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PARTIAL REPLACEMENT OF CEMENT IN CONCRETE BY USING GGBS AND CERAMIC WASTE POWDER

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ABSTRACT

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 In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 0%, 5%,10%, 15%%,20% and 25%by weight for M-25 grade concrete and in addition cement is also replaced by 15% 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, split tensile and flexure strength is increased up to 30-40% and more from the ordinary concrete for most of the mixes.

Keywords: *Compressive strength, Split Tensile, Flexure Strength, GGBS, Ceramic waste powder, GGBS*

1. INTRODUCTION

Concrete is a composite material consist of mainly water, aggregate, and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture. A solid mass that can be easily molded into desired shape can be formed by mixing these ingredients in certain proportions. Over the time, a hard matrix formed by cement binds the rest of the ingredients together into a single hard (rigid) durable material with many uses such as buildings, pavements etc., The technology of using concrete was adopted earlier on largescale by the ancient Romans, and the major part of concrete technology was highly used in the Roman Empire. The colosseum in Rome was built largely of concrete and the dome of the pantheon is the World's largest unreinforced concrete structure.

Ceramic wastes are separated into two categories in accordance with the source of raw materials One category is formed through generated fired ceramic wastes by structural ceramic factories that use only red pastes for product (brick, blocks and roof tiles) manufacture. The second encompasses fired ceramic wastes which are produced in stoneware ceramic (wall, floor tiles and sanitary ware). Meanwhile during ceramic production, studies have shown that about 30% of the material goes to wastes and currently they are not beneficially utilized. This attests to the need for exploring innovative ways of re-using ceramic wastes. Aggregates constitute about 70% of total constituents in concrete production. The cost is increasing as a result of high demand from rural and urban communities. Numerous researchers have identified ceramics as having the potential to replace natural aggregates Some investigations have suggested that ceramic wastes are good materials which could substitute conventional aggregates in concrete The influence of ceramic tiles wastes on the structural properties of concrete made using laterite was recently investigated It was reported that ceramic based laterized concrete performed considerably well when compared to the conventional concrete. Overall, ceramic waste utilization can solve problems of aggregate shortages in various construction sites.

In the study two types of filler have been used, the conventional filler i.e. lime and other is ceramic waste. The lime was obtained from local market and the ceramic waste was collected from Morbi Ceramic industrial area, Rajkot, Gujarat, India. Sieve analysis of powdered form ceramic waste and lime was carried out and result shows that 98.5% of ceramic powder and 58.37% of lime passed through 75μ Sieve as per the Indian codal provision (The chemical properties of the ceramic waste were considered as mentioned Bituminous concrete is the most commonly used pavement material due to its construction procedures. The ever-increasing economic cost and lack of availability of natural material have opened the opportunity to explore locally available waste material l. If industrial waste materials can be suitably used in road construction, the pollution and disposal problems may be partially reduced. As reported, Indian ceramics industry, which is comprised of wall and floor tiles, sanitary ware, bricks and roof tiles, refractory materials and ceramic materials for domestic and others use is producing approximately 15 to 30 MT per annum waste.

As regards the ceramics industry in Spain, some 30 million tons of ceramic products such as bricks, roof tiles, breeze blocks, etc., were produced in 2006. Although the recent industrial crisis had resulted in a 30% drop in production, the industry continues to generate a significant volume of material unsuitable for commercialization. The percentage of products considered unsuitable for sale and thus rejected depends on the type of installation and the product requirements. Such waste can be considered inert, due to its low capacity for producing contamination. However, dumping constitutes a major disadvantage, producing significant visual impact and environmental degradation. Ceramic factory waste known as masonry rubble, is not sorted according to the reason for rejection, which may include:

- Breakage or deformation, which does not affect the intrinsic characteristics of the ceramic material.

