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Analysis of Ceramic Waste as Supplementary Cementitious Material in Concrete: A Review

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ABSTRACT: Due to the rising demand for cement in building, it is necessary to cut cement output by partially substituting cement with alternative materials. When waste material is utilised to make cement, the cost is lowered and the environmental impact is favourable. The amount of cement produced emits the same amount of CO₂ as the amount of lime stone used, resulting in a very unfavorable environmental effect. The purpose of this study is to reduce the environmental impact and cement consumption in concrete by using ceramic material as a supplemental cementitious material. These studies initially explore the pozzolanic activity of ceramic electrical insulator waste material using three tests: strength activity test, frattini test, and saturated lime test. According to these discoveries in ceramic electrical insulator material, pozzolanic activity of material has been revealed, and it may be replaced up to 20% in mortar; nevertheless, more research, such as durability, is required. Following the successful completion of the pozzolanic activity test in mortar, research is conducted in concrete for the same ceramic electrical insulator material partial replacement with cement in the concrete, and its mechanical properties, workability, durability. Cement has been largely substituted in concrete with 5%, 10%, 15%, and 20% ceramic waste, respectively. Investigate the test performance in concrete for the exploitation of these ceramic waste, here workability test (by slump cone test), mechanical properties test (compressive strength test, flexural strength test. According to the results of the workability test, mechanical properties test, durability test, and micro-structure analysis, the ceramic waste material performs better up to 15% (Fifteen percent) replacement of ceramic waste, and higher than 15%, i.e. 20% or more, does not perform better. According to these findings, ceramic waste can replace up to 15% of cement in future applications; however, more study is needed. Because the ceramic has a low specific gravity (poor workability), the procedure is carried out with a low water cement ratio and fine dancing particle.

KEYWORDS: Ceramic waste, Cost analysis, Compressive strength, Workability

I. INTRODUCTION

A substantial amount of ceramic insulator trash has been discovered in the electrical board as a result of high voltage insulator breakage. These ceramic insulator wastes have not been utilized after breaking; nevertheless, in the research field, these ceramic waste have been used to substitute fine or coarse aggregate.

History of construction has witness that construction industry rapidly increases with increase in development of construction and due to high volume of raw material used in the construction and the environment has been impacted. High amount of waste generated in the construction industries, with respect to development of construction waste material and pollution has been generated day by day continuously. It's requiring to reuse the waste material in any purpose to reduce the environmental impact.

Infrastructure development is always rising, but the environmental effect is also increasing. The usage of a large volume of cement and other raw materials has a negative impact on sustainability because of the large amount of carbon-dioxides emitted during the cement manufacturing process. CO₂ has increased greenhouse gas emissions, contributing to the global warming impact. Because global warming is the primary issue or concern for the planet, it is necessary to regulate global warming and other environmental issues. Waste has been used in concrete in the scientific sector to lessen environmental effect. Currently, fly ash, silica fume, and other waste materials are routinely utilized as building materials up to a certain degree; similarly, ceramic insulator waste has been employed in concrete with the substitution of fine and coarse aggregate in study. If ceramic waste is used in concrete, it is environmentally and eco-friendly micro-structure properties of the material etc. In concrete adopted mechanical properties and durability test of concrete that which amount of ceramic waste material has been used for the replacement with cement, both test has a physical properties of the material that indicate the strength and durability of concrete.

In the mechanical characteristics of concrete, perform compressive strength, flexural strength, and split cylinder tests, as well as an analysis of the workability of concrete. Years ago, mechanical qualities were linked to concrete strength,

which defined structural stability. The workability of concrete has also played an essential part in determining whether the concrete is workable or not in the field. For the workability of concrete, two tests are often employed: the slump cone test and the compaction factor test. The compaction factor test produces more accurate results with less error, but it is not utilized in the field due to the weight of the instrument. The slump cone test was used in the field to determine the workability of concrete because it produces results quickly and is simple to apply.

Concrete durability testing pertains to the durability of concrete structures in construction sectors. There are several tests accessible in disabilities, such as sulphate attack test, acid attack test, carbonation test, chloride penetration test, water absorption and water penetration test, and so on. The water penetration test determines the permeability of concrete and is performed in accordance with DIN 1048.

