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# Analysing the Characteristics of Recycled Aggregate with Different Amounts of GGBS and Steel Slag

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**ABSTRACT:** Recycled aggregate is a good option to be used in concrete production as a coarse aggregate that results in environmental benefits as well as sustainable development. However, recycled aggregate causes a reduction in the mechanical and durability performance of concrete. On the other hand, the removal of industrial waste would be considerably decreased if it could be incorporated into concrete production. One of these possibilities is the substitution of the cement by slag, which enhances the concrete poor properties of recycled aggregate concrete as well as provides a decrease in cement consumption, reducing carbon dioxide production, while resolving a waste management challenge. Furthermore, steel slag was also added to enhance the tensile capacity of recycled aggregate concrete. The main goal of this study was analysing the characteristics of recycled aggregate concrete with different amount ground granulated blast-furnace slag (GGBS) and steel slag (SS). In this study GGBS has taken some percentage varying life (10%, 20%, 30% 40%), steel slag has taken some percentage of varying life (1%, 2%, 3%, 4%) and recycled aggregate has taken 40% as constant proportions. Mechanical performance was assessed through compressive strength and split tensile strength, while durability aspects were studied through water absorption, aggregate gradation of steel slag and recycled aggregate by sieve analysis and to measure the strength or quality of the materials specific gravity has done for GGBS, steel slag and recycled aggregate. The results detected from the different experiments depict that, at an optimum dose (40% RCA, 20% GGBS, and 2.0% SS) for both compressive and split tensile strength. GGBS and Steel slag gives high increase in strength when added in concrete and Incorporation of GGBS, steel slag and recycled aggregate in concrete is cost efficient, economical and good compressive and split tensile strength for concrete.

**KEYWORDS:** Compressive strength, Split tensile strength, Durability, Sustainable concrete.

## I. INTRODUCTION

The use of recycled materials in construction has gained significant attention in recent years due to environmental concerns and the need for sustainable building practices. Among these recycled materials, recycled aggregate concrete (RAC) has emerged as a promising alternative to traditional concrete. Traditional concrete production involves the extraction of natural aggregates and the consumption of significant amounts of energy and resources, contributing to environmental degradation and carbon emissions. In contrast, recycled aggregate concrete utilizes crushed concrete as a replacement for natural aggregates, reducing the demand for virgin materials and minimizing construction waste. The incorporation of GGBS, a by-product of the iron and steel industry and steel slag, a by-product of steel manufacturing, can further enhance the environmental benefits of RAC by reducing its carbon footprint. This research project focuses on analysing the characteristics of recycled aggregate concrete with different amounts of Ground Granulated Blast Furnace Slag (GGBS) and steel slag, two supplementary materials that can further enhance the performance and sustainability of concrete. The different cementitious materials such as fly ash, silica fume, waste glass, wheat straw ash, marble waste, bentonite clay as well as GGBS are the some cementitious materials can be used in concrete production. Ground granulated blast-furnace slag (GGBS) is an industrial waste by-product material that is rich in amorphous calcium, silica, and alumina, which makes it appropriate to utilize as a binder in cement concrete production. GGBS is widely used in several civil engineering projects to replace cement in concrete production. GGBS is an industrial by-product achieved in steel production and is generally utilized as a binding material in cement concrete production, since it enhances the mechanical performance of concrete and decreases permeability by improving the interface with the aggregate. The recycled aggregate concrete (RAC) is made by crushing, sieving, and cleaning the waste material from demolished concrete. Using recycled aggregates (RA) likewise decreases the raw material demand by extracting them from the ground, which also reduces the negative environmental effects. Compressive strength and other characteristics of RAC are affected by parent concrete properties, workability, mix proportion, etc. The mechanical and durability performance of RAC is very low compared to concrete with natural aggregates. This lower

performance of RAC could be reduced by utilizing fractional substitution of pozzolanic materials and mineral admixtures. These materials and admixtures enhance durability by filling the RAC porous microstructure and thus Materials reducing the RAC permeability. It has been concluded that RAC reduced the performance of concrete considerably. Therefore, it is recommended that it is necessary to use cementitious materials in recycled aggregate concrete to improve its permeance. It has also been recommended that it is necessary to add secondary cementitious materials such as steel slag and GGBS into the recycled aggregate concrete to improve their performance.

