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PARTIAL REPLACEMENT OF CEMENT BY GGBS AND FINE AGGREGATE BY CRUSHER DUST

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ABSTRACT
Due to rapid development in infrastructure it turns out to be very necessary to find and adopt some eco-friendly products. It is becoming more and more obvious that gradual evolution in the field of construction has adverse effect on the well-being the earth and putting future generations in danger. Concrete could also be used for a few special purpose that special properties are more important than those commonly considered. The most important objective of this study is to assess the chances of usage of GGBS (Ground Granulated Blast Furnace Slag) in concrete. The enhancement in a technology requires studying effects caused by the mineral admixture on the strength of the cementitious materials. This project represents the results of an experimental investigations accomplish to understand the suitability of GGBS in production of concrete. In this experimental study the impact of GGBS on strength of referral concrete M20 was prepared using 43 Grade OPC and the other mixes were prepared by replacing part of OPC with GGBS. The replacement levels were 0%, 20%, 30% & 40%(by weight of cement) for GGBS. And replacing fine aggregate with 0%, 20%, 30% & 40% crusher dust.

KEYWORDS: GGBS, Cement, CA & FA, Compressive Strength, Flexural Strength and Drying Shrinkage.

INTRODUCTION
Concrete is a very tough and adaptable construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement reacts with the water, it hardens and holds the entire mix together. The initial hardening reaction usually occurs within a couple of hours. It takes some weeks for concrete to reach full hardness and strength. Concrete has tendency to harden and attain strength for few more years. Concrete withstands compression (crushing), but is extremely poor in tension (stretching). For concrete to resist tension, it is reinforced with steel bars (rebar), polymer strands or fibres.
After the water, cement is second most used material within the world. But this rapid production of cement, create a big environmental problem for which it is need to find out civil engineering solutions. Emission of CO^2 within the production process of the cement. 1 tone of CO^2 is estimated to be released in the environment when 1 tone of OPC is manufactured. As people are more concerned about environment and creating an awareness among the public about the limited energy sources in earth crest and for future generation we have to save it or find an alternative energy sources. Similarly, it is needed to create awareness in construction field too. This is second environmental issue associated with consumption of lime. As there’s no alternative binding material which totally replace the cement so the utilization of partial replacement of cement is well accepted for concrete composites. In order to fulfil its commitment to the sustainable development of the whole society, the concrete of tomorrow will not only be more durable, but also should be developed to satisfy socioeconomic needs at the modest environmental impact. So the question is related to environment, problem is related to cost minimization but structural engineer will give the answer by proper analysing the properties of concrete made by using industrial waste material.

LITERATURE REVIEW
Vinayak Awasare, Prof. M. V. Nagendra has done research on strength properties of partially replaced GGBS concrete and also compared crushed sand with natural sand in concrete. Research has shown that 30% cement

can be replaced by cement with 100% crushed sand gives better compressive strength and flexural strength than 100% cement and natural sand in concrete.

Gopireddy Madan and G. Vimalanandan (2019) In this analysis, GGBS used as a partial replacement of cement, crusher dust as a partial replacement of FA, SSW as a partial replacement of CA. This study has concluded that workability of concrete increases while GGBS, SSW and QD is replaced for cement, coarse aggregate and fine aggregate respectively. The compressive strength increases by 6.40% and the split tensile strength increases by 9.52% for cement, fine aggregate and CA replacement by GGBS, QD and SSW respectively when compared to conventional concrete.

Amunuri S Kumar, P Indrateja, G Nikhil, Ramachander D (2017) have studied that use of GGBS significantly decreases the risk of damages caused by alkali–silica reaction (ASR), provides higher resistance to chloride ingress — reducing the risk of reinforcement corrosion — and provides higher resistance to attacks by sulphate and other chemicals. This research has shown that the increment in % of ggbs brings about abatement in quantity of cement. The diminishment in the cost of cement at the present market is 14%, on account of GGBS as substitution of PPC in concrete by GGBS gives the economy in the development as well as encourages ecological inviting transfer of the waste slag which is made in tremendous amounts from the steel ventures.

B K Varun, Harish B A (2018) The objectives of the study to evaluate the fresh properties of control concrete of M-30 grade and concrete made with partial replacement of cement by fly ash and ground granulated blast furnace slag. Research has come to the conclusion Making concrete with the combination of Fly ash and GGBS and cement with different percentages gives good results compared to control concrete. So the best method to use these materials is in fusion. Due to environmental issues in the production of cement, industrial by products like fly ash and GGBS are used as supplementary materials in concrete and it saves cost of production of concrete, and makes it eco-friendly.

