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Study on Mechanical Properties of Concrete by Partial Replacement of Recycled Glass Sand and GGBS

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ABSTRACT

The goal of this study was to examine the mechanical parameters of a Recycled Glass as Sand (RGS) including GGBS as a partial replacement for fine aggregate and cement, including compressive strength, split tensile strength, and flexural strength test. With water-to-binder ratios of 0.50, concrete cylinders with 150-mm diameter and 300-mm height were cast using 15 percent GGBS as a partial replacement of cement and replacement of fine aggregate with Recycled Glass sand as 0 percent -25 percent. The testing results showed that gradually increased with increasing GGBS up to 20%. However, at 15 percent GGBS, the highest results were found. RGS, on the other hand, has a consistent 15%. The use of 15% GGBS as a partial replacement for cement with a water-to-binder ratio of 0.50 was found to have a substantial impact on the mechanical properties of RGS.

Keywords: Recycled Glass Sand (RGS) ; Ground Granulated Blast Furnace Slag(GGBS); Compressive strength; Tensile strength; Flexural strength

I.INTRODUCTION

The flexibility, durability, sustainability, and economy of concrete have made it the most frequently used building material on the planet. One ton of lime stone cement requires 80 units of electric power to produce, as well as one ton of CO2 released into the atmosphere. Even industries provide roughly 7% of total CO2 emissions (from a range of sources) globally. Year after year, the global rate of cement production rises dramatically. If demand falls, manufacturing might be lowered. The use of supplemental cementitious materials and other components that reduce cement content in concrete can help to reduce demand. By employing by-products and natural wastes as supplemental cementitious materials, the characteristics of concrete can be improved. Using these natural materials and industrial by-products as a partial replacement for OPC can save a lot of energy and money.

In general, pozzolans are siliceous or siliceous and aluminous sources with little or no cementitious qualities that are finely ground and chemically react with calcium hydroxide during the hydration process at room temperature to produce a compound having cementitious capabilities.

Pozzolans are always utilized in conjunction with Portland cement since they are a hidden hydraulic substance. The two materials could be buried together or mixed together. It is sometimes used in conjunction with a concrete mixer. Pozzolanic cement has a low rate of heat development, making it a low heat cement. Pozolans help reduce capillary porosity and micro cracking in concrete and the interfacial transition region.

Due to enormous volume consumption and widespread construction sites, the use of waste glass in construction has sparked a lot of attention around the world. Many research have recently focused on the use of glass waste as a partial substitute for natural aggregates in mortar. The pozzolanic activity of finely powdered glass sands was extremely high. The alkali-silica reaction (ASR) that occurs between the alkali in cement and the reactive silica in waste glass is a key concern when employing waste glass in mortar. This reaction can be exceedingly damaging to the mortar's stability. Instead of employing glass waste alone in mortar, it may be more appropriate to blend it with industrial byproducts. Glass sand, as a Pozzolan, provides a more uniform distribution of hydration products and a higher volume of hydration products. The cement paste structure changes when glass sand is added to a concrete mix. In comparison to regular cement pastes, the resulting paste contains more of the strong calcium-silicate hydrates (C-S-H) and less of the weak and easily soluble calcium hydroxides (Ca (OH)2). The calcium silicate hydrate that forms is the glue that keeps the system together and provides the majority of the concrete's strength. Calcium hydroxide, which is weaker, does not act as a binder and can take up space. Furthermore, calcium hydroxide can react with carbon dioxide to generate a soluble salt that can leach through concrete and cause efflorescence. Glass sand particles are small enough to enter and block capillary pores in concrete, resulting in smaller, fewer pores and denser concrete. When compared to ordinary sand, the micro filler effect reduces permeability and improves the paste-to-aggregate binding of concrete with glass sand.