Firing defects, due to excessive heat or insufficient heat (under-firing), faults particularly associated with the use of old kilns and which may affect the physico-chemical characteristics of the product

The ground Granulated Blast Furnace Slag is a of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace and molten slag floats above the molten iron at a temperature of approximately 15000C to 16000C as a resultant. The composition of molten slag about 30% to 40% SiO2 and about 40% CaO, which is nearly same to the chemical composition of Portland cement. The molten slag, is water-quenched unexpectedly, after the molten iron is trapped off which results within the formation of a glassy granulate. The molten slag includes specifically siliceous and aluminous residue. This glassy granulate is dried and floor to the required duration, that is known as ground Granulated Blast Furnace Slag (GGBFS)The production of GGBFS requires greater strength in comparison with the strength needed for the production of Portland cement. through replacing the Portland cement with GGBFS will consequences in discount of carbon dioxide gas emission. it is consequently an environmentally pleasant construction fabric. GGBFS from modern thermal electricity plants generally does not require processing previous to being incorporated into concrete and is consequently considered to be an environmentally free input material. we can replace about 80% of the Portland cement by using the use of GGBFS in concrete. GGBFS has characteristics of higher water permeability as well as advanced resistance to corrosion and sulphate attack. due to decrease heat hydration, it reduces the risk of thermal cracking. It has better durability, workability, reduces permeability to external organizations, which enables in making, placing and compaction less difficult. As a result, the service life of a structure is more desirable and the protection cost reduced.

There are many worldwide examples of using the GGBS concrete in the construction; following are some examples where the GGBS concrete were used.

- World Trade Centre in New York city with about 40% replacements.
- Airfield Pavement of Minneapolis Airport with about 35 % replacement.
- One of the largest aquarium- Atlanta,s Georgia Aquarium with about (20% to 70% replacements).
- Detroit Metro Terminal Expansion with about 30% Replacement.
- The Air Train linking New York’s John Kennedy International Airport with Long
- Island Rail Road Trains with about 20%-30% replacements.
- Tsing Ma Bridg in Hong Kong city with about 59%-65% replacement. Above examples shows that the world is aware of the advantages of GGBS replacement in concrete.

The main aims of the replacement of GGBS are:

- To improve the durability
- Reduce the maintenance cost
- To increase the service life
- Increase the economy of the construction with using the cheaper material as replacement of the cement
- Reduce the cement consumption.

2. LITERATURE REVIEW

1. **Bayram, Kasım Mermerdaş[1]** Current tendencies aimed at reducing negative environmental impacts and encouraging sustainable construction have resulted in ever increasing demands for the use of waste materials in the production of asphalt mixes. The basic objective of this research was to analyses research conducted so far with regard to the use of various waste materials as replacement for traditional fillers in asphalt mixes. The analysis of individual filler replacement in asphalt mixes was selected due high influence of filler on the quality of asphalt. According to research made by many authors, it can be concluded that waste glass, cement industry waste materials, concrete, bricks, ceramics, fly ash and other raw materials can be used as replacement for standard filler in bituminous mixes. It can also be concluded that the use of various non-conventional fillers should additionally be studied through construction of trial sections in order to enable better analysis of behavior of such asphalt layers in actual use. The use of various waste fillers in the production of asphalt mixes has led to the fall in the price of mixes, and in a more acceptable influence of asphalt industry on natural environment.

2. **Wioletta et al.**[2] Studied about the properties of cement matrix modified with ceramic waste by the addition of ceramic filler (10%, 15% and 20% of cement mass) with Mortar and tested its consistency retention, workability retention, shrinkage test, freeze-thaw resistance test, flexural and compressive test (2,7,14,28 and 56 days).

3. **Jiménez et al.**[3] Tested the replacement of natural fine aggregate with ceramic waste in masonry mortar with the replacement of fine aggregate (0%, 5%, 10%, 20% and 40%) of natural sand with ceramic recycled fine aggregate in a ratio of 1:7 volumetric cement-to-aggregate.

4. **Katzer et al.**[4] Did the strength performance comparison of mortar made with waste fine aggregate and ceramic fume with exchange of cement by ceramic fume (0%,10%,20%,30%,40% and 50%) along with w/c ratio equal to 0.50, 0.55 and 0.60 for each % group of concrete and tested consistency of fresh mix, density, compressive strength and flexural strength.

