INVESTIGATION ON STRENGTH OF CONCRETE WITH MINERAL ADMIXTURES

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ABSTRACT

Concrete is a most broadly and commonly utilized construction material right now and about six billion tonnes was produced each year and was next to the water production. However for the production of cement which is considered as a primary substance for the concrete production and this heavy production of cement can damage the atmosphere by releasing Carbon-di oxide. Therefore, the concept of green concrete is introduced to lessen the damage caused by the production of cement. In this work, investigation is made on properties of concrete when it is partially replaced with Ground granulated blast slag (GGBS) and Silica fume instead of cement. On account of its physical and chemical properties, it is more reactive pozzolanic substitute. Silica fume when added to concrete provides high strength and can be highly durable. The replacement levels of 30%, 50% and 70% of cement with GGBS and 5% of Silica fume is added onto the 50% of GGBS on concrete cubes of 150x150x150 mm size on M20 and M40 grades of concrete. The replacement level 30% of cement with GGBS is considered to be the optimum replacement level. The curing periods for these cubes and cylinders were 7 days, 28 days and 56 days.

KEYWORDS: Concrete, Production, Compressive Strength, Split Tensile Strength, Replacement, Percentage

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INTRODUCTION

Cement is basic constituent for the preparation of the concrete and nearly 6 billion tonnes is produced per year and due to this heavy production of cement there maybe damage to the atmosphere due to the release of CO₂ to the atmosphere. Due to this release, green concrete is adopted worldwide and is effective because of the use of wastage residues from the various manufacturing industries which have similar properties similar to cement. These wastage residues can be used in concrete in the place of cement either wholly or partially. The presence of 12% of Portland cement accounts for 93% of strength of the cement concrete. This combination of the waste products by replacing the cement is together called as a self-compacting concrete and its important factor is developed by increasing the performance of concrete and the working environment. SCC is highly effective in terms of binding and durability properties.

GGBS is a residual material obtained in the processing of iron ore. The GGBS composition exactly similar to the cement composition and so it is used. The use of GGBS can also have resistance to the permeability of water into the concrete structures and also have high resistance towards the corrosion of the reinforcement from various harmful gases like sulphates and chlorides. Due to the micro-structural properties the use of GGBS can also used as a micro-filler in the concrete structures. This use of GGBS can cause reduction in the dumping of waste. Effective usage of GGBS reduces atmospheric pollution. It also subsequently enhances service lifetime and reduce maintenance cost

Silica fume is an amorphous polymorph of silicon di-oxide. During the silicon and ferrosilicon alloy

manufacture, a residual material which is an ultra-fine powder is collected and is called as silica fume. During the last three decades, mainly Silica fume (SF) and fly ash individually or in combination are incomparable in production of high strength concrete for practical application in construction. The use of silica fume can enhance the various properties such as cohesiveness, strength, permeability and durability. Silica fume concrete may be highly used in places where high abrasion resistance and low permeability are of utmost importance or where very high cohesive mixes are required to avoid segregation and bleeding.

REVIEW OF LITERATURE

Bahador Sabet Divsholi et al have experimented that by the usage of GGBS the micro-pore structure in the concrete was reduced. In the compression testing, it was found that the replacement level of 30% of GGBS found to be good and the value of slump was increased by 20%, 35% and 55%. **Mohan kumar et al** have made a research that by using GGBS at varied percentages and found that the about 20% GGBS have better compression and tensile strength after certain days of curing. It has better resistance power against Concentrated Hydrochloric acid (HCl) and Sodium hydroxide (NaOH) for replacement level of GGBS of about 50% in M40 grade concrete. **J. Vengadesh et al** have made a study on mechanical properties GGBS for the percentage replacement levels of about 25%,30%,35% and 40%. In this study he found that the GGBS of about 25% replacement has maximum compressive strength, it improves the flexural strength also. However, there is reduction in strength beyond 30% replacement level. **Santosh Kumar Karri et al** had done a work on obtaining maximum strength by using GGBS for the replacement levels of about 0%,30%,40% and 50% for various tests for 28 and 90 days of curing under water for two different mixes of concrete and the highest strength is achieved in 40% of replacement. **A. Jayseeliabitha et al** found a research on the replacement levels of about 0%, 10%,20% and 30% of GGBS and micro silica each and have found that for 30% of replacement the strength is enhanced abruptly in mechanical characteristic tests compared to conventional concrete. **Shreyas. K** have made an experiment by altering the use of admixture GGBS in the place of cement for the replacement level of 30% and have obtained maximum strength in mechanical testing mechanisms. Also, replacement above 40% can increase the durability and workability characteristics of the concrete.

