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Investigation on Strength of Concrete by Partial Replacement of Cement by Flyash and Sand by Ggbs

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Abstract:

Concrete is mainly classified into three types based on the density. Concrete containing natural sand and gravel or crushed- rock aggregate and water, when placed in the skeleton of form and allowed to cure, becomes hard like stone. Generally weighing about 2400kg/m3 is called "normal-weight concrete" and it is the most commonly used concrete for structural purposes. For applications where a higher strength-to-weight ratio is desired, it is possible to reduce the unit weight of concrete by using natural aggregate with lower bulk density. The term lightweight concrete is used for concrete that weightless than 1800 kg/m3. Heavy weight concrete used for radiation shielding, is a concrete produced from high density aggregate and generally weigh more than 3200kg/m3.

In this praper only 53 grade of cement is used. This paper reports comparative study on effects of concrete properties by partially replacement of OPC of 53 grades with fly ash and sand were partially replaced by blast furnace slag. The main variable investigated in the study of variation of fly ash dosage of 10% and slag dosage of 10%, 20%, 30%, fly ash dosage of 20% and slag dosage of 10%, 20, 30%, fly ash dosage of 30% and slag dosage of 10%, 20%, and 30%. The compressive strength and split tensile strength & acid attack of concrete were mainly studied. Test results shows that, inclusion of fly ash and GBFS generally improves the concrete properties up-to certain percentage of replacement in53 grade of cement..

I. INTRODUCTION

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry. Regrettably, production of cement involves emission of large amounts of carbon dioxide gas into the atmosphere, a major contributor for green house effect and the global warming. Hence it is inevitable either to search for another material or partly put back it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact.

In this thesis, the different admixtures were used to study their sole and combined effects on the resistance of concrete in addition to their effects on mechanical and stability properties by the replacement of cement by 10% fly ash and sand replacement 10%, 20%, 30% of slag, cement by 20% fly ash and sand replacement 10%, 20, 30% of slag, cement replacement of 30%fly ash and sand replacement 10%, 20%, 30% of slag.

The secondary materials used in our project are pozzolanic materials. The term pozzolana is a siliceous or a siliceous and aluminous material which itself possesses no cementitious value but in presence of water, chemically react with calcium hydroxide to form compounds possessing cementitious properties .The material which having the pozzolanic property known as pozzolanic material. The pozzolanic materials that are used in our project are

1. Fly ash
2. Granulated Blast Furnace Slag

Granulated Blast Furnace Slag is a by-product of the steel industry. Granulated Blast furnace slag is defined as "the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with iron in a blast furnace." In the production of iron, blast furnaces are loaded with iron ore, fluxing agents, and coke. When the iron ore, which is made up of iron oxides, silica, and alumina, comes together with the fluxing agents, molten slag and iron are produced. The molten slag then goes through a particular process depending on what type of slag it will become. Air-cooled slag has a rough finish and larger surface area when compared to aggregates of that volume which allows it to bind well with Portland cements as well as asphalt mixtures. GBFS is produced when molten slag is quenched rapidly using water jets, which produces a granular glassy aggregate. This glassy aggregate with little fines used as sand replacement in the present investigation.

II. LITERATURE REVIEW

In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used to increase Portland cement because fly ash is an low-cost replacement for Portland cement used in concrete, while it actually improves strength, separation, and ease of pumping of the concrete. Fly ash is also used as an ingredient in brick, block, paving, and structural fills. This waste is causing problems to human health and environmental pollution.

The challenge for the civil engineering population in the near future will be to realize projects in harmony with the concept of sustainable development, and this involves the use of high-performance materials and products manufactured at sensible cost with the lowest possible ecological impact. Concrete is the most widely used construction material worldwide. However, the production of Portland cement, an essential constituent of concrete, releases large amounts of CO2 which is a major contributor to the greenhouse effect and the global warming of the planet and the developed countries are considering very severe regulations and limitations on CO2 emissions. In this scenario, the use of supplementary cementing materials (SCMs), such fly ash, slag and silica fume, as a replacement for Portland cement in concrete presents one viable solution with multiple benefits for the sustainable development of the concrete industry. The most commonly available SCM worldwide is fly ash, a by-product from the combustion of pulverized coal in thermal power stations. Fly ash, if not utilized has to be disposed off in landfills, ponds or rejected in river systems, which may present serious environmental concerns since it is produced in large volumes.

