International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Effect of Recron 3s Fibers on GGBS Replaced Cement Concrete

Priya A. Bhosale[1], Urmila. R. Kawade[2]

[1]PG Student, Pune University, Department of Civil Engineering, PDVVPCOE, Ahmednagar, Maharashtra, India

[2]Associate Professor, Pune University, Department of Civil Engineering, PDVVPCOE, Ahmednagar, Maharashtra, India

Abstract: ***From last many decades, usage of concrete has increased on large scale all over the world. Concrete ingredients used are becoming more costly day by day and also demand for the same is increasing widely all over. These ingredients are also extinguishing with time and some of them are also polluting the surrounding environment on large scale. One of the main ingredients is cement, while production of cement CO_2 is emitted out. Replacement of cement by a pozzalanic material named Ground Granulated Blast Furnace Slag, which is byproduct or waste product of steel manufacturing industries. Ground Granulated Blast Furnace Slag act as cost reducing ingredient and also increase many mechanical properties of concrete. Glass fiber of 12mm size were also added to increase both compressive and tensile strength of concrete. This concrete is more environments friendly and will give more life to concrete. To maintain workability for lower water/cement ratio and to maintain the effect of admixture added, Superplasticiser is added by trial and error method. Mechanical properties of pozzalanic concrete using GGBFS show that this concrete gives better compressive strength and increases durability of concrete. Glass fiber also increases mechanical properties like compressive strength, flexural strength and split tensile strength of concrete. This page revives all details of the material, test to be conducted on concrete using the supplementary admixture and literature showing the advantages of using GGBFS and Glass Fiber in concrete in different proportion.***

Keywords: GGBS, Recron 3s fiber, Compressive strength, Spilt-tensile strength, flexural strength etc.

1. Introduction

1.1 General

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing cementitious materials, water, aggregate 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. As a consequence of the liberties taken, the durability of concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self– destruction.

This is particularly true of concrete structures which were constructed since 1970 or thereabout by which time

a) The use of high strength rebar's with surface deformations (HSD) started becoming common,
b) Significant changes in the constituents and properties of cement were initiated, and
c) Engineers started using supplementary cementitious materials and admixtures in concrete, often without adequate consideration.

The setback in the health of newly constructed concrete structures prompted the most direct and unquestionable evidence of the last two/three decades on the service life performance of our constructions and the resulting challenge that confronts us is the alarming and unacceptable rate at which our infrastructure systems all over the world are suffering from deterioration when exposed to real environments.

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, 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 replace 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.

Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, High Reactive Metakaolin, silica fume are some of the pozzalanic materials which can be used in concrete as partial replacement of cement. A number of studies are going on in India as well as abroad to study the impact of use of these pozzalanic materials as cement replacements and the results are encouraging. The strength, durability and other characteristic of concrete depends on the properties of its ingredients, proportion of mix, method of compaction and other controls during placing and curing.

With the passage of time to meet the demand, there was a continual quest in human being for the development of high strength and durable concrete. The history of high strength concrete is about 35 years old, in late 1960s the invention of water reducing admixtures lead to the high strength precast products and structural elements in beam were cast in situ using high strength concrete. Since then the technology has come of age and concrete of the order of M60 to M120 are commonly used. Concrete of the order of M200 and above are a possibility in the laboratory conditions. The definition of high strength concretes is continually developing. In the 1950s 34N was considered high strength, and in the 1960s compressive strengths of up to 52N were being used commercially. More recently, compressive strengths approaching 138N have been used in cast-in-place buildings. The advent of pre-stressed concrete technology has given impetus for making concrete of high strength. In India high strength concrete is used in pre-stressed concrete bridges of strength from 35 MPa to 45 MPa. Presently (in 2000) Concrete strength of 75 MPa is being used for the first time in one of the flyover at Mumbai. Also in construction of containment Dome at Kaiga power project used HPC of 60MPa with silica fume as one of the constituent. The reasons for these demands are many, but as engineers, we need to think about the durability aspects of the structures using these materials. With long term durability aspects kept aside we have been able to fulfill the needs. The concrete of these properties will have a peculiar Rheological behavior.

Now a day the construction industry turning towards pre-cast elements and requirement of post-tensioning has made the requirement of the high strength of concrete invariable and the engineers had to overcome these drawbacks, which to a great extent we have been able to do. The construction today is to achieve savings in construction work. This has now turned into one of the basic requirement of concreting process.

1.2 Objective of Project Work

Concrete is used widely in many construction activities. As cement is getting costlier and demand is growing more day by day, investigators have been trying to replace cement with other materials to save money either by maintaining the properties using waste materials or by enhancing the properties using selected materials. This paper is an attempt to study the various engineering properties of a concrete made with cement replaced by ground granulated blast furnace slag. To maintain the engineering properties, a synthetic fiber namely Recron 3s fibers manufactured by Reliance Industry Limited, India (RIL) and commonly available in the local retail market of India, has been used in various proportions. The experimental investigations include basic tests for cement, and conventional tests for concrete such as compressive strength, split tensile strength and flexural strength have been taken up. The capillary tests and porosity tests have been also conducted to study the effects of concrete in respect of resistance to seeping or dampening. It has been observed that the Recron fibers to the extent of 0.2% fiber content maintain the satisfactory properties of concrete. However, the resistance to capillary action and porosity problems in concrete is improved considerably.