Quaid Johar B, Kuldeep Dabhekar (2016) have studied on the effect of concrete with various replacement of GGBS, and this research paper mainly specialise in compressive strength and flexural strength of concrete. With the replacement of OPC of 53 grade with GGBS will get a notable reduction of CO^2 gas emission. And therefore GGBS is an eco-friendly construction material. when utilized in concrete it replaces as much as 80% of ordinary Portland cement of 53 grade. GGBS concrete has better water impermeability characteristics and make concrete resistance from sulphate and chloride attack. And hence service life is enhanced and the maintenance cost is reduced.

MATERIALS USED

In the present investigation materials used are
1. Portland Pozzolana Cement 43 grade PPC.
2. GGBS (Ground Granulated Blast Furnace Slag).
3. Crushed sand as fine aggregate.
5. Crushed Granite as coarse aggregate of size not greater than 20 mm.
6. Water

MATERIAL PROPERTIES:

Cement: In this present work 43 grade ordinary Portland cement (OPC) will be used for casting cubes and cylinders for all concrete mixes. The cement is of uniform colour i.e. Grey with light greenish shade and is free from any hard lumps. The tests will be conducted on cement are initial and final setting time and normal consistency. Testing on cement is completed as per IS codes.

Initial setting time Final setting time	110 mins 180 mins
Normal consistency	32%
Specific Surface Area	2921 cm^2/gm

GGBS: Ground granulated blast furnace slag is in white colour and is free from lumps. Tests conducted on GGBS are initial and final setting time and normal consistency.

Initial setting time Final setting time	100 mins 156 mins
Normal consistency	36.5%
Specific Surface Area	3085 cm^2/gm

Fine aggregate: Artificial fine aggregates were obtained from crusher plant. The sand used for this project was locally procured and conformed to grading zone II as per IS 383-1970. The test result indicated that, the sand was satisfying the requirement according IS code, the silt content and clay lumps were within the limits. Same sand was used throughout all concrete mix.

Specific gravity	2.805
Water absorption (%)	2.459
Loose bulk density (Kg/lit)	1.77
Fineness modulus	2.785

Coarse aggregate: Coarse aggregates (natural aggregates) used was a crushed volcanic basalt rock. The following tests were carried out for both natural and recycled coarse aggregates, as per the method given in relevant IS code of practice.

Specific gravity	2.8
Water absorption (%)	2.04
Loose bulk density (Kg/lit)	1.33

Mixing of concrete – The design formulation is based on the IS CODE 10262-2000 for M20 grade of concrete (Fck20Mpa). Water cement ratio is calculated as 0.54. The mix ratio is (1:1.58:3.03). Mixing of concrete was carried out by machine. Machine mixing isn't only efficient but also economical. Before the materials are put in to drum about 25% of the total quantity of water demand is poured into the mixer and to stop sticking of cement on the bodies or at the bottom of the drum. Exact mixing of material is done and is very necessary for the production of uniform concrete until the mass of the concrete becomes homogeneous and uniform in colour with a proper consistency. The mixing is done by replacing cement by GGBS with percentage of 0%, 10%, 20%, 30% & 40% and replacing fine aggregate by Crusher dust with percentage of 0%, 10%, 20%, 30% & 40%.

The following are mix proportions with designation for further reference. %C%G%; %FACD which is for:
% of GGBS (G) + % of Cement(C); % of Fine Aggregate (FA) + % of Crusher dust (CD).
For example, 80C20G; 80FA20CD stands for 80%CEMENT + 20% GGBS & 80%FA + 20% Crusher dust.

Table 1: Mix design combination

Designation	% Replacement	Cement	GGBS	Coarse Aggregate	Fine Aggregate	Crusher dust	Units
MD-1	100C0G; 100FA0CD	273	0	903	888.00	0	Kg/m^3
MD-2	90C10G; 90FA10CD	245.7	27.3	903	699.3	77.7	Kg/m^3
MD-3	80C20G; 80FA20CD	218.4	54.6	903	621.6	155.4	Kg/m^3
MD-4	70C30G; 70FA30CD	191.1	81.9	903	543.9	233.1	Kg/m^3
MD-5	60C40G; 60FA40CD	163.8	109.2	903	466.2	310.8	Kg/m^3
MD-6	60C40G; 90FA10CD	163.8	109.2	903	699.3	77.7	Kg/m^3
MD-7	70C30G; 80FA20CD	191.1	81.9	903	621.6	155.4	Kg/m^3
MD-8	80C20G; 70FA30CD	218.4	54.6	903	543.9	233.1	Kg/m^3
MD-9	90C10G; 60FA40CD	245.7	27.3	903	466.2	310.8	Kg/m^3

