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To Study the use of Ceramic Waste as Partial Replacement of Coarse Aggregate on the Concrete - A Review

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Abstract: Most serious problems of the world today is related to removal of waste and to find solution of reusing it. Various waste materials are generated from manufacturing processes, service industries, construction and demolition works and municipal solid wastes. Increasing awareness about the environment has tremendously contributed to the concerns related with disposal of these generated wastes. All Solid waste management is one of the major environmental concerns in the world and with the scarcity of space for land filling and due to its ever increasing cost; waste utilization has become an attractive alternative to disposal. There are numerous researches that are being carried out to utilize these wastes in the construction industry where most of them are related to using these wastes in concrete. This study will help improving the usage of ceramic wastes in concrete and its effect on various required properties of concrete.

Use of waste products in concrete not only makes it economical but also solves some of the disposal problems. In ceramic industry, about 25% productions go as waste. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant to biological, chemical, and physical degradation forces. As the ceramic waste is piling up every day, there is a pressure on ceramic industries to find a solution for its disposal. The use of crushed ceramic aggregate can be used to produce lightweight concrete, without affecting.

Keywords: ceramic waste, coarse aggregate, strength and durability, concrete, floor tiles.

I. INTRODUCTION

Concrete as the world's largest amount of man-made materials is the preferred material that cannot be replaced in twenty-first Century for all kinds of infrastructure construction, but with the increasing amount of concrete, the consumption of natural resources such as sand and gravel aggregate are also increasing rapidly. It is estimated that the consumption of concrete industry is now at an annual rate of about 5 billion tons of natural aggregate, sand and gravel has become one of the largest amount of raw materials, A lot of mountains, quarrying has severely damaged the natural mountain landscape and green vegetation. To the Digging river sand has changed the bed position and shape, resulting in serious consequences, such as soil erosion or river diversions. Since many countries and regions have no merit even gravel and sand, concrete aggregate resources in a serious crisis. In response to this situation, people began to seek new aggregate resources, and has achieved some success, for example, the system of sea sand aggregate, waste concrete recycled aggregate, the used tailings production of aggregate, artificial aggregates. In the production, transportation, sale, storage and use of all kinds of ceramic products during the period, due to the bump, eliminate aging and other factors cause a lot of waste ceramics. Literature survey showed, 25% of the world's ceramic industry product as industrial waste. Ceramic industry as a traditional industry in China, the amount of waste is high. But this part of ceramic waste, according to the present, doesn't have any form of effective recycling. In order to meet the economic development and people's living needs, ceramic industry and construction still have to continue to develop, so caused by the traditional concrete production of ceramic waste pollution and how to effectively use the ceramic waste have become an urgent problem nowadays, how to apply the ceramic waste generated by the ceramic industry effectively in the construction industry production of raw materials is an important issue in the field of waste treatment and resource recovery. Reusing ceramic waste powder in building material production is not only to more efficient use of resources, and reduces the pollutant emissions, but is conducive to the sustainable development of society and nature. It is believed that mixing of ready mixed concrete products with ceramic powder waste to some extent can be considered environmentally friendly concrete, Ceramic products are part of the essential construction materials used in most buildings. Some common manufactured ceramics include wall tiles, floor tiles, sanitary ware, household ceramics and technical ceramics. They are mostly produced using natural materials that contain high content of clay minerals. However, despite the ornamental benefits of ceramics, its wastes among others cause a lot of nuisance to the environment.

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).