GGBS cement, along with Portland cement, aggregates, and water, can be mixed into concrete in the batching plant of a concrete factory. In the mix, the regular ratios of aggregates, water, and cementitious material remain intact. On a weight-for-weight basis, GGBS is utilized as a straight replacement for Portland cement. GGBS (Ground Granulated Blast Furnace Slag) is a by-product of the iron-making blast furnaces. These run at around 1500 degrees Celsius and are fed with a precisely regulated blend of iron ore, coke, and limestone. The iron ore is converted to iron, with the remaining components coming from a slag that floats on top.

This slag is periodically tapped off as a molten liquid, and it must be quickly cooled in vast amounts of water if it is to be employed in the production of GGBS. The quenching improves the cementitious characteristics and creates coarse sand-like granules. After that, the "granulated" slag is dried and milled into a fine sand. Although it is commonly referred to as "GGBS" in the UK, it can alternatively be called "GGBS" or "Slag cement." Fine aggregate, coarse aggregate, and cement are used to make concrete. The fundamental issue is that traditional building materials are decreasing, thus we're on the lookout for alternatives, which brings us to the goal of GGBS. Because it is a waste and a by-product, using it properly to some extent contributes to a greener environment while also ensuring that the strength of the concrete is not compromised.

II.LITERACTURE REVIEW

This chapter reviews the literature, including a brief glossary of terms and previous research on recycled glass sand (RGS) and GGBS. Studies on the activation of low-calcium and high-calcium fly ashes and natural pozzolans; studies on the GGBS addition of properties of concrete, namely workability and mechanical properties; studies on the GGBS addition of properties of concrete, namely workability and mechanical properties; studies on the GGBS addition of properties of concrete, namely workability and mechanical properties; studies on the GGBS addition of properties of concrete, namely workability and mechanical properties; studies on the GGBS addition of The study of mix proportioning methods, the effect of elevated temperature, mechanical and durability properties, and the influence of recycled glass sand and GGBS in concrete are all included in this paper. The material on recycled glass sand and GGBS that was accessible at the time was evaluated and presented.

Rakesh Sakale et al. [1] investigated the effects of replacing cement with waste glass sand in percentages of 10%, 20%, 30%, and 40% by volume of cement, respectively, on compressive strength, split tensile strength, workability, and flexural strength. The compressive, flexural, and split tensile strengths of concrete are shown to increase initially as the percentage of cement replaced by glass sand increases, peaking at around 20% and then declining. As the fraction of cement replaced by glass sand increases, the workability of concrete decreases monotonically. Glass sand can be used to substitute cement up to 20% of the time without affecting compressive strength.

Oluko et al. [2] studied the compressive strength of Compressed Stabilized Earth Block (CSEB) by partially substituting the cement (stabilizer) in the block with Waste Glass Sand (WGP), and discovered that the strength of compressed stabilized earth block decreases as WGP is added to it. CSEB with WGP had strengths higher than 3N/mm2 specified as minimum strength for CSEB at 28 days for the percentage of replacements used in this investigation, the highest of which was 60%. Although no optimum value for WGP addition to the CSEB as a replacement for cement was found, at 20% replacement of cement with WGP in the CSEB, sufficient strengths strong enough for handling at early stages of the CSEB, whether at particle sizes of 150 m or 75 m, were attained. It might be concluded that WGP serves as a filler rather than a binder in CSEB.

Shuhua Liu et al. [3] investigated the inhibitory effect of waste glass sand (WGP) on waste glass aggregate-induced Alkali-Silica Reaction (ASR) growth. These investigations found that sand containing more than 30% glass aggregate poses an ASR danger when the ASR expansion rate exceeds 0.2 percent. WGP, on the other hand, can successfully control ASR expansion and keep the glass aggregate-induced expansion rate below 0.1 percent. The anti-correlation between the specific surface area of WGP and the ASR expansion causes the pozzolanic reaction to be more intense and faster, with a greater inhibitory influence on ASR expansion. When the WGP concentration is 10%, 20%, or 30%, and the specific surface area is larger than 1137.40, 604.37, or 71.34m2/kg, respectively, or when the average particle size is low, the ASR expansion can be controlled in a safe range.