II. LITERATURE REVIEWS

Researchers are attempting to reduce the usage of cement in concrete and mortar by using various types of waste materials in the concrete with partial replacement of cement, such as fly ash, rice straw, slag, glass trash, industrial waste, and so on. In these studies, ceramic waste material was used to replace 5 to 20% of the cement.

Dima M. Kannan et al. [21] created "High performance concrete employing ceramic waste powder as a major partial substitute of Portland cement." They employed ceramic waste powder as a partial substitute for cement, and according to these performance or research work, ceramic waste powder replaced a considerable quantity of 10 to 40% of the cement. According to these studies, ceramic waste powder can be replaced up to 40% of the time. Mechanical, durability, and microstructural investigations of high performance concrete mixtures were performed, and microstructure shows that incorporating ceramic waste powder did not make a significant difference in cement hydration when compared to cement without ceramic waste powder.

Amr S. El Dieb et al. [20] conducted study on "Ceramic waste powder as an alternative cement substitute - Characterization and assessment." According to this study, ceramic waste powder outperforms cement by up to 20%. Ceramic waste powder was substituted up to 10% to 40% in these study papers, and it produced improved results in mechanical and durability qualities in concrete up to a 20% replacement with cement.

Luiz Renato Steiner et al. [4] conducted study on the "Effectiveness of ceramic tile polishing residues as additional cementitious materials for cement mortars." According to these research, the sludge generated by the polishing of ceramic tiles, particularly 'porcellanato' and 'monoporosa,' creates a massive amount of rubbish that must be disposed of in controlled landfills. Based on compressive strength, pozzolanic activity index, thermal behaviour (calorimetry), and autogenous shrinkage, these ceramic waste materials were substituted by cement up to 15%.

Salman Siddique et al. [3] investigated the "durability qualities of bone china ceramic fine aggregate concrete." According to these findings, bone china ceramic fine aggregates (BCCFA) can be employed in structural applications to replace BCCFA up to 40%. The BCCFA was used as a 0 percent, 20%, 40%, 60%, 80%, and 100% partial replacement of fine aggregate in several studies. X-ray photoelectron spectroscopy was used to evaluate the hydration products. Concrete samples were tested for water-based qualities such as percentage voids, apparent density, water absorption, water permeability (DIN), and chloride ion permeability.

Wioletta Jackiewicz-Reka et al. [18] investigated the "Properties of cement mortars amended with ceramic waste fillers." According to these studies, replacing fine aggregate with sanitary ceramic fillers up to 20% of the cement by weight enhances compressive and flexural strength while decreasing shrinkage. The test findings were examined in light of published data on the effect of ceramic waste on the characteristics of fresh and cured concretes. Their impact on workability (consistency, plasticity, and pore volume), mechanical characteristics (compressive and flexural strength), and freeze-thaw resistance was assessed.

S.M.A. El-Gamal et al. [2] Sayed have conducted study on "Ceramic waste as an efficient material for strengthening the fire resistance and mechanical qualities of hardened Portland cement pastes." The primary purpose of this research is to use industrial byproducts such as ceramic waste (CW) to improve the microstructure, mechanical characteristics, and fire resistance of hardened ordinary Portland cement (OPC) pastes. Various cement mixes were created by partially replacing OPC with 5, 10, and 20 CW (mass percent). Based on the mechanical characteristics and heat resistance compressive strength values at 1, 3, 7, 28, and 90 days of hydration, the ceramic waste has been replaced up to 15%.

P.O. Awoyera et al. [19] conducted study on the "Suitability of mortars manufactured from laterite and ceramic wastes: Mechanical and microscale examination." According to these findings, a mortar sample comprising 10% ceramic powder and 100% ceramic aggregate as substitutes for cement and sand yielded greater strength values than the reference and other mixtures. Microstructural study of the best mix found that it had higher quantities of ettringite, portlandite, and calcite than the reference mix, which might account for the increased strength. Thus, despite its



apparent poor reactivity, crushed ceramic material can increase bonding in cement-based mixtures when applied at an adequate dosage.