Testing Of Specimen

Test on fresh concrete – The workability test was taken as per IS CODE 456-2000. Workability is that the capability of a fresh concrete mix to fill the form/mould accurately with the specified vibration and without compromising the concrete's quality. Workability depends on water content, aggregate (shape and size distribution), Cementitious content and age (level of hydration and may be changed by adding chemical admixtures, like Super plasticizer.

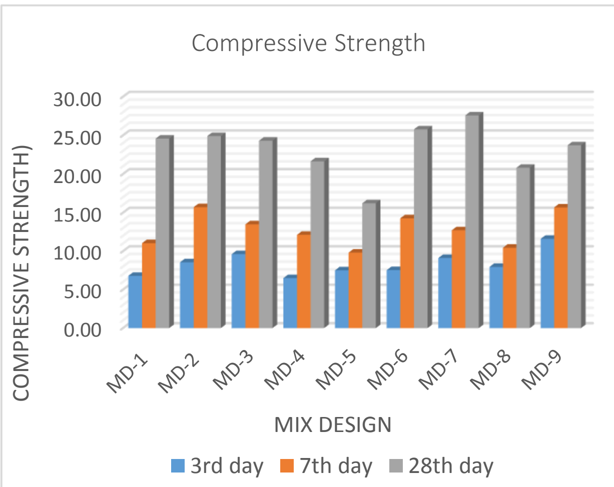
Slump Cone Test – The concrete slump test measures the consistency of fresh concrete before it sets. It is carried out to check the workability of freshly made concrete, and thus the convenience with which concrete flows. It also can be utilized as an indicant of an improperly mixed batch. Slump test is employed to work out workability of fresh concrete. Slump test as per IS CODE 1199-1959 is followed. The apparatus used for doing slump test are Slump cone and tamping rod. Workability can be measured by the concrete slump test, a simplistic measure of the plasticity of fresh batch of concrete. Slump is generally measured by filling an "Abrams cone" with a sample from a fresh batch of concrete.

Test on hardened concrete

Compression Strength test – The compression test is used to determine the hardness of cubicle specimens of concrete. The strength of a concrete specimen depends upon cement, aggregates, bond, w/c ratio, curing temperature & age & size of specimen. Mix design is that the major factor controlling the strength of concrete. Cubes of size 15cm x 15cm x15 cm will be tested. The specimen should be given sufficient time for hardening (approx. 24 h) and then it should be cured for 3, 7 & 28 days.

Table 2: Compressive strength result

Sample Designation	Average Value		
	3rd day	7th day	28th day
MD-1	6.80	11.04	23.77
MD-2	8.55	15.71	24.68
MD-3	9.61	13.49	24.31
MD-4	6.50	12.12	21.64
MD-5	7.51	9.82	16.22
MD-6	7.54	14.27	25.78
MD-7	9.11	12.71	27.58
MD-8	7.95	10.45	20.81
MD-9	11.60	15.68	23.72

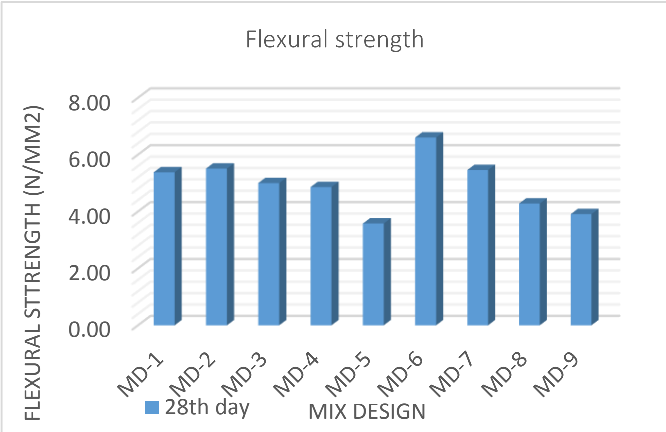


Graph 1. Compressive strength

Flexural strength test – The concrete prism specimens was fixed in the UTM in such a way that the load was applied on the top most surface as cast in the mould, along two lines with the spacing of 13.33 cm. The axis of the sample was carefully aligned with the axis of the loading device, the load was applied through to similar steel rollers, 38mm in diameter, positioned at the third points of the supporting span i.e., with the spacing of 13.33 cm centre to centre. A Universal testing machine (UTM), is used to test the flexural strength of concrete. The Flexural strength of concrete was determined at the age of 28 days as presented below. The beams were casted for flexural test. The beams were casted and tested as per IS CODE 516:1959.

