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EXPERIMENTAL STUDY OF CERAMIC WASTE POWDER AND GGBS CONCRETE OF M25 GRADE

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ABSTRACT

Concrete is very strong in compression but weak in tension. The cost of concrete by partial replacement of cement from ceramic waste powder and GGBS. The ceramic industry inevitably generates wastes, irrespective of the improvements introduced in manufacturing processes. In the ceramic industry, about 15%-30% production goes as waste. In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight for M-25 grade concrete and in addition cement is also replaced by 10%- 50% of GGBS. Specimens will cast of size 150X150X150mm with and without ceramic waste powders by replacing cement and GGBS. The result shows core compressive strength (30% increases) achieved up to 20% replacement of ceramic waste powder without affecting the characteristic strength of M25. Compressive strength is increased up to 30-40% and more from the ordinary concrete for most of the mixes.

***Keywords: Compressive strength, GGBS, Ceramic waste powder, Waste material utilization*.**

I. INTRODUCTION

Concrete is a blend of cement, sand, coarse aggregate and water. Concrete is the material of choice where strength, performance, durability, impermeability, fire resistance and abrasion resistance are required. Concrete produced should be strong enough to carry design load and durable enough so that structure constructed lives for its design life. It is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, highways, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. It is used in large quantities almost everywhere mankind has a need for infrastructure. The amount of concrete used worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined. Concrete's use in the modern world is exceeded only by that of naturally occurring water. Concrete is also the basis of a large commercial industry. In fresh state, it is essential to have a fairly high degree cohesiveness, pumpability, slump retention and also self-compacting nature. In hardened state, properties such as high early strength and late strength, high elastic modulus, low creep, dimensional stability, low permeability, sulfate and chloride resistance, chemical resistance, frost resistance and abrasive resistance are required in combinations depending on the type of structure being constructed and its environment.

1.1 CERAMIC WASTE POWDER

Ceramic waste is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Ceramic waste powder is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health.

Concrete with partial cement which is replaced by ceramic powder although it has minor strength loss possess increase durability performance. Ceramic waste partially replaced in the form of aggregate, sand and cement.

1.2 GGBS

Blast furnace slag is a by-product of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace, and the resulting molten slag floats above the molten iron at a temperature of about 1500^{o}C to 1600^{o}C. The molten slag has a composition of 30% to 40% silicon dioxide (SiO2) and approximately 40% CaO, which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which mainly consists of siliceous and aluminous residues, is then rapidly water- quenched, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size which is known as ground granulated blast furnace slag (GGBS). The replacement of Portland cement with GGBS will lead to a significant reduction of carbon dioxide gas emission. GGBS is therefore an environmentally friendly construction material.

II. LITERATURE REVIEW

A lot of work has been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. Literature review of Ceramic Waste powder, GGBS is presented in the following sections.

2.1 CERAMIC WASTE POWDER

F. Pacheco Torgal1 et al., (2010): presented the result of a study on compressive strength and durability properties of ceramic wastes based concrete. Several concrete mixes possessing a target mean compressive strength of 30MPa were prepared with 20% cement replacement by ceramic powder. A concrete mix with ceramic sand and granite aggregates were also prepared as well as a concrete mix with natural sand and coarse ceramic aggregates. The mechanical and durability performance of ceramic waste based concrete are assessed by means of mechanical tests, water performance, permeability, chloride diffusion and also accelerated aging tests.

D. Tavakolia et al., (2012): presented the study on the properties of concrete produced with waste ceramic tile aggregate and a large bulk of ceramic tiles change into wastage, these waste materials are not reusable and recyclable due to their physical and chemical structure. Given the high amount of concrete production and the possibility of wastage materials in them, using ceramic wastage could be an effective measure in maintaining the environment and improving the properties of concrete. The characteristics of ceramic aggregate are measured and then being grind they are used in concrete as the substitute for coarse aggregates with 0 to 40 percent of substitution and also for sand with 0 to 100 percent of substitution. Besides, all other parameters are constant.

