known forms of life, even though it provides no calories or organic nutrients. Its chemical formula is H_2O, meaning that each of its molecules contains one oxygen and two hydrogen atoms, connected by covalent bonds. The water content i.e. the quantity of maximum mixing water per unit volume of concrete may be determined from the following table:

Table.6: Maximum water content per cubic meter of concrete

S.No.	Nominal maximum size of agg.	Maximum water content
1.	10 mm	208 kg
2.	20 mm	186 kg
3.	40 mm	165 kg

*e) **FLY ASH:***

Fly ash, an artificial Pozzolona, is the un burnt residue resulting from combustion of pulverized coal or lignite, mechanical or electrostatic separators called hoppers collect it from flue gases of power plants where powdered coal is used as fuel. This material, once considered as a by-product finding difficulty to be disposed off has now become a material of considerable value when used in conjunction with concrete as an admixture.

The earliest literature available on the use of Fly Ash is in 1932 which was carried out by Cleveland Electric Illuminating Company and The Detroit Edison Company. However, the use of Fly Ash in concrete was first carried out by Davis and his associates in University of California in 1937. Extensive research was carried out throughout the world to promote the use of Fly Ash in construction, only a few milestones could be achieved till 1960 and that too in developed countries only.

As far as India is concerned, the first ever study on use of fly ash in concrete was carried out in 1955 by CBRI, Roorkee, in the form of a review of American and Australian research work on Fly ash. Later, Fly ash was used in small proportions in mass concreting for dams and other hydraulic structures.

Fly ash or pulverished fuel ash (pfa) is a finely divided powder thrown out as a waste material at the thermal power plants using pulverized coal for raising steam in the boilers. In the building industry, the use of fly ash a part replacement of cement in mortar and concrete at the construction site has been made all over the world including India and is well known. The important building materals which can be produced from fly ash are:

– Portland flyash cement
– Ready-mixed fly ash concrete
– Precast fly ash concrete building units
– Sintered fly ash lightweight aggregate for concrete
– Lime fly ash cellular concrete
– Fly ash building bricks
– Fly ash stabilized high-magnesia cement
– Oil-well cementing composition
– Hydraulic binders and
– Bitumious products

Fly ash or flue ash, also known as pulverised fuel ash in the United Kingdom, is a coal combustion product that is composed of the particulates(fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler's combustion chamber (commonly called a firebox) is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys.

ADVANTAGES OF FLY ASH:

Fly ash use in concrete improves the workability of plastic concrete, and the strength and durability of hardened concrete. Fly ash use is also cost effective. When fly ash is added to concrete, the amount of portland cement may be reduced. Benefits to Fresh Concrete.

- It is highly economical.
- Use of Fly Ash is environmentally friendly as the waste materials from industries are effectively being used to create quality building materials.
- Fly Ash has very small particles which makes the concrete highly dense and reduces the permeability of concrete. It can add greater strength to the building.
- The concrete mixture generates a very low heat of hydration which prevents thermal cracking.
- Fly Ash concrete is resistant to acid and sulphate attacks.
- The shrinkage of fly ash concrete is very less.
- The use of fly ash gives concrete good work ability, durability and finish.

DISADVANTAGES OF FLY ASH:

- The quality of fly ash can affect the quality and strength of Cement concrete.
- Poor quality fly ash can increase the permeability of the concrete and cause damage to the building.Hence the advantages

of using fly ash in concrete are more than the disadvantages

III. MIX DESIGN OF CONCRETE M40 GRADE

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the objective of producing concrete of certain minimum strength and durability as economically as possible.

The design of concrete mix is not a simple task on account of widely varying properties of the constituent materials, the condition that prevail at the work and the condition that are Demanded for a particular work for which mix is designed

IV.EXPERIMENTAL WORK

A.Initial Test:

For the design mix concrete, it is necessary to do the initial test for all materials which are going to be used in concrete. Like wise the result of the initial test are equal to the appropriate values provided in the Indian standards. So it is noted that, the materials can be used in the concrete for design mix concrete.

B.Compressive Strength Test

From the design mix concrete, the results are necessary to be equal, for that the cubes of size 50mmX150mmx 150mm have been casted. The casted cubes are to be tested for 3rd day, 7day and 28th day. The result of this will be compared with the target mean strength of theoretical values which are obtained.

