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Green Concrete - A Low Cost and Sustainable Solution for a Better Environment

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Abstract: The concrete is the world's 2nd mostly used material. As the technology and population is increasing day by day the usage of concrete structures has also increased. The concrete is one materials which provides the strong and durable structures. The cost and the pollution that has been increasing day by day of the concrete, for which the cement is the cause of concern. As the cement is the material which plays a vital role in the concrete in binding and attaining and attaining the required strength. But cement is also the material which is most costly among other materials in the concrete and production of cement is been contributing in world's 5% of pollution. In the present research study silica fume(S.F) and ground granulated blast furnace slag(GGBS) are partially replaced to the cement at different percentages individually and in combinations and rare testes for mechanical and durability properties of the concrete. The results show that the S.F and GGBS have shown the better compressive strength than the normal concrete. The S.F and GGSB when added in combinations have shown better compressive strength than when they are added individually and normal concrete. The S.F and GGBS have better resistance to hydrochloric acid HCL and HNO_3 attack than the normal concrete. we were able to produce a concrete which is more safe and economical.
Keywords: Compressive strength, GGBS, Silica fume, high strength concrete, pollution.

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1. Introduction

The cement is one of the most important material in the concrete and also the material which costs high. The raw materials that are required to produce the cement are decreasing or finding difficulty to obtain them day by day. Not only with the aspect to reduce the pollution but also with the view that the cement producing raw materials are reducing with a fast speed. It's becoming mandatory to find a better cement replacement. The use of industrial wastes is seem to be best ample solution that we can provide for this problem that are facing or will be facing. (Abdul-wahab et al., 2020).currently concrete structure are at risk of getting affected by the various environmental conditions which are deflecting the structures in and out(Shibao et al., 2019). Industrial development has lead to rapid increase in greenhouse gas effect among which cement industry has also okayed a vital role by contributing in world's 55 pollution. That too the cement industries are oil fuel based and gas based where oil fuel based cement industries has shown 2.7% more CO_2 when compare to the gas based cement industry in a study which was conducted in Iran. The results of the study has also showed just by replacing the roller mills with the vertical has shown to be reducing electricity up to 720 million kWh/y(Karbassi et al., 2010). Different admixtures natural, industrial by products are emerging out y proving their worth to be replaceable to the cement such as rice husk ash which has not only shown better results in increasing the strength but also shown good workability(Bheel, 2021). When we a industrial by product such as GGBS it is seen that the about 55-59% addition in concrete will show the ebst results in terms of strength.

The carbonization effect on reinforced steel structures has become the cause of concern as this effect results in corrosion of the steel present in the concrete structures. Treated pal oil fuel ash has shown good results in reducing the carbonization effect(Tang, 2018). The fly ash is classified in to class C and class F fly ash where class F fly ash when added up to 70% gives the high volume fly ash and this high volume fly ash concrete has shown relatively high strength where as when slag and silica fume are added in 10% of amount with 50% of fly ash in concrete has shown the better resistivity to fire when the concrete specimens are subjected to high temperatures(Rashad, 2015). 60% class C fly ash with 10% silica fume has shown the better resistance to freeze thaw, chloride attack along with increase in strength where as it is seen that when silica fume is not added with the fly ash then the strength values are reduced. This shows the the important role silica fume plays when the admixtures are added in combination(Yazıcı, 2008). Curing plays a important role in attaining the strength of the concrete when the curing is done less then it affects the strength of the concrete. It is said that when we want to know the full potential if the concrete then it is mandatory that we fully cure the concrete. Its becomes more important to concentrated on curing of the concrete structures which consists of fly ash, silica fume and slag as the cement replacements as they will be exposing to the outer environment as soon as they are constructed(Ramezanianpour, 1995). Once the structures are de molded they should received good curing or else they will show the poor performance. When the concrete is cured in 39degress and 65% humidity levels gives not only good strength but also better resistance to the chloride penetration but when they are not maintained properly or no curing is given once the structures are de molded the reverse can happen to the concrete structures.(Ramezanianpour, 1995). Adding the fly ash, GGBS, silica fume have also shown better frost resistance and sodium chloride solutions(Liu et al., 2018). it is necessary for us to produce a concrete which is more safer and costs less. A low cost and more safer concrete will not only helps the environment but also helps to increase the Indian economy.