5. **Medina et al**[5] Tested sanitary ceramic wastes as coarse aggregate in eco-efficient concretes as partial replacement of natural coarse aggregate with ceramic coarse aggregate (15%, 20% and 25%) and performed consistency test and Hardened concrete properties (Mechanics and microstructures) like Compressive strength, X-ray Diffraction (XRD) and X-ray microanalyses (EDX).

6. **Hunchate et.al**[6] Tested the Compressive strength and split tensile strength of concrete with ceramic waste aggregate as a replacement of natural coarse aggregate by ceramic waste aggregate at 0%, 20%, 40%, 60%, 80% and 100%.

7. **Raval et al.**[7] Studied the replacement of OPC cement replaced by ceramic waste 0%, 10%, 20%, 30% 40%, & 50% by weight for M-30 grade concrete.

8. **Tavakoli et al.**[8]Tested the properties of concrete made with ceramic waste as the substitute for coarse aggregates with 0 to 40 percent and for sand with 0 to 100 percent of substation. Tested the 20%, 25%, 35%, 50%, 65%,75%,80%, and 100% replacement of natural aggregate with ceramic coarse aggregate in 40 Mpa concrete mix.

9. **Mandavi et.al.**[9]Tested the 10%, 20%, 30%, 40% and 50% replacement of natural sand with waste ceramic tiles and prepared M25 grade concrete

10. **D. Tavakolia, A. Heidari*, b and M. Karimianb**[10] conducted by using ceramic wastage in concrete production causes no remarkable negative effect in the properties of concrete. The optimal case of using tile wastage as sand are amounts of 25 to 50 percent, besides, the best case of their use as coarse aggregate are as amounts of 10 to20 percent.

3. MATERIALS AND METHODOLOGY

Ceramic Waste Powder and GGBS in place of cement by the percentage of 0%, 5%, 10%, 15%, 20% and25%. Slump cone test is used for performing workability tests on fresh concrete. And compressive strength test, split tensile strength and flexural strength is also conducted for 7-, 28,56- and 90-days curing periods by casting cubes to analyze the strength variation by different percentage of this waste materials. This present study is to understand the behavior and performance of ceramic waste powder in cement. The ceramic waste powder and GGBS are used to partially replace with cement by 0%, 5%, 10%, 15% 20%, 25% and 30%.

Ordinary cement OPC:

Ordinary Portland cement (Ultra tech cement) of 53 grade confirmative to IS: 12269-1987 remained used. It was tested for its physical properties as per IS 4031 (part II)-1988

Ceramic waste:

Ceramic waste is produced from ceramic bricks, roof and floor tiles and stoneware industries**.** Indian ceramic production is 100 Million ton per year. In the ceramic industry, about 15%-30% waste material generated from the total production. 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. Ceramic waste powder is settled by sedimenta- tion and then dumped away which results in environmental pollution.

Coarse Aggregate:

Crushed aggregates of less than 12.5mm size produced from local crushing plants were used. The aggregate exclusively passing through 12.5mm sieve size and retained on 10mm sieve is selected.

Fine Aggregate:

River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity in accordance with IS: 2386-1963.

Water:

Water plays a vital role in achieving the strength of concrete. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

GGBS

The ground Granulated Blast Furnace Slag is a of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace and molten slag floats above the molten iron at a temperature of approximately 15000C to 16000C as a resultant. The composition of molten slag about 30% to 40% SiO2 and about 40% CaO, which is nearly same to the chemical composition of Portland cement. The molten slag, is water-quenched unexpectedly, after the molten iron is trapped off which results within the formation of a glassy granulate. The molten slag includes specifically siliceous and aluminous residue. This glassy granulate is dried and floor to the required duration, that is known as ground Granulated Blast Furnace Slag (GGBFS)The production of GGBFS requires greater strength in comparison with the strength needed for the production of Portland cement.

