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STUDY ON PARTIAL REPLACEMENT OF CEMENT BY GGBS AND MARBLE POWDER IN CONCRETE

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ABSTRACT

In this present construction era concrete is the most used construction material in the world. Concrete is second most consumed material after the water. As we know concrete is a mixed composition of cement, fine aggregates, coarse aggregates and water, it plays an important role in development of infrastructure i.e., construction of buildings, highways, bridges etc. Ordinary Portland cement is the main ingredient used for the production of concrete. Manufacturing process of cement emits large number of carbon dioxide. It causes greenhouse effect and global warming. As the pollution is increasing and the environmental sustainability is affected, there is need to find alternative material for cement. Ground granulated blast furnace slag (GGBS) and Marble powder are supplementary materials used to replace with cement to reduce the consumption of the cement. GGBS is obtained from the blast furnace of iron and can be used in concrete production. Marble powder is a by-product of marble processing factory which is also best replacing material for cement. In this experimental study, GGBS and Marble powder will be use for partial replacement for cement for investigating strength of concrete.

KEYWORDS- *Cement, Concrete, GGBS, Marble powder*

1. INTRODUCTION

The world without concrete cannot be imagined. Concrete is one of the most essential composite material uses for any modern construction. Concrete is the second most used substance in the world after water and most widely used building material. Concrete is a composition of cement, sand (fine aggregate), coarse aggregate and water. Cement is used as a binding material in concrete. Cement can binds fine aggregate and coarse aggregate together using water. Concrete has ability to be formed into any shape or size. The production cement keeps increasing by 9% annually worldwide. Binding is the main purpose of cement in concrete. This rate of increase poses a great danger to the environment due to the large volume of CO_2 being released into the atmosphere during cement production. The production of cement leads to heat production, CO_2 emission and consumption of a large number of natural resources. Thus, the issue of global warming is increased and which has an adverse effect on the environment. Traditional concrete emits around 0.4 tons of CO_2. Therefore, there is need to replace traditional concrete by environmental friendly concrete. We need to adopt environmental friendly and sustainable materials. These sustainable materials have recently attracted considerable attention from

researchers due to their environmental benefits. These sustainable or eco-friendly materials are waste or residual materials from different industries, and require less amount of energy for production. Compared to traditional concrete, it produces less carbon dioxide, and is considered cheap and more durable. The aim of using environmental friendly and sustainable materials is to lesser the burden on natural resources, and increase dependency on recyclable materials. Partial replacement of cement with reusable materials is among the best strategies used to achieve eco-friendly construction material.

There are various bi-products of industries. Few of the beneficiary materials are Ground granulated blast furnace slag (GGBS) which is obtained from the blast furnace of iron and can be used in concrete production and Marble powder. The blast furnace slag is a by-product of the iron manufacturing industry. The Ground granulated blast furnace slag (GGBS) has a composition of about 30% to 40% SiO_2 (silica) and about 40% CaO (lime), which is close to the chemical composition of Portland cement. Marble powder is marble waste powder in cement and in concrete production is a by-product of marble processing factory which is also best replacing material for cement. A lot of researches have been done on partial replacement of cement by Ground granulated blast furnace slag (GGBS) and Marble powder separately. But the combinatorial research has not been done yet. Replacing cement by Ground granulated blast furnace slag (GGBS) and Marble powder gives arises to Green Concrete Technology, which has low emission of CO_2 directly or indirectly in the environment. Using proper mix proportion, it will give good result, like early strength, high workability and water reducer. There will be wide future for replacement of cement by eco-friendly materials like GGBS and marble powder.

2. PROBLEM STATEMENT

We know that main constituent of concrete are cement, sand, aggregate, water, admixture etc. But production of cement leads to heat production, CO_2 emission and consumption of a large number of natural resources. Hence there is need to replace cement with eco-friendly materials. These materials are Ground granulated blast furnace slag (GGBS) and Marble powder.

3. OBJECTIVES

Increasing demand of concrete construction and due to this depletion of natural resources, CO2 emission has brought a need for the replacement of conventional concrete. The aim of this project is to find the alternative material for cement. In study I will do the combinatory research on Ground granulated blast furnace slag (GGBS) and Marble powder.

