

EFFECT OF FLY ASH ON MECHANICAL PROPERTIES OF HIGH STRENGTH CONCRETE

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Abstract– Concrete is a vital ingredient in infrastructure development with its versatile and extensive applications. It is the most widely used construction material because of its mouldability into any required structural form and shape due to its fluid behavior at early ages. However, there is a limit to the fluid behavior of normal fresh concrete. Thorough compaction, using vibration, is normally essential for achieving workability, the required strength and durability of concrete. Inadequate compaction of concrete results in large number of voids, affecting performance and long-term durability of structures. Since due to the vast construction in the urban development programs there is an Effect of fly ash on mechanical properties of high strength concrete, fly ash is being used as a mineral admixture, and glemium sky 8233 being used as chemical admixtures materials in concrete. Fly ash based cement concrete. Concrete mixe M40, are designed as per the Indian standard code (IS-10262-82) by adding, 0%, 10%, 20%, 30%, 40%, and 50% of fly ash and chemical admixture of master glemium sky-8233 (0.9% weight of cementitious materials), it is used to improve the workability of concrete. Concrete cubes of size 100mm X 100mm X 100 mm, beam size 500 mm X 100 mm X 100 mm, and impact cylindrical size is 150 mm (diameter) X 60 mm (depth) were casted and tested for compressive strength, flexural strength, impact strength, and sorptivity, at 7 days, and 28 days curing for all mixes and the results are compared with that of conventional concrete.

Key Words: High strength concrete, Fly ash, impact strength, Sorptivity

1. INTRODUCTION

Concrete is an exceptionally solid and adaptable mouldable developments material. It comprises of bond, sand and total (e.g., rock or smashed shake) blended with water. The concrete and water shape a glue or gel which coats the sand and total. At the point when the concrete has synthetically responded with the water (hydrated), it solidifies and ties the entire combine. The underlying solidifying response more often than not happens inside a couple of hours. It takes a little while for cement to achieve full hardness and quality. Cement can proceed to solidify and pick up quality over numerous years.

Early history of High Strength Concrete

High Strength concrete was first achieved in the year 1930's in Japan, Yoshida reported this high strength concrete in the year 1930s with 28days curing, the compressive strength of 120Mpa was obtained, and this result was obtained by the combinations of vibrating and pressing process without using any mineral admixture and chemicals, super plasticizer was developed in the year of 1960 in West Germany and Japan, which was very effective chemical admixtures for reducing the water content in concrete. By using super plasticizer, it is possible to decrease the water to cement ratio while maintaining the workability of this high strength concrete, so this type of technique will be applied very widely and in many bridges, high rise buildings, and precast concrete.

Based on strength concrete is classified as Normal Strength Concrete (NSC), High Strength Concrete (HSC), Ultra High Strength Concrete (UHSC), the high concrete mixtures which are to be showed with compressive strength of 48Mpa or more are to be cured for 28 days, were designated as High Strength Concrete, and this type of concrete are used for constructing of Long Span bridges, Sky Scrapers etc., hence strength developed concrete are classified into 3types of Strength Concrete are Normal Strength Concrete, High Strength Concrete, and Ultra High Strength Concrete. For normal strength concrete its compressive strength will be in between 20-50Mpa, for high strength concrete compressive strength is between 50-100Mpa and Ultrahigh Strength concrete compressive strength will be varying between 100-150Mpa, High Strength concrete is specially achieved for some applications, such as Abrasion resistance, Modulus of Elasticity etc.

1.1 Need for the Study

The main investigation is to evaluate the optimum utilization of fly ash as partial replacement material cement

- To develop, high strength concrete (HSC), for optimum percentage of fly ash by using code IS 10262-2009 with design of M40 grade concrete.
- To determine the optimum percentage of fly ash, it can be used for the given concrete to satisfy both fresh properties (slump test) and mechanical

properties (compressive strength, flexural strength, impact strength, and sorptivity of concrete).

2. LITERATURES REVIEW

These are various experimental investigations that have been done in the field of High strength of concrete (HPC); some of the papers have been discussed.

