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INFLUENCE OF CERAMIC WASTE POWDERAND GGBS ON CONCRETE OF GRADE M25

Shiva Kant[1], Divyanshu Dixit[2]
[1,2] Assistant Professor, Civil Engineering Department, Krishna Institute of Technology, Kanpur, India

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Abstract: *Concrete is very powerful in compression but feeble in tension. The cost of concrete is decreased by partial substitution of cement from ceramic waste powder and GGBS. The ceramic industry necessarily develops wastes, irrespective of the development introduced in manufacturing processes. About 15%-30% production are waste in ceramic industry. Ordinary Portland Cement has been substituted by ceramic waste powder in the range of 0%, 10%, 20%, 30%, 40%, and 50% by weight for M-25 concrete grade in this research study, and cement has also been substituted by 10% - 50% of GGBS. Cast the specimens in the size of 150X150X150mm with and without ceramic waste powders by the substitution of cement and GGBS. The result shows core compressive strength (30% enhancement) achieved up to 20% substitute of ceramic waste powder without affecting the characteristic strength of M25. Compressive strength is improved up to 30-40% and more from the ordinary concrete for most of the mixes.*

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

I. INTRODUCTION

Cement, sand, coarse aggregate, and water are used to make concrete. Concrete is the material of choice where strength, performance, durability, impermeability, fire resistance, and abrasion resistance are required. Concrete hould be strong enough to carry the design load and durable enough to last the design life of the structure. It is used to construct architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, roads, runways, parking structures, dams, pools/reservoirs, pipes, gate, fence, and pole footings, and even boats. It's utilised in big quantities practically everywhere there's a requirement for infrastructure in the world. Concrete is utilised twice as much as steel, wood, plastics, and aluminium combined on a global scale. Only naturally occurring water outnumbers concrete's use in the modern world. Concrete also serves as the foundation for a significant commercial sector. It is critical to have a high degree of cohesiveness, pumpability, slump retention, and self-compacting nature in the fresh condition. Properties like high early and late strength, high elastic modulus, low creep, dimensional stability, low permeability, sulphate and chloride resistance, chemical resistance, frost resistance, and abrasion resistance are required in combination in the hardened state, depending on the type of structure and its environment.

Ceramic Waste Powder: Ceramic waste is one of the most active study fields, spanning a variety of disciplines such as civil engineering and building materials. Ceramic waste powder settles by sedimentation and is subsequently discarded, resulting in pollution, as well as the formation of dust in the summer, posing a hazard to agricultural and public health. Although it has a little strength loss. Aggregate, sand, and cement were used to partially replace ceramic waste.

GGBS: Slag from blast furnaces is a by-product of the iron-making industry. Iron ore, coke, and limestone are fed into the furnace, and the molten slag that results floats above the molten iron at temperatures between 1500 and 1600degrees Celsius. The molten slag contains 30 to 40% silicon dioxide (SiO_2) and about 40% calcium oxide (CaO), which is similar to the chemical makeup of Portland cement. After the molten iron is tapped out, the remaining molten slag, which is mostly siliceous and aluminous leftovers, is promptly water-quenched, forming a glassy granulate. Crushed granulated blast furnace slag is made from this glassy granulate that has been dried and ground to the necessary size

(GGBS). The use of GGBS instead of Portland cement will result in a significant reduction in carbon dioxide emissions. As a result, GGBS is an environmentally beneficial building material.

II. LITERATURE REVIEW

There has been a lot of research into the advantages of using pozzolanic materials in the production and enhancement of concrete characteristics. The following sections give a review of the literature on Ceramic Waste Powder, GGBS.

Ceramic Waste Powder:

Amr S. El Dieb The research work on "Ceramic waste powder as an alternative cement replacement - Characterization and evaluation" has been analysed. According to this, ceramic waste powder provides a better result when compared to cement by up to 20%. In this investigation, ceramic waste powder was used to replace up to 40% of cement in concrete, and it produced better mechanical and durability results up to a 20% cement replacement.

P.O. Awoyera "Suitability of mortars built utilising laterite and ceramic wastes: Mechanical and microscale study" was the subject of my research. According to the findings, a mortar sample using 10% ceramic powder and 100% ceramic aggregate as cement and sand replacements yielded higher strength values than the reference and other mixes. Microstructural study of the best mix found that it has higher quantities of ettringite, portlandite, and calcite than the reference mix, which may account for the increased strength. Despite the apparent low reactivity of crushed ceramic material, when added at the right concentration, it can increase bonding in cement-based mixtures.