II. LITERATURE REVIEW

- 1) *Reusing ceramic wastes in concrete by F. Pacheco-Torgal, S. Jalali (7 November 2009) [1]* This paper examines the feasibility of using ceramic wastes in concrete. Results show that concrete with 20% cement replacement although it has a minor strength loss possess increase durability performance. Results also show that concrete mixtures with ceramic aggregates perform better than the control concrete mixtures concerning compressive strength, capillary water absorption, oxygen permeability and chloride diffusion thus leading to more durable concrete structures. Water cement ratio 0.5 was taken.
- 2) *Reusing ceramic wastes in concrete by F. Pacheco-Torgal a, S. Jalali b (7 November 2009) [2]* The ceramic industry is known to generate large amounts of calcined-clay wastes each year. So far a huge part is used in landfills. Reusing these wastes in concrete could be a win-win situation. For one hand by solving the ceramic industry waste problem and at the same time leading to a more sustainable concrete industry by reducing the use of non renewable resources like cement and aggregates and avoiding environmental problems related to land filled wastes. This paper examines the feasibility of using ceramic wastes in concrete. Results show that concrete with 20% cement replacement although it has a minor strength loss possess increase durability performance. Results also show that concrete mixtures with ceramic aggregates perform better than the control concrete mixtures concerning compressive strength, capillary water absorption, oxygen permeability and chloride diffusion thus leading to more durable concrete structures.
- 3) *Properties of recycled ceramic aggregate concretes: Water resistance by C. Medina, M.I. Sánchez de Rojas, M. Frías (17 April 2013) [3]* Water permeability is a durability indicator, for it quantifies concrete resistance to penetration by external agents, due to that water is one of the main carriers of aggressive substances. The present study explores whether substituting 20% and 25% recycled sanitary ware for gravel in coarse aggregate affects structural recycled concrete resistance to water. The findings reveal that the slightly higher porosity in the recycled concrete does not translate into greater permeability. These new recycled concretes, which prove to be as durable as the conventional material, will therefore perform well throughout their design service life.
- 4) *Properties of recycled ceramic aggregate concretes: Water resistance C. Medina, M.I. Sánchez de Rojas, M. Frías (17 April 2013) [4]* Water permeability is a durability indicator, for it quantifies concrete resistance to penetration by external agents, due to that water is one of the main carriers of aggressive substances. The present study explores whether substituting 20% and 25% recycled sanitary ware for gravel in coarse aggregate affects structural recycled concrete resistance to water. The findings reveal that the slightly higher porosity in the recycled concrete does not translate into greater permeability. These new recycled concretes, which prove to be as durable as the conventional material, will therefore perform well throughout their design service life. Abrupt temperature change (freeze-thaw cycles) is one of the most damaging actions affecting concrete, in as much as it induces microcracking. The formation of this crack reduces the mechanical behaviour of the material, moreover increase the penetration of aggressive substances into the concrete matrix, reducing its durability and possibly leading to structural collapse. The present study explored the durability of concrete made with aggregate containing 20-25% ceramic sanitary ware industry waste, analysing the scaled surface, exploring aggregate/paste de-bonding and measuring the mean and maximum crack widths in both the paste and at the interfacial transition zone between paste-aggregate after 56 freeze thaw cycles. The findings showed that concrete freeze-thaw resistance rose with rising recycled aggregate content. This better performance was due to the high mechanical quality of recycled concrete and the intrinsic properties of the new aggregate.
- 5) *Using ceramic sanitary ware waste as concrete aggregate by Anna Halicka, Pawel Ogrodnik, Bartosz Zegardlo (30 July 2013) [5]* The procedure of aggregate production (crushing, dividing particles into two groups – fine and coarse particles and establishing their proportion) and designing the concrete mix are described. Studies on properties of this aggregate and properties of concrete containing this aggregate, are presented. Tested concrete displayed high strength and high abrasion resistance. This paper presents also results of examination of concrete with alumina cement and ceramic sanitary ware wastes as aggregate in 1000 °C temperature. For comparison purposes, specimens with traditional natural aggregate and alumina cement were heated as well. As opposed to specimens of concrete with traditional aggregate, specimens with ceramic aggregate preserved their shape and cohesion and showed no cracks and defects. Despite some decrease in strength, these specimens after heating continued to display high compressive and tensile strength. On the basis of described studies, sanitary ceramic