Compressive Strength

Compressive strength results for 7, 28, 56, 90 days

% of Replacement	7 Days Mpa	14 Days Mpa	28 Days Mpa	56 Days Mpa	90 Days Mpa
CWP0 & GGBS0	20.57	23.37	28.54	33.18	42.82
CWP5 & GGBS15	24.09	26.79	31.39	36.50	54.86
CWP10& GGBS15	26.27	29.05	32.8	39.52	56.30
CWP15&GGBS15	28.05	32.54	37.53	43.14	59.53
CWP20&GGBS15	28.05	32.54	37.53	43.14	59.53
CWP25&GGBS15	23.96	26.76	31.77	37.16	53.65
CWP30&GGBS15	21.16	22.78	26.74	33.27	44.12

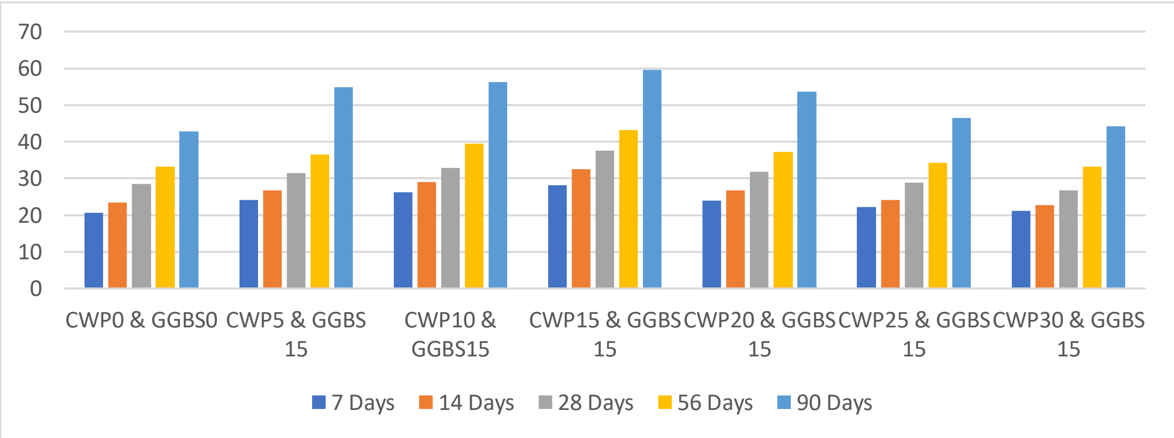


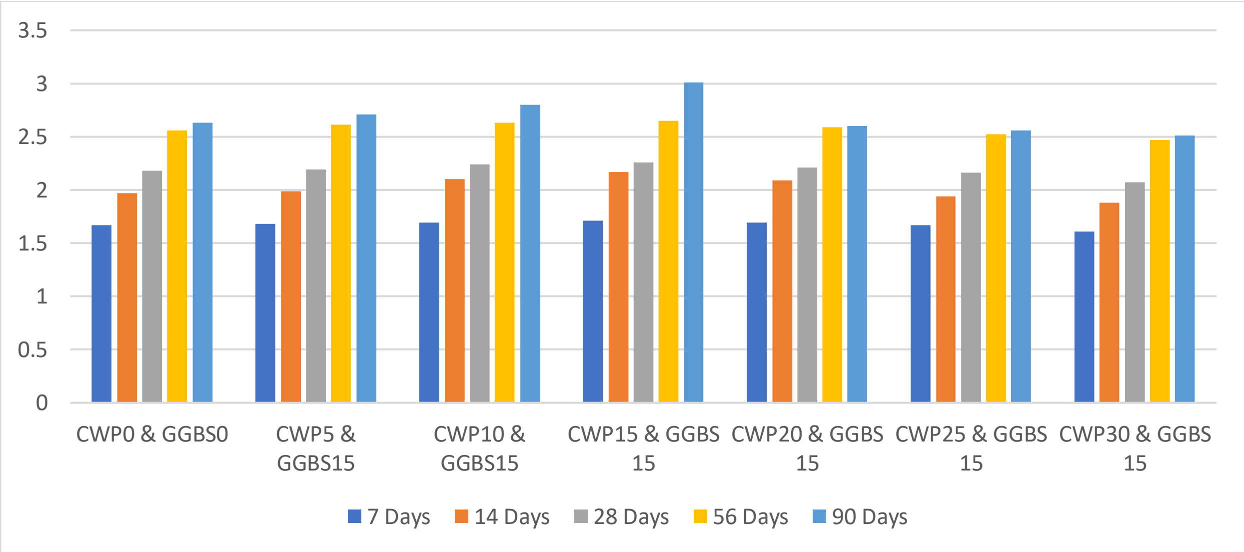
Fig: Comparision of Compressive strength results of M25 grade of concrete for 7,14, 28,56 and 90 days

