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Strength Characteristics of High Strength Concrete using Recycled Aggregate and GGBS, Fly Ash

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Abstract*: The present investigations are getting considerable attention under sustainable development now-a-days. This research work is to study the attitude of coarse aggregate replaced with Recycled Aggregates in volume of 10% , 20%, 30% and 40% and cement replaced with the GGBS in weight of 10%, 20%, 30%,and 40% and Fly Ash in weight of 10%, 15%, 20%. The mix has been designed for M_{40} grade concrete. In this research, cubes, cylinders and beams of standard size have been cast and tested after 3 days, 7 days 28 days & 56 days curing period. The properties of concrete mix proportions were evaluated by measuring workability (using slump test), compressive strength, split tensile strength and Flexural Strength. The mixing of GGBS, Fly Ash enhanced workability, compressive strength, split tensile strength of the concrete for the types of cement. The Ordinary Portland Cement concrete mixtures including RA had almost the same behaviors
Keywords: Fly ash, GGBS, Recycled Aggregate, Compressive strength, Split Tensile Strength

I. INTRODUCTION

Concrete is the most commonly used material in various types of construction, from the flooring of a hut to a multi-storied high rise structure from pathway to an airport runway, from an underground tunnel and deep sea platform to high-rise chimneys and TV Towers. In the last millennium concrete has demanding requirements both in terms of technical performance and economy while greatly varying from architectural masterpieces to the simplest of utilities. It is difficult to point out another material of construction which is as versatile as concrete. Concrete is one of the versatile heterogeneous materials, civil engineering has ever known. With the advent of concrete civil engineering has touched highest peak of technology. Concrete is a material with which any shape can be cast and with any strength. It is the material of choice where strength, performance, durability, impermeability, fire resistance and abrasion resistance are required. Cement is the second most consumed product in the world. Around 5-8% of the world's man made greenhouse gas emissions are from the cement industry. On the other hand, the demand for concrete is increasing day by day because of its ease of preparation and fabrication into all sorts of convenient shapes. To overcome this problem, environment friendly concrete has to be utilized by replacing the cement with industrial by-products which are dumped on open lands leads to pollution.The large construction activity undertaken during the various 5 years plans necessitated the growth of cement industry. However, until the year 1982, the growth remained stinted due to the complete control exercised by the Government over the cement industry. The partial deep control in 1982 prompted various industrial houses to setup new cement plants in the country. The full decontrol on cement industry in 1988 further provided momentum for the growth.

II. LITERATURE REVIEW

The High Performance Concrete particularly with the structural advantages of using high strength concrete have been described in various researches. These include a reduction in member size, reduction in the self-weight and super-imposed Dead Load with theaccompanying saving due to smaller foundations, reduction in form-work area and cost construction of High-rise buildings with the accompanying savings in real estate costs in congested areas, longer spans and fewer beams for the same magnitude of loading, reduced axial shortening of compression supporting members ,reduction in the number of supports and the supporting foundations due to the increase in spans ,reduction in the thickness of floor slabs and supporting beam sections which are a major component of the weight and cost of the majority of structures, superior long term service performance under static, dynamic and fatigue loading, low creep and shrinkage . Achieving high strength concrete by using various chemical and mineral admixtures is also a subject of research and different design mix methods and trial mix approaches have been proposed for the development of highstrengthconcrete.

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J. Hegger, studied the economical and constructional advantages of High-strength concrete for a 186 m high office building in Frankfurt, Germany concluded that, for columns designed for a vertical load of 20 MN with a 85 MPa-concrete more than 50 of the reinforcement can be saved compared to a 45 MPa concrete. And in spite of the approximately 60%higher concrete cost the total costs can be reduced by about results concrete with 40% and 50% replacement of cement with GGBS together with 50% replacement of recycled aggregates shows adequate strength compared to control mix. The maximum compressive strength of 28 days cubes is 49.33 N/mm2 for 50% recycled aggregates used.

Partha, Prabir and Pradip [2014] investigated that when the GGBS was added in the range of 0 - 20% of total binder, significant increase in strength and some decrease in workability was observed in Geopolymer concrete. The addition of GGBFS enhanced the setting of concrete at ambient temperature. The effect of mixture variables on the development of tensile strength was similar to that on the development of compressive strength

V. Eswaraiah, G. NageshKumar(2014) ,This analysis and design of recorn 3s- polypropylene fibers in GPC under hot air oven curing temperature of 600C for 24 hours. They observed less shrinkage and water absorption property when compared with ordinary Portland concrete.