III. RESULT AND DISCUSSION IN MORTAR

According to the code BS 3892, if the SAI is 80 percent and ASTM C618, if the SAI is 75 percent, the material has pozzolanic activity in the mortar. These figures represent the average of three cubes of mortar strength. Before SAI first find out the water cement ratio by flow table test is given below:

Table 1: Flow table test results

Sl. No.	Sand (in gm)	Cement (in gm)	Ceramic waste (20%) (in gm)	Water (in gm)	Water binding ratio(W/B)	Flow length (in mm)
1.	480	160	0	105.6	0.66	205
2.	480	128	32	104	0.65	207

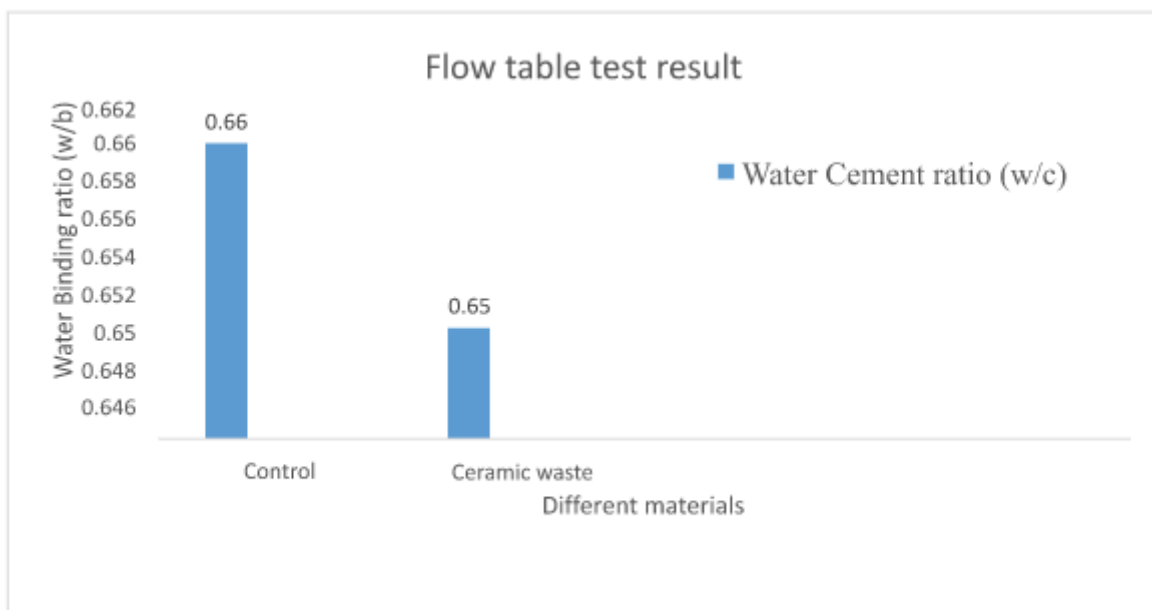


Figure 1: Flow table test for workability of mortar

According to the flow table test results, less water is required for the ceramic insulator waste material as compared to the control mix in mortar, which indicates a lower water cement ratio with equivalent workability to the control mortar.

Table 2: Strength activity index test results at 7 days.

Sl. No.	Mortar mix	Strength at 7 days (in MPa)	SAI (Strength activity index)
1.	Control mix	9.48	1
2.	Ceramic replacement with 20%	7.77	0.82