2 Objective and Methodology of the Study

2.1 Objective of the Study

The study is conducted with a to develop a high strength concrete of M40 grade using the industrial By products such as Silica Fume and GGBS.

To investigate how the silica Fume and the GGBS will resist the HCL and HNO_3 attack on the concrete.

To know whether the Silica Fume and GGBS will give better strength and resistance to HCL and HNO_3 attack individually or in combinations.

To investigate the Silica Fume and GGBS gives the better strength than the normal concrete and prove that they are good partial replacement to the cement in the concrete.

2.1 Methodology:

In the present study M40 grade concrete is been produced. The water cement ratio taken is 0.36. the study is focused on only compressive strength of the concrete as the concrete is known for its higher compressive strength. The concrete is tested against the HCL and HNO_3 attack. The mechanical tests are done for 7 and 28days and the durability tests are done for 28, 90 days. For durability tests the 5% HCL and HNO_3 are added in water and in this water the concrete specimens are cured for 28days and 90days. Every week the water is removed and new water is added along with the HCL and HNO_3 solutions. This is done with a view that the concrete structures which are located at the river banks are subjected to flowing river water and face the new water every day and new level of chemicals in it.

2.2 M40 Grade Concrete Material Quantities

Grade of Concrete =M40
Cement = 412kg/m^3
Coarse Aggregates = 1228 kg/m^3
Fine Aggregates =642 kg/m^3
Water = 160kg/m^3

3 Materials and Properties:

3.1 Cement:

Bharathi cement OPC 53grade is been taken in the present study.

3.2 Fine Aggregates:

Natural River sand is been used in the study whose size is below the 4.73mm which falls under zone - II. Crushed 20mm size aggregates are used in the study. The Coarse Aggregates used in the study meets the requirements of the IS: 2386-1963.

3.3 Coarse Aggregates:

Crushed 20mm size aggregates are used in the study. The Coarse Aggregates used in the study meets the requirements of the IS: 2386-1963.

3.4 Admixture:

Conplast SP430 chemical admixtures has been added in the concrete.

3.5 Ground Granulated Blast Furnace(GGBS)

The GGBS used in the study meets the IS 12089:1987 standards and is been taken from the Madhavi industries Pvt.LTd, kadapa, YSR District, Andhra Pradesh, India. Whitish in color

3.6 Silica Fume (S.F):

The S.F used in the present study meets the requirements of the IS code book. The S.F is taken from the Madhavi industries Pvt.LTd, kadapa, YSR District, Andhra Pradesh, India. Dark Grey in color

Table 1 Properties of the Materials used in the Concrete.

S. No	Property	Cement	Fine Aggregates	Coarse Aggregates	GGBS	S.F
1	Specific Gravity	3.02	2.3	2.98	2.9	2.2
2	Bulk Density	1190 kg/m^3	1640 kg/m^3	1700 kg/m^3	1200 kg/m^3	240 kg/m^3
3	Fineness	225kg/m^2	2.78	7.5	350 kg/m^3	
4	Consistency	31%	-	-	-	-
5	Initial Setting Time	30mins	-	-	-	-
6	Final Setting Time	600mins	-	-	-	-
7	Void Content	-	-	37.16%	-	-
8	Crushing Strength	-	-	25.45%	-	-
9	Dry rodded unit weight	-	1720 kg/m^3	-	-	-

4 Tests on Hardened Concrete

4.1 Compressive Strength

The concrete is known for its compressive strength property and its tested in the standard compressive testing machine. The compressive strength for a concrete is tested once the concrete is properly cured for 7, 28days, 90days. In the present study the compressive strength test value are given below.

Table 2Compressive Strength of M40 Grade Concrete when Silica Fume(S.F) is added

S.No	**Specimen**	**Compressive Strength N/mm^2**	
		7days	28days
1.	Convectional Concrete	28.6	44
2.	5% S.F	29.9	46
3.	10% S.F	31.2	48
4.	15% S.F	26.78	41.2

Graph 1 Graphical Representation of Compressive Strength of M40 Grade Concrete when Silica Fume(S.F) is added

