COMPARATIVE STUDY ON GREEN CONCRETE WHILE USING RECYCLED AGGREGATES, SILICA FUMES AND BAGASSE ASH

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Abstract: *Every development leads to some negative impact on the environment; concrete is also one of them that have an enormous toll on the environment. The prime ingredient to concrete is the cement that contributes around 2.5 billion tonnes of CO2 which is being emitted in the environment per year. Different researchers have tried and succeeded to replace cement (a root cause of environmental degradation) with other eco-friendly and waste materials such as fly ash, slag, bagasse ash, rice husk ash, silica fumes and aggregates by iron slag, recycled concrete aggregates etc. The current study involves the partial substitution of cement & coarse aggregates at various levels with bagasse ash (5%, 10% and 15%) & silica fumes (5%, 10% and 15%), recycled coarse aggregates (15%, 30% and 45%) respectively to produce green concrete and the obtained results were compared with the results of previous conducted studies.*

Keywords: **Green Concrete, Aggregate Substitution, Cement Substitution.**

1. INTRODUCTION

Unlike primitive times, the concrete industry has become the most imperative part of the modern era and the demand for this material has reached beyond any imagination. Concrete is a material that is produced by mixing cement, aggregates, water, and admixtures and entails different strengths and behavior depending upon the proportion of raw materials. The concrete industry has positive as well as negative impacts on our society and environment as this material has transformed the planet Earth drastically in many ways and became the foundation of the modern world. The production is on a high scale throughout the globe but still meeting the daily construction demands is difficult, perhaps, due to the availability of raw materials or the demand for this product being enormous.

Since, in the modern era, every development leads to some negative impact on the environment, concrete is also one of them that have an enormous toll on the environment. The prime ingredient to concrete is the cement that is being manufactured over 4 billion tonnes per annum and it alone contributes around 2.5 billion tonnes of CO2 emitted in the environment per year which is approximately 8% of the total CO2 emissions. The manufacturing industry of cement also needs large land equivalent to two football fields. Due to these reasons, concrete is being considered to be a hazardous material rather than a boon. Many environmentalists and researchers are trying their best to overpower the negative impact by conducting various research and surveys. Professors and different researchers have tried and succeeded to replace cement (a root cause of environmental degradation) with other eco-friendly and waste materials such as fly ash, slag, bagasse ash, water powder from marble, wood, and many other industries. Green concrete is a concrete developed that reduces the environmental impact. In the production of green concrete, one or more raw materials were replaced with environmentally friendly materials to minimize the detrimental effects of concrete on the ecosystem.

Recycled concrete aggregates are extensively used to minimize the disposal problem of dismantled structures and reduce the utilization of raw aggregates. These aggregates exhibit the same properties as those raw aggregates. For replacing cement, many researchers have used silica fumes and bagasse ash in the concrete manufacturing process and they also succeeded in improving the different properties of concrete when these materials were used.

2. LITERATURE

In the past two decades, a plethora of research work has been conducted while using different materials that have the ability to fully or partially substitute the raw material of concrete such as the replacement of cement [4,8,11,18], replacement of aggregates [5,7,10,20], etc. But repeated experimental work has been done by using silica fumes, bagasse ash, and recycled aggregates in an attempt to minimize the burden of pollution on the environment and the utilization of raw materials in the production of cement. Different studies have revealed that the chemical composition of silica fume and bagasse ash aid them to become a good binding material that can be utilized to replace cement in concrete shown in table 1. The cementitious behavior of these materials is perhaps due to the high degree of fine particles. However, the chemical composition and the degree of fineness are highly dependent on the source of the material. The available literature for the replacement of cement with silica fumes and bagasse ash surely suggests that the effect of these replacement materials enhances the mechanical properties (such as compressive, flexural, and tensile strength) of concrete. However, sometimes it exhibits a negative effect on concrete by reducing the strength. Moreover, the replacement of Fine and coarse aggregates with recycled crushed aggregates is also an imperative study and helps in reducing the burden of utilization of raw aggregates.

Table 1. Chemical composition of Cement, Silica Fumes and Bagasse ash.