The objective of the present work is to develop concrete with good strength, less porous, less capillarity so that durability will be reached. For this purpose it requires the use of different pozzalanic materials like fly ash, ground granulated blast furnace slag, silica fume along with fiber. So the experimental program to be undertaken;

1) To evaluate effective use of pozzalanic materials with fiber to achieve the desire needs.
2) To find optimum dosage of Recron 3s fibers to get maximum strength for the M30 grade concrete
3) Obtaining the optimum Replacement % of pozzalanic with a constant dosage of fiber.
4) Comparison of results.

1.3 Significance of Study

This paper is an attempt to study the various engineering properties of a concrete made with additives such as a synthetic fiber and a super plasticizer in combination with Portland slag cement in different material proportions. Attempt has also been made to use GGBFS in order to replace partly the Portland slag cement. Recron 3s fibers manufactured by Reliance Industry Limited, India (RIL) and commonly available in the local retail market have been used. The capillary and porosity tests have been also conducted to study the effects of concrete in respect of resistance to seeping or dampening of concrete thus prepared.

1.4 Scope of Work

High-performance concrete is defined as concrete that meets special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices. Ever since the term high-performance concrete was introduced into the industry, it had widely used in large-scale concrete construction that demands high strength, high flow ability, and high durability.

A high-strength concrete is always a high-performance concrete, but a high-performance concrete is not always a high-strength concrete. Durable concrete Specifying a high-strength concrete does not ensure that a durable concrete will be achieved. It is very difficult to get a product which simultaneously fulfill all of the properties. So the different pozzalanic materials like Ground Granulated Blast furnace Slag (GGBS), silica fume, Rice husk ash, Fly ash, High Reactive Metakaolin, are some of the pozzalanic materials which can be used in concrete as partial replacement of cement, which are very essential ingredients to produce high performance concrete.

Use of synthetic fiber (i.e. Recron fiber) in different percentage i.e. 0.0%, 0.1%, 0.2%, 0.3% to that of total weight of concrete and casting was done. Finally we used different percentage of silica fume with the replacement of cement keeping constant fiber content and concrete was casted. In our study it was used two types of cement, Portland slag cement and ordinary Portland cement. We prepared mortar, cubes, cylinder, prism and finally compressive test, splitting test, flexural test are conducted. Finally porosity and permeability test conducted.

2. Methodology

2.1 General

The objective of the present work is to develop concrete with good strength, less porous, less capillarity so that durability will be reached. For this purpose it requires the use of pozzalanic material like ground granulated blast furnace slag, along with fiber. So the experimental program to be undertaken;

- To determine the mix proportion with ground granulated blast furnace slag with synthetic fiber to achieve the desire needs.
- To determine the water/ binder ratio, so that design mix having proper workability and strength.
- To investigate different basic properties of concrete such as compressive strength, splitting tensile strength, flexural strength etc and comparing the results of different proportioning.
- Determination of porosity and capillary of different proportioned concrete.

2.2 Materials used

2.2.1. Cement

The Ordinary Portland Cement of 53 grade is to be used specifying all the properties from IS12269-1987. OPC 53 grade of cement is selected from Ultra-Tech. Following properties were seen as mentioned in table below:

Table 2.1: Physical properties of cement

Type of cement	Vasavdatta 53 grade OPC	
Specific Surface	225 m^2/kg is minimum value	
Setting Time in min	Initial Setting Time	Final Setting Time
	130 min	315 min
Soundness	Le Chatelier	Autoclave
	10mm	0.8%
Compressive Strength i) 3 Days ii) 7 Days iii) 28 Days	27MPa 37MPa 53MPa	
Specific Gravity	3.15	

2.2.2 Coarse Aggregate

Crushed black trap basalt rock as coarse aggregate confirming IS383-1970 was used. The coarse aggregate of two sizes, viz 20mm and 10mm (refer JP no. 3). Coarse aggregate of size reduce the voids and provide well graded coarse aggregate. 20mm and 10mm coarse aggregate are selected by passing the aggregate through 20mm and 10mm sieves respectively. Particle shape of both the aggregate is angular. Different test are to be conducted like specific gravity, fineness modulus and water absorption. Coarse aggregate is dust free and free from surface moisture.

2.2.3 Fine Aggregate

Natural Sand is selected as fine aggregate from Godhavari river at Paithan. Sand is sieved from 4.75 mm sieve and also washed to reduced the silt content. Sand contains well graded particles and rounded in shape. Here water demand is slightly less for natural sand, which is therefore more preferable. The specific gravity, fineness modulus and water absorption are different test to be conducted on Natural sand.

Table 2.2: Fine and Coarse aggregates

Properties	Coarse Aggregate	Fine Aggregate
Type	Crushed angular	Spherical (River sand)
Maximum Size	20mm	4.75 mm
Specific Gravity	2.632	2.559
Water Absorption	0.63%	1.63%

2.2.4 Super Plasticizers

Polycarboxylate based super plasticizer is more effective than naphthalene sulphonate based super plasticizers. Muraplast FK30 is synthetic super plasticizer on the MC Polycarboxylatether technology which is used for the work. The development of initial strength is enhanced; therefore use of Muraplast FK30 is appropriate for use with pozzolanic concrete containing Ground Granulated Blast Furnace Slag. GGBFS have lower rate of achieving the initial strength one of the drawback. The specific functioning-mechanism makes it possible to produce concrete with extremely low water contents and excellent workability.