The World Bank has reported that by 2015, disposal of fly ash will require 1,000 square kilometers, or 1 square meter of land per person. The Indian government has begun to take positive steps in the utilization of fly ash in construction, such as mandating the use of fly ash in road and building construction projects within a 100 km radius of a coal fired power plant.

Presently in India, most ready-mixed concrete for private industry has fly ash between 20 to 30% of the cementitious material in it while many government departments still have reservations towards its use.

Batching plants on large construction sites are comfortable with fly ash up to about 25 – 30%. Much of the concrete mixed onsite with tilting drum mixers does not use fly ash as a separate additive but blended cement use is common. As regards cement, nearly 60 to 70% of it being manufactured and sold is blended cement with 22 to 32 % of fly ash. Unfortunately, many specifiers are unaware of the benefits that addition of fly ash brings to concrete. It is still considered a cheap, low grade replacement of cement.

III. METHODOLY

Specific Gravity of Cement

S.No.	Specifications	Sample-1	Sample-2
1	Weight of empty gravity bottle(W_1)	28	25
2	Weight of empty bottle+ cement(W_2)	38	35
3	Weight of empty bottle+ cement + Kerosene(W_3)	73	74.5
4	Weight of bottle + Kerosene(W_4)	66.2	67.9

Specific gravity of Sample-1 = (W2-W1)/((W2-W1)-(W3-W4))
= 10/ (10)-(6.8)
= 3.12

Specific gravity of sample-2 = $(W_2-W_1)/ ((W_2-W_1) - (W_3-W_4))$
= 10/ (10)-(6.6)
= 2.94

Specific Gravity of cement = (3.12+2.94)/2
=3.0

Table 1: Normal Consistency of Cement

B	percentage of water to be added	Depth not penetrated(mm)
1	28%	37
2	30%	33
3	32%	12
4	34%	5

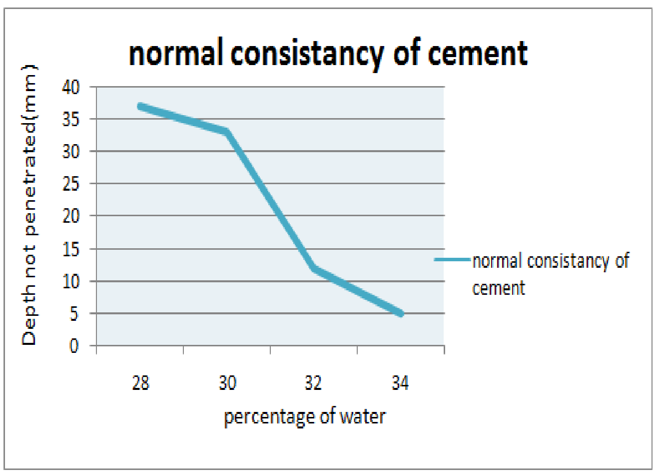

Figure 1: shows the normal consistency of cement.

Table 2: Normal Consistency of Cement 10% replacement of flyash

S. NO	Percentage of water to be added	Depth not penetrated(mm)
1	30%	29
2	32%	21
3	33%	15
4	34%	6

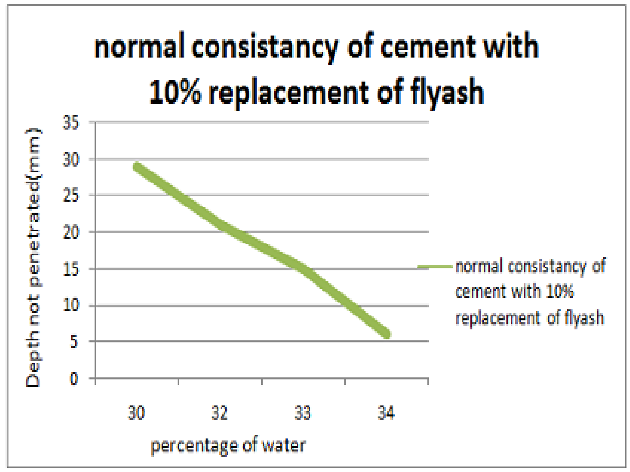

Figure 2: shows the normal consistency of cement with 10%replacement of Fly Ash.