History of concrete use Fly ash

P. Nath (1a) and P. Sarker (1b) 2008: In this diary, they clarified about the use of fly ash as a supplementary cementitious material which adds manageability to concrete by producing the CO₂ discharge from the bond. In this examination, solidness properties of high-quality cement have been considered by utilizing high volume Class F fly cinder. A solid blend with fly fiery remains, as 30% and 40% of the aggregate blend was utilized to cast the test examples by measuring parameters like compressive quality, drying shrinkage, sorptivity and quick chloride penetrability of the fly cinder and traditional solid examples. The compressive quality of the solid blends changed from 65 to 85 MPa in 28 days. The fly fiery debris solid examples demonstrated less drying shrinkage than the traditional solid specimens when intended for a similar 28-day compressive quality of the customary cement. Incorporation of fly fiery debris lessened sorptivity and chloride particle penetration altogether at 28 days and diminished further at a half year. This paper closed the fly slag as the fractional supplement for bond enhanced the strength properties of cement.

R. D. Padhye, N. S. Doe, (2016): In this researches explained about the compressive strength of concrete mixtures was increased by reducing the fly ash mixture ratio. Usually fly ash up to 40% it's better for replacement, but beyond 40% is not good for changed concrete mixtures. As there is an increase in the fly ash content, there is steep increase in strength from 7 to 28 days indicating that early strength of concrete is reduced. The various mixtures of fly ash with varying the curing day's results in the varying of the strength of the specimens. However, it was observed that the M50 with 60% fly ash obtained higher strength in 28 day and as well as M30 with 40% fly ash increased compared to conventional concrete.

Dr S L Pati1 et.al [2012]: They have studied fly ash concrete, a technical analysis for compressive strength. Hence the study proved that Deep Nagar fly ash can be successfully used in the cement concrete in minor amount as a supplement cementitious material. Considering the intangible cost of disposal problem of fly ash and hidden cost of environmental protection, the methodology appears to be indeed successful. Fly ash is actually a solid waste. So, it is priceless. 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 safer and eco-friendly method of disposal of fly ash. However

the rate of strength developed was less. Due to lesser rate of strength the ash 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.

Sandhya B and Reshma E.K (2013): a study on mechanical properties of cement concrete by partial replacement of fine aggregates with bottom ash. The study was carried out using coal bottom ash as a partial replacement with fine aggregates in the concrete mix by 20%, 30%, 40%, and 50% by weight. The various strength properties studied consists of compressive strength, flexural strength and splitting tensile strength. The results shows that the compressive strength, split tensile strength and flexural strength decreased as the percentage of replacement of bottom ash increased as compared to plain concrete. The compressive strength of the plain concrete specimen for 7 days, 28 days and 56 days was found to be 38.22 N/mm², 48.7 N/mm² and 54.22 N/mm² respectively. The 28 days strength of the mix is 48.7 N/mm² which concludes, mix has reached the required strength of m40. The workability of the fresh concrete decreases with increase in percentage of bottom ash.

Syed afzal basha et.al[2014]: In this study carried out to concrete bulk for concrete achieving the requirement of concrete in bulk, in this paper attempt is made for assessment of compressive strength, the fly is used for mineral admixture in concrete, the design of concrete mixes M25 and M30 grade concrete as per code (IS-10262-82), the fly ash concrete replaced range at 0%, 10%, 20%, 30%, and 40%, they have conducting the experiment for compressive strength of concrete cube of size is 150X150X150mm were casted and verified for compressive strength, the days of curing for all mixes and results it will be taken to 7 day, 14 day, 21 day and 28 day and this results are related with that of conservation concrete, in this mixes are used to purpose of decrease the compressive strength for the design of M25 and M30 grade concrete and also increase by the fly ash % of concrete,

3. MATERIALS USED

The Main ingredients which are used in this investigation are described below

Cement

This effort, Ordinary Portland Cement of 53-grade Ultra tech confirms to IS: 12269-1987 has been used.

Fine aggregates

M-Sand as a Fine aggregate which is used in the project were collected from Bengaluru conforming IS 383-1970 passing 4.75 mm and retained on 75 micron were used.

Coarse Aggregates

Coarse aggregate which is use in the project were collected from Bengakuru conforming IS 383-1970 passing 20mm & retained on 4.75mm were used.

FLY ASH

Was taken from thermal power plant at kudithini bellary thermal power station was used in the investigation. the specific gravity is 2.08.

Super plasticizer Master glenium sky-8233

To improve the workability of the mixes, a high range water reducing agent master glenium sky-8233 0.9% weighted of cementitious materials has been used.

Water

The water, which was used for making concrete and for the curing, and it should be clean and free from harmful impurities. The PH value should be less than 7.