Product to be used has following properties:

- Good water saving
- Excellent fluidity
- Relatively fast mixing in concrete
- Low cohesiveness
- High Early Strength
- High Quality Concrete Surfaces
- Free of corrosion promoting components

2.2.5 Water

Portable water available in laboratory is used for mixing and curing of concrete. Water is free from unwanted substances and chemical oxides.

2.2.6 GGBS

Ground Granulated Blast furnace slag (GGBS) is a by-product for manufacture of pig iron and obtained through rapid cooling by water or quenching molten slag. Here the molten slag is produced which is instantaneously tapped and quenched by water. This rapid quenching of molten slag facilitates formation of “Granulated slag”. Ground Granulated Blast furnace Slag (GGBS) is processed from Granulated slag. If slag is properly processed then it develops hydraulic property and it can effectively be used as a pozzalanic material. However, if slag is slowly air cooled then it is hydraulically inert and such crystallized slag cannot be used as pozzalanic material. Though the use of GGBS in the form of Portland slag cement is not uncommon in India, experience of using GGBS as partial replacement of cement in concrete in India is scanty. GGBS essentially consists of silicates and alumina silicates of calcium and other bases that is developed in a molten condition simultaneously with iron in a blast furnace. The chemical composition of oxides in GGBS is similar to that of Portland cement but the proportions varies.

The four major factors, which influence the hydraulic activity of slag, are glass content, chemical composition, mineralogical composition and fineness. The glass content of GGBS affects the hydraulic property, chemical composition determines the alkalinity of the slag and the structure of glass. The compressive strength of concrete varies with the fineness of GGBS.

Ground granulated blast furnace slag now a day's mostly used in India. Recently for marine out fall work at Bandra, Mumbai. It has used to replace cement to about 70%. So it has become more popular now a day.

Table 2.3: Chemical composition of GGBS:

SiO_2	39.18
Al_2O_2	10.18
Fe_2O_3	2.02
CaO	32.82
MgO	8.52
Na_2O	1.14
K_2O	0.30

Performance of Ground Granulated Blast furnace Slag in Concrete:

The replacement of cement with GGBS will reduce the unit water content necessary to obtain the same slump. This reduction of water content is more pronounced with increase in slag content and also on the fineness of slag. This is because of the surface configuration and particle shape of slag being different than cement particle. Surface hydration of slag is slightly slower than that of cement. Reduction of bleeding is not significant with slag of 4000 cm2/g fineness but significant when slag fineness of 6000 cm2/g and above.

Advantages of using GGBS:

- Reduce heat of hydration
- Refinement of pore structures
- Reduce permeability to the external agencies
- Increase resistance to chemical attack.

Reaction Mechanism of Ground Granulated Blast furnace Slag:

Although GGBS is a hydraulically latent material, in presence of lime contributed from cement, a secondary reaction involving glass (Calcium Alumina Silicates) components sets in. As a consequence of this, cementitious compounds are formed. They are categorized as secondary C-S-H gel. The interaction of GGBS and Cement in presence of water is described as below:

$OPC(C_3S/C_2S) + H_2O \longrightarrow C\text{-}S\text{-}H + CH$

Product of hydration of GGBS

$GGBS(C_2AS/C_2MS) + H_2O \longrightarrow C\text{-}S\text{-}H + SiO_2$

Reaction of pozzalanic material

$SiO_2 + CH + H_2O \longrightarrow C\text{-}S\text{-}H$

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

2.2.7 Recron Fiber

Recron Fiberfill is India's only hollow Fiber specially designed for filling and insulation purpose. Made with technology from DuPont, USA, Recron Fiberfill adheres to world-class quality standards to provide maximum comfort, durability, and ease-of-use in a wide variety of applications like sleep products, garments and furniture. Reliance Industry Limited (RIL) has launched Recron 3s fibers with the objective of improving the quality of plaster and concrete.

Application of RECRON 3s fiber reinforced concrete used in construction. The thinner and stronger elements spread across entire section, when used in low dosage arrests cracking. RECRON 3s prevents the shrinkage cracks developed during curing making the structure/plaster/component inherently stronger.

Further when the loads imposed on concrete approach that for failure, cracks will propagate, sometimes rapidly. Addition of RECRON 3s in concrete and plaster prevents/arrests cracking caused by volume change (expansion & contraction).

A cement structure free from such micro cracks prevents water or moisture from entering and migrating throughout the concrete. This in turn helps prevent the corrosion of steel used for primary reinforcement in the structure. This in turn improves longevity of the structure.

The modulus of elasticity of RECRON 3s is high with respect to the modulus of elasticity of the concrete or mortar binder. The RECRON 3s fibers help increase flexural strength. RECRON 3s fibers are environmental friendly and non hazardous. They easily disperse and separate in the mix.