- aggregate may be recommended for preparing special types of concrete: abrasion resistant concrete and concrete dedicated for members working in high temperatures.
- 6) *Leaching in concretes containing recycled ceramic aggregate from the sanitary ware industry by César Medina , Moisés Frías , María Isabel Sánchez de Rojas (5 November 2013) [6]* The re-use of construction and demolition, ceramic and similar waste in the construction industry has aroused considerable interest in recent years, as an avenue for furthering the sustainable use of resources and reducing the volume of waste dumped in landfills. Recycling materials as components in the manufacture of cement-based products, however, calls for an understanding of the leachability of the elements present in the new materials that may be harmful to human health or the respective ecosystems. The present study addresses the effect of including recycled ceramic sanitary ware waste as a partial substitute (25%) for natural coarse aggregate in the manufacture of recycled concrete in direct contact with water intended for human consumption. The findings show that the inclusion of ceramic aggregate raises the alkali concentration (Na and K) slightly and lowers the concentration of other elements (B, Si, Cl and Mg) in the water. The levels of all the leached elements were observed to be lower than the limits specified in the legislation in effect on water for human consumption.
 - 7) *Properties of high performance concrete made with recycled fine ceramic and coarse mixed aggregates by Gonzalez-Corominas, M. Etxeberria (3 July 2014) [7]* In this study the waste material has been obtained from building demolition and also from the ceramic industry (known for the production of large amounts of rejected ceramic wastes). High performance concretes (HPC) was produced using fine ceramic aggregates (FCA) in substitution of 15% and 30% of natural sand, and using 20%, 50% and 100% of coarse mixed aggregates (CMA) on substitution of natural coarse aggregates. The physical, mechanical and durability properties of the recycled aggregate concretes were determined and compared to those of the results of conventional concrete. The results showed that concrete produced with up to 30% of FCA achieved similar or improved mechanical and durability properties to those of conventional concrete. Concrete made with up to 20% of CMA achieved similar compressive strength to High Performance conventional Concrete of 100 MPa. At 180 days of curing the concretes produced with up to 50% CMA obtained low corrosion risk.
 - 8) *Utilisation of crushed floor and wall tile wastes as aggregate in concrete production by Hakan Elçi (1 July 2015) [8]* Industrial wastes are often used as aggregate in concrete production to lower their production cost. Large quantities of tiles are discarded during the tile production in the ceramic factories due to substandard and low quality production. The tile waste can reach up to 7% of the total tile production in the ceramic tile sector. At present, the tile wastes are not used for any purposes in Turkey, they are continuously stored at waste dumps. Studies are carried out to determine the possibility of using the tile waste as aggregates in concrete production to decrease the production cost and also to minimise the environmental impact of tile wastes. Properties of tile made concretes are compared with the properties of the concrete made using the limestone aggregates
 - 9) *Durability of recycled concrete made with recycled ceramic sanitary ware aggregate. Inter-indicator relationships by C. Medina , M.I. Sánchez de Rojas , C. Thomas , J.A. Polanco , M. Frías (22 December 2015) [9]* Direct and indirect durability indices can be used to ensure that such concrete is able to withstand the actions to which it will be exposed throughout its service life to design safety, functionality and aesthetics and with no unexpected maintenance costs. In the present study, 20% and 25% of the natural coarse aggregate in concrete was replaced with recycled aggregate from the sanitary ware industry to explore the effect on chloride penetration and electrical resistivity, as well as the relationship among the durability indicators that predict concrete performance during its service life. The findings showed that chloride penetration was slightly deeper in recycled concretes, while no alterations were observed in the relationship among durability indicators. Electrical resistivity, in turn, was observed to rise with the use of recycled aggregate due to the intrinsic characteristics of this material. The new concretes proved to be as durable as the conventional material, performing satisfactorily throughout their service life.
 - 10) *Green concrete production with ceramic wastes and laterite by Paul O. Awoyera , Joseph O. Akinmusuru , Julius M. Ndambuki (26 April 2016) [10]* Laterite is a dominant soil material in Nigeria but its use in structural concrete has not been overly explored. In this study, ceramic wastes obtained from construction and demolition activities and laterite were used as replacement for natural aggregates. Workability and strength characteristics of the concrete and microstructure of selected samples were obtained. Results showed that natural aggregate concrete was more workable than the laterised concrete. Both the compressive strength and splitting tensile strength increased with curing age, however, laterised concrete with 10% laterite content and 75% ceramic coarse aggregate yielded higher strength at 28 days than the reference concrete.
 - 11) *Mechanical properties of concrete utilising waste ceramic as coarse Aggregate by Derrick J. Anderson , Scott T. Smith , Francis T.K. Au (29 April 2016) [11]* A coarse aggregate replacement scheme in concrete is investigated with three different waste ceramic tile materials in replacement ratios including 20%, 25%, 35%, 50%, 65%, 75%, 80% and 100%. Results show

waste ceramic as a possible practicable natural coarse aggregate replacement material with minimal changes in mechanical properties.