EXPERIMENTAL WORK

Methodology

- The basic materials for casting such as manufactured sand, cement and coarse aggregate with admixtures like GGBS and silica fume were collected
- The preliminary tests were done on these basic materials and those values were noted down
- With those initial test values, design mix was calculated for M20 and M40 grade concrete by using IS 10262:2009
- According to the mix design, the cubes and cylinders were casted for these grade concrete mixes along with the varied percentages of GGBS and silica fume
- These cubes and cylinders were then tested under compression testing machine
- Optimum replacement level for M20 grade mix and for M40 grade mix of concrete with replacement percentages were found

PROPERTIES OF MATERIALS

Cement

Construction industry is highly dependent on the basic material called cement. When present in concrete produces increase in microstructural properties for its better performance. In this project work, 53 grade of cement is used.

Table 1: Properties of Cement

Specific Gravity	3.14
Fineness	3%
Consistency	30%
Initial Setting Time	40 minutes

Fine Aggregate

In my present work, manufactured sand was replaced by river sand. It is one of the important constituents of concrete. It possess high strength, durability and shape characteristics.

Table 2: Properties of M. Sand

Specific Gravity	2.81
Grade Zone	ZONE II

Coarse Aggregate

It is the basic material used in the concrete mix. They are also used in the preparation of the moisture break under the slab and vapour barrier. Here, we use aggregate passing below 20 mm of size sieve.

Table 3: Properties of Coarse Aggregate

Specific Gravity	2.85
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GGBS

Ground granulated blast slag is a resulting product from heating of molten iron slag at several temperatures in a water or stream from blast furnace. This is then kept for drying and was powdered to form a glassy and granular product called GGBS.

Table 4: Properties of GGBS

Specific Gravity	2.54
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Silica Fume

Silica fume is a resulting material obtained by manufacturing of a silicon metal. This is one of the important addition to the concrete to improve its quality.

Table 5: Properties of Silica Fume

Specific Gravity	2.24
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EXPERIMENTAL INVESTIGATION

General

The concrete cubes of size 150mmx150mm and concrete cylinders of size 100 mm (diameter) and 200 mm(height) were both casted for M20 and M40 mix of concrete as per IS 10262-2009. The different replacement percentages of GGBS and silica fume is done along with the conventional mix design calculation and the mix proportions were formulated.

Mix Design

M20 and M40 grademix along with admixtures of GGBS and Silica fume are obtained at various replacement percentages.

Mix Design for M20 Grade Concrete

The M20 grade mix design calculation is done and the quantity of materials is calculated and tabulated in table 7.