Table 3: Normal Consistency of Cement with20% replacement of fly ash.

S.NO.	Percentage of water to be added	Depth not penetrated(mm)
1	30%	30
2	32%	23
3	33%	13
4	34%	5

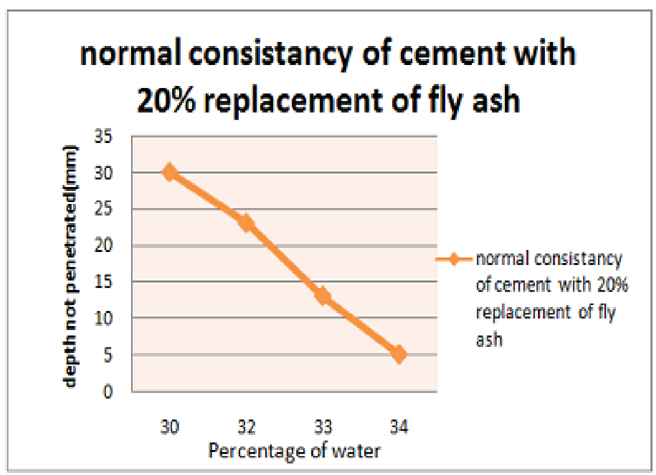

Figure.3 shows the normal consistency of cement with replacement of 20% Fly Ash

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Table 4: Normal Consistency of Cement with replacement of30% fly ash

S.NO.	Percentage of water to be added	Depth not penetrated (mm)
1	30%	33
2	32%	21
3	33%	17
4	34%	12
5	35%	5

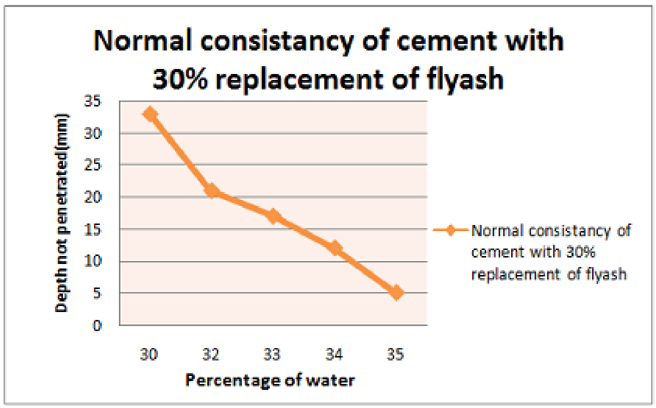

Figure 4 shows the normal consistency of cement with 30% replacement of fly ash.

NORMAL CONCRETE INITIAL AND FINAL SETTING TIMES:

Weight of cement = 400gms

Amount of water added = 0.85*P*Weight of cement

= 0.85*0.34*400

= 115.6 ml

Table 5: shows the Initial setting time of normal cement

S. No.	Time(min)	Depth not penetrated(mm)
1	30	2
2	35	3
3	40	5
4	42	5

Initial setting time =40 min
Final setting time =380 min
AS PER IS12269-1987
Initial setting time >30 min
Final setting time <600 min

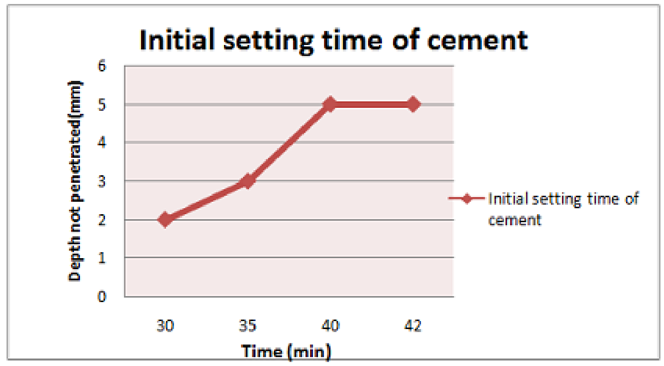

Figure 5 shows the initial setting time of cement.