Raghavendra K. and Virendra Kumara K. N [4] studied the compressive strength, split tensile strength, and water absorption of M40 grade concrete mixes with a constant 20% waste glass sand replacement in cement and a partial waste foundry sand replacement in fine aggregate. The strength gained on the 7th and 14th days was quite low, but it increased on the 28th day, according to the test results. At a 40% replacement level in strength parameters, high strength values were discovered. At 7, 14, and 28 days, the compressive strength and split tensile strength of concrete improves initially as the fraction of waste glass sand and waste foundry sand replaced increases, peaking at roughly A40 and A40, respectively.

Ana Mafalda Matos [5] wanted to see if leftover glass sand could be used in sand type SCC. It may be concluded that waste glass sand can be successfully employed in SCC to improve chloride penetration and water absorption through capillary while preserving strength levels. Despite the high alkali concentration of soda lime glass, using ground waste glass as a cement replacement in mortar enhanced ASR resistance. These findings support the pozzolanic nature of glass sand and its long-term behavior. Despite the fact that glass sand is a little coarser than cement, it still has benefits when used in cement.

Jitendra B. Jangid and A.C. Saoji [6] tested the Workability, Compressive Strength, Split Tensile Strength, Alkalinity test, Density Measurement, Water Absorption test, Volume of permeability test, and Ultrasonic Pulse Velocity test of Glass Sand varying partially from 0 to 40%, at intervals of 10%, and compared the results to those of conventional concrete at 7, 28, and 56 days. The overall test result indicated that waste glass sand might be used as an effective cement substitute in concrete. It was also discovered that when the quantity of glass sand in concrete grows, the workability of the concrete diminishes. The best compressive strength was recorded when Glass Liquid Sand (GLP) replacement was about 20%. Slump value of the experiment's concrete varies from 60 to 80 mm. When GLP replacement is around 20%, the highest split tensile strength is seen.

III. MATERIALS AND EXPERIMENTATION

In this section various materials are used for investigation and experimental methods conducted are discussed in detail. The detailed methodology employed is to be presented.

Cement:

Cement is a binder material, which is used in construction that sets and binds to another material together. In the present investigation, commercially available 53 grade ordinary Portland cement was supplied by UltraTech cement with specific gravity of 3.15 and fineness modulus of $225m^2/kg$ was used.

Aggregate:

After cement, the aggregate is the basic material used in any concrete to comprise the body of concrete for increasing the strength to the material quantity, and to minimize the consequential volume change of concrete.

Fine Aggregate:

For filling the voids present in coarse aggregate, the fine aggregates usage plays a important role in concrete. In this investigation natural sand was used as fine aggregate. Sand was obtained from Kundhu River near Nandyal in Kurnool district.

Coarse Aggregate:

In the present investigation crushed aggregates of 20mm size was used. The specific gravity of coarse aggregate is 2.75. The aggregate was obtained from crushing machine nearby college surrounding areas.

Recycled Glass Sand:

Brown-coloured, soda-lime glass beer bottles were collected from a local waste recycler. The bottles were soaked in tap water for one day to remove residua. Then it was cleaned manually with scrubber. After that, they were air dried and crushed using a road roller. The glasses were reduced to a smaller size. The crushed glass was then sieved through 4.75mm IS sieve and the retained pieces of glass were discarded. The glass particles were again sieved through a set of IS sieves. The glass passing through 2.36mm IS sieve and retained on 300µm IS sieve was chosen.

Ground Granulated Blast Furnace Slag

As GGBS is a by-product of iron manufacturing industry, it is reported that the production of one tonne of GGBS would consume only about 1300 MJ of energy which is lesser than the 5000MJ of energy which is required for the manufacture of one tonne of Portland cement.