Amit kumar D. Raval et al., (2013): worked on the effective replacement of cement for establishing sustainable concrete. Ceramic waste is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Ceramic waste powder is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the ceramic waste powder in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. It is most essential to develop eco-friendly concrete from ceramic waste. In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight of M-20 grade concrete. The Compressive Strength of **M20 grade** Concrete increases when the replacement of Cement with Ceramic Powder up to **30% replaces** by weight of Cement and further replacement of Cement with Ceramic Powder decreases the Compressive Strength. Concrete on **30%** replacement of Cement with Ceramic Powder, Compressive Strength obtained is **22.98 N/mm^2** and vice-versa the cost of the cement is reduced up to **12.67% in M20** grade and hence it becomes more economical without compromising concrete strength than the standard concrete.

2.2 GGBS

Shariq et al.(2008): Studied the effect of curing procedure on the compressive strength development of cement mortar and concrete incorporating ground granulated blast furnace slag. The compressive strength development of cement mortar incorporating 20, 40 and 60 percent replacement of GGBFS for different types of sand and strength development of concrete with 20, 40 and 60 percent replacement of GGBFS on two grades of concrete are investigated. Tests results show that the incorporating 20% and 40% GGBFS is highly significant to increase the compressive strength of mortar after 28 days and 150 days, respectively. Peter et al. (2010) studied the BS 15167-1 which requires that the minimum specific surface area of GGBS shall be 2750 cm2/g (BS 15167-1:2006).

Gidion Turu'allo(2015): Ground granulated blast furnace slag (ggbs) is a waste material generated from iron production,and is one of the cementitious materials that can be used to replace part of the cement in concrete. The aim of this research was to determine the effects of the water-binder ratios and levels of GGBS in concrete, with regard to the activation energy, which is needed for predicting the concrete's strength. A number of mixtures with different water-binder ratios (ranging from 0.30 to 0.51), GGBS levels, and curing temperatures were cast and tested at 0.5, 1, 2, 4, 8, 16, and 32 days. The activation energies were determined using the American society for testing and materials (ASTM) standard C1074, and the Freiesleben Hansen and Pedersen (FHP) method.

M.S.Chennakesava Rao (2016): One of the main challenges now confronting the concrete industry in India is to meet the demand posed by enormous infrastructure needs due to rapid industrialization and urbanization.

With the shrinkage of natural resources to produce ordinary Portland cement (OPC), increased use of suitable industrial waste materials having pozzzolanic characteristics that can replace cement clinker is one of the ways to meet the challenge. Such a policy has many-fold advantages-utilization of industrial waste in an eco-friendly way, preserving resources, and finally the improvement in properties of concrete culminating in the sustainable development of the society. Minimizing greenhouse gas emissions associated with manufacturing of opc. Environment friendly and economical disposal of millions tones of GGBS. Considering the above beneficial effects of using GGBS in concrete, this should be considered as resource material rather than an industrial waste. This research study presented the study of behavior of high volume of slag concrete and OPC concrete.

3. MATERIAL PROPERTIES

The properties of material used for making concrete mix were determined in laboratory under controlled conditions as per relevant IS codes of practice. The material characterization was carried out for all the major ingredients of concrete which include cement, coarse aggregates, fine aggregates, and water. The purpose of the characterization is to check their acceptability as per relevant Indian standards so as to enable an engineer to design a concrete mix for a particular strength. The properties of the various materials used in this study, are discussed in the succeeding sub-sections.

3.1 Cement

Cement is the most active component of concrete and usually has the greatest unit cost, thus, its selection and proper use are important in obtaining most economical balance of properties desired for any particular concrete mixture. It fills up voids existing in the fine aggregate and makes the concrete impermeable. It provides strength to concrete by binding the aggregate into a solid mass due to its setting and hardening properties when mixed with water. Although, it constitutes only about 20% of the total volume of concrete mix, its contribution to the compressive strength of concrete is the maximum.