F. Pacheco Torgal1 et al., (2010): The findings of a study on the compressive strength and durability qualities of ceramic waste-based concrete were reported. Ceramic powder was used to replace 20% of the cement in many concrete mixes with a desired mean compressive strength of 30MPa. A concrete mix containing ceramic sand and granite aggregates, as well as a concrete mix containing natural sand and coarse ceramic particles, were also created. Mechanical tests, water performance, permeability, chloride diffusion, and accelerated ageingtests are used to evaluate the mechanical and durability performance of ceramic waste-based concrete.

D. Tavakolia et al., (2012): provided a study on the qualities of concrete made with waste ceramic tile aggregate, and a considerable portion of ceramic tiles ends up as waste; due to their physical and chemical structure, these waste materials are not reusable or recyclable. Given the huge volume of concrete manufacturing and the likelihood of wasting materials, repurposing ceramic waste could be a cost-effective way to protect the environment while also enhancing concrete qualities. The characteristics of ceramic aggregate are measured, and after grinding, they are utilised in concrete as a substitute for coarse aggregates with a substitution rate of 0 to 40%, as well as sand with a substitution rate of 0 to 100%. Aside from it, all other variables remain constant.

Khuram Rashid "Experimental and analytical selection of sustainable recycled concrete with ceramic waste aggregate" was the subject of my research. According to these studies, a 30% partial replacement of ceramic waste aggregate with conventional aggregate provides the highest compressive strength, has the least environmental impact, and is chosen as a sustainable concrete, as demonstrated by the analytical hierarchy process (AHP) and the technique for order preference by similarity to ideal solution (TOPSIS). The experimental and analytical inquiry is carried out in order to build a sustainable recycled concrete by utilising ceramic waste as coarse aggregate in the research effort. Traditional aggregate is substituted with varying proportions of ceramic waste aggregate to produce the desired result. The qualities of conventional and ceramic waste aggregate concrete, both fresh and cured, are evaluated.

Wioletta Jackiewicz-Reka "Properties of cement mortars modified with ceramic waste fillers" was the subject of his research. According to these studies, replacing fine aggregate with sanitary ceramic fillers up to 20% by weight of cement enhances compressive and flexural strength while reducing shrinkage. The test findings were compared to published data on the effects of ceramic waste on the characteristics of fresh and hardened concretes. Workability (consistency, plasticity, and pores volume), mechanical characteristics (compressive and flexural strength), and freeze-thaw resistance were also examined.

Amit kumar D. Raval et al., (2013): worked on the effective replacement of cement in the creation of long- lasting concrete Ceramic waste is one of the most active study fields, spanning a variety of disciplines such as civil engineering and building materials. Ceramic waste powder settles by sedimentation and is subsequently discarded, resulting in pollution, as well as the formation of dust in the summer, posing a hazard to agricultural and public health. As a result, the use of ceramic waste powder in many industrial sectors, particularly building, agriculture, glass, and paper, would aid in environmental protection. The development of eco-friendly concrete from ceramic waste is critical. In this investigation, the (OPC) cement was substituted with ceramic waste powder in the proportions of 0%, 10%, 20%, 30%, 40%, and 50% by weight of M-20 grade concrete. When Cement is replaced with Ceramic Powder up to 30% by weight of Cement, the Compressive Strength of M20 grade Concrete increases, and when Cement is replaced with Ceramic Powder further, the Compressive Strengthdeclines. Concrete with 30% ceramic powder substitution has a compressive strength of 22.98 N/mm2, and vice versa, the cost of cement is lowered by 12.67 percent in M20 grade, making it more cost-effective than regular concrete.

GGBS:

Shariq et al.(2008): The effect of curing technique on the development of compressive strength in cement mortar and concrete using ground granulated blast furnace slag was investigated. The compressive strength development of cement mortar with 20, 40, and 60% GGBFS replacement for various types of sand, as well as the strength development of concrete with 20, 40, and 60% GGBFS replacement on two concrete grades, are explored. The results of the tests demonstrate that integrating 20% and 40% GGBFS significantly increases the compressive strength of mortar after 28 and 150 days, respectively.