Compound	Cement (%)	Silica Fume (%)	Bagasse Ash (%)
SiO_2	26.2	93.15	66.48
Al_2O_3	6.4	0.82	28.65
Fe_2O_3	5.8	1.45	4.11
CaO	56.2	0.81	1.95
MgO	2.9	0.24	0.83
SO_3	3.4	-	0.54
Na_2O	0.12	0.70	0.10

3. EXPERIMENTAL PROGRAM

The current study involves the partial substitution of cement & coarse aggregates at various levels with bagasse ash (5%, 10% and 15%) & silica fumes (5%, 10% and 15%), recycled coarse aggregates (15%, 30% and 45%) respectively to produce green concrete. For this purpose, M25 grade of concrete and raw cement of grade 43 was considered. Replacement material (bagasse ash, silica fume and recycled concrete aggregates RCA) were collected from local source and their properties were tested. Specific gravity of cement, BA, SF, RCA was 3.15, 1.85, 2.25, 2.35g/cc respectively. To determine the mechanical properties of control and green concrete, compressive strength test and split tensile strength test were carried out.

Table 2. Various Concrete mixes

Mix Designation	BA%, SF%, RCA%
CM	-
ARC1	5%, 5%, 15%
ARC2	5%, 5%, 30%
ARC3	5%, 5%, 45%
BRC1	10%, 10%, 15%
BRC2	10%, 10%, 30%
BRC3	10%, 10%, 45%
CRC1	15%, 15%, 15%
CRC2	15%, 15%, 30%
CRC3	15%, 15%, 455%

4. RESULTS

The results of Compressive strength test and split tensile strength test were collected and represented in table 4, fig.1 and fig. 2. The compressive strength of control mix comes out to be 21.4 MPa and 30.6 MPa at 7 days and 28 days respectively and maximum compressive strength was attained for BRC2 i.e., 23.1 MPa at 7 days and 32.2 MPa at 28 days. Whereas, the split tensile strength of control mix comes out to be 2.1 MPa and 2.85 MPa at 7 days and 28 days respectively and maximum split tensile strength was attained for BRC2 i.e. 2.13 MPa and 3.02 MPa at 7 days and 28 days respectively.

Table 4. Laboratory Test Results for various concrete mixes.

Mix Designation	C.S. at 7 days	C.S. at 28 days	S.T.S. at 7 days	S.T.S. at 28 days
CM	21.4	30.6	2.1	2.85
ARC1	20.6	28.9	1.85	2.73
ARC2	21.1	29.3	1.95	2.82
ARC3	20.2	28.2	2.05	2.85
BRC1	22.9	31.5	2.00	2.81
BRC2	23.1	32.2	2.13	3.02
BRC3	22.2	31.2	1.98	2.79
CRC1	20.5	27.6	1.89	2.75
CRC2	19.9	27	1.82	2.66
CRC3	18.7	26.2	1.73	2.51

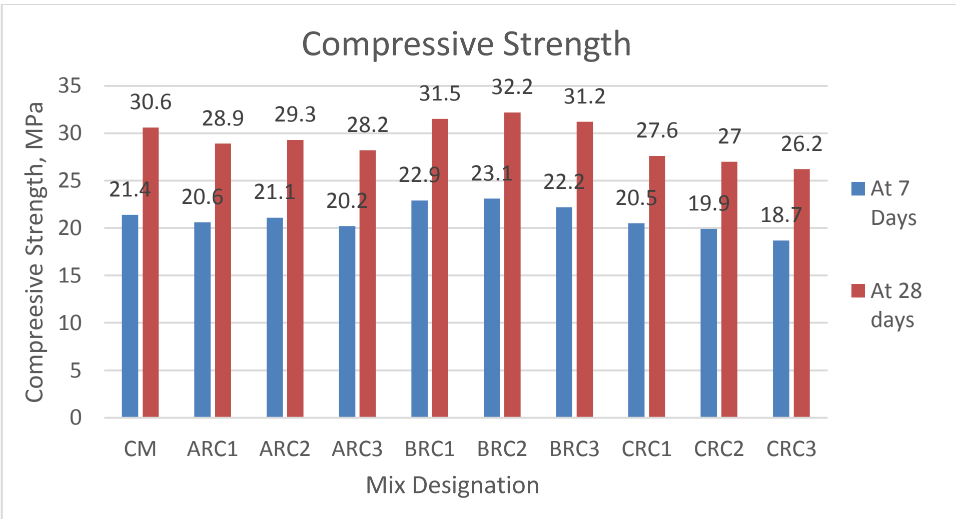

Figure 1. Effect of Replacement on Compressive Strength.

