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REPLACEMENT OF CEMENT WITH GGBS & FLY ASH

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ABSTRACT

The word concrete is defined as concrete that meets special combinations of strength and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices. The concrete is widely used in large scale in the construction industry, not only for its strength and also with the demands of high strength, high performance and high durability at desirable cost. And also at the same time the demand for reducing the usage of cement quantity with partial replacement of other Pozzolanic materials to save the environment without any deviations in the concrete strength. It is very difficult to get a product which simultaneously fulfills all of the properties. For this in recent years the word "Blended cements" is introduced into the construction industry to partial replacement of cement with any other Pozzolanic materials to reduce the quantity of ordinary Portland cement, and also to reduce the cost of concrete.

The Blended cements are also used to increase the compressive strength of concrete and sometimes to prepare high performance concrete. So the different Pozzolanic materials like, Ground Granulated Blast furnace Slag (GGBS), silica fume, Rice husk ash, Fly ash and High Reactive Met kaolin, are some of the Pozzolanic materials which can be used one or more in concrete as partial replacement of cement, which are very essential ingredients to produce required strength and properties of concrete. From the above we have used Ground granulated blast furnace slag and Fly ash Materials in our project for partial replacement of cement. And also it is very important to maintain the water cement ratio within the specified range to achieve the required strength, for that we have selected water cement ratio has 0.40 for M40 grade of concrete.

I. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing of fine aggregates, coarse aggregates and cement with water and sometimes admixtures in required proportions. Fresh concrete or plastic concrete is freshly mixed material which can be molded into any shape hardens into a rock-like mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for long period leading to stronger with age.

The utility and elegance as well as the durability of concrete structures, built during the first half of the last century with ordinary Portland cement (OPC) and plain round bars of mild steel, the easy availability of the constituent materials (whatever may be their qualities) of concrete and the knowledge that virtually any combination of the constituents leads to a mass of concrete have bred contempt.

Strength was emphasized without a thought on the durability of structures. The

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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. Unfortunately, in the production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contribution for green house effect and the global warming. Hence it is inevitable either to search for another material or partly replace it by some other materials to save our environment. It is a fact that their use save energy and conserve natural resources but their technical benefits are the strongest. They affect the progress of hydration, reduce the water demand and improve workability.

The concrete containing Ground Granulated Blast Furnace slag (GGBS), on vibration becomes 'mobile' and compacts well. Silica fume greatly reduces, or even eliminates bleeding; the particle of Pozzolanic Fly Ash (PFA) is spherical and thus improves the workability. Their inclusion has the physical effect of modifying the flocculation of cement, with a resulting reduction in the water demand. The pore size in concrete is smaller. The fine particles 'fit in between cement particles, thereby reducing permeability.

The Fly ash (FA), Ground Granulated Blast Furnace slag (GGBS), Silica fumes being finer than OPC, less bleeding is observed. The freshly placed concrete is very stable, being very cohesive and having strong internal cohesion. This has a negative effect in the form of plastic shrinkage. The workability increases, and thus water content can be reduced by about 3%.

The 'ball bearing' action of cementations particles improves the workability. Silica fumes demand high water due to higher fineness. The problem is circumvented by the addition of suitable super plasticizers. Recent research evaluated the behavior of concrete made with supplementary cementations materials (SCMs) such as fly ash and ground granulated blast-furnace slag (GGBS) under a various conditions. Correlations were found among the source and proportion of the Supplementary cementations materials (SCM), curing conditions, concrete set time, maturity, strength development, and cracking potential.

II. MIXTURE AND ITS CHENICAL REACTIONS

The tallest concrete systems inside the international are made with concrete wherein fly ash is a important component. Its capability to contribute to greater Calcium silicate hydrate (CSH), lower water name for, Low warmth of hydration and its best particle length are crucial to make immoderate power concrete.

Reaction mechanism of fly ash

The ability of fly ash to react depends strongly on the alkali content and temperature. The chemical reaction for the fly ash is depends on silica, aluminum oxide, alkali and iron oxide.

$SiO_2 + 2OH = SiO_3^{2-} + H_2O$

And that AL_2O^3 is hydrated according to

$Al_2O^3 + 2OH^- = 2AlO_2^- + H_2O$

That CaO (and MgO) reacts as follows

$CaO + H_2O = Ca^{2+} + 2OH^-$

That Na_2O (and K_2O) reacts as follows

$Na_2O + H_2O = 2Na^+ + 2OH^-$

That Fe_2O_3 reacts as follows

$Fe_2O_3 + 3H_2O = 2Fe^{3+} + 6OH^-$

Ground granulated blast furnace slag

Ground granulated blast furnace slag now an afternoon's ordinarily used in India. Recently for marine out fall art work at Bandra, Mumbai. It has used to update cement up to 70%. So it has come to be extra famous now a day in India moreover.