Manufacturing of Portland cement would require approximately 1.5 tonnes of mineral extractions and would generate 0.95 ton of CO_2 equivalent. On The other hand, GGBS would generate only about 0.07 ton of CO_2 equivalent

Ground granulated blast furnace slag is off-white in colour. If the replacement is greater than 50% this whiter colour is also seen in concrete made with GGBS, the more aesthetically pleasing appearance of GGBS concrete can help soften the visual impact of large structures such as bridges and retaining walls. For colored concrete, the pigment requirements are often reduced with GGBS and the colors are brighter.

Mix Proportions:

In the present investigation M30 grade concrete is used with a constant W/C ratio of 0.5. Concrete mixes were prepared by varying the percentage of replacement of Fine aggregate with Recycled Glass Sand as constant 0%, 10%,15%, 20%, and 25% and cement replaced with GGBS constant as 15%.

Mix Designation	Proportions of Binding Materials
A1	Normal Concrete
A2	15% GGBS + 0% Glass Sand
A3	15% GGBS+ 10% Glass Sand
A4	15% GGBS+ 15% Glass Sand
A5	15% GGBS+ 20% Glass Sand
A6	15% GGBS + 25% Glass Sand

Batching:

Batching is the process of measuring the quantities of concrete either by volume or by mass for preparation of concrete mix. In this weight batching method is adopted to measure the quantities of fine aggregate, cement, coarse aggregate, recycled glass sand and GGBS.

Mixing of concrete:

The ingredients of concrete in the required quantities were charged into the capacity laboratory concrete mixer. After through mixing, i.e., having achieved uniform colour, workable consistency to concrete, the concrete was delivered into the pan for casting the specimens.

IV.RESULTS & CONCLUSION

This chapter explains the mechanical properties of concrete. The compressive strength, split tensile strength and Flexure strength of mechanical tests for concrete mixture with Recycled Glass Sand and GGBS are to be tested and relative discussions are presented.

Compressive Strength:

Mix Design	Mix Proportion	Compressive strength N/mm^2				
		7-days	14-days	28-days	56-days	90-days
A1	Normal Concrete	31.86	32.34	38.67	39.45	40.23
A2	0% Recycled glass sand + 15% GGBS	32.70	33.15	38.82	39.60	40.31
A3	10% Recycled glass sand + 15% GGBS	33.23	33.92	39.24	40.10	40.45
A4	15% Recycled Glass sand+ 15% GGBS	33.94	34.25	40.21	40.47	41.72
A5	20% Recycled Glass sand + 15% GGBS	33.71	33.40	38.01	39.04	40.36
A6	25% Recycled Glass sand + 15% GGBS	33.12	32.86	37.81	38.71	38.54