Split Tensile Strength

% of Replacement	7 Days Mpa	14 Days Mpa	28 Days Mpa	56 Days Mpa	90 Days Mpa
CWP0 & GGBS0	1.67	1.97	2.18	2.56	2.63

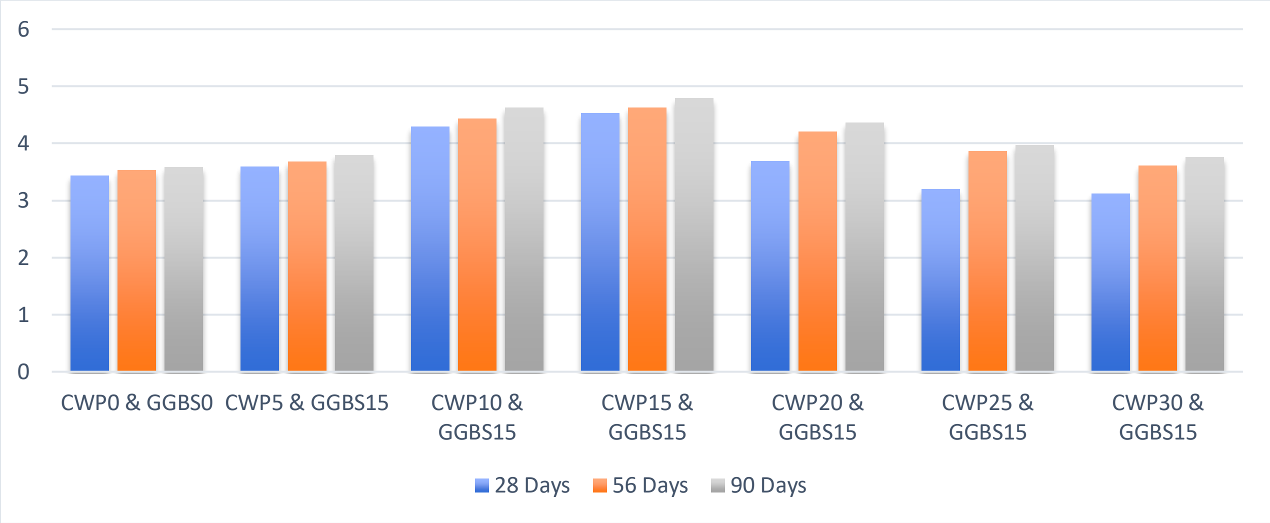
CWP5 & GGBS15	1.68	1.99	2.19	2.61	2.71
CWP10& GGBS15	1.69	2.10	2.24	2.63	2.80
CWP15&GGBS15	1.71	2.17	2.26	2.65	3.01
CWP20&GGBS15	1.69	2.09	2.21	2.59	2.60
CWP25&GGBS15	1.67	2.09	2.21	2.52	2.56
CWP30&GGBS15	1.61	1.88	2.07	2.47	2.51

Graph: Comparison of Split tensile strength results for M25 grade of concrete 7,14, 28, 56 and 90 days



