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A REVIEW PAPER ON USE OF CERAMIC TILE WASTE AS A REPLACEMENT OF AGGREGATE AND CEMENT OF CONCRETE

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ABSTRACT- This study highlights the benefits of ceramic waste in the construction industry. The majority of generated globally waste comes from construction demolition of building. The question of whether Ceramic Waste can act as pozzolana material in cement production has been effectively investigated. The aim of this study was to investigate some of the mechanical and physical properties of concrete produced in laboratory to which fine aggregate formed of white ceramic powder was added in a range of proportions from waste from demolition sites and the ceramics industry. Replacement of Cement or Aggregates should not be utilized where strength is the prime factor. Both structural and non-structural operations could make use of ceramic waste.

Keywords: *Ceramic waste powder, cost-effective, pozzolanic material, eco-friendly, durability performances.*

I. INTRODUCTION

The ongoing industrial and technological growth faces a major problem of waste disposal. Utilizing the rubble from historic buildings as concrete aggregate after cleaning would be a good solution given the growing importance of controlling waste material pollution. When the powder dries, causes a serious environmental impact, air pollution and occupies a significant amount of land, thus it is imperative to swiftly dispose of any waste generated due to use of ceramic and use it in the building sector. In the ceramics sector, waste material makes up 15% to 30% of overall production. Ceramic dust and Ceramic waste is highly resistant to forces of natural decomposition due to its tough and resilient nature. The adoption of the such wastes as substitute materials results in lower cost, less energy use, and

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fewer environmental hazards. Such wastes when recycled as a sustainable construction material looks to be suitable alternate for coping up with pollution issues as well as an affordable choice in the design of green structures.

Ceramic waste has pozzolanic characteristics and is regarded as a non-hazardous solid waste. Researchers have produced green concrete (environment friendly) with replacing 20% of the natural aggregates with ceramic waste. The workability and strength of cement concrete made from pottery scraps were demonstrated. Researchers discovered that the split tensile strength and compressive strength, both increases by the inclusion of ceramic waste. Replacing of 20% ceramic waste with natural aggregates used, the cube strength increases by 30% at a w/c ratio of 0.46.

Benefits of ceramic based waste dust as a mineral filler in road construction is also studied as follows:

- Availability of Ceramic Dust at negligible cost;
- Consistent chemical and physical properties;
- Activity of road construction moves toward being environmentally friendly; and
- Ceramic dust is highly resistant to external factors of physical, chemical and biological degradation. It also has a durable and tough nature.

This review paper describes the impact of replacing ceramic based waste with natural coarse aggregate for the generation of cementitious concrete. In terms of compressive strength, chloride diffusion, capillary water absorption, Workability And oxygen permeability, concrete mixes within more durable concrete buildings. Recycled eco-friendly ceramic concrete is reported to have better mechanical properties than conventional concrete.

II. MATERIAL, PROPERTIES AND THEIR USES

Coarse aggregate

The commonly used coarse aggregate size was 20mm. The removed natural coarse aggregate has specific gravity of 2.74 and is assumed to have zero water content. Coarse aggregates from a local source were separated into two fractions. H. 20mm and 10mm. Riverbed gravel and mechanical gravel were used as coarse aggregate.

Fine aggregate

The natural fine aggregates used were sieved from 4.75 mm of sieve. Water absorption was generally found out to be 1% and have a specific gravity of 2.31.

Cement

Cement is the active ingredient in concrete. The commonly used cement is plain Portland cement, chosen according to the type of concrete. The initial curing time was 180 minutes, the final curing time was 240 minutes, and the compressive strength after 3 days, 7 days and 28 days was 37 N/mm2, 48 N/mm2, and 59 N/mm2, respectively. The cement's specific gravity was calculated to be 2.71. At a w/c ratio of 0.4, cement content is 495 kg/m3 and at w/c ratio of 0.5, the cement content is 395 kg/m3.

Water

The potable water was used in concrete mix. Aggregates were wetted with water in order to developed the adhesive quality as cement paste binds quickly. Water is an important component of cementitious concrete because it

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chemically reacts with cement to form hydrated binder compounds. Typically, water to cement ratio ranges from 0.40 to 0.60 were used.