Atul Dubey et.al The effect of partially replacing Blast furnace slag for cement on the strength of concrete (usually compressive) was investigated. The degrees of replacement ranged between 5% and 30%. The cubes were conventional sizes of (150x150x150)mm, and the tests were evaluated at 7,14,28 days. He discovered that the percentage of replacement has an inverse relationship with concrete strength. As a result, he came to the conclusion that after the optimum amount of GGBS replacement, strength begins to deteriorate.

Gidion Turu'allo(2015): GGBs (ground granulated blast furnace slag) is a waste product from the iron industryand one of the cementitious materials that can be used to replace some of the cement in concrete. The goal ofthis study was to see how the water-binder ratios and quantities of GGBS in concrete affected the activation energy, which is needed to forecast the strength of the concrete. A variety of mixes were cast and evaluated at 0.5, 1, 2, 4, 8, 16, and 32 days with varying water-binder ratios (ranging from 0.30 to 0.51), GGBS levels, and curing temperatures. The activation energies were calculated using the Freiesleben Hansen and Pedersen (FHP) method and the American Society for Testing and Materials (ASTM) standard C1074.

A.Oner & S.Akyuz Cement was replaced with GGBS in various percentages ranging from 15% to 100%. At 7, 14, 28, 63, 119, 180, and 365 days, the specimens were cured. The compressive strength test was likewise carried out in the above-mentioned order. It was discovered that the effect of GGBS is not as strong at younger ages. This is owing to the fact that pozzolanic action takes a long time to manifest itself. It also depends on the amount of CaO available for the reaction. It was discovered that when the percentage of replacement increases, the strength parameter increases. The optimal level of GGBS substitution fluctuates between 50 and 60 percent. The amount of GGBS in a freshly made mix affects its workability positively.

Thejas kumar HM & Dr. V Ramesh The features of modified concrete were investigated. The modification is accomplished by partially substituting slag powder for cement. The effect of acid on concrete was also investigated. A hydrochloric acid and sulphuric acid solution was employed. The concentrations of the solutions were 10% and 15%, respectively. Specimens were evaluated at various stages of curing. Slag powder was replaced up to 60% as age progressed, and strength increased dramatically. Around 40-50 percent substitution is ideal. Due to its cure in acidic solution, slag powder has a positive sensitivity to acidic effects.

M.S.Chennakesava Rao (2016): One of the most significant issues now facing India's concrete industry is meeting the tremendous infrastructure demands generated by growing industrialization and urbanisation.

With the scarcity of natural resources to create ordinary Portland cement (OPC), one method to solve the challenge is to enhance the use of acceptable industrial waste materials with pozzzolanic properties that can replace cement clinker. Such a policy has numerous benefits, including the environmentally friendly exploitation of industrial waste, the conservation of resources, and lastly, the improvement of concrete characteristics, all of which contribute to society's long-term sustainability. reducing greenhouse gas emissions related with opc production Millions of tonnes of GGBS can be disposed of in an environmentally friendly and cost-effective manner. Because of the aforesaid advantages of employing GGBS in concrete, it should be seen as a resource rather than an industrial waste. The behaviour of high volume slag concrete and OPC concrete was investigated in this research work.

III. MATERIAL PROPERTIES

The qualities of the materials used to make concrete mix were determined in a laboratory under controlled settings in accordance with the IS norms of practise. All of the primary constituents of concrete, including cement, coarse aggregates, fine aggregates, and water, were subjected to material characterisation. The goal of the characterisation is to determine whether they are acceptable according to Indian requirements, allowing an engineer to construct a concrete mix for a specific strength. In the next sub-sections, the qualities of the various materials employed in this investigation are discussed.

Cement:

Because cement is the most active component of concrete and has the highest unit cost, its selection and careful application are critical in achieving the most cost-effective balance of qualities for any given concrete combination. It makes the concrete impermeable by filling spaces in the fine aggregate. Because of its setting and hardening qualities when mixed with water, it gives concrete strength by combining the aggregate into a solid mass. Although it only accounts for around 20% of the total volume of the concrete mix, it has the greatest impact on the concrete's compressive strength.