- To study the various physical and chemical properties of Ground granulated blast furnace slag (GGBS) and Marble powder used for partial cement replacement
- To study the workability properties of concrete when cement is partially replaced with GGBS and Marble powder in concrete
- To study the various mechanical properties of concrete such as compressive, split tensile and flexural properties of this study
- To determine the performance of concrete by partial replacement of cement by GGBS and Marble powder
- To determine the most optimized mix of GGBS and marble powder
- Use of industrial waste in use full manner to reduce the disposal problem in present and future days and significantly reduce the CO_2 emission and also avoid adverse effect on environment

- To provide economic construction material to the construction industry

4. LITERATURE REVIEW

V.M. Sounthararajan et.al (2013) study has been conducted on Effect of the Lime Content in MDP for Producing High Strength Concrete. They found that the MDP up to 10% by weight of cement was investigated for hardened concrete properties. Furthermore, the effect of different percentage replacement of MDP on the compressive strength, splitting tensile strength and flexural strength was evaluated.

Yogendra O. Patil (2013) researched on the effects on compressive strength and flexural strength of concrete when cement is partially replaced with various percentages of GGBS. The tests were conducted with replacement ranging from 10 % to 40 % at 7, 28 and 90 days. It was observed that the strength of concrete is inversely proportional to the percentage of replacement of cement with GGBS.

Sabeer Alavi.C et.(2013) studied the effects of partial replacement of cement with 10 - 50% of GGBFS and found that 30% GGBFS replacement is good as beyond that the compressive strength starts decreasing. He also concluded that the split tensile strength and flexural strength conducted at 7 and 28 days increases with increase in GGBFS content. It was also found that the workability increases with the increase in percentage of GGBFS

S. Arivalagan (2014) investigated the effects of partially replacing cement with 20% , 30% and 40% GGBS at different ages on strength and strength efficiency factors of hardened concrete. The specimens showed increase in compressive strength when tested at 7 and 28 days, for 20% replacement of cement. Split tensile strength and flexural strength of concrete also increased at 20% cement replacement.

M. Ramalekshmi et. al. **(2014)** discussed the results of partial replacement of cement using slag in various percentages (50% – 80%). He tested various properties of concrete and found that the compressive strength and tensile strength of mortar mixes with slag when determined at the ages of 7, 14, 28 and days decreases at early ages of curing (3 and 7 days). She concluded that slag replacement decreases the strength of concrete in short term when compared to control

5. MATERIALS

5.1 Cement:

Cement is a binder, a chemical substance used for construction that sets, hardens and adheres to other materials to bind them together. In this experimental investigation Ordinary Portland cement (OPC) of 53 grade is use.

Fig 1: Cement

TABLE: Properties of cement

Sr No	Name of test	Test Results	As per IS code
1	Specific gravity test	3.15	In between 3.10 to 3.15
2	Fineness test	6.64 %	IS 4031 Part 1 1988
3	Initial setting time	35 Min	Should not be less than 30 min
4	Final setting time	534 Min	Should not more than 600 min
5	Standard consistency test	33 %	IS 4031 Part 4 1988 Varies between 25-35%
6	Soundness test	5 mm	IS 4031 Part 3 1988 Should be less than 10 mm

5.2 Fine aggregate:

The aggregate which passes through 4.75 mm IS sieve and retain on 75 microns IS sieve are known as fine aggregates. Fine aggregate is basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. Fine aggregate is also an inert material filling the voids between the coarse aggregates.

TABLE: Properties of Fine aggregate

Sr No	Name of test	Test Results	As per IS code
1	Specific gravity test	2.15	IS 2720 part 4 1985
2	Grading zone	II	-
3	Fineness modulus	2.50	IS 383-1970
4	Silt content	2.50%	IS 2389 part 2 1963 Less than 5%

5.3 Course aggregate:

The aggregate which pass through 75mm IS sieve and retain on 4.75mm IS sieve are known as coarse aggregates. Coarse aggregate is an inert material in concrete provides strength to the structure. So the quality of coarse aggregate is an important factor in concrete mix. Generally angular shape aggregates free from dissolving particles and chemical are preferred.

TABLE: Properties of Coarse aggregate

Sr No	Name of test	Test Results	As per IS code
1	Shape and max size	Angular (20mm)	
2	Fineness modulus	6.67	IS 2386-1963 In between 6.0 to 6.9
3	Specific gravity test	2.65	IS 2386 Part 3 1963 In between 2.65 to 2.67
4	Water absorption	0.43%	IS 2386 Part 4 1963 Shall not exceed 2%

5.4 Water:

Water plays an important role in concrete production (mix) in that it starts the reaction between the cement and the aggregates. It helps in the hydration of the mix. The amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking.