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Table 1:Chemical composition (%) of GGBS

SiO_2	30-38
Al_2O_2	16-23
Fe_2O_3	1.6-3.5
CaO	30-42
MgO	8-13
Mno	0.1-0.4
S	0.5-0.8

Reaction mechanism of ground granulated blast furnace slag

Although Ground Granulated Blast furnace slag (GGBS) is a hydraulically latent material, in presence of lime contributed from cement, a secondary reaction concerning glass (Calcium Alumina Silicates) additives sets in. As a effect of

S.L. No	Designation	Specific Gravity	Fineness (blains) Cm2/gm
1.	Cement	3.15	2600
2.	Fly ash	2.23	2700-2900

Table 2. Physical properties of cement

They are classified as secondary C-S-H gel. The interaction of GGBS and Cement in presence of water is defined as beneath:

Product of hydration of OPC :

OPC (C_3S/C_2S) + H_2O —> C-S-H + CH

Product of hydration of GGBS:

GGBS (C_2AS /C_2MS) +H_2O —> C-S-H + SiO_2

Reaction of pozzolnic material:

SiO_2+ CH + H_2O >C-S-H

The generation of secondary gel results in formation of additional C-S-H, a principal binding material. This is the main attribute of ground granulated blast furnace slag, which contributes to the strength and durability of the structure.

III. Experimental study

The application consists of casting and trying out of well-known 420 cubes, 320 prisms specimens. The specimen of fashionable cube (150mm x 150mm x 150mm) and fashionable prism of (100mm x 100mm x 500mm) were cast with and without fly ash and GGBS. Compressive checking out system (CTM) changed into used to check all the specimens. In first collection the specimen have been forged with M40 grade concrete with one-of-a-type substitute tiers of cement with the resource of fly ash as 10% regular and GGBS of minimal 10% to most of fifty%.

And the second one collection specimens were casted for the identical M40 grades of concrete with 20% opportunity of flay ash as constants and GGBS of 10% to 50%. Similarly 30% of fly ash is maintained constantly with the one-of-a-kind chances of GGBS i.e., 10% to 50%. The Chemical Properties of cement (as consistent with IS 12269) is examined at Natural Resources Development Co-operative Society Limited; Hyderabad is supplied in desk proven beneath.

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Table 3 Chemical properties of cement

Oxide name	Oxide compound	Percentage
Calcium	Cao	4.6
Silica	Sio2	38.10
Alumna	Al2o3	8
Iron oxide	Fe2o3	5.4
Magnesium oxide	Mgo	2.1
Sulphate	SO3	1.2
Others	(Alkalis)	0.09

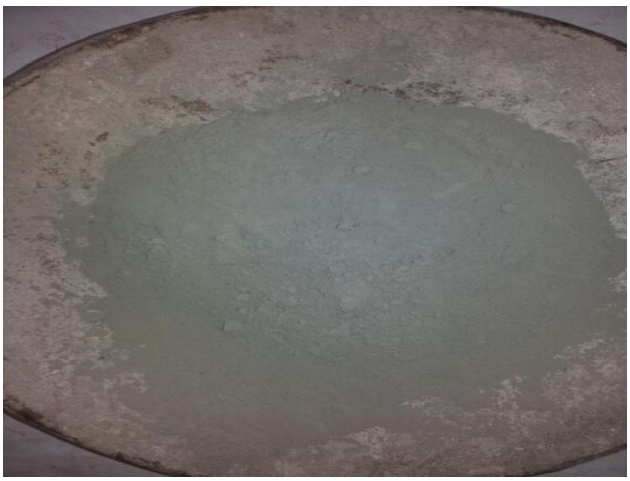

Plate 1. Cement

Fly ash: For this present look at we've got used fly ash of class C procured from thermal strength station, Vijayawada. Physical & chemical homes of fly ash as consistent with ASTMC -ninety nine, are tested at Natural Resources Development Co-operative Society Limited, Hyderabad inside the table proven below.