INITIAL AND FINAL SETTING TIMES OF CEMENT WITH 10% REPLACEMENT OF FLY ASH:

Table 6: shows the Initial setting time of cement with replacement of 20% fly ash

S. No.	Time(min)	Depth not penetrated(mm)
1	33	2
2	36	2
3	40	3.1
4	45	3.4
5	50	4
6	70	5

Initial setting time =70 min
Final setting time =280 min
AS PER IS12269-1987
Initial setting time >30 min
Final setting time <600 min

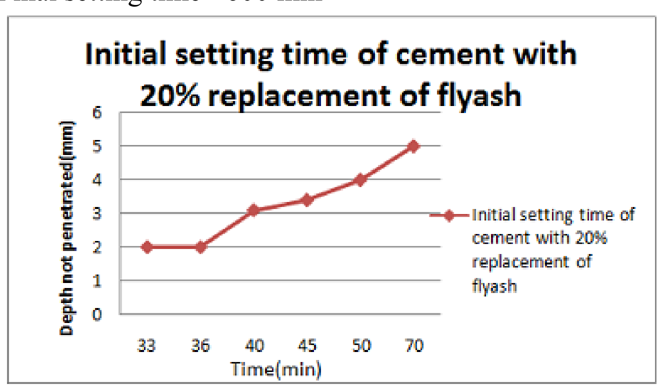

Figure 6: Initial setting time of cement with 20% replacement of fly ash.

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Initial and Final Setting Times Of Cement With 30% Replacement of Fly Ash:

Table 7: Initial setting time of cement with replacement of 30% fly ash

S. No.	Time(min)	Depth not penetrated(mm)
1	32	2
2	39	2
3	44	3.2
4	50	3.4
5	55	3.8
6	60	4
7	70	4.9
8	80	6

Initial setting time =80 min
Final setting time =200 min
AS PER IS12269-1987
Initial setting time >30 min
Final setting time <600 min

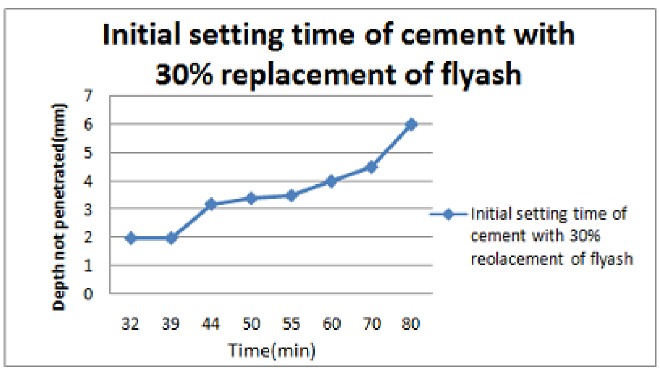


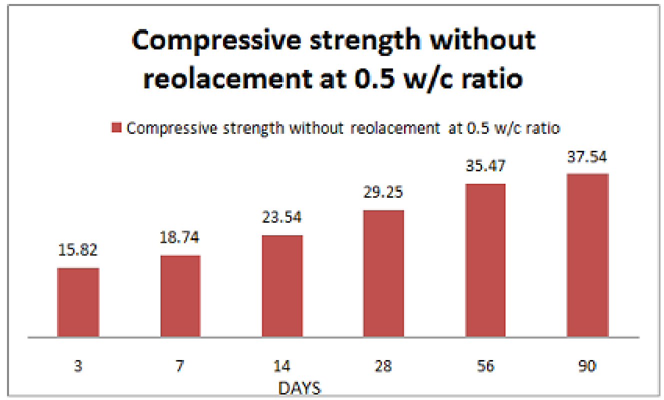
Figure 7: initial setting time of cement with 30% replacement of Fly Ash.