Table 3. 1: Properties of ordinary Portland cement

Characteristics		**Values Obtained**	**Standard value**	**Method ofTest Ref.**
Specific Gravity		3.14	--	IS 4031 part 11
Normal Consistency		33%	--	IS 4031 part 4
Initial/Final Setting-time (minutes)		28min/256mins	30 (minimum) / 600(maximum)	IS 4031 part 5
Fineness		4.5%	<10	
Compressive strength (N/mm^2)	**At 3 days**	**26.1**	23	IS 4031 part 6
	At 7 days	**35**	33	IS 4031 part 6
	At 28 days	**47.9**	43	IS 4031 part 6

3.2 AGGREGATE

Aggregate occupy a large volume in concrete mixture and give dimensional stability to concrete. In the cement concrete, to provide good quality of concrete, aggregates are generally used in two size groups: coarse aggregates – Particle size more than 4.75mm and fine aggregate particle size less than 4.75mm. Coarse aggregates make solid and hard mass of concrete with cement and sand and increase the crushing strength of concrete. It also reduces the cost of concrete, since it occupies major volume. The fine aggregate assist the cement paste to hold the coarse particle in suspension this action promotes plasticity in the mixture and prevent the possible segregation of paste and coarse aggregate. The aggregate must be proper in shape, clean hard and well graded

Coarse aggregates: The aggregates which are retained over IS sieve 4.75mm are termed as coarse aggregate. The coarse aggregate may be of following types: Crushed gravels or stone obtained by crushing of gravel or hard stone and partially crushed gravel or stone obtained as a product of blending of above two types. The coarse aggregate used in the present study was locally available crushed stones of 10mm and 20 mm sizes.

Table 3.2: Sieve analysis of 10 mm coarse aggregate

S.No.	IS-Sieve (mm)	Wt. Retained (gm)	%age Retained	%age Passing	Cumulative % retained
1	80	0.00	0.00	100.00	0.00
2	40	0.00	0.00	100.00	0.00
3	20	447	22.35	77.65	22.35
4	10	415	20.75	56.90	43.1
5	4.75	1055	52.75	4.15	95.85
6	2.36	80	4.0	0.15	99.85
7	1.18	0	0	0	100
8	600	0	0	0	100
9	300	0	0	0	100
10	150	0	0	0	100
11	Pan	3	0.15		
Total		2000		Sum	661
Fineness Modulus (FM)= 6.61					

3.3 CERAMIC WASTE POWDER

Ceramic material is hard, rigid. It is estimated that 15 to 30% waste are produced of total raw material used, and although a portion of this waste may be utilized on-site, such as for excavation pit refill. The principle waste coming into the ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing.

Table 3.6: Chemical Properties of ceramic waste is as per table.

Materials	Ceramic Powder (%)	Materials	Ceramic Powder (%)
SiO2	63.29	Na2O	0.75
Al2O3	18.29	SO3	0.10
Fe2O3	4.32	CL-	0.005
CaO	4.46	TiO2	0.61
MgO	0.72	SrO2	0.02
P2O5	0.16	Mn2O3	0.05
K2O	2.18	L.O.I	1.61

3.4 GGBS

The GGBS enhances concrete workability due to its surface properties and fineness (approximately 460 Blaine (m2/kg.min)). According to this author, this makes GGBS 2-3 times finer than Portland cement, leading to an enhanced workability and a better performance in bleeding and setting times

Table 3.7: Chemical Properties of GGBS is as per table.

S.no.	Constituents	Proportion
1	CaO	32-34
2	Al_2O_3	18-20
3	Fe_2O_3	1.8-2
4	SO_3	0.3-0.7
5	MgO	8-10
6	SiO_2	33-35

Table 3.8: Physical Properties of GGBS is as per table

S.no.	Characteristics	Value
1	Bulk Density	600-700kg/m3
2	Surface Area	12000cm2/gm
3	Particle shape	Irregular
4	Particle Size	<2 µ
5	D50	<5 µ
6	D90	<9 µ

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3.5 Mix Design

Mix	Cement	Fine AGGREGATES	Coarse Aggregates10mm (Kg/m^3)	Coarse Aggregates 20mm (Kg/m^3)	GGBS (Kg/m^3)	water
M-0	400	624	580	580	0	186
M-1	360	624	580	580	40	186
M-2	320	624	580	580	80	186
M-3	280	624	580	580	120	186
M-4	240	624	580	580	160	186
M-5	200	624	580	580	200	186

VI. RESULTS

The main function of the concrete in structure is mainly to resist the compressive forces. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal. The vertical cracks occur due to lateral tensile strain. A flow in the concrete, which is in the form of micro crack along the vertical axis of the member will take place on the application of axial compression load and propagate further due to the lateral tensile strain.