Table 4. Physical properties of fly ash

Fineness	280 m^2/kg
Specific gravity	2.2

Table 5. Chemical properties of fly ash

S.L. No	Characteristics	Result (0% by Mass)
1	Loss of ignition	3.15
2	Silica (sio_2)	2.27
3	Alumina (Al_2o_3)	4.42
4	Iron (fe_2o_3)	11.38
5	Calcium (cao)	58.51

Plate 2. Fly ash

Ground granulated blast furnace Slag

For this present study we have used ground granulated blast furnace slag procured from one of the major cement factory ACC Limited, Vishakhapatnam. Physical & chemical properties of ground granulated blast furnace slag as per IS: 4031 & IS: 4032 are tested at their own laboratory and the physical & chemical properties of ground granulated blast furnace slag are shown in tables.

Table 6. Physical properties of GGBS

Fineness	390 m^2/kg
Specific gravity	2.875

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Plate 3. GGBS

The measured portions of coarse mixture and nice aggregate were positioned in laboratory tilting drum mixer that is to be had in college laboratory and device is began out for a uniform mixing of coarse and exceptional aggregates. Then the normal Portland cement of Ultratech made is poured into drum mixer. Similarly the measured possibilities of fly ash and GGBS had been poured in to drum mixer and the device turned around for 2 to 3 minutes to acquire uniform blend. Then the desired quantity of water is added to the dry combo and it changed into thoroughly blended to advantage homogeneous concrete. The time of rotation of tilting drum mixer became maintained three to four minutes to get the uniform blend of concrete. The mixed concrete grows to be placed in trays on a certain floor to casting of specimen cubes and specimen prisms.

Table7Details of concrete mix proportions for M40

Mix Id	% of FA	Qty of FA	% of GGBS	Qty of GGBS	% of Cement	Qty of Cement	Qty of F Ag	Qty of C Ag	W/C Ratio
F0-G0-C100	0	-	0	-	100	438	689.27	1124.60	0.45
F10-G10-C80	10	48.2	10	48.2	80	385.6	666.36	1087.23	0.41
F10-G20-C70	10	48.2	20	96.4	70	337.4	665.32	1085.53	0.41
F10-G30-C60	10	48.2	30	144.6	60	289.2	664.28	1083.83	0.41
F10-G40-C50	10	48.2	40	192.8	50	241	663.24	1082.13	0.41
F10-G50-C40	10	48.2	50	241	40	192.8	662.20	1080.43	0.41
F20-G10-C70	20	96.4	10	48.2	70	337.4	660.12	1077.03	0.41
F20-G20-C60	20	96.4	20	96.4	60	298.2	659.07	1075.34	0.41
F20-G30-C50	20	96.4	30	144.6	50	241	656.99	1071.94	0.41
F20-G40-C40	20	96.4	40	192.8	40	192.8	655.95	1070.24	0.41
F20-G50-C30	20	96.4	50	241	30	144.6	655.95	1070.24	0.41
F30-G10-C60	30	144.6	10	48.2	60	289.2	653.87	1066.84	0.41
F30-G20-C50	30	144.6	20	96.4	50	241	651.79	1063.44	0.41
F30-G30-C40	30	144.6	30	144.6	40	192.8	650.75	1061.17	0.41
F30-G40-C30	30	144.6	40	192.8	30	144.6	649.70	1060.05	0.41
F30-G50-C20	30	144.6	50	241	20	96.4	648.66	1058.35	0.41

IV. Compressive strength of concrete

The compressive electricity test changed into carried out conforming to IS 516-1959 to gain compressive power for M40 grade of concrete. The compressive

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electricity of concrete with ordinary Portland cement on the aspect of fly ash and floor granulated blast furnace slag concrete on the age of 7days, 28 days, 56days, 90days and 180days are conducted. There is massive Improvement inside the electricity of concrete because of the excessive Pozzolanic nature of the fly ash and GGBS and its void filling capability. It is observed that from the compressive power of blend M40 at 28 days age, with alternative of cement by way of the use of fly ash and

GGBS modified into extended normally as a lot as an only substitute stage of 40%, 40% and 50%, for one-of-a-type trials and the compressive strengths are alternatively increased at ninety days and180 days. After 50% of replacement the strengths are reduced little by little. And after 60% and 70% replacement of cement the electricity are decreased unexpectedly. These comparisons are offered within the form of tables, graphs and bar charts.

The most 28 days cube compressive electricity of M40 grade with substitute in aggregate of 10% of fly ash and 30% of floor granulated blast furnace slag modified into fifty 3.Seventy 3 Mpa.