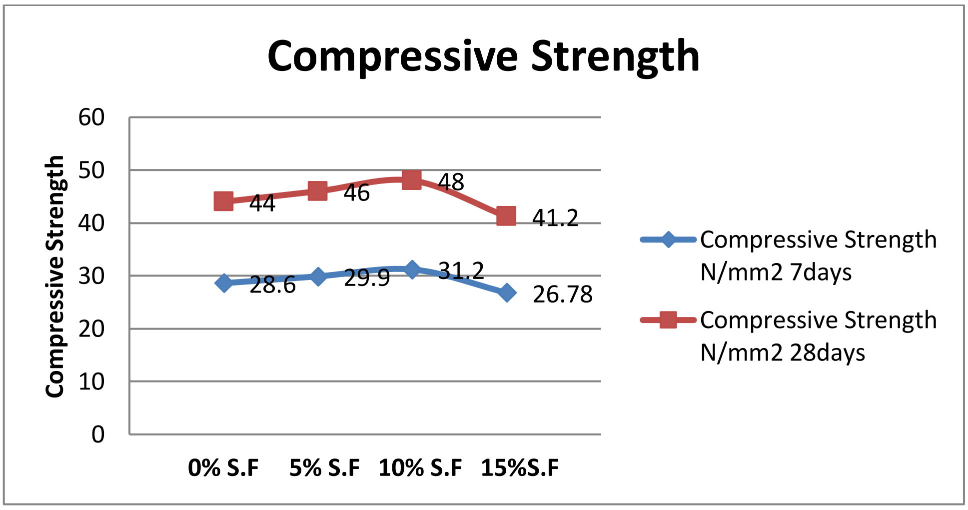


Table 3Compressive Strength of M40 Grade Concrete when GGBS is added

S.No	Specimen	Compressive Strength N/mm^2	
		7days	28days
1.	Convectional Concrete	28.6	40.09
2.	10% GGBS	27.81	42.79
3.	20% GGBS	29.17	44.88
4.	30% GGBS	25.40	39.09

Graph 2 Graphical Representation of Compressive Strength of M40 Grade Concrete when GGBS is added:

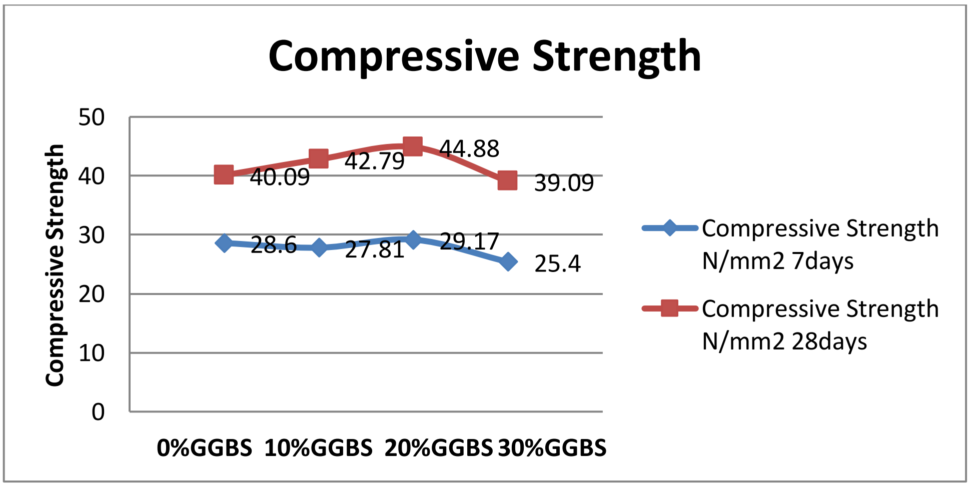


Table 4Compressive Strength of M40 Grade Concrete when Silica Fume (S.F) and GGBS are incorporated

S.No	Specimen	Compressive Strength N/mm^2		
		7days	28days	90days
1.	Convectional Concrete	28.6	44	46
2.	5% S.F + 10% GGBS	29.50	45.39	46.09
3.	10% S.F + 10% GGBS	32.63	50.21	52.99
4.	10% S.F + 15% GGBS	34.71	53.41	54.89

Graph 3 Graphical Representation of Compressive Strength of M40 Grade Concrete when Silica Fume (S.F) and GGBS are incorporated