Ceramic Waste

Ceramic tile scrap was collected from construction sites where ceramic tiles were used as floor and wall components. Pottery scraps such as flowerpots and clay bricks were smashed finely with a hammer and these small pieces were sieved through a series of sieves to a required size of 14-20 mm [1-2]. In general, the water absorption and bulk density of ceramic waste were 0.08% and 2.35 g/cc, respectively. The density of waste ceramic concrete has been found to be about the same as that of conventional concrete. Ceramic waste concrete showed good resistance to sulfate attack. Replacing part of the concrete with ceramic waste has many benefits, such as reducing the cost of concrete and reducing waste to the environment from landfills. The use of ceramic waste powder in cement concrete increases up to 20% increase in tensile strength. Substantial loss of strength has been observed with more than 20% ceramic waste replacement. Compressive strength of ceramic waste concrete is better with little concrete damage.

III. Test Performed

Ccompressive Sstrength Test

The most common strength indicator for cement concrete is Compressive strength test led on hardened concrete. Compressive strength test predominantly indicates the quality of cement concrete constituents. Concrete cubes samples of size 150x150x150 mm were casted using cement concrete. After 24 hours concrete cubes were immersed into water for curing for next 28 days. The compressive strength test were done and following references were obtained:

- F. Pacheco-Torgal et al. [6] shows that concrete cubes made by replacing ceramic waste coarse aggregate and ceramic waste sand have higher strength compared to control concrete cubes made with conventional aggregate.
- Paul O. Awoyera et al. [7] found that compressive strength of ceramic waste based concrete cubes increases to 22.1% at 100% with rate of aggregate increased. Compared to the natural concrete after 28 days, concrete containing 100% CCA showed a strength improvement of approximately 36.1%. The compression strength of hardened cement concrete has been evaluated according to the requirements of BS EN 12390-3 [16]. At 3, 7, 14 and 28 days, the compressive strength of Ceramic concrete varies with content (0%, 25%, 50%, 75% & 100%).
- Amit Kumar D. Laval et al. [3] Conducted a comparative study of characteristic strength at a concrete mixing ratio of 1:1.80:3 Cement was partially replaced by 10, 20, 30, 40 and 50 percent ceramic waste. The compressive strength of M20 concrete cube increases when cement is replaced by ceramic powder up to 30% by weight. Replacing cement with ceramic powder reduces its compressive strength.
- E.E. Ikponmwosa1, et al. [8] found that the cubes he tested for compressive strength were tested at cure ages of 7, 14, 28, 45, and 90 days. The characteristic strength of each cube was measured with a universal testing machine. Three specimens of each mixture were tested at each cure age and the breaking load values

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were averaged and used to determine the average strength for each heat. A total of 75 cubic samples were built and tested.

- Yuko Ogawa and others [23] investigated that the compressive strength of concrete with ceramic waste replacing 40% of natural coarse aggregate was 160 MPa, which is 30% higher than concrete without PCWA. Based on JIS A 1108 (concrete compressive strength test method), compressive tests were conducted at ages 1, 7, 28, 56, 91, 182, and 364 days.

Flexural Strength Test

- Joseph O. Akinmusuru et al. [7] Flexural strength increased by up to 50% after incorporating ceramic waste aggregates after 2 days, and over time the effect became less significant, and after 56 days he saw a 12% increase. Replacing 15% coarse aggregate and 30% FA with fine ceramic aggregate increases the 7-day bending strength.
- Jimenez et al. [13] It can be seen that the flexural strengths of the five replacement percentage at different curing duration are nearly the same, all average bending- flexural strengths for 7, 28, 90 and 180 days of curing time. Addition of ceramic waste to alternative cements decreases the tensile strength of the self-compacting concrete. Split Tensile Strength was found to be 4.30 MPa, 3.90 MPa, 3.55 MPa, 3.13 MPa, 2.18 MPa and 4.94.4 MPa after 7 days.
- Katzer [14] found that by 10% volume replacement of cement with ceramic based fume at w/c 0.55, the highest flexural strength was reached then after that flexural strength was decreasing. This also determined that when 20% ceramic waste tiles were used in concrete, then 28-day Split tensile strength increased by 28.9% of that of natural aggeregate concrete and increasing the percentage with 25% fly ash in concrete it decreases the Split tensile strength in both types of concrete grade (M30 & M35)

  Split Tensile Strength Test

  By using ceramic aggregates (fine ceramic) in concrete mixes with 20%, 40%, 60% and 80% replacement levels, the tensile strength (Split tensile strength) was found to increase as replacement percentage increases. This increase can be due to decrease in free water content as ceramic aggregates have high water absorption rate.