4.0 MIX PROPORTIONS

The investigation of the high strength concrete is developed based on the available works and to achieve the desired objectives by replacing cement concrete with industrial wastes like fly ash and chemical admixture (master glenium sky 8233). The present investigation is about Concrete Cubes, Prism (beams), Impact Cylindrical Specimens, casted for studying the fresh and hardened properties of HSC. The industrial waste used is fly ash which is replaced in the range of 0%, 10%, 20%, 30%, 40%, and 50% of cementitious materials and chemical admixture for master glenium sky 8233 (0.9% wt of cementitious materials), the chemical admixture, it was used for improve the workability of concrete, and to design for M40 grade of concrete. The fine aggregate used is 4.75mm down, M-sand is use and coarse aggregate used is of 20mm passing and 10mm retain. The methodology for satisfying the desired objectives can be categorized as follows:-

- Procedure and testing the basic properties of cement, fly ash, fine aggregate, coarse aggregate, of high strength concrete.
- Selection of mix proportions of HSC by reducing the cement proportion with partial replacing of fly ash, and chemical admixture is gleniun sky 8233 (0.9% weight of cementitious materials) thereby casting the fly ash mixture concrete into different shapes as Cubes, prism, and Cylindrical specimens of desired quality.
- To determine the fresh and hardened properties of newly casted HSC by slump test as per code and also

determine, hardened properties of HSC for example Compressive Strength, flexural strength, Impact Strength and also sorptivity tests were conducted

Mix Proportions	C* Kg/M ³	FAsh Kg/m ³	FA Kg/m ³	CA Kg/m ³	SP* 0.9% Kg/m ³	W* Kg/m ³	W/C Ratio
mix-1 0% fly ash	374	0	696.08	1275.9	3.36	136	0.4
mix-2 10%fly ash	336	37.4	689.66	1263.51	3.36	136	0.4
mix-3 20%fly ash	299.2	74.8	684.29	1253.66	3.36	136	0.4
mix-4 30%fly ash	261.8	112.2	679.10	1244.16	3.36	136	0.4
mix-5 40%fly ash	224.4	149.6	673.82	1234.48	3.36	136	0.4
mix-6 50%fly ash	187	187	669.38	1226.36	3.36	136	0.4

Table - 1.0: Material requirement and mix design



Figure - 1.0 Casting of high strength Concrete.



Figure - 2.0 Specimens prepared for casting.



Figure - 3.0 Casting of HSC Cylinders.



Figure - 4.0 Specimens curing in in water..

5. TEST RESULTS

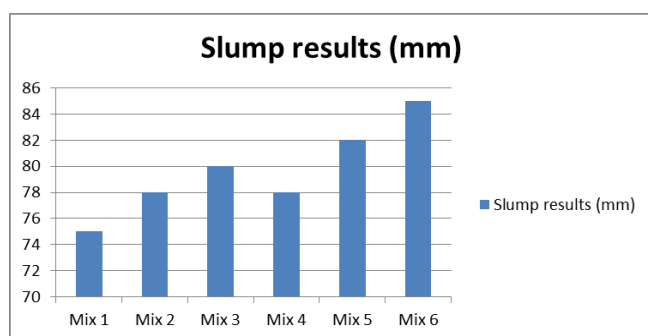
The various strength tests that are to be done listed as below.

5.1 Slump test

It's a one of the process, to measure the fresh properties of concrete essentially for consistency and balanced (equality of) concrete mix. The dimension of mould having at the diameter for top and bottom is 100mm & 200mm (base diameter), and height of the mould is 300mm. And its sited on smooth surface, with 100mm diameter is opening at top phase, and filled by concrete by 3 layers. Each layer by tamped at 25 times with typical tamping rod (16 mm dia). That cone must not be tilted at the time of lifting and its must be lift straight up and down. That was decrease in the level of slumped concrete is called slump. This slump test is weighed, by using 30cm scale. Slump was classified into 3 types such as collapse slump, shear slump, true slump, this types of slump is mainly depending on various shapes, that takes place after the lifting.