## II. METHODOLOGY

In this experimental study, M40 grade concrete is designed as per the IS code. The materials are collected i.e. cement, fine aggregate, coarse aggregate, GGBS, steel slag and recycled aggregate with the control concrete with 10%, 20%, 30% and 40% of cement is partially replaced with the GGBS , 1%, 2%, 3% and 4% of fine aggregate is partially replaced with steel slag and 40% recycled aggregate concrete is partially constant replacement in coarse aggregate. The mould is casted for both conventional concrete and replaced concrete with GGBS, recycled aggregate concrete and steel slag. Casted specimen are cured in water for 7, 14, 28 days respectively. After curing, the compression strength test is conducted at 7, 14 and 28days and split tensile strength test is conducted at 7 and 28 days. These cubes are tested for each designation and average of three results will be taken. Mould is cleaned properly and greased with Mould oil. Concrete is placed in the Mould of dimension 150mmX150mmX150mm in 3 layers each layer of height approximately 50mm. After the placement of first layer of concrete it is compacted by a tamping rod of 16mm diameter, 0.6m long and bullet pointed at the lower end. The stroke of the bar is uniformly distributed over the cross section of the mould. Each layer is compacted with 35 strokes and next scoop of concrete is placed followed by same manner of compaction and top layer is finished.

The cylindrical moulds of 300mm length and 150mm diameter are cleaned properly and greased with oil. Concrete is placed in mould in 3 layers, each is approximately 1/3th the mould. After the placement of first layer of concrete it is compacted by using a tamping rod of 16mm diameter 600mm long and bullet pointed at the lower end .the stoker of the bar are uniformly distributed over the cross section or the mould. Each layer is compacted with 25 strokes and the next scoop of the concrete is placed followed the same manner of compaction and the top layer is finished.

## III. EXPERIMENTAL RESULTS

The properties and the quantity of proportions remain same for all the mixes but the percentage of admixtures changes for every mixes. The strengths of self-curing concrete is compared to the strengths of normal concrete

### COMPRESSIVE STRENGTH RESULTS FOR DIFFERENT PERCENTAGE OF GGBS , STEEL SLAG AND RECYCLED AGGREGATE FOR M40 GRADE

SL NO	Percentage replacement of GGBS	Percentage replacement of Steel slag	Percentage replacement of RAC	Compressive strength in MPa		
				7 days	14 days	28 days
1	0	0	0	23.71	26.39	36.63
2	10	1	40	29.91	31.46	41.45
3	20	2	40	31.21	34.01	48.33
4	30	3	40	30.74	31.61	42.15
5	40	4	40	30.34	30.90	38.46

