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Evaluation of Strength and Durability Properties of Concrete by Partial Replacement of Cement with Ceramic Waste

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ABSTRACT

Ceramic waste is one of the most active research areas that hold within a number of regulations including civil engineering and construction materials. Ceramic waste powder is settled by alluviation and then dumped away which results in environmental pollution, in addition to forming dust in summer and menacing both agriculture and public health. Therefore, utilization of the ceramic waste powder in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. It is most essential to develop eco-friendly concrete from ceramic waste.

In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 10% 20%, 30% by weight ofM25 grade. Concrete mixtures were produced, tested and compared in terms of compressive strength, split tensile strength and flexural strength and durability to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. This research work is concerned with the experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 10%, 20%, 30%, of ceramic waste. Keeping all this view, the aim of the analysis is to study the performance of concrete while replacing the ceramic waste with different proportions in concrete.

INTRODUCTION

This research analyzed the impact of the use of ceramic powder, procured as residue from the ceramics industry, on the mechanical properties of conventional concrete. The councils of large-and medium-sized towns have for years been increasingly concerned with the collection, storage and more recently treatment of domestic waste. Parallel to this, there has been a growing social and political awareness of environmental issues, particularly where this relates to the deterioration of the environment.

Ceramic waste from factories producing construction industry materials has been accumulating on frequently illegal rubbish tips, creating increasingly large piles. Although they are usually chemically inert, the rubbish tips where this waste accumulates, given their size and the scant environmental control exercised, have a significant visual impact that destroys the intrinsic quality of the landscape The reduction of natural and energy sources with increasing the advancement of concrete technology.

They have forced to focus on improvement, reuse of natural resources and find other substitutes.

Presently large amounts of Ceramic waste are generated in ceramic industries with an important impact on the environment and humans. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment. The industrial and economic growth witnessed in recent decades has brought with it an increase in the generation of different types of waste (urban, industrial, construction, etc.) despite the waste management policies which have been adopted nationally and internationally.

The practice of dumping and/or the inadequate management of waste from the various manufacturing sectors have had a notable impact on the receiving environment, leading to water, soil, air and noise pollution, amongst other complications, and adding to existing environmental problems. At the same time, these practices represent an economic cost.

Recycling of ceramic:

The pollution of ground and surface waters began as soon as industry began producing manufactured goods and wasting liquids and solid matter simultaneously. In the 1930s, industries began to be aware of the eventual danger of their wastes when sent untreated into waterways. It was natural for industry at that time to follow the lead of municipalities in using similar treatments to attempt to resolve their pollution problems. In the World War II there is an accelerated industrial production activity (Numerous, 2006), and two developments in the post-World War II era led to significant escalation in the problems of managing waste. First, a new phenomenon called "consumerism" emerged.

A long period of prosperity, combined with improvements in manufacturing methods led to rapid growth in the number and variety of consumer goods. In addition, new marketing and production practices were introduced, such as planned obsolescence and "throw-away" products. The growth of advertising, along with the electronic media, played an important role in the evolution to our society's current level of overconsumption. The end result was a dramatic increase in the amount and variety of consumer goods—and, hence, wastes (The waste crisis). The second development was the birth of the "chemical age," which resulted in a dramatic change in the composition of the waste stream.

The petrochemical industry has grown explosively since that time, yielding a vast array of new synthetic organic compounds, a kind of pollution that had never existed before entered the environment, exhibiting toxicity as well as non-biodegradability (Tammemagi, 1999; Nemerow, 2006). Radioactivity, petrochemical, and synthetic organic chemicals were largely developed and surfaced in the environment in the 1940s and 1950s. During this period, major environmental problems surfaced with rapid and serious consequences. Hence was born the advent of what was to become the pollution problems of the twentieth century (Nemerow, 2006). Historically, waste was simply dumped in depressions, ravines, and other handy locales that were close to the population centers producing the waste. Even though recycling was commonly practiced by all households during pre-industrial ages, large-scale recycling programs did not arise until the twentieth century.

The first organized programs were created in the 1930s and 1940s, when a worldwide depression limited people's ability to purchase new goods and the outbreak of World War II dramatically increased demands for certain materials.