Table no 2: slump test results

Mix Proportions	Slump results(mm)
Mix 1(0% flyash)	75
Mix 2(10% of flyash)	78
Mix 3(20% of flyash)	80
Mix 4(30% of flyash)	78
Mix 5(40% of flyash)	82
Mix 6(50% of flyash)	85



graph-1: slump test

5.2 Compressive Strength Test:

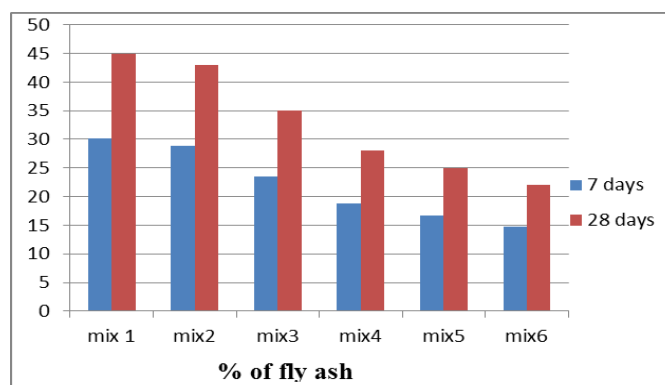
The compressive strength of concrete is defined as the loads, which has causes that failure of standard specimen /area of cross section in uniaxial compression, under that given rate of loading. This compressive strength test was made on at the standard of 100mm size cubes. By placing that cubes in the compression-testing machine. Then this machine was run which started applying the load gradually with the piston. Then piston was lifted up along with the lower plate and thus the specimen was applied with a load of 140kg/cm²/min which were controlled by load rate control knob until the specimen can't offer further resistance without breakage even after continuous apply of the load. After breakage the Ultimate load is noted for each specimen. The values are tabulated and calculations are done.



Figure - 5.1 Compressive tests on concrete cube.

Mix praportion	Compressive strength cubes N/mm2	
	7 days	28 days
Mix 1(0% fly ash)	30.15	45
Mix 2(10% of fly ash)	28.81	43
Mix 3(20% of fly ash)	23.45	35
Mix 4(30% of fly ash)	18.76	28
Mix 5(40% of fly ash)	16.75	25
Mix 6(50% of fly ash)	14.74	22

Table - 3.0 Experimental results of compressive strength of cube at 7 and 28 days in N/mm²



Graph -2: Cube compressive strength results at 7 and 28 days.

5.3 Flexure Strength Test:

The flexural strength is also identified as modulus of rupture, the fracture strength or bend strength. That material was able to resist deformation under applied load. Whenever, those most materials fail under tensile stress before they flop under a compressive stress, so, that maximum tensile stress value, it can be sustained before that beam or rod, that fails is its flexural strength. These types of test can be done either center point loading or three points loading. In the case of three points loading load is applied at 1/3 of the span of prism. In those cases, the center point load is applied at the center of the span. Flexure strength, for prism can be calculated by using

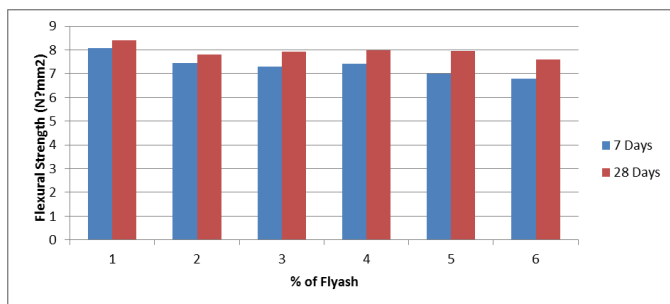
$$f_b = \frac{Pl}{bd^2}$$



Figure - 5.2 flexural strength test.

Table - 4.0 flexural Strength results at 7 and 28 Days of age in N/mm².

Mix proportion	7 days of specimens N/mm ²	28days of specimens N/mm ²
Mix 1(0% fly ash)	8.08	7.403
Mix 2(10% of fly ash)	7.45	7.8
Mix 3(20% of fly ash)	7.3	7.92
Mix 4(30% of fly ash)	7.42	8
Mix 5(40% of fly ash)	7	7.96
Mix 6(50% of fly ash)	6.8	7.6



Graph -3: flexural strength results at 7 and 28 days.

5.4 Impact Strength Test:

For impact strength test, cylindrical specimens having 150mm diameter & 60mm height were prepared. To adopted the Drop weight test for testing in impact specimen.

The specimens were kept in the Schrader's impact testing machine and hammer weight having 4.54 kg it was dropped from the height of 457mm. And then that blows were carried on until the crack was observed in the specimen and also counted the number of blows for the crack specimen was noted. The final failure is defined as the opening of cracks in the specimen sufficiently so that pieces of concrete are touching at least three out of the four. Positioned lugs on the base plate. These numbers of blows were converted into impact energy by the following formulae.

$$\text{Impact energy} = w * h * n.$$

Where

w = weight of the hammer = 4.54 kg = 45.4 N.

h = height of the fall = 45.7 cm = 0.457 m.