Table 3. 1: Properties of ordinary Portland cement

Characteristics		Values Obtained	Standard value
Specific Gravity		3.12	--
Normal Consistency		31%	--
Initial/Final Setting-time (minutes)		29min/256mins	30 (minimum) / 600(maximum)
Fineness		4.8%	<10
Compressive strength (N/mm^2)	**At 3 days**	**27.2**	23
	At 7 days	**36**	33
	At 28 days	**48.4**	43

Aggregate:

Aggregate fills a huge volume in the concrete mix and gives it dimensional stability. Aggregates are used in cement concrete in two sizes to offer acceptable quality: coarse aggregates (particle size greater than 4.75mm) and fine aggregates (particle size less than 4.75mm). Coarse aggregates boost the crushing strength of concrete by forming a solid and hard mass with cement and sand. It also lowers the cost of concrete because it takes up a lot of space. The fine aggregate helps the cement paste keep the coarse particles suspended, which increases plasticity in the combination and prevents paste and coarse aggregate segregation. The aggregate must be in good condition, clean, firm, and evenly graded.

Coarse aggregates: Coarse aggregate is defined as aggregate that is retained after passing through an IS sieve of 4.75mm. The coarse aggregate can be one of the following: Crushed gravels or stone produced by crushing gravel or hard stone, as well as partially crushed gravel or stone produced by combining the two types. The coarse aggregate utilised in this investigation was crushed stones with diameters of 10mm and 20mm that were readily available in the area.

Table 3.2: Sieve analysis of 10 mm coarse aggregate

S.No.	IS-Sieve (mm)	Mass Retained (kg)	%age Retained	Cumulative %age Retained	Percent Passing
1	20	0	0	0	100
2	12.5	2.1960	72.883	72.8925	22.1265
3	10	0.6795	22.488	95.371	4.639
4	4.75	0.1353	4.3353	99.6953	0.3153
5	pan	0.009	0.3		0
Total		3		Sum= 267.95	
Fineness Modulus (FM)= 2.68					

Ceramic Waste Powder:

Ceramic is a hard, inflexible substance. Although some of this trash may be used on-site, such as for excavation pit refill, it is estimated that 15 to 30 percent of total raw material used is wasted. Ceramic powder, specifically in powder form, is the most common waste that enters the ceramic industry. During the dressing and polishing process, ceramic waste is formed as a waste.

Table 3.3: Chemical Properties of ceramic waste is as per table.

Materials	Ceramic Powder (%)	Materials	Ceramic Powder (%)
SiO_2	62.19	Na_2O	0.83
Al_2O_3	19.26	SO_3	0.13
Fe_2O_3	4.64	CL-	0.008
CaO	5.05	TiO_2	0.57
MgO	0.68	SrO_2	0.03
P_2O_5	0.18	Mn_2O_3	0.04
K_2O	2.12		

GGBS:

Due to its surface characteristics and fineness (about 460 Blaine (m2/kg.min), the GGBS improves concrete workability. One makes GGBS 2-3 times finer than Portland cement, according to this author, resulting in improved workability and faster bleeding and setting periods.

Table 3.4: Chemical Properties of GGBS is as per table.

S.no.	Constituents	Proportion
1	CaO	31-33
2	SiO_2	32-34
3	Al_2O_3	18.5-20.5
4	MgO	9-12
5	Fe_2O_3	1.7-2
6	SO_3	0.4-0.9

Table 3.5: Physical Properties of GGBS is as per table.

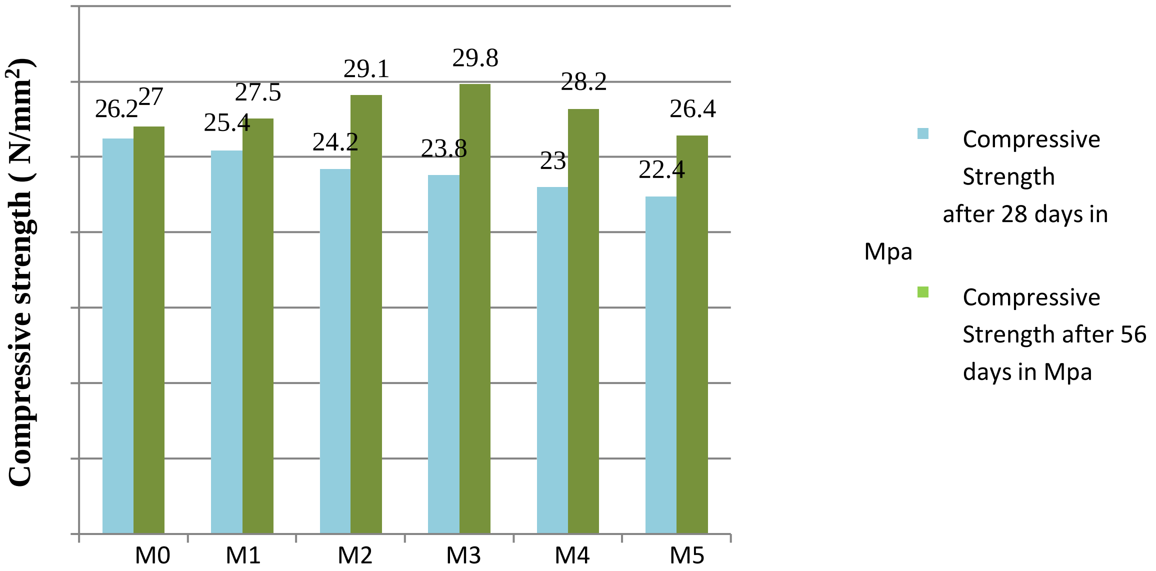
S.no.	Characteristics	Value
1	Bulk Density	650-750kg/m3
2	Surface Area	12500cm2/gm
3	Particle shape	Irregular
4	Particle Size	<2 µ
5	D50	<5 µ
6	D90	<9 µ