Table 6: Stipulations for Proportioning of M20 Concrete Mix

S. NO	DESCRIPTION	VALUES
1	Grade of concrete	M20
2	Type of cement	OPC 53 grade
3	Maximum size of aggregate	20 mm
4	Aggregate type	Crushed angular aggregate
5	Exposure condition	Moderate
6	Maximum water cement ratio	0.5
7	Minimum cement content	300 kg/m ³
8	Maximum cement content	383.16 kg/m ³
9	Workability	75 mm slump

Table 7: Quantity of Materials for M20 Grade Concrete

MATERIALS Kg/m ³	GGBS CONTENT			
	0%	30%	50%	70%
Cement	383.16	268.21	191.58	114.95
Coarse aggregate	1194.49	1180.36	1169.75	1157.39
Fine aggregate	721.83	713.29	706.88	699.41
GGBS	0	114.95	191.58	268.2
Water	192	192	192	192
Silica fume	0	0	19.16	0

Comparing the values of table 7 the mix ratio for M20 grade of concrete is found to be

Cement	:	Fine aggregate	:	Coarse aggregate	:	Water
1		1.88		3.1		0.5

Mix Design for M40 Grade Concrete

The M40 grade mix design calculation is done and the quantity of materials is calculated and tabulated in table 9.

Table 8: Stipulations for Proportioning of M40 Concrete Mix

S. NO	DESCRIPTION	VALUES
1	Grade of concrete	M40
2	Type of cement	OPC 53 grade
3	Maximum size of aggregate	20 mm
4	Aggregate type	Crushed angular aggregate
5	Exposure condition	Moderate
6	Maximum water cement ratio	0.4
7	Minimum cement content	300 kg/m ³
8	Maximum cement content	478.95 kg/m ³
9	Workability	75 mm slump

Table 9: Quantity of Materials for M40 Grade Concrete

MATERIALS Kg/m ³	GGBS CONTENT			
	0%	30%	50%	70%
Cement	478.95	335.10	239.48	143.69
Coarse aggregate	1178.30	1156.42	1149.38	1129.38
Fine aggregate	653.49	641.35	634.68	626.38
GGBS	0	143.69	239.48	335.27
Water	192	192	192	192
Silica fume	0	0	23.95	0

Comparing the values of table 9 the mix ratio for M40 grade of concrete is found to be

Cement : Fine aggregate : Coarse aggregate : Water
 1 1.36 2.46 0.4

TEST AND RESULTS

Compression Test Results

The test for compression is done for the replacement percentages of 0%, 30%, 50% and 70% with GGBS and its values were obtained at varied intervals of curing and for replacement percentages of 50% of GGBS with 5% of silica fume and the results were obtained after 28 days and 56 days of curing.

Table 10: Compressive Strength for M20 Grade Concrete

Grade of Concrete	% Replacement of Cement with GGBS	Compression Strength for Specimens (N/mm ²)		
		7 days	28 days	56 days
M20	0%	25.51	27.73	37.32
	30%	18.59	33.53	37.96
	50%	25.94	32.29	31.83
	70%	12.14	21.24	22.57

Table 11: Compressive Strength for M40 Grade Concrete

Grade of Concrete	% Replacement of Cement with GGBS	Compression Strength for Specimens (N/mm ²)		
		7 days	28 days	56 days
M40	0%	29.95	39.77	41.01
	30%	24.09	36.35	42.97
	50%	32.42	29.88	33.18
	70%	18.70	18.11	26.71

Figure 1

Figure 2

Table 12: Compressive Strength for M20 Grade Concrete with 5% of Silica Fume

Grade of Concrete	% Replacement of Cement with GGBS + 5% of Silica Fume	Compression Strength for Specimens (N/mm ²)	
		28 days	56 days
M20	0%	27.73	37.32
	50%	26.02	30.47

Figure 3

Table 13: Compressive Strength for M40 Grade Concrete with 5% of Silica Fume

Grade of Concrete	% Replacement of Cement with GGBS + 5% of Silica Fume	Compression Strength for Specimens (N/mm ²)	
		28 days	56 days
M40	0%	39.77	41.01
	50%	36.68	37.50

Figure 4

Split Tensile Test Results

The test for tensile is done for the replacement percentages of 0% and 50% with GGBS and the resulting values were obtained at three intervals of curing.