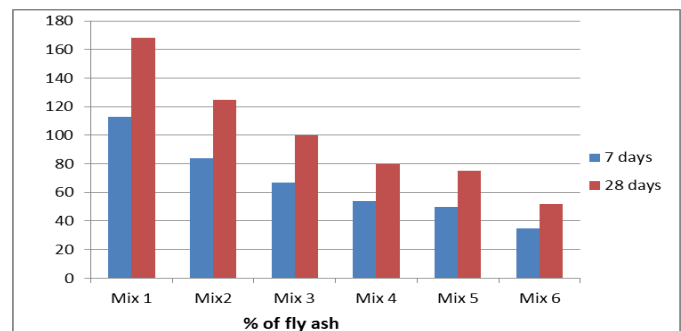
n = number of blows required to cause first crack and final crack as the case may be.



Figure 5.3: impact strength

Table 5: impact strength test results at 7 and 28 days

Mix Proportions.	Impact strength in no of cycles	
	7 days specimens	28 days specimens
Mix 1(0% of fly ash)	113	168
Mix2(10% of fly ash)	84	125
Mix 3(20% of fly ash)	67	100
Mix 4(30% of fly ash)	54	80
Mix 5(40% of fly ash)	50	75
Mix 6(50% of fly ash)	35	52



Graph 4: impact strength

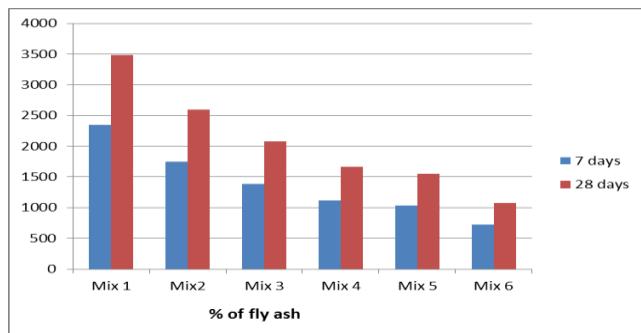
5.41: impact energy:

Calculations of impact energy : WXNXh

w = weight of the hammer = 4.54 kg = 45.4 N.
 h = height of the fall = 45.7 cm = 0.457 m.
 n = number of blows required to cause first crack and final crack as the case may be

Table 6 : impact energy at 7 and 28 days

Mix Proportions	Impact energy= w*h*n (n-m)	
	7 days specimens	28 days specimens
Mix 1(0% of fly ash)	2344.5	3485.6
Mix2(10% of fly ash)	1742.81	2593.4
Mix 3(20% of fly ash)	1390.1	2074.7
Mix 4(30% of fly ash)	1120.38	1659.8
Mix 5(40% of fly ash)	1037.39	1556.0
Mix 6(50% of fly ash)	726.17	1078.8



Graph 5: Impact energy for 7 and 28 days.

5.5 Sorptivity Test:

To determine the amount of water absorption by concrete cubes, sorptivity test were done. It will take 7 days and 28 days of curing. Cubes from each mixture taken from curing set up and oven dried at 110 °C for 24 hours. After 24 hours of oven dried the specimen are taken out from the oven and allowed to cool the specimens. The four looks of the cubes are wrapped with electrical tape. to avoid the evaporation of moisture content and initial weights of specimen are measured. Test were carried out as per ASTM C-1585 by placing unsealed face of cube on 5 mm depth of water and allowed to unidirectional flow of water. Measuring the weight of the cubes at regular time intervals (30min, 60min, 90min, 120min, 150min and 180min). The sorptivity value of concrete cube can be determined by

$$I = \frac{m/a}{d}$$

Where

- I = water immersion in mm
- m = change in mass of the specimen in grams
- d = density of water i.e. 0.001 g/mm³
- a = external zone of the specimen through which water entered.

$$\text{Sorptivity} = \frac{I}{\sqrt{t}}$$

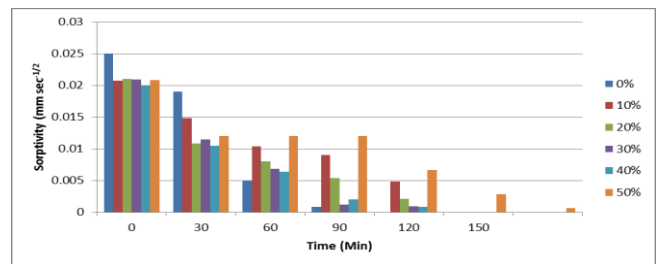
Where, t = time in seconds



Figure - 7.0 Schematic of Sorptivity Test.