Only 0.2-0.4% by cement RECRON 3s is sufficient for getting the above advantages. Thus it not only pays for itself, but results in net gain with reduced labor cost & improved properties. So we can briefly summarize the advantages of Recron 3s fiber as,

- Control cracking
- Increase ductility, compressive, flexural and tensile strength.
- Reduction in water permeability
- Reduction in rebound loss in concrete
- Safe and easy to use.
- Increase abrasion resistance
- Improves durability of concrete
- Reduce shrinkage crack/ Micro cracks
- This can be used in various aspects such as,
- PCC and RCC plastering
- Shortcrete and gunniting
- Slabs, footings, foundations, walls and tanks
- Pipes, prestressed beam etc
- Concrete blokes, railway sleepers, manhole cover and tiles etc
- Roads and pavements
- Bridges and dams

Table 2.4: Specification of Recron:

Denier	1.5d
Cut length	6mm,12mm,24mm
Tensile strength	About 6000 kg/cm^2
Melting point	250^0 C
Dispersion	Excellent
Acid resistance	Excellent
Alkali resistance	Good

2.3 Preparation of fiber reinforced concrete

First of all consistency tests of cement with replacement of GGBFS were conducted. In case of fiber reinforced concrete, Recron fiber in different percentages i.e. 0, 0.1, 0.2 and 0.3% to the weight of concrete was used. For each fiber concentration GGBFS was varied at 10, 20, 30 and 40% to study the effect of GGBFS replacement. The slump was maintained in the range of 50-75mm to ensure proper workability and to maintain this, admixture such as super plasticizer (local trade name: Sika) was used suitably varying water cement ratio. The super plasticizer concentration also varied for fiber reinforced concrete without and with GGBFS. Then with different concentrations of GGBFS, fiber content was maintained at 0.2%, keeping appropriate water cement ratio and admixture dosage.

All mixtures were mixed in a conventional rotary drum concrete mixer. The mixer was first loaded with the coarse aggregate and a portion of the mixing water, then sand, cement and the rest of water were added and mixed for 3 min. The fibers in the case of fibrous mixtures were randomly distributed. The admixture Sika was added to the mixing water and in case of GGBFS, the same was added with cement simultaneously. Samples were prepared with due reference to relevant BIS codes of practice such as BIS 10262 (1982), BIS 9103 (1999) and BIS 456 (2000).

2.4 About Materials

GGBS is a non-metallic product essentially consists of silicates and alumina silicates of calcium and other bases. The four major factors, which influence the hydraulic activity of slag, are glass content, chemical composition, mineralogical composition and fineness. The granulated material when further ground to less than 45 micron will have specific surface of about 400-600 m2/kg (Blaine). But here in our present study we have delved into the use of GGBS in different percentages in mortar testing, where we have used GGBS passing through 75 micron sieve. Here the specific surface of about275-550 m2/kg. We are going to use of GGBS as partial replacement of cement because of its advantages like lower energy cost, higher abrasion resistance, lower hydration heat evolution, higher later strength development.

Synthetic fiber i.e. Recron fiber is used in concrete for the production of fiber reinforced concrete. We are going to use Recron fiber in different percentage i.e., 0%, 0.1%, 0.2%, 0.3% to the weight of concrete and study the 7 days and 28 days compressive strength, splitting tensile and flexural strength of concrete to that of normal concrete with maintaining the water cement ratio in the range of 0.35-0.41.Finally Porosity and Capillary absorption test was conducted.

2.5 Tests on Aggregates:

2.5.1 Aggregate Impact Value

The test is to be considered to be an important test to assess the suitability of aggregates as regards the toughness property.

Table 2.5: Allowable limits of Aggregates as per I.R.C.

Sr. No.	*Aggregate impact value (%)*	*Comment*
1	<10	Exceptionally strong
2	10-30	Strong
3	20-30	Satisfactory
4	>35	Weak

2.5.2Aggregate Crushing Value

Significance of test:

- The aggregate crushing value is an indirect measure of crushing strength of aggregates.
- Low aggregate crushing values indicate strong aggregates, as the crushed factor is low.

2.5.3 Shape Test

The particle shape of aggregates is determined by the percentages of flaky and elongated particles contained in it. In the case of gravel it is determined by its angularity number.

I. Test for Elongation Index

Significance of test:

- The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four fifth times (1.8 times) their mean dimension.
- The elongation test is not applicable to sizes less than 6.3 mm.
- Flaky & elongated particles are to be avoided.
- If flaky & elongated aggregates are present in appreciable proportions, the strength would be adversely affected due to possibility of breaking down under loads.

II. Test for Flakiness Index:

Significance of test:

- The flakiness index of aggregates is the percentages by weight of particles whose least dimension (thickness) is less than three-fifth of their mean dimension.
- The test is not applicable to sizes smaller than 6.3 mm.

2.5.4Specific Gravity And Water Absorption Test:

Significance of test:

- The specific gravity of aggregate normally used ranges from about 2.5 to 3.0 with an average value of about 2.68.
- High specific gravity of an aggregate is considered as an indication of high strength.
- Water absorption of an aggregate is accepted as measure of its porosity.
- Sometimes this value is even considered as a measure of its resistance to frost action, through this has not been yet confirmed by adequate research.

- Water absorption value ranges from 0.1% to 2.0% for aggregates.
- I.R.C has specified the maximum water absorption value as 1.0% for aggregates.

2.5.5 Mix design for grade M-40

Initial Parameters:

1) Cement Grade- O.P.C.53, Vasavdatta Cement, Concrete Grade-M_{40}.
2) Specific Gravity of Cement- 3.15
3) Fine Aggregates- Sand-Zone-II
4) Specific Gravity of F.A- 2.50
5) Coarse Aggregates- 20 mm (60%)
   10 mm (40%)
6) Specific Gravity of C.A- 2.74

Mix Design calculations:

1. Target Mean strength – (F_{ck}).

$$F_{ck} = f_{ck} + K.S$$

Where, f_{ck} = Characteristics Compressive Strength at 28 days
K = Statistical value for risk factor
S = Standard Deviation
F_{ck}= 40 + (1.65 × 5) = 48.25 N/mm^2

2. Selection of Water-Cement ratio:
So, Assumed W/C = 0.4 (As per IS 456 – 2000)
W/C As per IS 20262 we have 0.38 from graph.
Therefore, Considering W/C =0.4

3. Selection of Water & Sand content: W/C = 0.4
Taking Cement upto 400 kg/m^3
As per IS 456 for M_{40} grade minimum cement content is 360 kg/m^3
Therefore as Weight of Cement taken are 400 kg/m^3
Weight of water = 0.4 × 400
= 160 kg water.