C. Procedure Cube Casting

- Measure the dry proportion of ingredients (Cement, Sand & Coarse Aggregate) as per the design requirements. The Ingredients should be sufficient enough to cast test cubes
- Thoroughly mix the dry ingredients to obtain the uniform mixture
- Add design quantity of water to the dry proportion (water-cement ratio) and mix well to obtain uniform texture
- Fill the concrete to the mould with the help of vibrator for thorough compaction
- Finish the top of the concrete by trowel & tapped well till the cement slurry comes to the top of the cubes

D. Curing

- After some time the mould should be covered with red gunny bag and put undisturbed for 24 hours at a temperature of 27 ° Celsius ± 2
- After 24 hours remove the specimen from the mould.
- Keep the specimen submerged under fresh water at 27 ° Celsius. The specimen should be kept for 7 or 28 days. Every 7 days the water should be renewed.
- The specimen should be removed from the water 30 minutes prior to the testing.
- The specimen should be in dry condition before conducting the testing.
- The Cube weight should not be less than 8.1 Kgs

E.Testing

- Now place the concrete cubes into the testing machine. (centrally)
- The cubes should be placed correctly on the machine plate (check the circle marks on the machine). Carefully align the specimen with the spherically seated plate.
- The load will be applied to the specimen axially.
- Now slowly apply the load at the rate of 140kg/cm^2 per minute till the cube collapse.
- The maximum load at which the specimen breaks is taken as a compressive load.

Compression Test Results for 7days and 28 days

Table.7-Compressive Strength of Concrete Cubes at an Age of 7 Days and 28 Days Compression Test Results Average Values (N/mm2)

V. REBOUND HAMMER TEST

S.NO	*% of Fly Ash*	*7 Days Strength (N/mm2)*	*28 Days Strength(N/mm2)*
1	*0*	*33.4*	*47.7*
2	*5*	*48.3*	*55.8*
3	*10*	*45.1*	*51.3*
4	*15*	*37.3*	*38.0*
5	*20*	*31.3*	*37.3*
6	*25*	*24.9*	*31.3*
7	*30*	*24.33*	*29.6*

Rebound Hammer test is a Non-destructive testing method of concrete which provide a convenient and rapid indication of the compressive strength of the concrete. The rebound hammer is also called as Schmidt hammer that consist of a spring controlled mass that slides on a plunger within a tubular housing.

A. Procedure for Rebound Hammer Test

Procedure for rebound hammer test c concrete structure starts with calibration of tl rebound hammer. For this, the rebound hammer tested against the test anvil made of steel havir Brinell hardness number of about 5000 N/mm2.

After the rebound hammer is tested f accuracy on the test anvil, the rebound hammer is he at right angles to the surface of the concrete structu for taking the readings. The test thus can be conducte horizontally on vertical surface and vertically upwarc or downwards on horizontal surfaces as shown figure below If the rebound hammer is held intermediate angle, the rebound number will b different for the same concrete.

B. Points to Remember in Rebound Hammer Test

1. The concrete surface should be smooth, clean and dry.
2. Ant loose particles should be rubbed off from the concrete surface with a grinding wheel or stone, before hammer testing.
3. Rebound hammer test should not be conducted on rough surfaces as a result of incomplete compaction, loss of grout, spalled or tooled concrete surface.
4. The point of impact of rebound hammer on concrete surface should be at least 20mm away from edge or shape discontinuity.
5. Six readings of rebound number is taken at each point of testing and an average of value of the readings is taken as rebound index for the corresponding point of observation on concrete surface.

Average Rebound test Results and Graphs

S.NO	% of Fly Ash	7Days Strength N/mm2	28Days Strength N/mm2
1	*0%*	*16.6*	*21*
2	*5%*	*22.3*	*26.3*
3	*10%*	*20.6*	*22.3*
4	*15%*	*18.3*	*20*
5	*20%*	*16.6*	*18.3*
6	*25%*	*16.6*	*17*
7	*30%*	*15*	*16*