I. Mix Design

Mix	Cement	Fine Aggregates	Coarse Aggregates 10mm(Kg/m^3)	Coarse Aggregates 20mm (Kg/m^3)	GGBS (Kg/m^3)	water
M-0	500	674	580	580	0	186
M-1	460	674	580	580	40	186
M-2	420	674	580	580	80	186
M-3	380	674	580	580	120	186
M-4	340	674	580	580	160	186
M-5	300	674	580	580	200	186

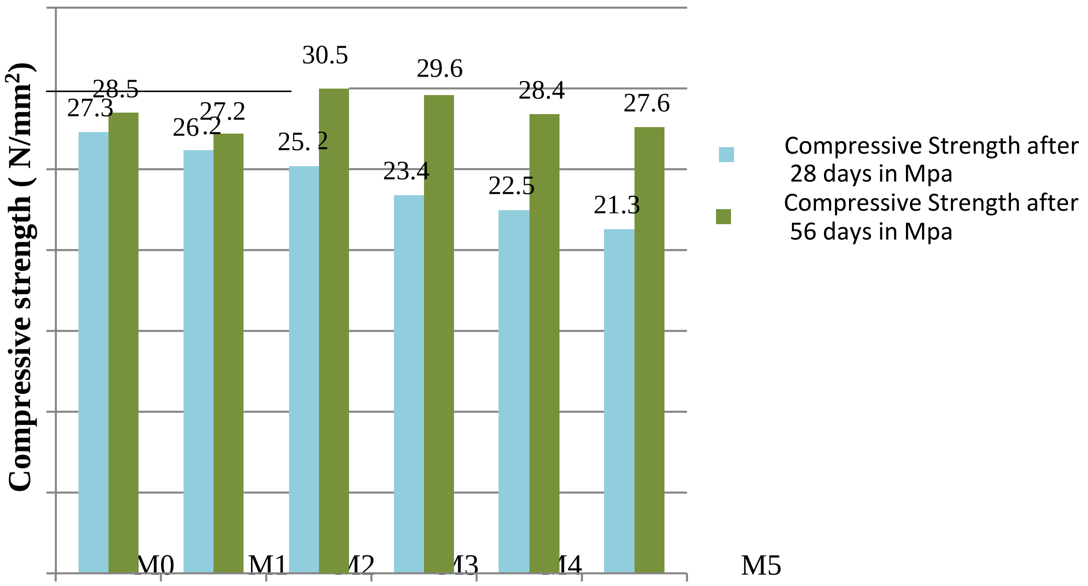
IV.RESULT

The primary purpose of concrete in a structure is to resist compressive forces. When a plain concrete member is compressed, the member fails along the diagonal in its vertical plane. Vertical cracks form as a result of lateral tensile strain. The application of axial compression load causes a flow in the concrete in the form of a micro fracture along the vertical axis of the member, which propagates further due to lateral tensile strain.



At 28 and 56 days compressive strength, GGBS Concrete(0-50%) compared to ordinary mix.

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



At 28 and 56 days compressive strength, GGBS Concrete(0-50%) compared to concrete having 30% ceramic powder

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

V. CONCLUSION

For the M25 concrete grade, the optimum level of ceramic waste powder replacement is found to be 20% with a 30% increase in compressive strength. At 56 days, there is an increase in compressive strength due to the inclusion of GGBS to the mix.

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