Maneeshkumar C S et al.(2015) , have studied about The necessity of heat curing of concrete was eliminated by incorporating GGBS and fly ash in a concrete mix. The strength of Geopolymer concrete increased with increase in percentage of GGBS in a mix and gave maximum compressive strength of 74.67Mpa. GGBS and Fly ash-based Geopolymer concrete has excellent compressive strength and is suitable for structural applications.

Mr. Gautam L et.al(2015) , this investigatigated are a successful development of fly ash based and fly ash and GGBS based Geopolymer concretes with low Molarity is achieved. Twenty different mixes using NaOH solutions of Molarities 3, 4, 5 and 6 were selected. The W/B ratio is observed to have a significant effect on the strength realized.

Mr. Ahmed Mohmed Ahmed BlashDr. T.V. S. VaraLakshmi (2016), The replacement of GGBS in the Geopolymer concrete mixes resulted in finer pore structure thus producing low permeability concrete for longer curing durations . It was also observed that high performance concrete may be used in terms of high strength and durability and is significant to special structures such as marine structures

III. MATERIALS USED

A. Cement

53 grades (OPC – Ultra -tech Cement) were used in the experimental investigation. It was tested for its physical properties in accordance with Indian Standard specifications

Table.1. Physical Properties of Cement (IS:12269-1987)

S.NO	PROPERTY	VALUES
1	Fineness of Cement	225 m^2/kg
2	Specific Gravity	3.05
3	Normal Consistency	33 %
4	Setting Time i) Initial Setting time ii) Final setting time	 30mins 6 hours

B. Fine Aggregate

The fine aggregate obtained from river bed, clear from all sorts of organic impurities was used in this experimental program. The fine aggregate was passing through 4.75 mm sieve and had a specific gravity of 2.44. The grading zone of fine aggregate was zone II as per Indian Standard specifications.

C. Coarse Aggregate

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone, and trap rock. The maximum size of coarse aggregate was 20 mm and specific gravity of 2.59.

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Water should be free from acids, oils, alkalies, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. 1. it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. 2. it serves as a vehicle or lubricant in the mixture of fine aggregates and cement.

Table.2. Properties of Recycled Aggregates

Sl. No.	Properties	**Recycled Aggregates**
1	Specific Gravity	2.60
2	Water Absorption	0.35-0.40%
3	Bulk Density	1469.8 kN/m^3
4	Crushing Value	36.30%
5	Impact Value	35.20%

D. Fly Ash

The Fly ash was obtained from the Af sin-Elbistan Thermal Power Plant in Turkey. It contained High amounts of calcium and sulfate (Erdogan, 1997; Tokyay and Erdogdu, 1998). The fly ash was class, C, since it was obtained from lignite coal (ASTM C618, 1991). The total fly ash reserves are about million a year. The chemical composition is given in

Table.3. The Chemical Composition of Fly Ash

0xide	Fly Ash
Sio2	18.95
Al2o3	7.53
Fe2o3	3.85
Cao	51.29
Mgo	1.58
So3	12.06
K2o	1.51
Na2o	0.32
Loi	1.94

GGBS can be added to concrete in the concrete manufacturer's batching plant, along with Portland cement, aggregates and water. The normal ratios of aggregates and water to cementations material in the mix remain unchanged. GGBS is used as a direct replacement for Portland cement. Replacement levels for GGBS vary from 30% to up to 85%. Typically 40 to 50% is used.

Table.3. Properties of GGBS

Sl. No.	Properties	GGBS
1	Specific Gravity	2.90
2	Bulk Density	Loose-1.0 to 1.1 t/m^3 Dense-1.2 to 1.3 t/m^3
3	Relative Density	2.85 to 2.95 g/cc
4	pH	9 to 11 (T-20^{o}c in water)
4	Specific Surface Area	350 to 459 m^2/kg

IV. RESULTS AND DISCUSSIONS

The investigations were conducted for workability on fresh concrete, compressive strength, split tensile strength on hardened specimens. Standard procedures were adopted for testing. The experimental program was designed to compare the mechanical properties i.e., Compressive Strength of Cubes & Cylinders, Flexural Strength, Splitting Tensile Strength and Modulus of

Elasticity of high strength concrete with M_{40} grade of concrete and with different replacement levels of Ordinary Portland cement (Ultra Tech cement 53 grade) with Recycled Coarse Aggregates and Silica Fume.