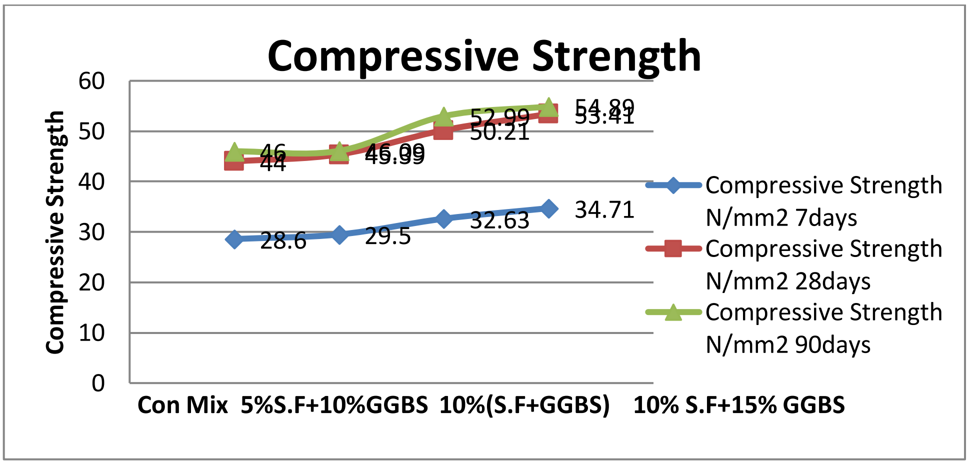


Table 5Compressive Strength of M40 Grade Concrete under HCL attack when Silica Fume (S.F) and GGBS are incorporated

S.No	Specimen	Compressive Strength N/mm^2	
		28days	90days
1.	Convectional Concrete	42.88	38.97
2.	5% S.F +10% GGBS	44.27	44.97
3.	10% S.F + 10% GGBS	49.09	50.87
4.	10% + 15% GGBS	52.29	52.77

Graph 4 Graphical Representation Compressive Strength of M40 Grade Concrete under HCL attack when Silica Fume (S.F) and GGBS are incorporated

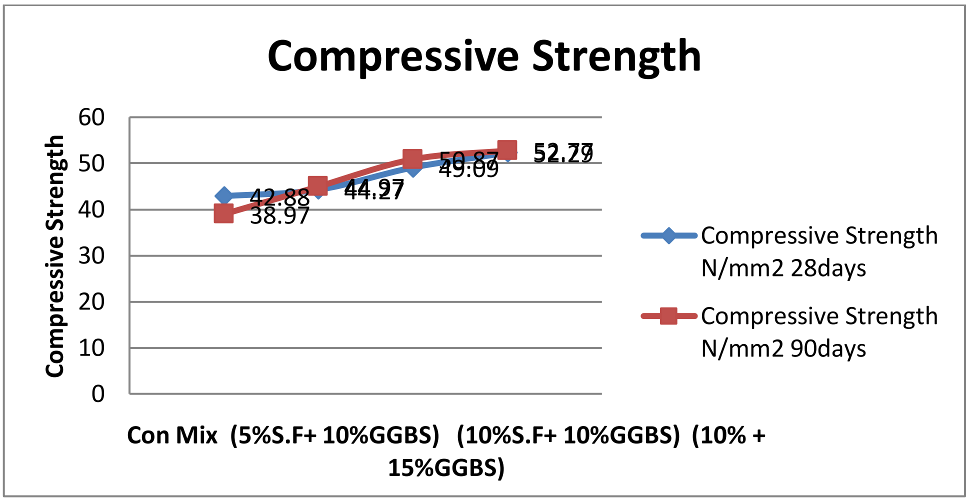
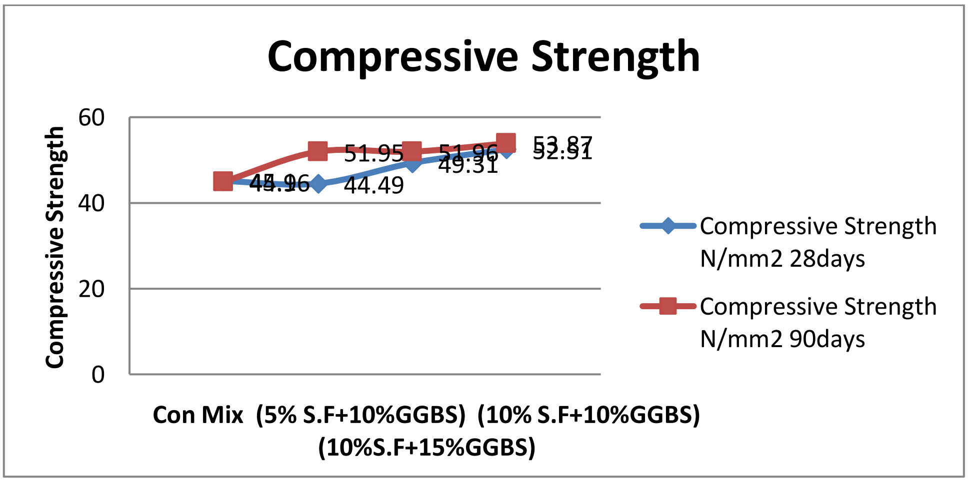