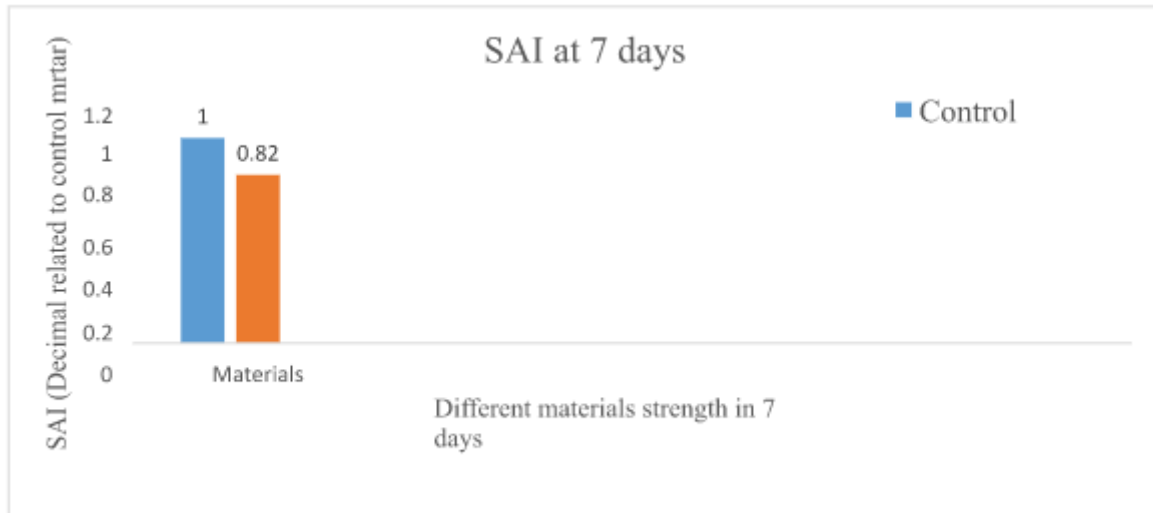


Figure 2: SAI at 7 days

According to SAI, the value at 7 days is 0.82, indicating that the ceramic waste material has an 82 percent outcome strength when compared to the control mix mortar. So it indicates the pozzoalnic activity at 7 days according to BS 3892 and ASTM-C618.

Table 3: Strength activity index test results at 28 day

Sl.No.	Mortar mix	Strength at 28 days (in MPa)	SAI (Strength activity index)
1.	Control mix	12.8	1
2.	Ceramic replacement with 20%	11.65	0.91

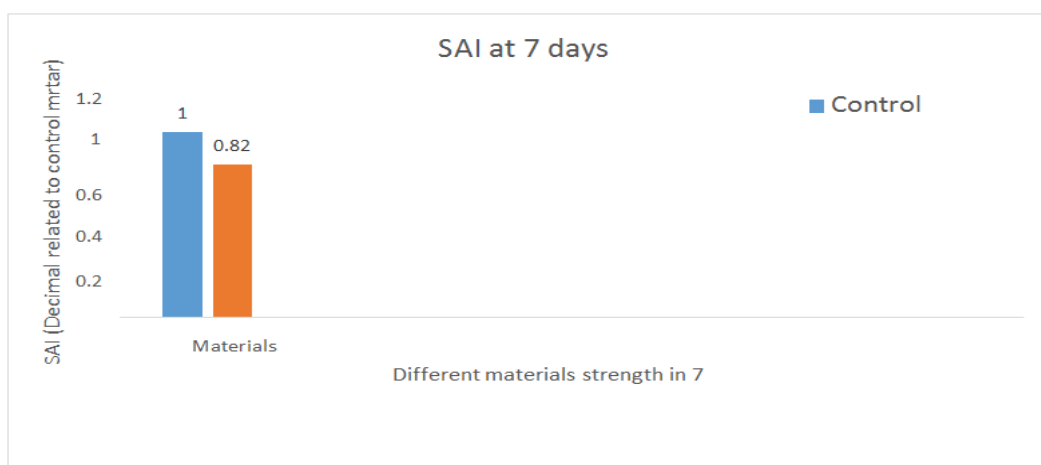


Figure 3: SAI at 28 days

According to SAI, the value at 28 days is 0.91, indicating that ceramic waste material has a 91 percent outcome strength when compared to control mix mortar. So it indicates the pozzoalnic activity at 28 days according to BS 3892 and ASTM-C618.



According to the results of 7 and 28 days, the percentage of strength has grown, and the pozzolanic activity of the ceramic material has increased with time. As a result of both the ceramic insulator waste and the pozzolanic activity in mortar,

Frattini test

Table 4: Frattini test result at 8 days.