Sample	Compressive Strength (MPa)			
	3 Days	7 Days	28Days	56 Days
CON	22.53	33.12	49.88	53.14
RA10%+ GGBS10%+ FA20%	32.88	45.25	57.99	63.92
RA20%+ GGBS20%+ FA20%	34.26	47.23	59.74	64.54
RA30%+ GGBS30%+ FA20%	21.96	27.89	37.36	46.10
RA40%+ GGBS40%+ FA20%	19.59	23.23	30.02	41.52
Sample	Compressive Strength (MPa)			
	3 Days	7 Days	28Days	56 Days
CON	22.53	33.12	49.88	53.14
RA10%+ GGBS10%+FA15%	29.54	38.89	54.00	57.58
RA20%+ GGBS20%+FA15%	30.92	40.56	55.60	59.56
RA30%+ GGBS30%+FA15%	27.26	35.23	47.36	55.08
RA40%+ GGBS40%+FA15%	24.26	29.23	42.36	50.42

Table.4.Average Compressive Strength for M_{40}

Table.5.Split Tensile Strength for M_{40}

S. No	Age in Days	Split Tensile Strength (MPa)		
		0%RA+0%GGBS + 0 % Fly Ash	40% RA+ 20%GGBS+ 0% Fly Ash	40%RA+, 20%GGBS +10% Fly Ash
1	3	4.0	4.36	4.40
2	7	4.24	4.40	4.44
3	28	4.38	4.45	4.56

V. CONCLUSIONS

A. Based on the present experimental investigation, the following conclusions are drawn. It investigation observed that there is an increase in the compressive strength for different concrete mixes made with partial replacement of cement by 20% GGBS. The increase in strength is due to high reactivity of GGBS with Cement. The use of GGBS as a replacement of cement helps to reduce the Energy consumption in the manufacturing of cement. Concrete with reduced permeability increases the durability of the structure. . Use of GGBS in the concrete generates less heat while mixing with the water as against cement. It also helps to reduce the heat of hydration resulting less shrinkage and temperature cracks in the concrete.

B. Cement replacement with 15% SF and 20%, GGBS & Coarse replacement with 40%RCA leads to increase in Compressive Strength, Split Tensile Strength is 27%, 56%, respectively. Finally, it can conclude that though the permeability is reduced even up to30%, 40%, replacement of cement with GGBS and 20% SF, Keeping the workability and compressive strength in decrease, 20% replacement of GGBs is recommended for use in M_{40} grade concrete.