IV. TEST RESULTS

1. COMPRESSIVE STRENGTH RESULTS

Table 8: Normal concrete compressive strength

S.No.	Days	Compressive strength in N/mm²
1	3	15.82
2	7	18.74
3	14	23.54
4	28	29.25
5	56	35.47
6	90	37.54



Figures 8: Compressive strength graph

Table 9: compressive strength for cubes at10% fly ash and 10%,20%,30% of slag

S. No.	Days	10%FA+10%GBFS in N/mm²	10%FA+20%GBFS in N/mm²	10%FA+30%GBFS in N/mm²
1	3	20.66	20.88	19.33
2	7	32.66	23.55	20.66
3	14	33.33	24.22	20.44
4	28	36.88	25.99	22.88
5	56	39.77	32.22	25.15
6	90	42.55	35.55	28.66

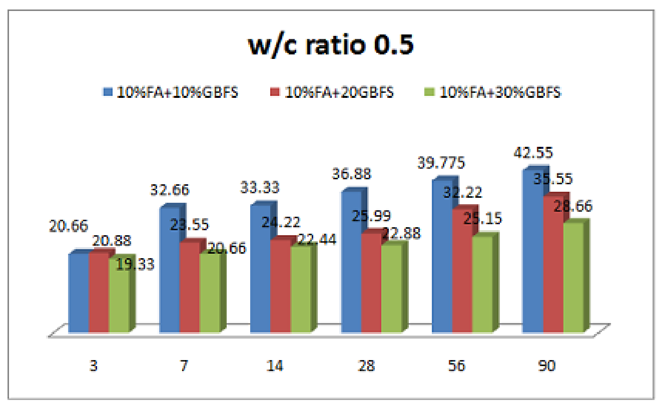


Figure 9: Compressive strength graph at replacement 10% of fly ash and 10%,20%,30% of Slag.

From graph as compared to the normal concrete (0% fly ash and 0% slag), the 3,7 14,28,56,90 days compressive strength is increased at fly ash dosage of 10% and slag dosage of 10%, 20%, 30%.

The Compressive strength of concrete for 10% FA and 10% GBFS is more compared to that for 10% FA and 20% GBFS and 10% FA and 30% GBFS.

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Compressive Strength AT fly ash dosage of 20% and slag dosage of 10%, 20%, 30%.

Table 10: Compressive strength for cubes at20% fly ash and 10%,20%,30% of Slag

S. No.	Days	20%FA+10%GBFS	20%FA+20%GBFS	20%FA+30%GBFS
1	3	23.77	18.88	14.22
2	7	26.44	20.44	19.11
3	14	26.22	23.77	21.77
4	28	31.32	29.99	24.88
5	56	33.11	31.11	26.21
6	90	35.11	32.66	27.77

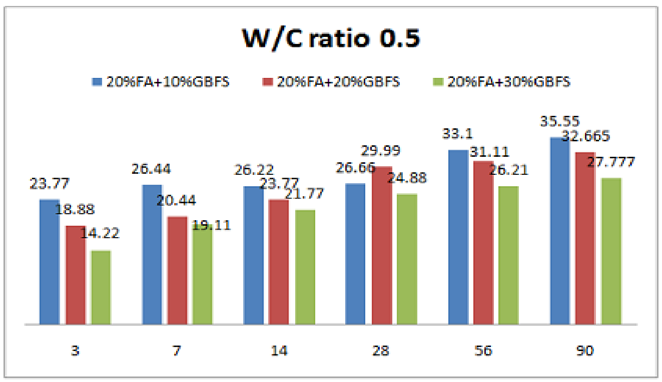

Figure 10: Compressive strength at 20% replacement of fly ash and 10%,20%,30% replacement of GBFS.

The graph is drawn between compressive strength Vs. days at fly ash dosage of 20% and slag dosage of 10%, 20%, 30%,.The horizontal axis represents the days and compressive strength shown in vertical axis. From graph as compared to the normal concrete (0% fly ash and 0% slag), the 3,7 14,28,56,90 days compressive strength is increased at fly ash dosage of 20% and slag dosage of 10%, 20%, 30%.