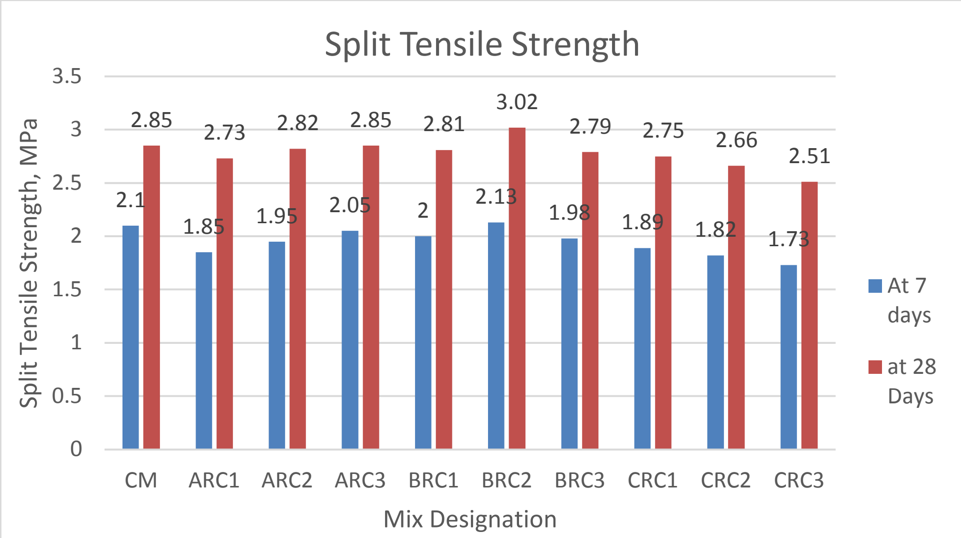

Figure 2. Effect of Replacement on Split Tensile Strength.

Now to understand the behavior of these replacement materials in concrete, a comparison was made between some of the previous research studies and the present study. Table 5 shows the performance effect of replacement materials SF, BA and RCA while replacing cement and aggregates on mechanical properties of concrete.

Table 5. Effect on Mechanical Properties while using SF, BA and RCA.

Material	Concrete Grade	Replacement Level (%)	Mechanical Property	Optimum Dose	Effect (max % inc. or dec.)	RF
BA	M25	5, 10, 15, 20, 25, 30	CS, STS	Up to 20%	Max CS inc.:15% Max STS inc.: 10%	[1]
BA & RCA	M45	BA: 20, 35, 50 RCA: 100	CS	20% with minimum decrease	Max dec.: 21% at 50% BA	[3]
BA	M65	10, 20, 30	CS	10%	Max CS inc.: 5%	[2]
SF, FA	M65	SF: 5, 10 FA: 10	CS, STS	5%	Max CS dec.: 14% at 10% Max STS dec.: 23% at 10%	[13]
RCA		F-RCA: 15, 30, 70, 100 C-RCA: 15, 30, 70, 100	CS	Upto 30%	Max inc.: 2.5%	[14]
BA, RCA	M60	BA: 20, 35, 50 RCA: 100	CS	20% with minimum decrease	Max dec.: 18% at 50% BA	[16]
BA, MS	M40	BA: 5, 10, 15, 20 MS: 10	CS, FS	10%	Max CS inc.:7.5% Max FS inc.: 8%	[19]
SF, BA, RCA	M25	SF: 5, 10, 15 BA: 5, 10, 15 RCA: 15, 30, 45	CS, STS	SF: 10 BA: 10 RCA: 30	Max CS inc.:6% Max FS inc.: 6%	Present Study

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Note: BA= Bagasse Ash, RCA= Recycled concrete aggregate, SF= Silica Fume, MS= Micro Silica, GGBS: Ground Granulated Blast Furnace Slag, CS= Compressive Strength, STS= Split Tensile Strength, FS= Flexural Strength.

5. CONCLUSION

This paper emphasis on utilization of waste and end product of different industries to replace the cement and natural aggregates. After scrutinizing and comparing all the previous researches and current experimental work, the final conclusion was drawn. It is concluded that the optimum replacing percentage of cement by BA and SF is less than 20% whereas, the optimum replacing percentage of natural aggregates by RCA is less than 30% through which maximum strength results were obtained.

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