Table 2: Tensile strength result

Sample Designation	Average Value
	28th day
MD-1	5.38
MD-2	5.51
MD-3	5.00
MD-4	4.86
MD-5	3.58
MD-6	6.6
MD-7	5.46
MD-8	4.28
MD-9	3.91

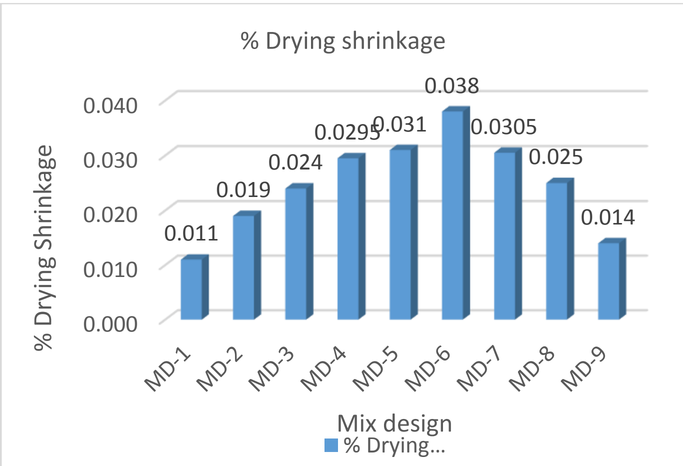


Graph 2. Tensile strength

Drying Shrinkage test - As the contracting of a hardened concrete mixture because of the loss of capillary water. This shrinkage causes an increase in tensile stress, which can cause cracking, internal warping, and external deflection, before the concrete is subjected to any quite loading. Specimen of size 160x40x40 mm is used to cast concrete and tested for shrinkage. Drying shrinkage was calculated as the difference in length between the wet and dry measurement (oven dried for 14 days at a temperature of 50 to 65°C), expressed as a percentage of the length of the specimen.

Table 3: Drying shrinkage result

Sample Designation	% Drying shrinkage
MD-1	0.011
MD-2	0.019
MD-3	0.024
MD-4	0.0295
MD-5	0.031
MD-6	0.038
MD-7	0.0305
MD-8	0.025
MD-9	0.014



Graph 3. Drying shrinkage

CONCLUSION:

1. Compressive strength of mix design 6 i.e., MD-7, where cement is 70%, ggbs 30%, fine aggregate is 80% and crusher dust is 20%, is the highest i.e., 27.58 N/mm^2 and that of MD-1 which contains 0% ggbs and crusher dust is 24.58 N/mm^2 which gives 12% less strength.
2. From results it is also found that highest strength achieved at 28th day is 25% greater than desired strength of M20 concrete. It is also observed that MD-9 i.e., 90% cement, 10% ggbs, 60% sand and 40% crusher dust has gained 50% strength on 3rd day itself. MD-2 i.e., 90% cement, 10%

3. ggbs, 90% sand and 10% crusher dust has gained 63% strength on 7th day of testing. as well as MD-9 has gained 66% strength on 7th day.
4. MD-5 which has 60% cement, 40% ggbs and 60% fine aggregate and 40% crusher dust has achieved very less strength due to more percentage of crusher dust which only acts as a filler but does not contributes in gaining strength. It has been observed that as the percentage of crusher dust increases strength decreases.
5. Flexural strength of MD-6, i.e., 60% cement, 40% ggbs, 90% fine aggregate and 10% crusher dust, is highest 6.6 N/mm^2. Also in flexural strength test it has been observed that as the percentage of crusher dust increases flexural strength decreases.
6. But MD-1 which does not contain ggbs and crusher dust has 22% less strength than MD-6. As the percentage of crusher dust increases strength decreases by 2%.
7. Making concrete with the combination of GGBS and cement with different percentages gives good results compared to control concrete. So the best way to use these materials is in combination.
8. As far as cost is concerned, the cost of GGBS in the market including packaging and transporting is three times less than that of OPC.

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