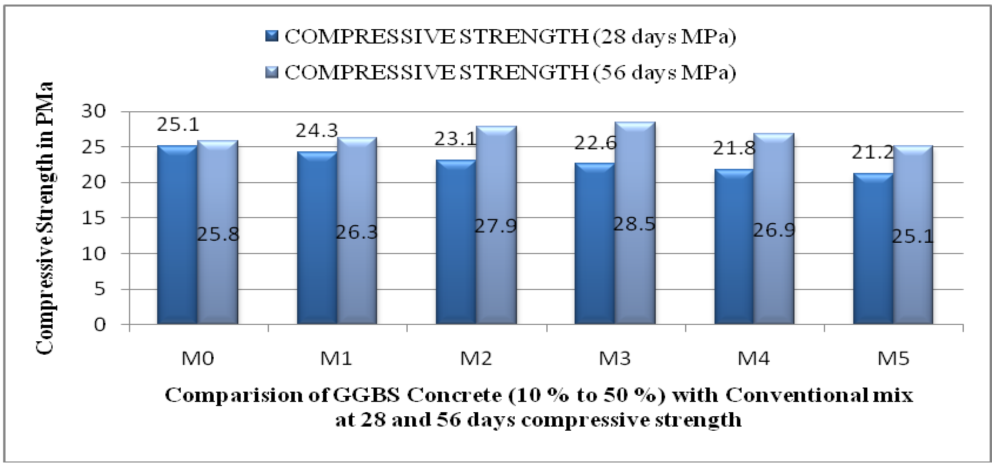

Figure 4.1: Compressive strength of the different mixes of the cubes

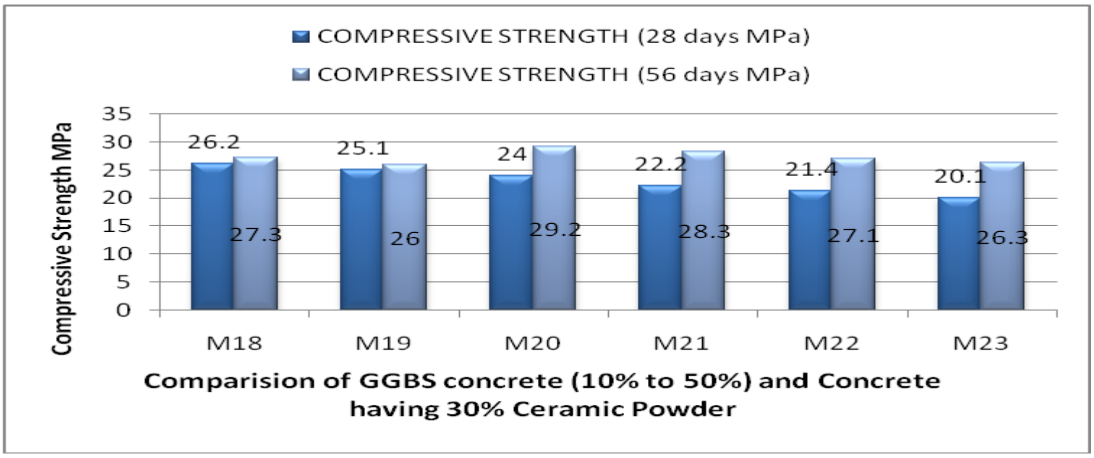

Figure 4.2: Compressive strength of the 30%ceramic waste powder concrete

V. CONCLUSION

The optimum replacement level of ceramic waste powder is found to be 20% with 30% increment in compressive strength for M25 grade of concrete. By addition of GGBS to the mix, an increment is noticed in the compressive strength is increased at 56 days.

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