Materials	(OH ⁻) reading In (mmol l ⁻¹)	(CaO) reading In (mmol l ⁻¹)	Theoretical maximum (CaO)reading in (mmol l ⁻¹)	(CaO) reduction in percentage
Portland Cement 43 Grade	46.80	10.92	11	0.7
Ceramic waste	40.87	10.21	13.54	24.53

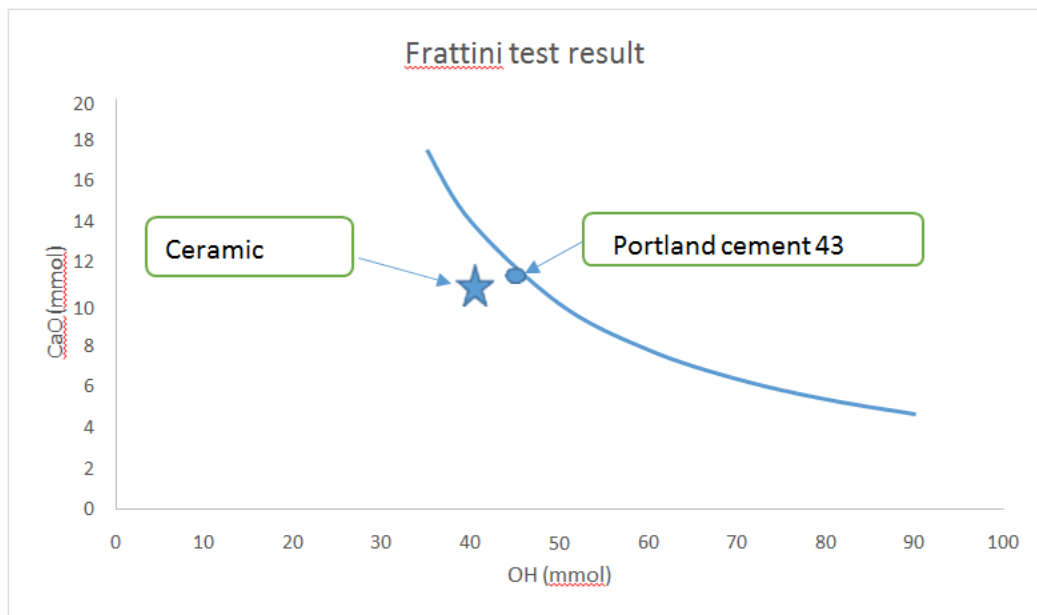


Figure 4: Frattini test of ceramic waste with comparison of control mortar

In the Frattini test, if the material is below the lime saturation curve, it suggests it is consuming calcium from the solution and Ca²⁺ is present, indicating pozzolanic activity in the material. If the point is above the lime saturation curve, there is no pozzolanic activity, and if it is below the curve, there is no pozzolanic activity. If the CaO reduction % figure in the table is positive, it indicates pozzolanic activity in the mortar. There are two samples: one with no replacement cement and one with replacement cement.

One is cement with a 20 percent replacement. The outcome is calculated by taking the average of three measurements. According to the table results, ceramic waste material exhibits a positive CaO reduction value, indicating pozzolanic activity.

The concentration of Ca²⁺ and OH⁻ in ceramic waste material is below the lime saturation line, according to the graph results. It signifies that the ceramic waste material devoured the calcium hydroxides and demonstrates the pozzolanic activity in the mortar solution.



Fresh concrete (Workability) test

Table 5: Workability of concrete

Sl. No.	ste replacement with cement in concrete (in %)	ability of concrete by slump cone test (in mm)
1.	Control – 0 %	110
2.	5 %	108
3.	10 %	100
4.	15 %	95
5.	20 %	85



Figure 5: Workability of concrete mix with different proportions of ceramic waste

According to the findings, the workability of concrete mix falls as the amount of ceramic waste material increases, implying that ceramic reduces the workability of concrete and requires less water for mixing.

IV. CONCLUSION

The following conclusions can be made on the basis of the investigations:

- The use of ceramic waste in concrete mix can be reduced the workability of concrete as replacement level increases.
- The strength of ceramic waste in concrete decreases due to high flakiness value, weaker bonding of aggregate and high water absorption ratio.
- The density of concrete reduced while using the ceramic waste replacement increases.
- The uses of ceramic waste are cost effective to reduce the overall cost of concrete mix.
- According to the mechanical characteristics and durability test results of ceramic insulator waste material replacement in concrete has been effective up to a limit of 15% replacement with cement.
- According to the pozzolanic activity test findings, the ceramic insulator waste has a positive result in the mortar, demonstrating pozzolanic activity in the saturated lime test, strength activity test, and frattini test.