Assumed 1kg = 1 liter, Hence Water requirement is 186liters for M40
Now for M_{40} as per IS Maximum cement content is 180 kg which is greater than calculated hence ok.

4. Calculation of C.A & F.A
V = [(W + C/S_C) + (1/P × F.A/$S_{F.A}$)] × 1/1000
and
V = {(W + C/S_C) + [1/(1-P) × C.A/$S_{C.A}$]} × 1/1000
Now as per IS – 20262, 2% is considered as air entrapment
V = 1- 0.2
= 0.98
For 100mm slum water requirement:
= 186 + {(6/100) X 186}
= 197 liters
Calculation of flash content: As water cement ratio is 0.4
Fly ash content = 197 / 0.4
= 492.5 kg
The volume of coarse aggregate:
= 0.62 X 0.9
= 0.57 m^3
Volume of fine aggregate:
= 1- 0.56
= 0.44 m^3

a) Volume of concrete = 1m^3
b) Volume of fly ash = {(mass of flash) / (specific gravity of flash)} X (1/1000)
=(492.5/2.3) X (1/1000)
= 0.2141 m^3
c) Volume of solution/water = {Mass of solution / sp. Gravity of solution} X(1/1000)
= (197X1000)/ 1
= 0.197 m^3
d) Volume all in aggregate = {a- (b+c)}
= {1-(0.214+0.197)}
= 0.5889 m^3
e) Mass of coarse aggregate = 0.5889 X 0.56 X 2.74 X1000
= 903.60 kg
f) Mass of fine aggregate = 0.5889 X 0.44 X 2.74 X 1000
= 709.89 kg

Table 2.6: Batch Mixing 30%GGBS

Test A with 20% GGBS					
Test 1st (with 0.1% Recron 3S)					
Material	Batch 1st	Batch 2nd	Batch 3d	Total	
Cement	16.281	16.281	12.211	44.773	kg
GGBS	4.131	4.131	3.098	11.36	kg
C-Sand	36.771	36.771	27.579	101.121	kg
10mm	20.196	20.196	15.147	55.539	kg
20mm	40.53	40.53	30.398	111.458	kg
Water	8.044	8.044	6.032	22.12	kg
Admix	163	163	123	449	ml
Fiber	20	20	15	55	Gms
Test 2nd (with 0.2% Recron 3S)					
Material	Batch 1st	Batch 2nd	Batch 3d	Total	
Cement	16.281	16.281	12.211	44.773	kg
GGBS	4.131	4.131	3.098	11.36	kg
C-Sand	36.771	36.771	27.579	101.121	kg
10mm	20.196	20.196	15.147	55.539	kg
20mm	40.53	40.53	30.398	111.458	kg
Water	8.044	8.044	6.032	22.12	kg
Admix	163	163	123	449	ml
Fiber	41	41	31	113	Gms
Test 3rd (with 0.3% Recron 3S)					
Material	Batch 1st	Batch 2nd	Batch 3d	Total	
Cement	16.281	16.281	12.211	44.773	Kg
GGBS	4.131	4.131	3.098	11.36	Kg
C-Sand	36.771	36.771	27.579	101.121	Kg
10mm	20.196	20.196	15.147	55.539	Kg
20mm	40.53	40.53	30.398	111.458	Kg
Water	8.044	8.044	6.032	22.12	Kg
Admix	163	163	123	449	Ml
Fibre	61	61	45	167	Gms

Table 2.7: Batch Mixing 30%GGBS

Test A with 30% GGBS					
Test 1st (with 0.1% Recron 3S)					
Material	Batch 1st	Batch 2nd	Batch 3d	Total	
Cement	14.337	14.337	10.753	39.427	kg
GGBS	6.075	6.075	4.556	16.706	kg
C-Sand	36.668	36.668	27.502	100.838	kg
10mm	21.39	21.39	15.104	57.884	kg
20mm	44.17	44.17	30.312	118.652	kg
Water	8.042	8.042	6.031	22.115	kg
Admix	163.296	163.296	122.47	449.062	ml
Fiber	20	20	15	55	gms
Test 2nd (with 0.2% Recron 3S)					
Material	Batch 1st	Batch 2nd	Batch 3d	Total	

Cement	14.337	14.337	10.753	39.427	kg
GGBS	6.075	6.075	4.556	16.706	kg
C-Sand	36.668	36.668	27.502	100.838	kg
10mm	21.39	21.39	15.104	57.884	kg
20mm	44.17	44.17	30.312	118.652	kg
Water	8.042	8.042	6.031	22.115	kg
Admix	163.296	163.296	122.47	449.062	ml
Fiber	41	41	31	113	gms
Test 3rd (with 0.3% Recron 3S)					
Material	Batch 1st	Batch 2nd	Batch 3d	Total	
Cement	14.337	14.337	10.753	39.427	kg
GGBS	6.075	6.075	4.556	16.706	kg
C-Sand	36.668	36.668	27.502	100.838	kg
10mm	21.39	21.39	15.104	57.884	kg
20mm	44.17	44.17	30.312	118.652	kg
Water	8.042	8.042	6.031	22.115	kg
Admix	163.296	163.296	122.47	449.062	ml
Fiber	61	61	45	167	gms