Table 6Compressive Strength of M40 Grade Concrete under HNO_3 attack when Silica Fume (S.F) and GGBS are incorporated

S.No	Specimen	Compressive Strength N/mm^2	
		28days	90days
1.	Convectional Concrete	45.1	44.96
2.	5% S.F +10% GGBS	44.49	51.95
3.	10% S.F + 10% GGBS	49.31	51.96
4.	10% + 15% GGBS	52.51	53.87

Graph 5 Graphical Representation of Compressive Strength of M40 Grade Concrete under HNO_3 attack when Silica Fume (S.F) and GGBS are incorporated:



5 Discussion

Industrial solid by products S.F and GGSB have been used as a replacement to the cement in the concrete and their compressive strength has been evaluated and they are also tested against two hazardous chemicals which acts on the concrete structures in the environment. We tried to derived the high strength concrete of the M40 grade and the results are as follows. The results show that the silica fume has shown the maximum strength when it is added up to 10% that is $48N/mm^2$ which is more than the normal concrete. The GGBS has shown the maximum strength when it is added up to 20% that is 44.88 N/mm^2 which is again more than more than the normal concrete. Here we can see that the among the S.F and GGBS the S.F have shown the better strength values compare to the GGBS and the normal concrete. The S.F and GGBS combination specimens have shown better values than other individual mixes of S.F, GGBS and convectional concrete mixes in terms of the compressive strength. The S.F and GGBS combination which have shown the higher compressive strength values along with the convectional mixes of concrete are subjected to HCL and HNO_3 attack and the S.F and GGBS have shown better resistance to HCL and HNO_3 attack than the normal concrete specimens.

From the above mentioned points it is clear that the S.F and GGBS can be replaced with the cement both individually and in combinations as they have provided better compressive strength and also better resistance to HCL and HNO_3 attack compare to the normal concrete. when we do the research on concrete structure by bringing a new materials in market as a good partial replacement to the cement we should not only focus on how we are getting the strength on curing of 28days but we should also make sure how the particular additional materials in concrete which are using in place of cement helps the concrete to sustain in the environment. The cement replacements should make sure that they not only give the good strength but also help the concrete in getting the better resistance to factors such as fire, corrosion, acid attack etc. these are the most dangerous scenario that the concrete structures are facing in the environment, when it's come to the durability of the concrete. We should make sure that the added material in place of cement covers all these areas in supporting the concrete. in the present study we have tested these industrial wastes GGBS and S.F not only for the mechanical strength but also for its durability properties which makes us to come to a conclusion that a green and economical concrete of high strength can be developed and it should be encouraged ,more and more in daily life activities.

6. Conclusion

The present research study is conducted that keeping in mind how the global warming is been increasing day by day and which internally effects the country's economy. we need to step in to the new era of green environment and try to preserve the environment as much as possible. being engineers we need to play our part as well by reducing the usage of materials such as cement which contribute about 5% in the global warming. usage of industrial wastes in proper place such as in place of cement will help in reducing the air pollution causing by the industrial byproducts. this study shows the solution in both ways by using the industrial byproducts and by reducing the cement usage. the usage of industrial wastes such as silica fume and GGBS should be encourage a greater extent.

7Future Scope:

In the present study the M40 grade is been tested and it is suggested that higher grade of concrete should be tested to even more different types of challenges which are facing by the concrete structures such as corrosion, permeability, alkinity attack, etc., in this way we will be getting a clear picture on how these industrial by products can help the concrete in resisting these attacks.

8.Acknowledgment:

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