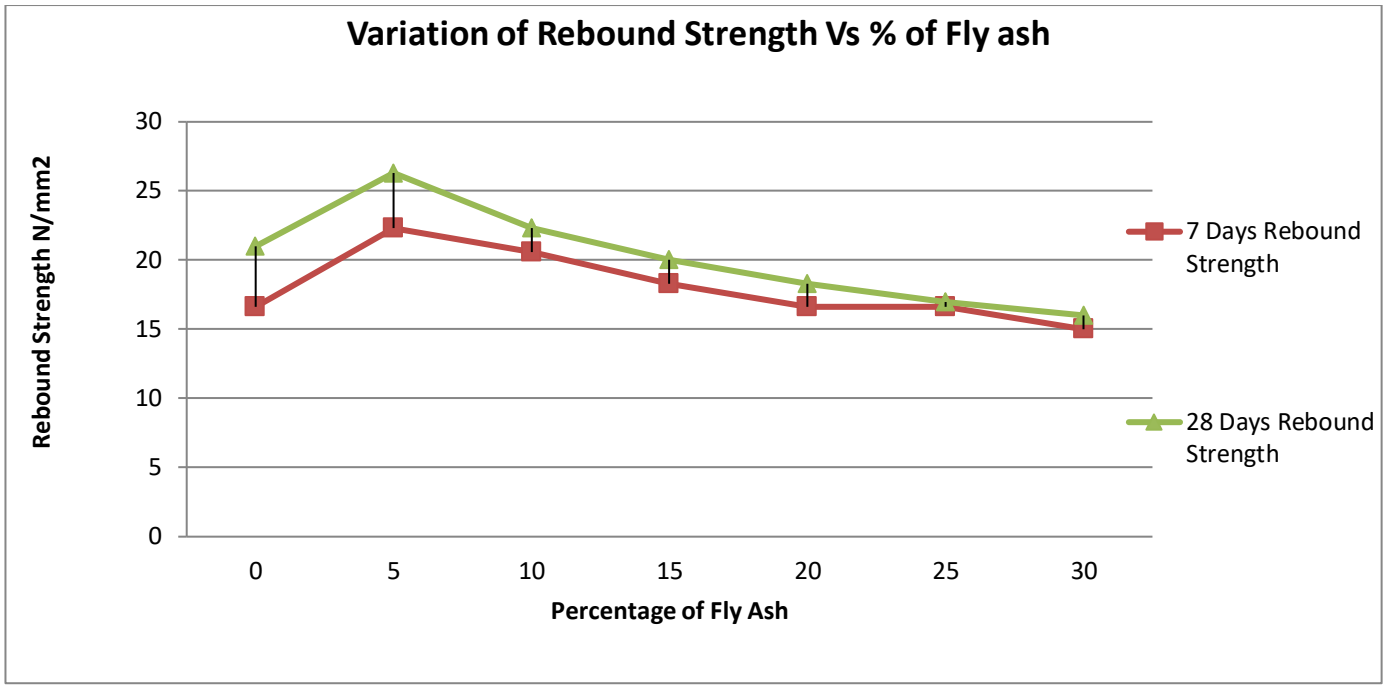

Fig:2 Variation of Rebound Strength Vs % of Fly Ash

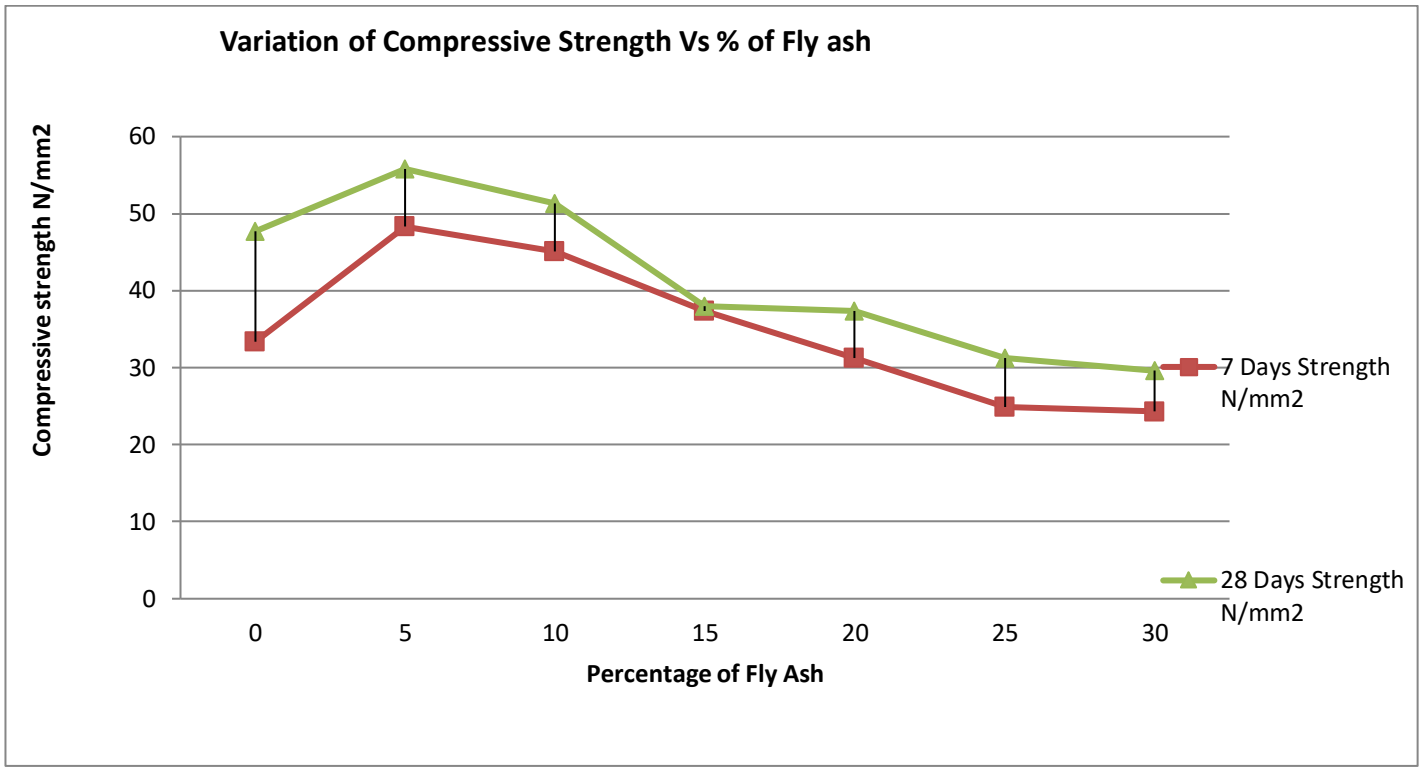

Fig: 3 Variation of Compressive Strength Vs % of Fly Ash

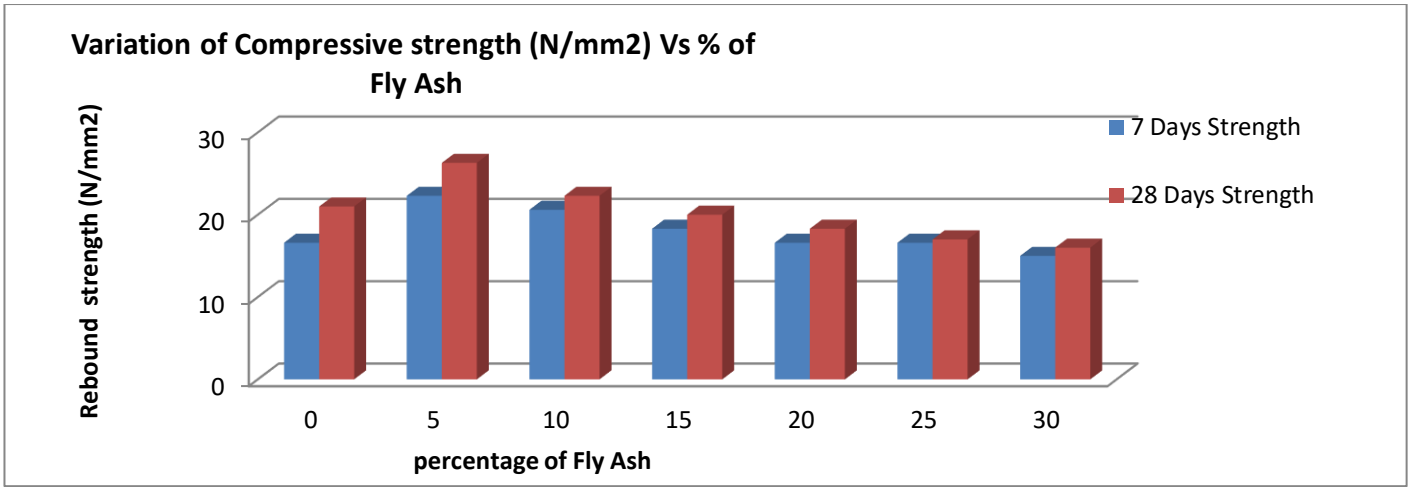

Fig:4 Variation of Compressive Strength Vs % of Fly Ash

VI. CONCLUSIONS

From this project it is concluded that, the comparison between the theoretical results and laboratory test results are compared, which are almost equal, so we concluded that the design mix concrete is better than nominal mix concrete.

1. The compressive strength of concrete decreases with increase in fly ash content. Expect 5% replacement.
2. In 7 days strength there is no increased in compressive strength than control mix3. As the cement was replaced with fly ash , the reduction in compressive strength of concrete was higher at the age of 7days as compared to 28 days .
4. At 5% replacement of Fly ash Compressive strength of concrete increased.
5. At 10 to 30% replacement of Fly ash does not give significant increment in compressive strength of concrete.
6. The workability and Consistency of cement increases with increase in fly ash content.
7. Not more than 30% of cement should be replaced with fly ash, other wise it may lead to significant reduction in the compressive strength of concrete.

8.The overall view of this experimental investigation destructive and non destructive tests resulted that compressive strength test values are higher than the Rebound Hammer test values according to strength criterion.

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