3. Results and Discussion of Experimental work

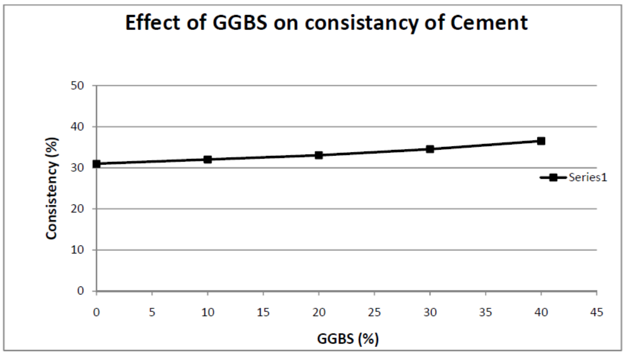
3.1. General

The procedure is taken in two stages
1) Plain GGBS replacement in concrete with cement
2) GGBS replacement along with Recron fiber.
Following test results were calculated accordingly.

3.2. Test on cement due to %replacement of GGBS:

3.2.1 Consistency of cement

As shown in figure 1 normal consistency increases with cement replacement. Normally consistency of cement depends upon its fineness. As GGBFS has greater fineness and, hence greater surface area than cement, the consistency increases with GGBFS replacement.

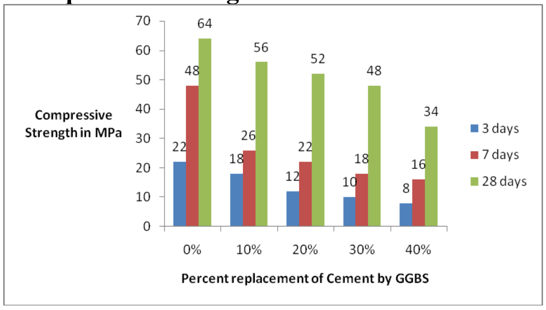


Graph 3.1: Consistency of cement by % GGBS replacement

3.3. Effect of GGBFS Replacement on Properties of Concrete:

In First stage, concrete is prepared without fibre addition, but with increasing GGBFS content replacing the cement and the following set of engineering properties are studied to decide the optimum dosage of GGBFS replacement.

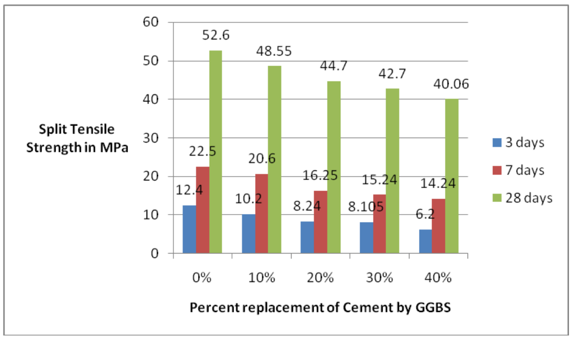
3.3.1. Compressive Strength



Graph 3.2: Compressive strength on % replacement of GGBS

As seen in graph no.4.2 the compressive strength (3 days, 7 days and 28 days) of cubes decreases with GGBFS content. It is also observed that upto 20% replacement acceptable strength can be obtained.

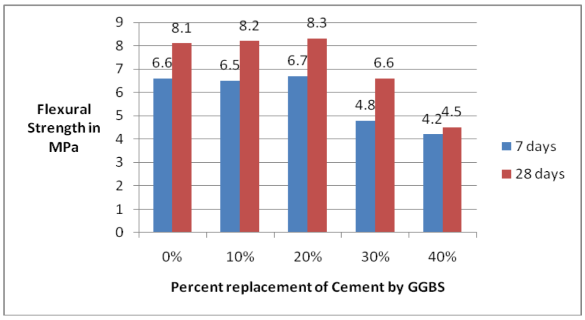
3.3.2 Split Tensile Strength



Graph 3.3: Split tensile strength on % replacement of GGBS

As seen in graph no.4.3, similarly the split tensile strength (7 days as well as 28 days) of concrete decreases with GGBFS replacement.

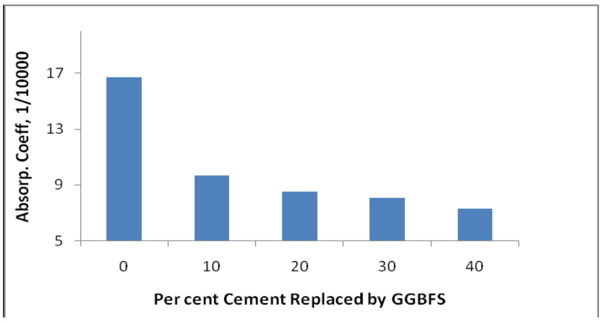
3.3.3 Flexural Strength



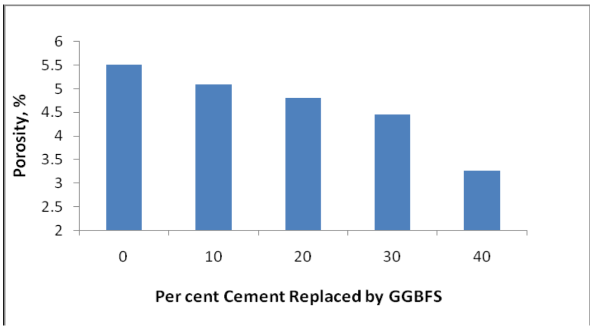
Graph 3.4: Flexural strength on % replacement of GGBS

As seen in graph no.4.4 the flexural strength (7 days as well as 28 days) of concrete also decreases with GGBFS Replacement.