Throughout the war, goods such as nylon, rubber, and various metals were recycled and reused to produce weapons and other materials needed to support the war effort. However, after the War there was a drastically decrease in the recycling efforts (Miller, 2010). It was not until the environmental movement of the 1960s and 1970s that recycling once again emerged as a popular idea.

This movement began in 1962 with the publication of Rachel Carson's book Silent Spring, detailing the toxic effects of the chemical DDT on birds and their habitats. The book raised the consciousness of many people about the dangers to the environment from chemicals and other toxins produced by modern industries (Miller, 2010). Thereafter, the increase in the environmental awareness and consciousness required industry to meet tighter environmental standards on a global basis. In many countries, such requirements generally cannot be met by using conventional disposal of residual solid wastes in landfills (Wang et al., 2010).

Accordingly, much more emphasis has to be placed on waste reduction and recycling technologies as a necessary first step to reduce to a minimum the extent of the waste treatments to be provided. In recent years there has been growing concern about the negative impacts that industry and its products are having on both society and the environment in which we live. The concept of sustainability and the need to behave in a more sustainable manner has therefore received increasing attention. With the world's population growing rapidly the consumption of materials, energy and other resources has been accelerating in a way that cannot be sustained (Hester, R. E. & Harrison, 2009). In this scenario, solid waste management has moved to the forefront of the environmental agenda, with the amount of related activities and concern by citizens and governments worldwide reaching unprecedented levels.

TYPES OF CERAMIC TO RECYCLE:

Kyocera has a wide range of advanced ceramic materials to offer. Each one with its own unique characteristics designed to meet the requirements of many diverse applications. Some of the more widely used materials are described below.

ALUMINA

Alumina is the most widely used advanced ceramic material. It offers very good performance in terms of wear resistance, corrosion resistance and strength at a reasonable price. Its high dielectric properties are beneficial in electronic products.

Applications include armor, semiconductor processing equipment parts, faucet disc valves, seals, electronic substrates and industrial machine components.

SILICON NITRIDE

Silicon nitride exceeds other ceramic materials in thermal shock resistance. It also offers an excellent combination of low density, high strength, low thermal expansion and good corrosion resistance and fracture toughness.

Applications include various aerospace and automotive engine components, papermaking machine wear surfaces, armor, burner nozzles and molten metal processing parts.

SILICON CARBIDE

Silicon carbide has the highest corrosion resistance of all the advanced ceramic materials. It also retains its strength at temperatures as high as 1400°C and offers excellent wear resistance and thermal shock resistance. Applications include armor, mechanical seals, nozzles, silicon wafer polishing plates and pump parts.

ZIRCONIA

Zirconia has the highest strength and toughness at room temperature of all the advanced ceramic materials. The fine grain size allows for extremely smooth surfaces and sharp edges.

Applications include scissors, knifes, slitters, pump shafts, metal-forming tools, fixtures, tweezers, wire drawing rings, bearing sleeves and valves.

ENVIRONMENTAL APPLICATIONS:

At the very core of these technologies are selected materials from a number of classes ranging from purely organic- and inorganic-based matrices to the precious metals and alloys that all ought to meet well defined operation-relevant conditions and efficiencies.

Depending on the targeted application, each material foreseen as a base for component development has to be evaluated individually and its properties have to be modified in terms of corresponding application requirements. In order to elaborate tailored ceramic materials for gas separation and ion/electron transport at the relevant operating conditions and stability ranges, improved electrical or ionic conductivities and permeation rates are required. That can be achieved by doping and substitution which are actors on a nano-scale that usually lead to macroscopic impacts

This chapter is dedicated to the fascinating world of tailoring ceramic material for energy and environmental applications. Selected approaches to tune ceramics will be discussed to illustrate the versatile effects that compositional variation can have on the macroscopic properties, e.g. the conductivity of protons, oxygen ions and or electronic carriers, stability, etc. The present chapter will therefore consider the structural features of selected material classes, as well as the principles of transport in bulk and micro porous solids. It will furthermore illustrate and discuss the effects of selected additives and substituent's on sinter ability, electrical electrochemical properties and stability of selected ceramic materials for energy and environmental applications. The material variety will cover ceramic materials with different crystal structures like fluorites, perovskites, pyrochlores, fergusonites, as well as selected zeolite structures.