And the maximum 28 days dice compressive electricity of M40 grade with alternative of 20% of fly ash and 20% of GGBS become fifty seven.84 Mpa. And also The maximum 28 days cube compressive strength of M40 grade with alternative of 30% of fly ash and 20% of GGBS changed into 49.34 Mpa . The most ninety days and 100 80 days specimen cube compressive power of M40 grade with replacement in aggregate of 10% of fly ash and 30% of GGBS turn out to be sixty nine.11 Mpa and 76.Seventy eight Mpa respectively. And the most ninety days and 100 and eighty days cube compressive electricity of M40 grade with alternative of 20% of fly ash and 20% of GGBS end up 65.19 Mpa and 70.89 Mpa respectively. The maximum ninety days and one hundred 80 days dice compressive electricity of M40 grade with substitute of 30% of fly ash and 20% of GGBS became sixty one.44 Mpa and sixty five. Seventy six Mpa respectively. The maximum compressive electricity of concrete in aggregate with fly ash and ground granulated blast furnace slag rely upon two parameters especially the alternative ranges and water cement ratio. And the compressive power is various with days also.

Compressive strength for different percentages of GGBS and constant of 10% fly ash for M40

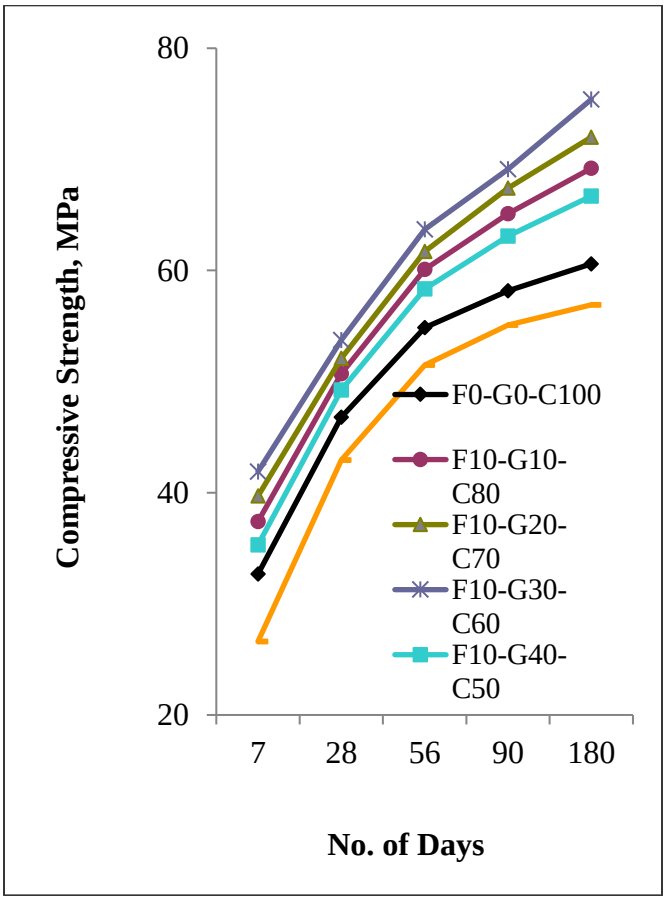

Figure 1. Compressive strength for different percentages of GGBS and constant of 10% fly ash for M40

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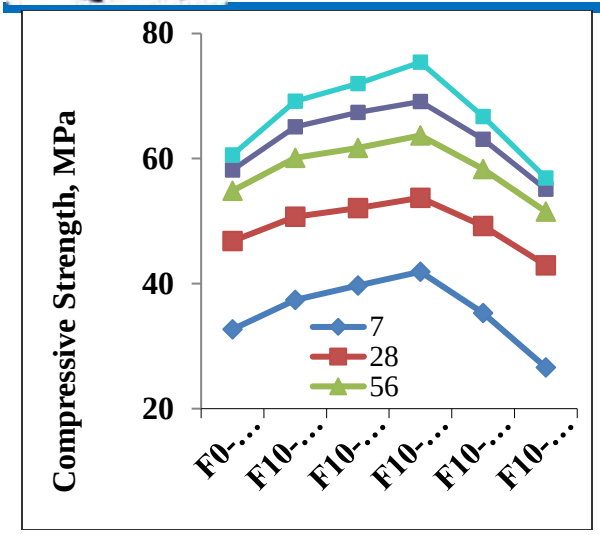

Figure 2. Effect on compressive strength by increasing of GGBS for constant of 10% fly ash for M40