Compressive Strength AT fly ash dosage of 30% and slag dosage of 10%, 20%, 30%:

Table 11: Compressive strength for cubes replacement of 30% of fly ash and 10%,20%,30% of GBFS

S. No	Days	30%FA+10%GBFS in N/mm²	30%FA+20%GBFS in N/mm²	30%FA+30%GBFS in N/mm²
1	3	14.44	13.77	11.77
2	7	20.66	19.77	17.22
3	14	21.11	20.55	18.22
4	28	23.33	21.33	18.99
5	56	28.22	27.55	23.55
6	90	30.22	29.33	27.66

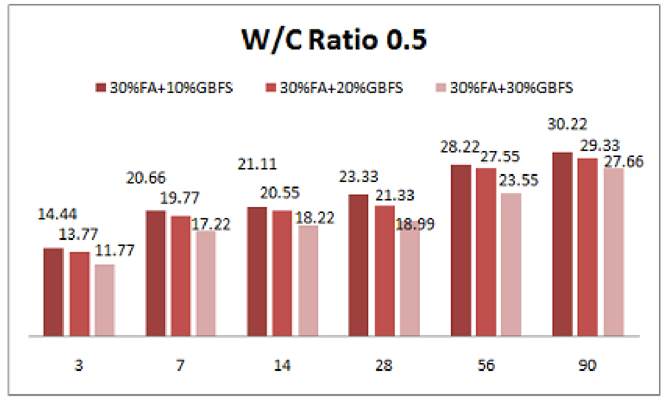

Figure 11: Compressive strength graph strength at 30% replacement of fly ash and 10%,20%,30% replacement of GBFS

The graph is drawn between compressive strength Vs. days at fly ash dosage of 30% and slag dosage of 10%, 20%, 30%,.The horizontal axis represents the days and compressive strength shown in vertical axis. From graph as compared to the normal concrete (0% fly ash and 0% slag), the 3,7 14,28,56,90 days compressive strength is increased at fly ash dosage of 30% and slag dosage of 10%, 20%, 30%.

In the present investigation the Fly Ash and slag has been used as a replacement of cement and percentage, the percentage of increase or decrease in compressive strength other percentage is calculated. Considering the normal M_{20} grade with zero percentage admixtures the compressive strength is 37.54 N/mm^2 at 90days.

2. SPLIT TENSILE TEST

Table 12: Normal concrete split tensile strength

S. No.	Days	Split tensile strength in N/mm²
1	3	2.55
2	7	2.68
3	14	2.41
4	28	2.68

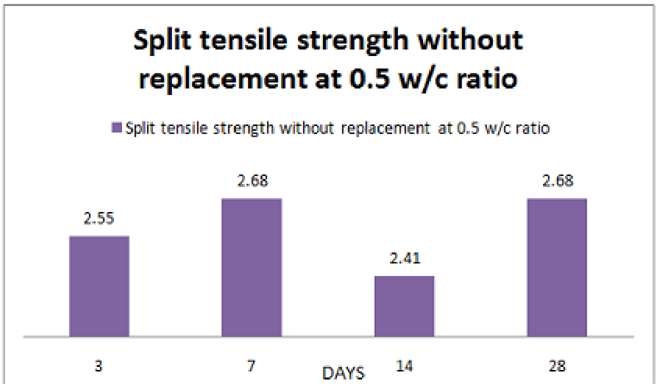

Figure 12: shows split tensile strength of normal concrete.

A).Split tensile Strength AT fly ash dosage of 10% and slag dosage of 10%, 20%, 30%:

Table 13: Split tensile strength for cylinders at replacement of 10%fly ash and 10%,20%,30% of Slag

S.No.	Days	10%FA+10%GBFS in N/mm²	10%FA+20%GBFS in N/mm²	10%FA+30%GBFS in N/mm²
1	3	2.05	1.50	2.12
2	7	1.76	1.32	1.41
3	14	2.05	2.90	1.98
4	28	2.97	2.61	2.05