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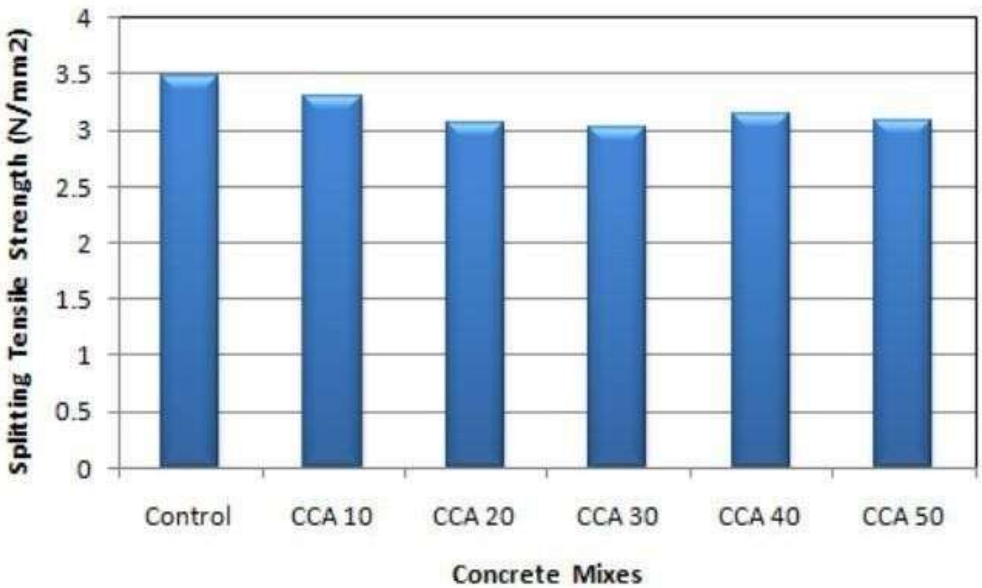

Fig.1 Split Tensile strength of coarse ceramic aggregate based concrete mixes [10]

- Julius M Ndambuki et al. [10] reported that for concrete mix containing Ceramic Fine Aggeragate, the split tensile strength produced properly between its 14th and 28th days of setting age found out to be 2.8 N/mm² to 3.6 N/mm². In all studies by the author, inclusion of ceramic waste aggregates causes an improvement in the concrete pore system and an increase in capillary pore volume.
- Paul O. Awoyeira et al. [2] stated that for concrete containing CFA, a curing period of 14 to 28 days was sufficient to develop a split strength, yielding results of 2.8 N/mm2 to 3.6 N/mm2.
- Anderson et al. [11] stated that the inclusion of ceramic he tile waste increases the tensile strength of concrete. Decreased tensile strength of concrete. As curing progresses, the split tensile strength of concrete increases. Tensile test results reached 10% and 20% exchange at, corresponding to 5.3 and 5.

Durability Performance

The durability (optimal replacement level) of concrete made using ceramic waste was measured in tap water, 5% and 10% chloride solutions, and these results are similar to those of same conventional mix concrete. Comparing the durability results are shown in Figures 2 and 3. It shows that the compressive strength of concrete in a chloride environment decreased after 120 days compared to samples cured with tap water. However, the compressive strength of samples made using CW (waste ceramic) and cured in a chloride based environment was higher than samples made from the reference PPC cured in tap water.

• Concrete Cubes were casted and maintained at a temp. of 270 °C ± 20 °C and at a relative humidity of approx.. 90% for 24 hours. After 24 hours, the cubes were removed from the mold and immersed in clean, fresh water until removed for testing. After 28 days of curing, he removed the cubes, weighed them accurately, and immersed them in 5% concentrated sulfuric acid (H2SO4) and 5% hydrochloric acid (HCL) for another 28 days. Fifty-six days after the casting date, the cubes were removed from the acid cure to remove the worst

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surface of the cubes. The sample was weighed again to determine the weight difference before and after acid curing. Samples were then pressure tested to determine strength loss due to acid attack [22]

Except for the Ceramic based blend, which had a 5% higher vacuum water absorption than the control blend, all other samples were Lower vacuum water absorption than die control mix. (figure. 2). Regarding oxygen permeability (Fig. 3), it may appear that two blends (CB and SB) show slightly higher values than the control, whereas the other two blends (WSTF and WSOF) showing low values. However, the difference is between 6% and 12% compared to the control mix. We can say that we see no relevant differences in the oxygen permeability of these mixtures.