- 12) *Ultra-high strength concrete made with recycled aggregate from sanitary ceramic wastes – The method of production and the interfacial transition zone by Zegardlo Bartosz , Szela,g Maciej , Ogrodnik Pawel (21 June 2016) [12]* The article describes a new model of ultra-high strength concrete (UHSC) production. It was assumed that the components will be generally available in the concrete plant such as cement, plasticizing admixtures and pozzolanic additives. Aggregate used will be a post-production sanitary ceramic wastes, selected to the two fractions of 0–4 mm and 4–8 mm. The goal of this study was to produce concrete with the highest strength parameters using iterative design method of concrete mix. For so obtained concrete, its basic physical and mechanical parameters were examined, such as: compressive and tensile strength, bulk density, water absorption, water permeability and frost resistance. The examined parameters were compared with results obtained on the reference samples made with the same ingredients, only used aggregate was gravel (0–4 mm) and basalt (4–8 mm). In addition, the interfacial transition zone (ITZ) between cement paste and aggregate (ceramic and basalt) was analyzed, using Scanning Electron Microscope (SEM). On this basis, conclusions on the impact of the ITZ's microstructure on the final characteristics of concrete were made. Own model of cement paste adhesion to the ceramic wastes aggregate was developed.
- 13) *Characterization of ceramic waste aggregate Concrete(Nigeria) Paul O. Awoyera , Julius M. Ndambuki , Joseph O. Akinmusuru , David O. Omole (15 November 2016) [13]* Workability of the fresh concrete was checked through slump test, and concrete cubes of 150 mm dimensions and cylinders of 100 mm _ 200 mm were cast in the laboratory. After 24 h of casting, the concrete samples were demolded and were cured by immersion in water tank at temperature of 22 _C. The compressive and split-tensile strengths of the hardened concrete samples were determined after curing them for 3, 7, 14 and 28 days. Results showed that both the compressive strength and split tensile strength increased appreciably with the curing age than the conventional concrete.
- 14) *Utilizing of waste ceramic powders as filler material in self-consolidating Concrete by Serkan Subas_, Hakan Öztürk , Mehmet Emirog̃lu a, (21 May 2017) [14]* Using filler materials finer than 0.125 mm is quite effective on the fresh state properties, strength and durability of self-consolidating concretes. Most common filler materials used in self-consolidating concretes are minerals, blended cements and natural or artificial pozzolans. In this study, usability of granulated waste ceramic powder as filler material in self-consolidating concretes was investigated. Properties of self-consolidating concretes produced with 550 kg/m³ dosage and cement was replaced with (WCP) in the amounts of 5%, 10%, 15% and 20% (by weight) were determined in the fresh and hardened phases. As a result, it is determined that use of WCP has some positive effect on viscosity of the mixes. However, a slight decrease was observed on the strength values based on the substitution of cement with ceramic powder. It can be concluded that finely ground WCPs could be evaluated up to 15% for production of self-consolidating concretes as a filler material if the strength and flowability parameters are evaluated together.
- 15) *Experimental and analytical selection of sustainable recycled concrete with ceramic waste aggregate by Khuram Rashid , Afia Razzaq , Madiha Ahmad , Tabasam Rashid , Samia Tariq (29 July 2017) [15]* This experimental and analytical investigation is conducted to develop a sustainable recycled concrete by incorporating ceramic waste as coarse aggregate. In order to achieve the designed goal, conventional aggregate is replaced by different amounts of ceramic waste aggregate. Fresh and hardened properties of conventional as well as ceramic waste aggregate concrete are assessed. Environmental impacts are also considered in terms of CO₂ footprints and consumption of volume of raw materials by concrete. Interfacial model is proposed at micro level to evaluate the behavior of ceramic waste and conventional aggregate with hydrated cement paste. Finally, sustainable concrete is selected which has the best performance with respect to compressive strength and environmental impacts. It is concluded that 30% partial replacement of ceramic waste aggregate with conventional aggregate provides the highest compressive strength, less environmental impacts and is selected as sustainable concrete, which is also verified by analytical hierarchy process (AHP) and technique for order preference by similarity to ideal solution (TOPSIS)
- 16) *Quality improvement of mixed and ceramic recycled aggregates by biodeposition of calcium carbonate(8 August 2017) [16]* This research focuses on improving the quality of mixed and ceramic recycled aggregates by microbially induced carbonate precipitation (*Bacillus sphaericus*). The precipitation contributed to a weight increase and unleashed a waterproofing response. The roughness of the ceramic particles created a more uniform layer compared to natural or concrete particles. For the concrete fraction, which had a higher macroporosity, the consolidation effect was more pronounced. High ceramic content aggregates profited from a greater biodeposition, leading to a remaining amount of precipitates after sonication which was still greater than in cementitious materials. Pore-filling effect was detected by SEM, supporting the waterproofing result.

III. CONCLUSION

Following are the conclusion made from the above study regarding our review study:-

- 1) Study on properties of concrete made with combination of recycled aggregate and tile aggregate in different proportions can be investigated to enhance the concrete properties and also to reduce the pollution or waste generation from construction industry
- 2) Use of tiles waste as a construction material would yield substantial technical, economic and environmental benefits, in particular from the perspective of sustainable development.
- 3) These new concretes are apt for use in such applications, for they ensure water quality.
- 4) The concrete made using the crushed floor tile aggregates have been found to have similar mechanical properties with that of the limestone concrete, on the other hand the concretes made with the wall tile aggregates have given lower mechanical properties than the floor tile aggregate concrete.
- 5) The use of crushed ceramic aggregate can be used to produce lightweight concrete, without affecting strength .
- 6) This will lead to utilization of wastes.
- 7) Reduction of usage of naturally occurring construction materials which in turn are depleting the natural resources due to the increasing demand of construction materials.
- 8) Use of ceramic as aggregate will make concrete economical.
- 9) Will reduce the disposal problems associated with these waste materials.

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