FLEXURAL STRENGTH

% of replacement	28 days (Mpa)	56 days (Mpa)	90 days (Mpa)
CWP0 & GGBS0	3.43	3.53	3.58
CWP5 & GGBS15	3.59	3.68	3.79
CWP10 & GGBS15	4.29	4.43	4.62
CWP15 & GGBS15	4.53	4.62	4.79
CWP20 & GGBS15	3.69	4.20	4.36
CWP25 & GGBS15	3.20	3.86	3.97
CWP30 & GGBS15	3.12	3.61	3.76



Graph: Comparison of Flexural strength results for M25 grade of concrete 28,56 and 90 days

4. CONCLUSIONS

The following conclusions are made based on the experimental investigations on compressive strength and split tensile strength and flexural strength considering the environmental aspects also:

Depending upon above results and methodology adopted following conclusion were made regarding properties of concrete incorporating waste ceramic waste powder and GGBS

- It is found that compressive strength of concrete mix increases with increase in the percentage waste ceramic powder and GGBS compared to regular concrete 90 days after curing was maximum for 15 % replacement after that it reduces.
- It is also found that split tensile strength increases with increase in percentage of waste ceramic powder and GGBS up to 15 % replacement after that it reduces.
- It is also found that Flexural strength strength increases with increase in percentage of waste ceramic powder and GGBS up to 15 % replacement after that it reduces.
- Workability of concrete mix increases with increase in percentage of waste ceramic powder and GGBS as compare to conventional concrete.
- As waste ceramic waste powder from construction industries therefore both wastes can be effectively use in concrete mix hence an eco-friendly construction material.

REFERENCES

[1] Abdullah, m., hussin, k., ruzaidi, c. And ramly, s. (2006). "Con- crete Ceramic Waste Slab (CCWS)" Journal of Engineering Re- search & Education Vol. 3, (139-145) Kolej Universiti Keju- ruteraan Utara Malaysia

[2] Amin, K., Sibak, H., Sherbiny S., and Abadir, M. (2016). "An Overview of Ceramic Wastes Management in Construction" In- ternational Journal of Applied Engineering Research, ISSN 0973–4562, Volume 11, Number 4, pp 2680–2685 © Research India Publications.

[3] Dieu, G. (2015). "Utilization of High Calcium Fly Ash as Filler Materials in Concrete Bituminous Mixes for Flexible Pave- ment.", International Journal for Scientific Research & Devel- opment,Vol. 2.

[4] Fatima, E., Sahu, S., Jhamb, A. and Kumar, R. (2014). "Use of Ceramic Waste as Filler in Semi-Dense Bituminous Concrete.", American Journal of Civil Engineering and Architecture, Vol. 2, No. 3, 102-106, Education Publishing DOI:10.12691/ajcea-2-3- 2.

[5] Kara, C. and Karacasu, M. (2015). "Use of Ceramic Wastes in Road Pavement Design.", Proceedings of the World Congress on New Technologies, Barcelona, Spain, Paper No. 226.

[6] Kofteci, S. and Kockal, N. (2014). "Using Marble Wastes as Fıne Aggregate in Hot Mix Asphalt Production.", Civil, Struc- tural And Construction Engineering, ISBN: 978-1-63248-020-0.

[7] Muniandy, R. and Aburkaba, E. (2011). "The Effect of type and particle size of industrial waste filler on Indirect Tensile Stiff- ness and Fatigue performance of Stone Mastic Asphalt Mix- tures.", Australian Journal of Basic & Applied Sciences.

[8] Nema, M., Jain, R. and Grover, R. (2014) "use of ceramic waste powder in road construction.", Global Journal of Multidiscipli- nary Studies, Volume 3, Issue 11, ISSN: - 2348-0459.

[9] Patel, H., Arora, N. and Vaniya, S. (2015). "The Study of Ce- ramic Waste Materials as Partial Replacement of Cement" Inter- national Journal for Scientific Research & Development Vol. 3,Issue 02, ISSN: 2321-0613

[10] Raval, A., Patel, I. and Pitroda, J. (2013). "Ceramic Waste: Ef- fectiveReplacement Of Cement For Establishing Sustainable Concrete" International Journalof Engineering Trends and Technology (IJETT) - Volume4 Issue 6