5.5 Ground granulated blast furnace slag (GGBS):

Ground granulated blast furnace Slag which is by-product of iron and steel-making, is manufactured by extinction melted iron slag from a furnace in water or steam, to supply a glassy, granular product that's then dried and made into a fine powder. Ground granulated blast furnace slag is off-white in color and substantially lighter than Portland cement Iron ore, Coke and limestone are fed into the furnace and the resulting molten slag floats above molten iron at a temperature of about 1500^0C to 1600^0C. Molten slag has a chemical composition of about 30% to 40% of SiO2 about 40% of CaO, which is nearly similar to the chemical composition of cement. After iron is removed off, remaining molten slag, which consists of mainly siliceous and aluminous residue is then water quenched and subjected to rapid cooling, resulting in the formation of Glassy crystalline granulates. This glassy granular material are dried and pulverized which is known as ground granulated blast furnace slag (GGBS). This replacement of GGBS with Portland cement leads to the significant reduction in emission of carbon dioxide. The GGBS therefore it's an eco-friendly product which can be used as a replacement in cement used in concrete.

Fig 2: Ground granulated blast furnace slag (GGBS)

TABLE: Properties of GGBS

Sr No	Name of test	Test Results
1	Specific gravity test	2.9
5	Standard consistency test	31 %
6	Water absorption	0.14%

5.6 Marble powder:

Marble is a metamorphic rock resulting from the transformation of a pure limestone. A large quantity of marble powder is generated during the cutting process. The result is that the mass of marble waste which is 20% of total marble quarried has reached as high as millions of tons. Leaving these waste materials to the environment directly can cause environmental problem. Moreover, there is a limit on the availability of natural resources used for making cement, and it is necessary to reduce energy consumption and emission of carbon dioxide resulting from construction processes, solution to this problem is use of marble powder as partial replacement of cement.

Fig 3 Marble powder

TABLE: Properties of Marble powder

Sr No	Name of test	Test Results
1	Specific gravity test	2.63
2	Moisture content	0.6%
3	Water absorption	0.97%

6. MIX DESIGN

Using the properties of material as linked above the mix design has been adopted from IS: 10262: 2019 to design concrete. Design is done for M25 grade of concrete. Cubes of size 150mm X 150mm X 150mm will be casted. The test will be performing on cube to check mechanical properties of concrete after partially replace cement by GGBS and Marble powder. The mix proportion of M25 grade of concrete is as follow,

Cement = 383.16 kg/m^3
Water =191.58 kg/m^3
Fine aggregate =545 kg /m^3
Coarse aggregate =1096 kg /m^3
Water cement ratio =0.5
Mix proportion = 0.5: 1: 1.42: 2.86

6.1 Trials

TABLE: Details of mix proportion for GGBS and Marble powder

Trials	Cement	GGBS (%)	Marble powder (%)	GGBS (Kg)	Marble powder (Kg)	W/C ratio	Coarse aggregate (Kg)	Fine aggregate (Kg)
1	383.16	-	-	-	-	0.45	1096	545
2	268.22	25	5	95.79	19.15	0.45	1096	545
3	249.06	25	10	95.79	38.31	0.45	1096	545
4	229.90	25	15	95.79	57.47	0.45	1096	545
5	210.74	25	20	95.79	76.63	0.45	1096	545

7. CASTING AND TESTING

Machine mixing was used for the mixing of materials. 6 cubes of 150x150x150mm casted for each trial.. i.e. 30 cubes were casted for testing. Cubes are casted to check compressive strength at 7 days and 28 days of curing.

Fig 4 Cube Casting

Fig 5 Material Mixing

Fig 6 Cube Testing

8. RESULT

TABLE: Compressive strength of cubes

Trials	Replacement (%)		Compressive strength (N/mm^2)	
	GGBS	Marble powder	7 days	28 days
1	0	0	21.2	32.8
2	25	5	20.6	32.3
3	25	10	20.1	31.8
4	25	15	18.5	27.41
5	25	20	17.2	25.2

For all the trials, it is seen that when GGBS and Marble powder is replaced, the strength is good up to 25% and 10% replacement respectively for. Therefore, we can conclude that GGBS and Marble powder is best partial replacement for concrete.

9. CONCLUSION

- On the basis of research on GGBS and Marble powder and after testing the materials in laboratory, it is concluded that this materials could be a good replacement option for cement in concrete.
- The optimum % of Ground granulated blast furnace slag (GGBS) and Marble powder for the replacement of cement in concrete material is up to 25% and 10% respectively.
- Material cost will be decrease in this type of concrete as compare to convention concrete

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[7] Indian standard code IS 456-2000