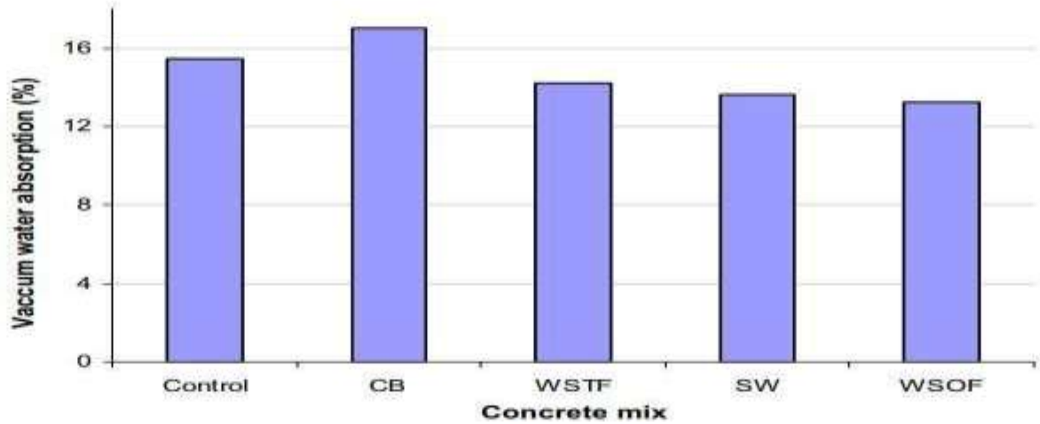

Fig. 2 Water absorption

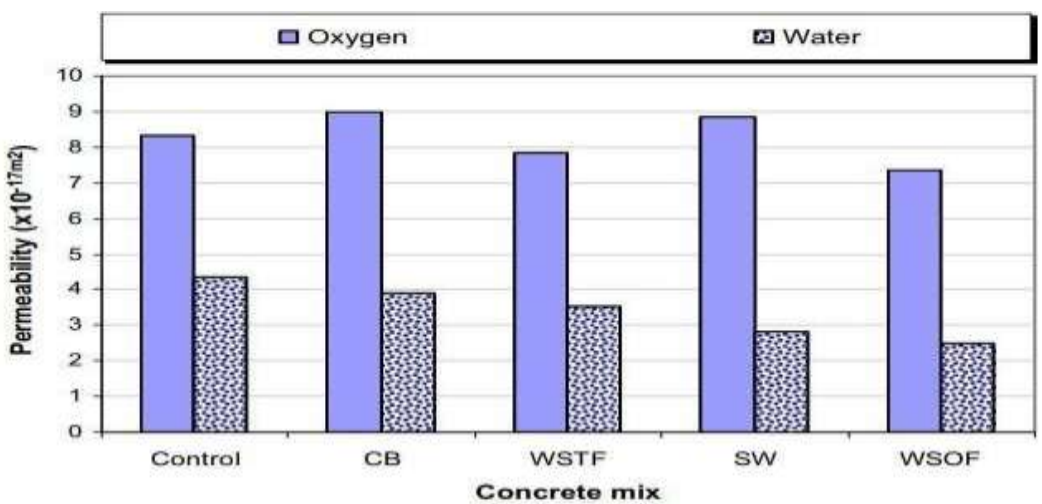

Fig. 3 Permeability Chloride ion permeation

- Ali et al. (2016) concluded that increasing WCP caused a decrease in chloride ion permeability in all mixtures. This is likely due to the lower porosity of WCP than slag and cement, and the smaller particles of WCP, resulting in micro-filling effect and close-packing in concrete microstructure
- Ali et al. (2019) found that the depth of chloride penetration decreased with increasing BCCFA content in concrete.

IV. CONCLUSION:

BASED ON THE EXPERIMENTAL STUDIES ON COMPRESSIVE STRENGTH OF CONCRETE, WE FOUND OUT THAT:

- Compressive strength of M25 concrete increases with replacement of cement by ceramic waste upto 30% (by weight) of cement and further replacement of cement. The use of ceramic powders reduces the compressive strength of concrete.
- Sustainable concrete made from ceramic waste exhibits better strength properties than conventional concrete.
- Sustainable ceramic powder (CP) concrete has been found to be economical and environmentally friendly.
- The use and application of ceramic waste is used in the development of the construction industry.The beneficial use of ceramic waste can minimize landfills.
- 10% volume replacement of cement by ceramic smoke with a water to cement ratio of 0.55 Peak flexural strength was achieved after flexural strength decline.
- Compressive strength of cement mortar decreased with increasing ceramic fume.

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