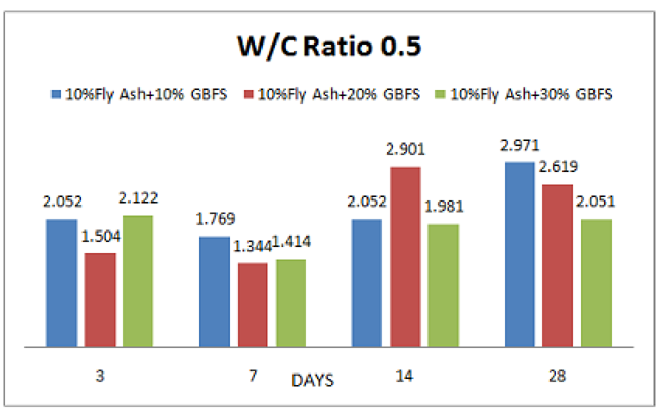

Figure 13: Split tensile strength at replacement of 10%fly ash and 10%,20%,30% GBFS.

B). Split tensile Strength AT fly ash dosage of 20% and slag dosage of 10%, 20%, 30%:

Table 14: Spilt tensile strength at replacement of 20% fly ash and 10%,20%,30% GBFS.

S. No.	Days	20%FA+10%GBFS in N/mm²	20%FA+20%GBFS in N/mm²	20%FA+30%GBFS in N/mm²
1	3	1.76	1.20	1.13
2	7	2.05	1.14	1.20
3	14	2.47	2.90	2.68
4	28	2.54	1.98	1.76

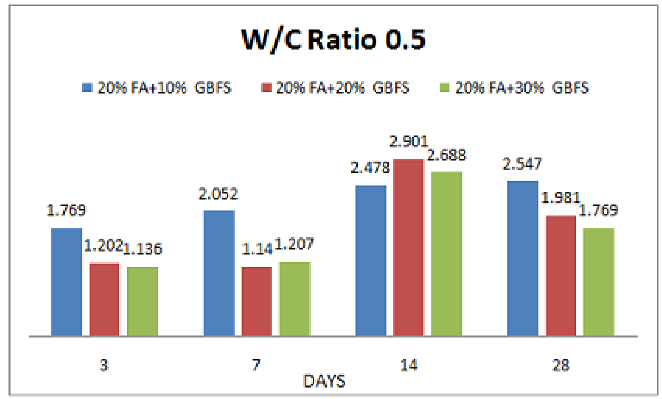

Figure 14: Split tensile strength at replacement of 20%fly ash and 10%, 20%, 30% GBFS.

C). Split tensile Strength AT fly ash dosage of 30% and slag dosage of 10%, 20%, 30%:

Table 15: Spilt tensile strength at replacement of 20% fly ash and 10%, 20%, 30% GBFS.

S. No.	Days	30%FA+10%GBFS in N/mm²	30%FA+20%GBFS in N/mm²	30%FA+30%GBFS in N/mm²
1	3	1.70	1.34	1.41
2	7	2.33	1.13	1.20
3	14	3.94	2.19	11.89
4	28	2.40	2.33	1.69

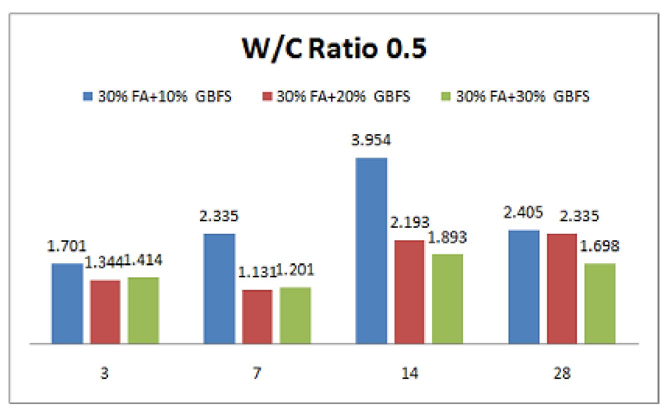

Figure 15: Split tensile strength at replacement of 30%fly ash and 10%,20%,30% GBFS.

In this project the results of split tensile strength values with replacement of fly ash and slag in concrete obtained are compared to the results obtained without replacement of fly ash and slag in concrete.