Table 4.1– Compressive strength test results for RGS and GGBS

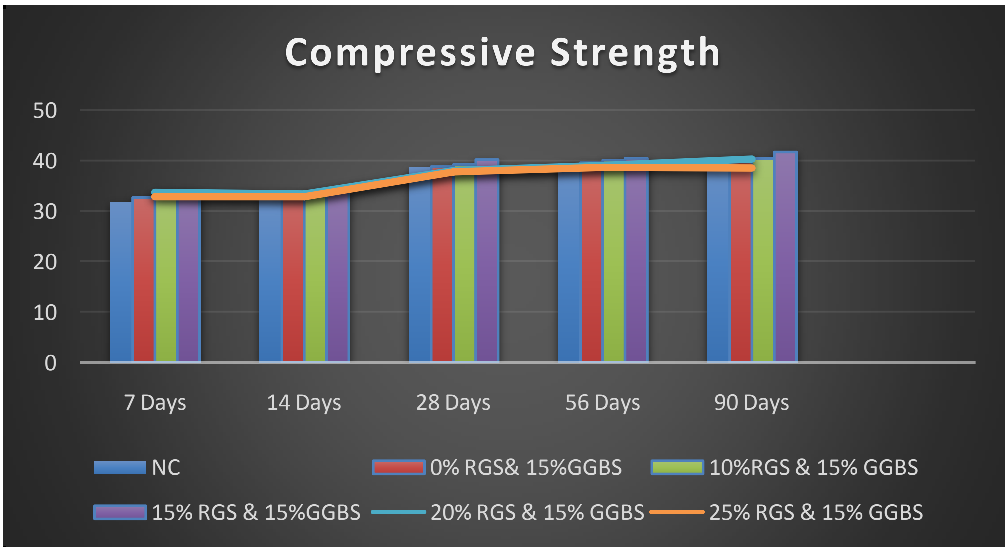

Fig. 1 Compressive Strength of Concrete for RGS and GGBS

Split Tensile Strength:

The Split Tensile strength of concrete is measured to be the most valuable and significant mechanical property of concrete since it gives the overall picture of the concrete quality.

Table 4.2– Split Tensile strength test results for RGS and GGBS

Mix Design	Proportions of coarse aggregate	Split Tensile strength N/mm^2				
		7-days	14-days	28-days	56-days	90-days
A1	Normal Concrete	2.91	3.47	4.22	4.51	4.62
A2	0% Recycled glass sand + 15% GGBS	3.2	3.52	3.92	4.1	4.21
A3	10% Recycled glass sand + 15% GGBS	3.4	3.61	3.96	4.15	4.32
A4	15% Recycled Glass sand+ 15% GGBS	3.71	3.83	3.98	4.22	4.38
A5	20% Recycled Glass sand + 15% GGBS	3.82	3.91	4.03	4.26	4.42

A6	25% Recycled Glass sand + 15% GGBS	3.66	3.71	3.80	4.02	4.14

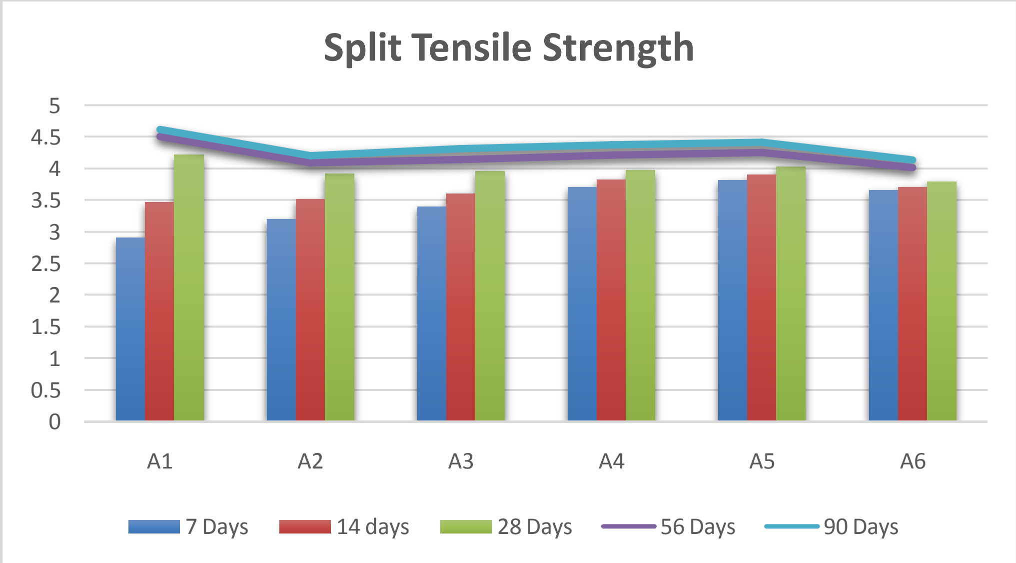

Fig.2 Split Tesile Strength of Concrete for RGS and GGBS

Flexural Strength:

The Flexural Strength of concrete is measured to be the most valuable and significant mechanical property of concrete since it gives the overall picture of the concrete quality.