3.3.4 Capillary Absorption and Porosity



Graph 3.5 Water Absorption on % GGBS replacement



Graph 3.6 Capillarity on % replacement of GGBS

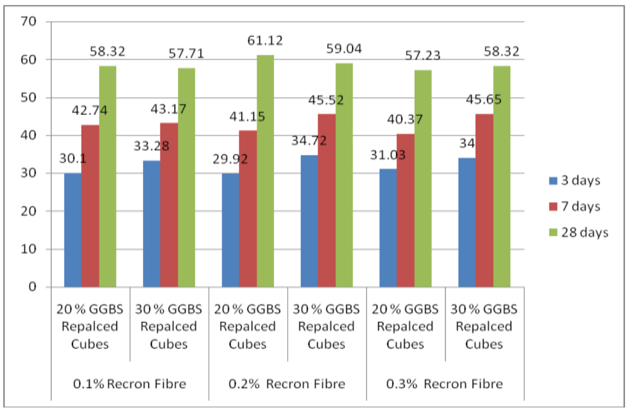
As seen in graph no. 4.5 and 4.6 the capillary absorption coefficient and porosity decrease with GGBFS replacement. However, the former is more phenomenal. The porosity of concrete decreases with GGBFS replacement, but at a slow rate. These two features are an added advantage of GGBFS replacement.

Considering the above results particularly the compressive strength results, it may be concluded that 20% GGBFS Replacement should be optimum. This has been used in further investigations.

3.4 Effect of Fiber Addition on Properties of Concrete:

In the second stage, keeping GGBFS Replacement of 20% as constant, concrete is prepared with increasing fiber content and different properties are studied to decide the optimum fiber content.

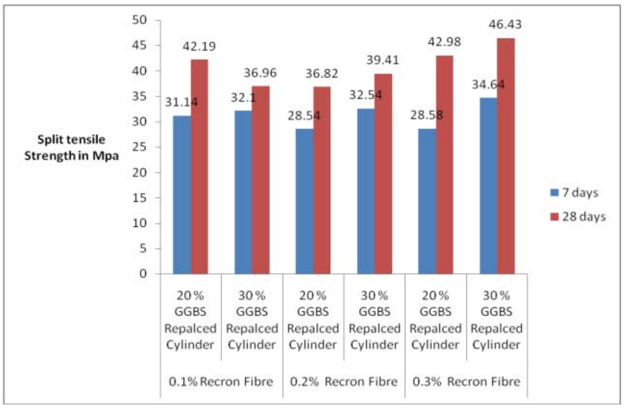
3.4.1 Compressive Strength



Graph 3.7 Compressive strength after Recron 3s fiber addition

As seen in graph no.6 the compressive strength (7 days as well as 28 days) of cubes decreases with increase in fiber content, however, the rate is more pronounced after 0.2% fiber content.

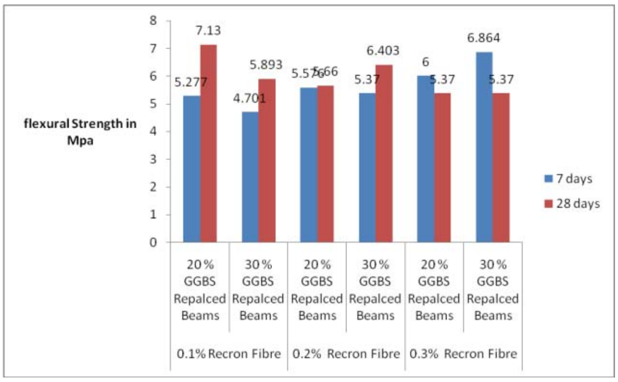
3.5.2 Split Tensile Strength



Graph 3.8: Split tensile strength after addition of Recron 3s fiber

As shown in graph no.7 it is clear that the split tensile strength behaves almost in the similar way, as compressive strength. It can be added that the decrease is more pronounced after 0.2% fiber content.

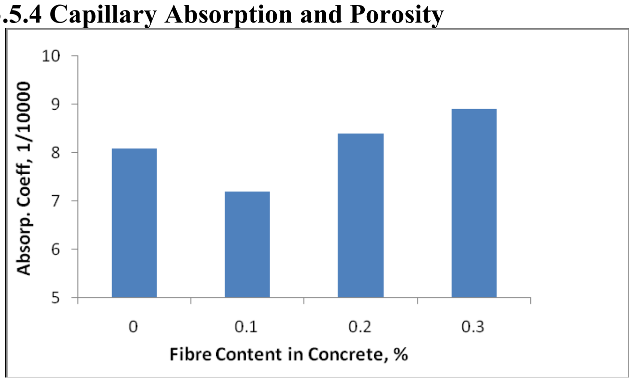
3.5.3 Flexural Strength



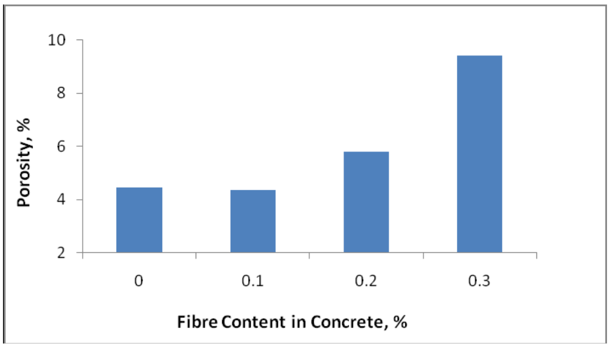
Graph 3.9: Flexural strength after addition of Recron 3s fibers

The flexural strength as presented in graph no.8 increases upto 0.2% fiber content after which it decreases.