V. CONCLUSION

Fly Ash and GBFS is used in production of concrete cubes and cylinders replacement cement by fly ash dosage of 10% at replacement sand by slag dosage of 10%, 20%, 30%, replacement cement by fly ash dosage of 20% at replacement of sang by slag dosage of 10%, 20, 30%, replacement of cement by fly ash dosage of 30% at replacement of sand by slag dosage of 10%, 20%,30%.These cubes and cylinders were cured and tested for compressive strength and split tensile strength for 3days, 7days, 14days, 28days, 56days, 90days and results were noted. Based on experimental investigation conducted following conclusions are made.

- ✓ With increasing of fly ash and slag percentages in concrete then the workability should be increased gradually as compared to normal concrete.
- ✓ By using of fly ash and slag in concrete the water absorption quantity should be increased gradually because of slag absorbed more quantity of water.
- ✓ The most interesting finding was that Fly Ash retards the initial setting and accelerates the final setting of concrete mortar.
- ✓ The experimental results show that the pozzolanic activity of fly ash and slag waste increases with increase of time.
- ✓ The physical properties of cement with the replacement of fly ash and slag were found to be increase with the increasing of the percentages of admixtures.

The compressive for

- 100% cement + 0% replacement mineral admixtures at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 15.82N/mm^2,18.74 N/mm^2,23.54 N/mm^2,29.25 N/mm^2,35.47 N/mm^2 and37.54 N/mm^2.
- 10%FA+10%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 20.66 N/mm^2,32.66 N/mm^2.33.33 N/mm^2,36.88 N/mm^2,39.77 N/mm^2,42.55 N/mm^2, 10%FA+20%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 20.88 N/mm^2,23.55 N/mm^2,24.22 N/mm^2,25.99 N/mm^2,32.22 N/mm^2,35.55 N/mm^2, 10%FA+30%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 19.33 N/mm^2,20.66 N/mm^2,20.44 N/mm^2,22.88 N/mm^2,25.15 N/mm^2,28.66 N/mm^2.
- 20%FA+10%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 23.77 N/mm^2,26.22 N/mm^2.26.22 N/mm^2,31.22 N/mm^2,33.11 N/mm^2,35.11 N/mm^2, 20%FA+20%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 18.88 N/mm^2,20.44 N/mm^2,23.77 N/mm^2,29.99 N/mm^2,31.11 N/mm^2,32.66 N/mm^2, 20%FA+30%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 14.22 N/mm^2,19.11 N/mm^2,21.77 N/mm^2,24.88 N/mm^2,26.21 N/mm^2,27.22 N/mm^2.
- 30%FA+10%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 14.44 N/mm^2,20.66 N/mm^2,21.11 N/mm^2,23.33 N/mm^2,28.22 N/mm^2,30.22 N/mm^2, 30%FA+20%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 13.77 N/mm^2,19.77 N/mm^2,20.55 N/mm^2,21.33 N/mm^2,27.55 N/mm^2,29.33 N/mm^2, 30%FA+30%GBFS at 3 days, 7 days, 14 days, 28 days, 56 days and 90 days were 111.77N/mm^2,17.22 N/mm^2,18.22 N/mm^2,18.99 N/mm^2,23.55 N/mm^2,27.66 N/mm^2.

- ✓ The Compressive strength of concrete for 10% FA and 10% GBFS is more compared to that for 10% FA and 20% GBFS and 10% FA and 30% GBFS.
- ✓ The Compressive strength of concrete for 20% FA and 10% GBFS is more compared to that for 20% FA and 20% GBFS and 20% FA and 30% GBFS.
- ✓ The Compressive strength of concrete for 30% FA and 10% GBFS is more compared to that for 30% FA and 20% GBFS and 30% FA and 30% GBFS.
- ✓ The maximum strength had attained 39.59% increased at 10 % FA and 10% GBFS replacement when compared to controlled concrete.
- ✓ The split tensile strength values were found to be gradually decreased while the combination of percentage replacement of admixtures is increased.

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8) IS 516-1965-Method of Test for Strength of Concrete.
9) IS 383-1970-Specification for coarse aggregate and fine aggregate from natural sources.
10) IS 650-1966-Specification for standard sand for testing of cement.
11) IS 2386 (Part 3)-Method of test for aggregates for concrete-Specific gravity, density, voids, absorption and bulking.