7 day	At 30 minute	At 60 minute	At 90 minute	At 120 minute	At 150 minute
0%	0.025	0.019	0.005	0.0008	0
10%	0.0207	0.0148	0.0104	0.009	0.0048
20%	0.021	0.0108	0.008	0.0054	0.0021
30%	0.0209	0.0115	0.0068	0.0012	0.0009
40%	0.0199	0.0105	0.0064	0.002	0.0008
50%	0.0208	0.012	0.0066	0.0028	0.0006

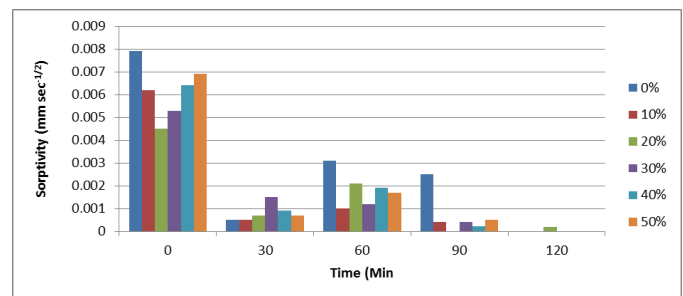
Figure - 8.0 Sorptivity Test.



Graph 6: sorptivity test for 7 days.

28 day	At 30 minute	At 60 minute	At 90 minute	At 120 minute	At 150 minute
0%	0.0069	0.0004	0.0031	0.0021	0
10%	0.0057	0.0004	0.001	0.0004	0
20%	0.0044	0.0008	0.0021	0	0.0002
30%	0.0052	0.0013	0.001	0.0002	0
40%	0.0084	0.0008	0.0021	0.00021	0
50%	0.0069	0.0008	0.0015	0.0004	0

Table - 6.0 Sorptivity results.



Graph 6.1: sorptivity test for 28 days.

6.0 CONCLUSION:

6.1 Slump test

- The workability of fresh concrete decreases with increases percentage of fly ash concrete.
- For mix 6 (50% fly ash concrete) is obtained by maximum slump compared to all mixes.
- Workability of conventional concrete is decreased, compared by flyash concrete.
- For workability of fly ash replaced concrete is decreased, to compare with conventional concrete.

6.2 Compressive strength

- To observe the compressive strength of high strength concrete, for 28 days is goes on decreasing with the incremental increase of fly ash content of 10%, 20%, 30%, 40%, and 50%.
- It is observed the 7 and 28 days, the compressive strength of fly ash concrete was decreased, by conventional concrete.
- In compare to all that 7 and 28 days, concrete strength, there is varying compressive strength. The maximum compressive strength found in 28 days of specimens.
- For replacement of fly ash based concrete is decrease that early strength and later strength will be increased.

6.3 Flexural strength

- From the above fig.5.3 it was observed that increase in the percentage of fly ash increase in the flexure strength.
- Flexure strength increase up to 10% replacement of fly ash and further increase in fly ash reduction in flexure strength at both ages 7 and 28 days. 10%, 20%, 30%, 40%, 50% replacement of fly ash has achieved optimum flexure strength at 7 and 28 days is 7.57 and 8.183 N/mm² which is higher than control mix at both ages 7 and 28 days is 7.39 and 7.989 N/mm².

6.4 Impact Strength and Impact energy

- It is observed the 7 and 28 days of specimens of fly ash concrete like 10%, 20%, 30%, 40%, and 50% of replacements was decreased by both impact strength (number of cycles) and impact energy, compared to normal concrete.
- It is observed that 7 and 28 days of flyash, for increase the fly ash content to decrease that impact strength and energy, compared by conventional concrete.

6.5 Sorptivity test

- From the above fig 5.5 and 5.6, it was observed that increase in sorptivity with the increase in percentage of fly ash.
- Further increase in percentage of fly ash reduction in sorptivity of concrete at both ages 7 and 28 days. At 10%, 20%, 30%, 40%, and 50% replacement of fly ash achieved sorptivity compared to the conventional concrete at 7 and 28 days.

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