Table 4.3– Flexural strength test results for RGS and GGBS

Mix Design	Proportions of coarse aggregate	Flexural strength N/mm^2		
		28 days	**56 days**	**90 days**
A1	Normal Concrete	6.13	6.31	6.87
A2	0% Recycled glass sand + 15% GGBS	4.23	4.36	4.75
A3	10% Recycled glass sand + 15% GGBS	5.76	6.14	6.61
A4	15% Recycled Glass sand+ 15% GGBS	6.18	6.53	7.10
A5	20% Recycled Glass sand + 15% GGBS	4.21	5.28	5.96
A6	25% Recycled Glass sand + 15% GGBS	3.96	4.74	4.81

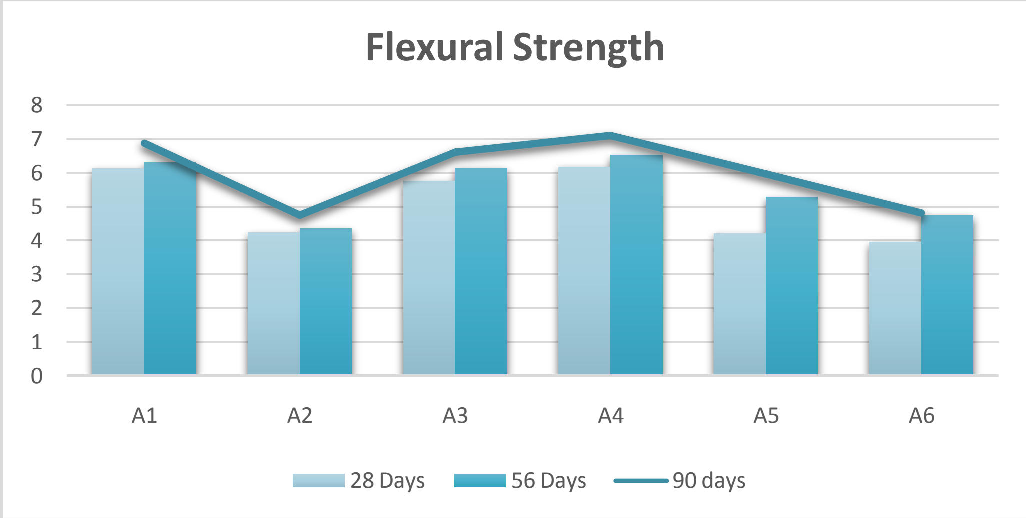

Fig.3 Flexural Strength Test of Concrete for RGS and GGBS

CONCLUSION

- Based on Research for the study of behavior of conventional by partial replacement of Recycled Glass Sand and GGBS
- The compressive strength of M_{30} concrete increases with increase in the replacement of Fine Aggregate with recycled glass sand 0%, 10%, 15%, 20% and 25% and GGBS 10% as constant and cement as proportions as Maximum compressive strength is obtained as 15% and RGS and 15% of GGBS when compared with conventional concrete.
- The Split Tensile strength of M_{30} concrete increases with increase in the replacement of Fine Aggregate with recycled glass sand 0%, 10%, 15%, 20% and 25% and GGBS 10% as constant and cement as proportions as Maximum compressive strength is obtained as 15% and RGS and 15% of GGBS when compared with conventional concrete.
- The Flexural strength of M_{30} concrete increases with increase in the replacement of Fine Aggregate with recycled glass sand 0%, 10%, 15%, 20% and 25% and GGBS 10% as constant and cement as proportions as Maximum compressive strength is obtained as 15% and RGS and 15% of GGBS when compared with conventional concrete.
- As I concluded that comparing with normal concrete the proportion 15% RGS and 15% GGBS is to be optimum where the strength is proportionally increased.

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