- g. The ceramic waste can be used for the both structural and non-structural works.
- h. Ceramic waste material could not be used in concrete structures where strength is main concerned.

FUTURE SCOPE

According to the test results, cement can be substituted up to 20% in the mortar, although durability and other tests are also necessary for the use of these waste materials. In the future, the amount of ceramic material replacement may be increased, and further research effort may be necessary for that study.

According to the mechanical properties and durability test results, such as water absorption and penetration test, ceramic can replace up to 15% of the concrete, but for confirmation, other durability tests such as acid attack test, chloride attack test, carbonation test, and micro- structure study are required.

REFERENCES

1. S. Donatello, M. Tyrer and C.R. Cheeseman (2009) "Comparison of test methods to assess pozzolanic activity". Journal paper at Elsevier on Science Direct at Cement & Concrete Composites 32 (2010) 121–127.
2. S.M.A. El-Gamal, F.I. El-Hosiny, M.S. Amin and D.G. Sayed (2017) "Ceramic waste as an efficient material for enhancing the fire resistance and mechanical properties of hardened Portland cement pastes". Journal paper at Elsevier on Science Direct at Construction and Building Materials 154 (2017) 1062–1078.
3. Salman Siddique, Sandeep Shrivastava and Sandeep Chaudhary (2018) "Durability properties of bone china ceramic fine aggregate concrete". Journal paper at Elsevier on Science Direct at Construction and Building Materials 173 (2018) 323–331.
4. Luiz Renato Steiner, Adriano Michael Bernardin and Fernando Pelisser (2015) "Effectiveness of ceramic tile polishing residues as supplementary cementitious materials for cement mortars". Journal paper at Elsevier on Science Direct at Sustainable Materials and Technologies 4 (2015) 30–35.
5. Serkan Subas, Hakan Ozturk and Mehmet Emirog Lu (2017) "Utilizing of waste ceramic powders as filler material in self-consolidating concrete". Journal paper at Elsevier on Science Direct at Construction and Building Materials 149 (2017) 567–574.
6. A. Roul, K. Boudeghdegh and N. Boufafa (2009) "Improving usual and dielectric properties of ceramic high voltage insulators" for the XRD test result discussion, Ceramic 55 (2009) 206-208.
7. Hong-seok Janga, Seung-young (2015) "The properties of cement-based mortar using different particle size of grinding waste insulator powder", Journal of Building Engineering 3 (2015) 48–57.
8. American society for testing and materials (ASTM) C-125 (2007). Saturated terminology relating to concrete and concrete aggregate; 2007.
9. Caijun Shia, YanzhongWua, Chris Rieflerb, Hugh Wangc(2004). "Characteristics and pozzolanic reactivity of glass powders" USA, Cement, and Concrete Research 35 (2005) 987–993.
10. Frias M, Villar-Cocina E, Sanchez de Rojas MI, Valencia-Morales E (2005). "The effect that different pozzolanic activity methods has on the kinetic constants of the pozzolanic reaction in sugar cane straw-ash/lime systems: application of a kinetic- diffusive model". Cem Concr Res 2005; 35:2137–42.
11. G. M. Sadiqul Islam, M. H. Rahman, Nayem Kazi (2017), "Waste glass powder as partial replacement of cement for sustainable concrete practice" International Journal of Sustainable Built Environment (2017) 6, 37–44.
12. British Standard (BS) 3892. Pulverised-fuel ash. Part 1: specification for pulverized fuel ash for use with Portland cement; 1997.
13. British Standard Euronorm (BS EN) 196. Method of testing cement. Part 5: pozzolanicity test for pozzolanic cement; 2005.
14. British Standard Euronorm (BS EN) 1015. Methods of test for mortar for masonry. Part3: Determination of consistence of fresh mortar (by flow table); 1996.



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