Table 14: Split Tensile Strength for M20 Grade Concrete

Grade of concrete	% replacement of cement with GGBS	Split tensile strength for specimens (N/mm ²)		
		7 days	28 days	56 days
M20	0%	2.067	3.08	2.41
	50%	1.55	2.88	2.57

Figure 5

Table 15: Split Tensile Strength for M40 Grade Concrete

Grade of Concrete	% Replacement of Cement with GGBS	Split Tensile Strength for Specimens (N/mm ²)		
		7 days	28 days	56 days
M40	0%	2.85	2.36	3.44
	50%	1.45	2.67	3.74

Figure 6

CONCLUSIONS

- The compressive strength for M20 grade and M40 grade concrete mixes with 50% of cement quantity replacement with GGBS after 7 days of curing showed 1.69% and 8.24% increase respectively.
- The strength for compression for M20 grade concrete with 30% in partial replacement of cement with GGBS after 28 days of curing showed 21% increase.
- The compressive strength for M40 grade of concrete with 30% of partial replacement quantity of cement with GGBS after 56 days of curing showed 5% increase.
- The compressive strength of M20 and M40 grade concretes with 50% replacement of cement with GGBS showed increase value after 7 days of curing.
- The compressive strength of M20 grade concrete with 30% replacement of cement with GGBS showed increase value after 28 days of curing
- The compressive strength of M20 grade concrete with 30% replacement of cement with GGBS showed increase value after 56 days of curing
- The split tensile strength for M40 grade of concrete with 50% partial replacement of cement with GGBS after 56 days of curing shows the better result.

REFERENCES

1. Bahador Sabet Divsholi et al(2013), "Durability Properties and Microstructure of Ground Granulated Blast Furnace Slag Cement Concrete",.
2. Shreyas (2017) "Characteristics of GGBS as an Alternate Material in Conventional Concrete", Volume 5, Issue 4 December.
3. B.Kaviya (2017), "Study of partial replacement of cement by ground granulated blast furnace slag", Volume 116, No.13.

4. Mohan kumar et al (2017) "Strength and durability studies on concrete with partial replacement of cement with GGBS", Volume 3(8)
5. Santhoshkumar karri et al (2015) "Strength and durability studies of concrete", Volume 2 ,Issue 10.
6. A.Jayseeliabitha et al (2017) has done their work on "Experimental investigation of high strength in which cement is partially replaced with GGBS and Silica fume", Volume 8, Issue 10.
7. V.Gopi et al (2019), "Experimental Investigation on Strength and Durability of Concrete Incorporated with Silica Fume and Fly Ash", Volume 7
8. Manjunatha and Jeevan (2015), "Study of Early Age Properties and behavior of concrete with GGBS as partial replacement of cement", Volume 4 .
9. Lakhbirsingh et al (2016) has done their work on "Study on Partial Replacement of cement by Silica Fume", Volume 4, Issue 7.
10. Sonali K. Gadpliwar et al (2014) "Partial replacement of cement with the help of GGBS and RHA and replacement of Quarry sand with that of Natural sand", Volume 11, Issue 2 Ver. II .
11. Subathra Devi V et al (2018) "Investigation on the Strength and Durability of concrete with GGBS and Silica fume", Volume 8, Issue
12. Musalaiah, G., Shireesha, Y., Kumar, P. K., & Raju, P. S. (2017). Compressive and Flexural Strength Improvement of Jute Fibre Reinforced Polymer Composite. *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)*, 7(4), 235-240.
13. Purushothaman, M., & Senthamarai, R. M. (2013). Strength properties of high performance concrete using bottom ash as fine aggregate. *International Journal of Civil*, 2(3), 35-40.
14. Jerry, C., Raj, J., Vs, L., & Chacko, A. Effect of Coconut Shell Powder on the Strength of Soil.
15. Rajesh, S., Ramnath, B. V., Prashanth, B., & Kumar, M. P. An Effect of Fiber Orientation of Tensile and Compressive Properties of Natural Hybrid Composites.