3.5.4 Capillary Absorption and Porosity



Graph 3.10: Water Absorption test after Recron 3s fiber addition



Graph 3.11: Capillarity test after Recron 3s fiber addition

As shown in graphs 9 and 10 , the capillary absorption decreases with 0.1% fiber addition, while porosity increases with fiber content. However, significant changes appear after 0.2%.

4. Conclusion

General

Using Portland cement and locally available aggregates, super plasticizer and water, an attempt has been made to study first, the effect of part replacement of cement by ground granulated blast furnace slag on engineering properties of concrete. As there is decreasing trend of the characteristics, a synthetic fiber which is commonly available in the local market under the trade name Recron 3S has been added in varying proportions. The following conclusions are drawn.

- The normal consistency increases with replacement of cement by pozzolanic material such as GGBFS.
- In case of normal concrete, part replacement of cement by GGBFS decreases the compressive strength. However, satisfactory results are obtained with 20% to 30% replacement.
- Addition of fibres decreases the compressive strength and split tensile strength, with phenomenal change after 0.2%. Flexural strength of concrete increases with fibre addition upto 0.1 % by weight after which they decrease.
- Similarly the capillary absorption parameter decreases with fibre content upto 0.1% after which the value of this parameter increases, while the porosity increases with fibre content, but significant being after 0.1-0.2%.
- Considering the above observations, it is concluded that within the range of tests conducted, 20% GGBFS replacement of Portland slag cement with 0.2% fiber addition with would improve the dampening or seeping action of water in concrete besides satisfying the other conventional criteria.
- In case of Portland slag cement with the use of Recron fiber , the 28 days compressive strength at 0.2% fiber content the result obtained is maximum. The 28 days splitting tensile and flexural strength also increases about 5% at 0.2% fiber content to that of normal concrete. Further if fiber percentage increases then it was seen a great loss in the strength
- So it is inculcated that 0.2% Recron fiber and 20% to 30% GGBS is the optimum combination to achieve the desired need.
- The research work on pozzolanic materials and fiber along with pozzolanas is still limited. But it promises a great scope for future studies. Following aspects are considered for future study and investigation;
- Percentage and actual fineness of GGBS require as partial cement replacement for good strength development.

References

[1] Alhozaimy A. M., Soroushian P. and Mirza F., *"Mechanical Properties of Polypropylene Fiber Reinforced Concrete and the Effects of Pozzolanic Materials"*, Cement & Concrete Composite, vol. 18, pp 85-92, 1996.

[2] BIS 383, Specification for Coarse aggregate and Fine aggregate from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi, 1970.

[3] BIS 456, Indian Standard Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standard, New Delhi, 2000.

[4] BIS 5816, Splitting Tensile Strength of Concrete Method of Test, Bureau of Indian Standards, New Delhi, 1999.

[5] BIS 9103, Indian Standard Concrete Admixture Specification, Bureau of Indian Standards, New Delhi, 1999.

[6] BIS 9399, Specifications for Apparatus for Flexural Testing of Concrete, Bureau of Indian Standards, New Delhi, 1959.

[7] BIS 10262, Recommended Guidelines for Concrete Mix design, Bureau of Indian Standards, New Delhi, 1982.

[8] Bhanja S. and Sengupta B., *"Influence of silica fume on the tensile strength of concrete, Cement and Concrete Research"*, vol.35, pp 743-747, 2005.

[9] Bozkurt N. and Yazicioglu S., *"Strength and capillary water absorption of light weight concrete under different curing condition"*, Indian Journal of Engineering and Material Sciences, Vol. 17, pp 145-151, 2010.

[10] Caijun Shi and Jueshi Qian, *"High Performance cementing materials from industrial slags, Resources Conservation & Recycling"*, Vol. 29, pp195-207, 2000.

[11] Ganesh Babu K, and Sree Rama Kumar V., *"Efficiency of GGBS in Concrete, Cement and Concrete Research"*, Vol. 30, pp 1031-1036, 2000.

[12] Safiuddin Md. and Hearn N., *"Comparison of ASTM saturation techniques for measuring the permeable porosity of concrete"*, Cement and Concrete Research, . vol. 35, pp 1008-1013, 2005.

[13] Zollo Ronald F., *"Fiber-reinforced Concrete: an Overview after 30 Years of Development"*, Cement & Concrete Composite, vol. 19, pp 107-122, 1997.




Author Profile

Priya Ashok Bhosale, PG Student, ME Civil (Stuctures), Pune University, Dept. of Civil Engineering, PDVVPCOE, Ahmednagar, Maharashtra, India.

Urmila R. Kawade, Associate Professor, Pune University, Dept. of Civil Engineering, PDVVPCOE, Ahmednagar, Maharashtra, India.