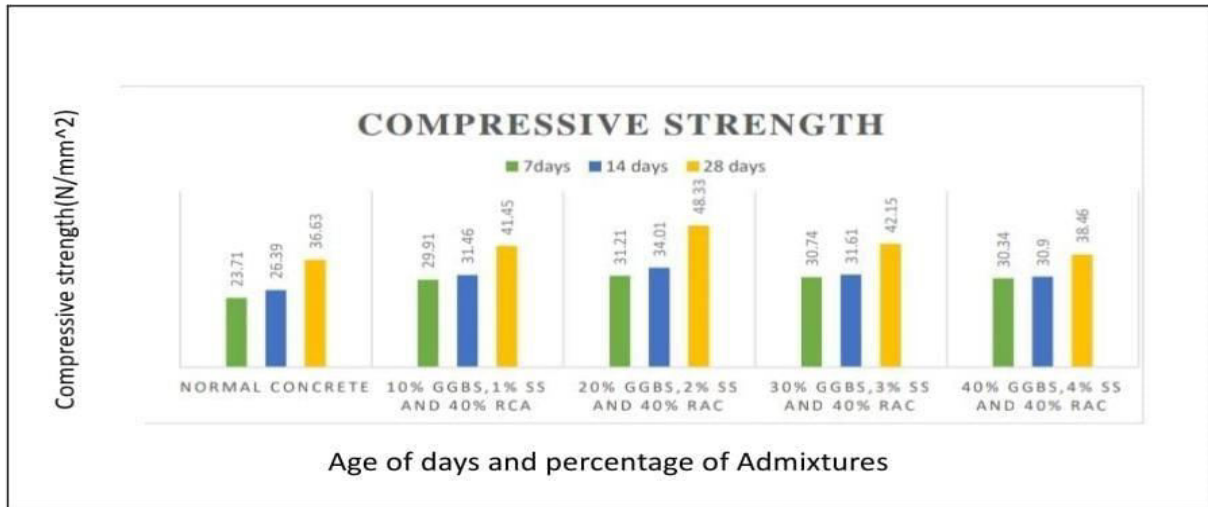


Fig 1. Compressive strength of concrete

The optimum value of compressive strength is obtained at 20% replacement of GGBS in cement, 2% replacement of Steel slag in fine aggregate and 40% replacement of recycled aggregate concrete in coarse aggregate.

**SPLIT TENSILE STRENGTH RESULTS FOR DIFFERENT PERCENTAGE OF GGBS, STEEL SLAG AND RECYCLED AGGREGATE FOR M40 GRADE**

SL NO	Percentage replacement of GGBS	Percentage replacement of Steel slag	Percentage replacement of RAC	Split tensile strength in MPa	
				7 days	28 days
1	0	0	0	0.52	1.67
2	10	1	40	0.96	1.95
3	20	2	40	1.31	2.23
4	30	3	40	1.08	1.99
5	40	4	40	0.86	1.71

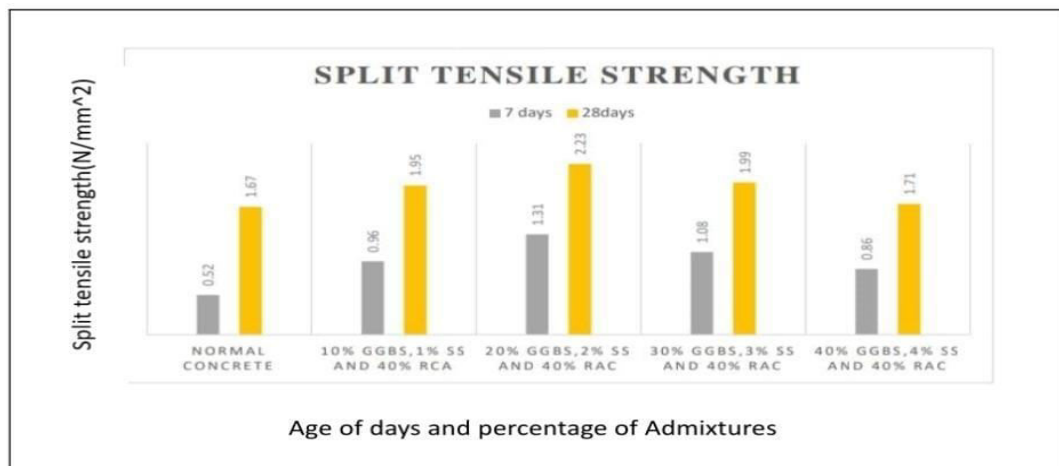


Fig 2. Split tensile strength of concrete

The optimum value of split tensile strength is obtained at 20% replacement of GGBS in cement, 2% replacement of Steel slag in fine aggregate and 40% replacement of recycled aggregate concrete in coarse aggregate.

#### IV. CONCLUSION

The Compressive strength and split tensile strength of concrete M40 grade mix is obtained by increase with increase in percentage of GGBS and steel slag with constant percentage of recycled aggregate as compared to conventional/normal concrete. It is noticed that the maximum results is obtained for 20% replacement of GGBS in cement, 2% replacement of steel slag in fine aggregate and 40% of recycled aggregate in coarse aggregate. The partial replacement of GGBS in cement with varying percentage as 0%, 10%, 20%, 30% and 40%, steel slag in fine aggregate with varying percentage as 0%, 1%, 2%, 3%, 4% and recycled aggregate in coarse aggregate with constant percentage as 40%, the strength results will increase upto 20% replacement of GGBS, 2% replacement of steel slag and 40% replacement of recycled aggregate. further varying the strength starts to decrease when compared with the conventional concrete. The optimum result is obtained for 20% GGBS, 2% Steel slag and 40% recycled aggregate replacement. GGBS and Steel slag gives high increase in strength when added in concrete. Incorporation of GGBS, steel slag and recycled aggregate in concrete is cost efficient and economical.

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