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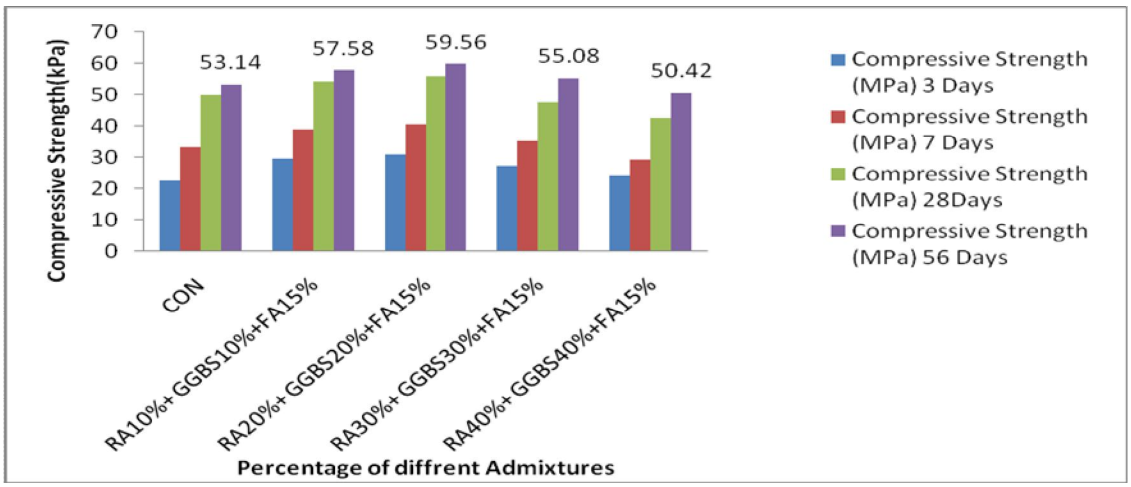
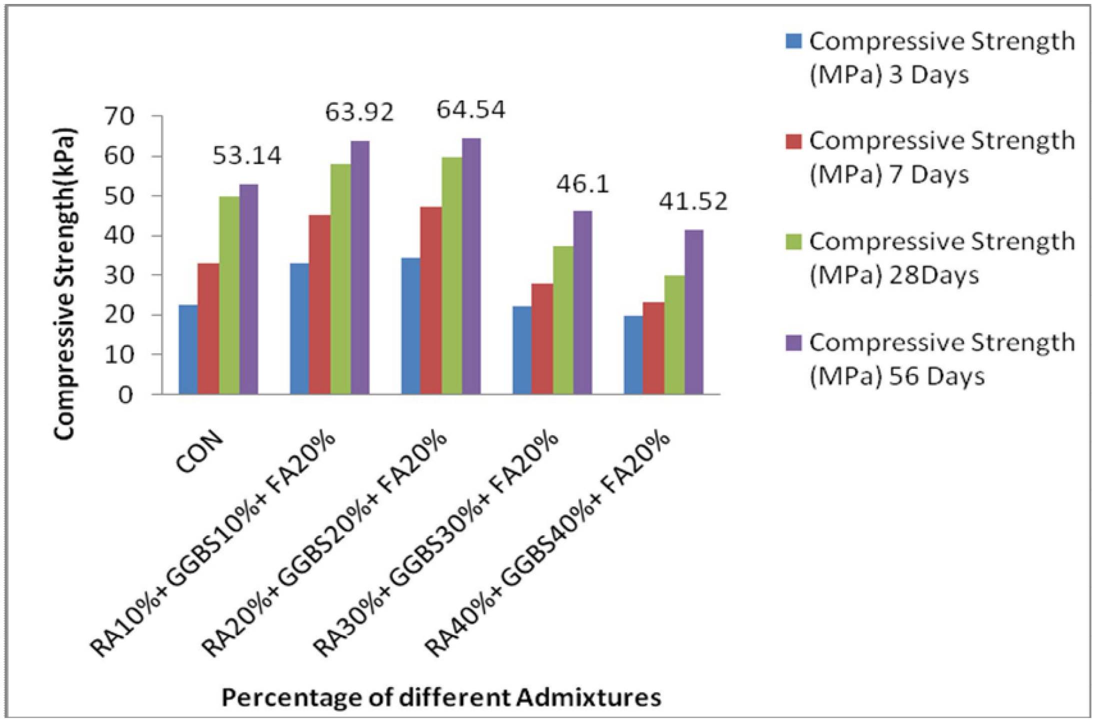
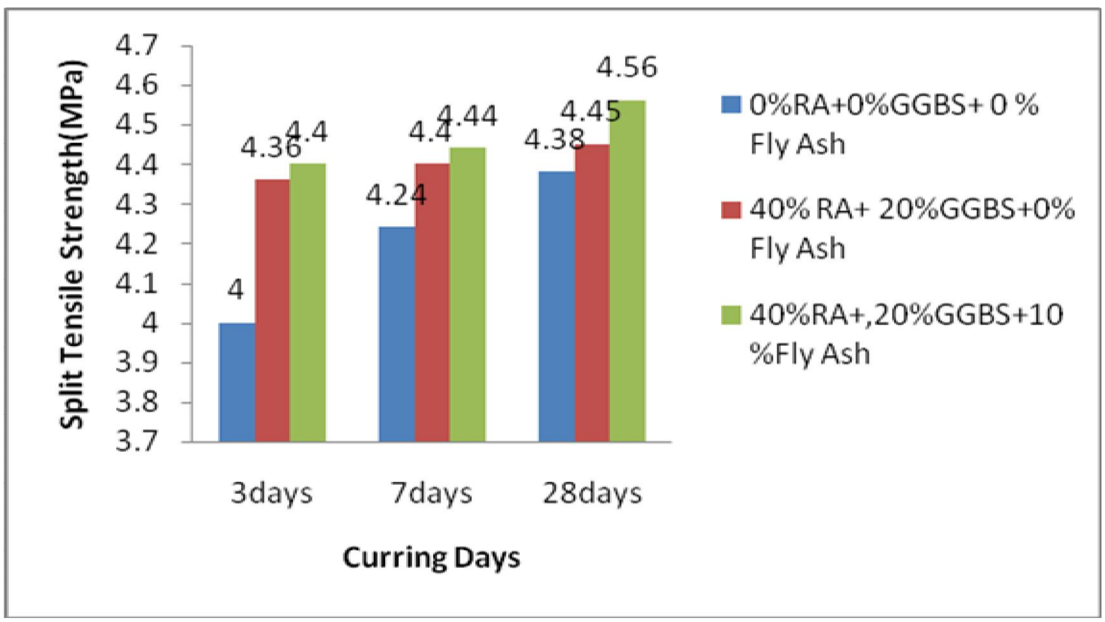


Graph.1. Variation of Cube Compressive Strength of M40 Grade Concrete with age



Graph.2. Variation of Cube Compressive Strength of M40 Grade Concrete with age



Graph.3. Variation of Cube Split Tensile Strength of M40 Grade Concrete with age