Table 9 Compressive strength of concrete for different percentages of GGBS and constant 10% of fly ash for M40

(ii) Compressive strength of different percentages of GGBS and constant of 20% fly ash for M40

MIX ID	7 days	28 days	56 days	90 days	180 days
F0-G0-C100	32.68	46.8	54.87	58.18	60.6
F10-G10-C80	37.4	50.7	60.1	65.1	69.2
F10-G20-C70	39.7	52.1	61.7	67.4	72
F10-G30-C60	**41.9**	**53.73**	**63.69**	**69.11**	**75.4**
F10-G40-C50	35.3	49.23	58.34	63.1	66.7
F10-G50-C40	26.6	42.94	51.5	55.08	56.91

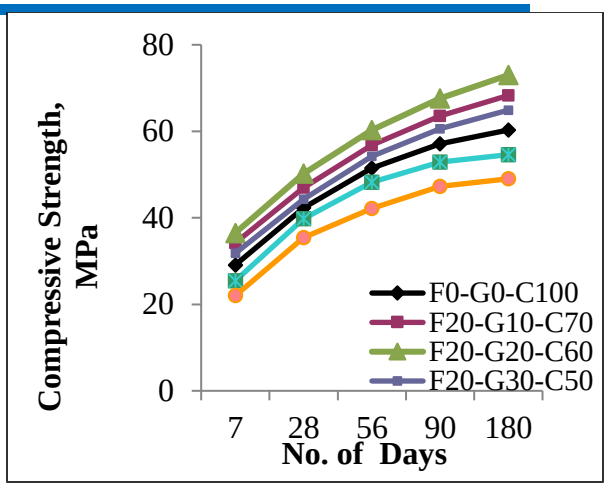

Figure3. Compressive strength for different percentages of GGBS and constant of 20% fly ash for M40

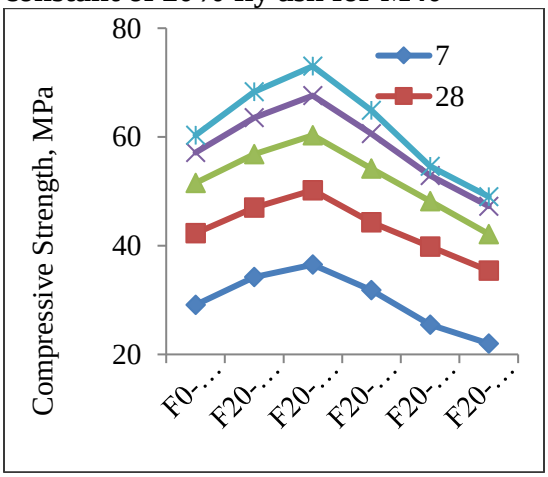

Figure 4. Effect on compressive strength by increasing of GGBS for constant of 20% fly ash for M40

V. CONCLUSION

Based on experimental investigations the conclusions are drawn. Cement replacement by in combination of fly ash and adding ground granulated blast furnace slag leads to increase in compressive strength and flexural strength up to 40% to 50% replacement for M40 grades of concrete. Beyond 50% replacement of fly ash and ground granulated blast furnace slag compressive strength and flexural strength decreased. It is observed that at 28 days compressive strength of M40 grade concrete

are increased by 14.80%, 7.26% & 11.53% and flexural strength of M40 grade of concrete was increased by 23.80%, 9.72% & 3.96%, respectively for different combination of mix proportions over controlled concrete. It is observed that at 90 days compressive strength of M40 grade concrete are increased by 18.78%, 16.19% & 7.42% and flexural strength of M40 grade of concrete was increased by 18.68%, 11.30% & 5.65%, respectively for different combination of mix proportions over controlled concrete.

There is a decrease in workability as the replacement level increases, and hence water consumption will be more for higher replacements. From the present study it is observed that, being the fly ash is maintained 10% constant the optimum value of ground granulated blast furnace slag is 30%. i.e., the total replacement of ternary Blended cement was 40%, for M40 grade and it is observed that, being the fly ash is maintained 20% constant the optimum value of ground granulated blast furnace slag is 20%. i.e., the total replacement of ternary Blended cement was 40%, for the both M40 grade and also it is observed that, being the fly ash is maintained 30% constant the optimum value of ground granulated blast furnace slag is 20%. i.e., the total replacement of ternary Blended cement was 50%, for the both M40 grade. The addition of GGBS has further increased initial 28 days, 90 days and 180 days strength as evident from the tables.

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