CONSTITUENT MATERIALS:

A ceramic-powder polymer composite, making use of a relaxer ferroelectric polymer that has a high room-temperature dielectric constant as the matrix, is developed. The experimental data show that the dielectric constant of the composites with Pb(Mg1/3Nb2/3)O3–PbTiO3powders can reach more than 250 with weak temperature dependence. In addition, the composites under a proper preparation procedure exhibit a high breakdown field strength (>120 MV/m), leading to a maximum energy storage density of more than 15 J/cm^3.

Experimental results also indicate that the high electron irradiation does not have much effect on the dielectric behavior of Pb(Mg1/3Nb2/3)O3–PbTiO3powders, possibly due to the relaxer nature of the ceramic.

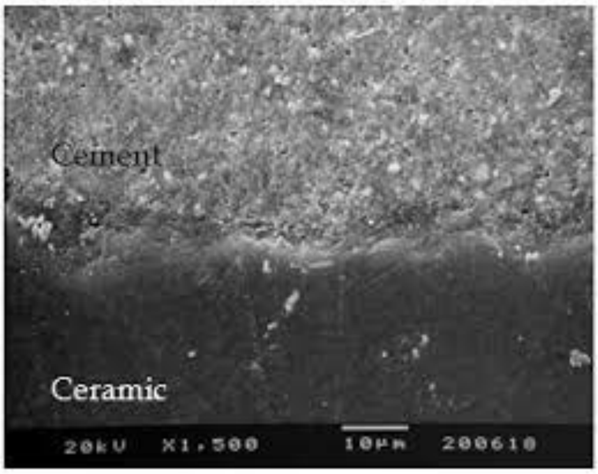

Figure.scanning electronic micrograph of a ceramic powder particles in cement paste

CASTING AND CURING:

For casting, all the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage out of slurry. Careful procedure was adopted in the batching, mixing and casting operations. The coarse aggregates and fine aggregates were weighed first with an accuracy of 0.5 grams.

The concrete mixture was prepared by hand mixing on a watertight platform. On the watertight platform, the coarse and fine aggregates were mixed thoroughly .to this mixture, the cement was added. These were mixed to uniform colour then water was added carefully so that no water was lost during mixing clean and oiled moulds for each category were then placed on the vibrating table respectively and filled in three layers .vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould.

The Specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition. After that these were de-moulded with care so that no edges were broken and were placed in the curing tank at the ambient temperature for curing the ambient temperature 27^{0}C After de-moulding the specimen by loosening the screws of the steel moulds, the cubes, cylinders and beams were allowed to dry for one day before placing them in the temperature controlled curing tank for a period of 7days, 14days,28 days.

CONCLUSION

The following are the various conclusions made out of the project are as follows:
The date presented in this paper show that there is great potential for the utilization of waste ceramic in concrete in several forms, including fine aggregate, coarse aggregate and ceramic powder. It is considered that the latter form would provide much great opportunities for value adding and cost recovery, as could be used as a replacement for expensive materials such as silica fume, fly ash and cement.

The use of ceramic powder in concrete would prevent expansive in the presence of susceptible aggregate. Strength gain of concrete is satisfactory. Miscrostructuralexaminiation has also shown that CP would produce a dense matrix and improve the durability properties of concrete incorporating it.

It has been concluded that 20% GP could be incorporated as cement replacement in concrete without any long term detrimental effects .concrete containing ceramic powder can achieve suitable strengths like control concretes. Fluidity of fresh concrete can be inhibited.

The feasibility of concrete blocks with replacement of cement showed technically in the present study .based on the experimental investigation reported in this paper. The following conclusions were drawn.

The replacement of cement by ceramic powder at leaven of 20% by weight had a significant effect on the some properties of concrete block sample as compared with the control sample. The compressive strength, the workability, the alkali silica reactivity are satisfactory.

The test results showed that the replacement at level of 20% had a potential to be used in the production of concrete blocks. It would be valuable to investigate the durability properties of these concrete blocks in the future work.

Ceramic is highly reactive with alkali due to its high silica content and amorphous structure and therefore the application of ceramic in concrete must take its special physical and chemical properties into consideration , e.g. irregular particle shape, smooth surface, aesthetic potential, hard but brittle, no water absorption, pozzolanic if finely ground. Ceramic could be used in concrete as coarse and fine aggregates and a substitute for cement.

The application of ceramic, no matter its form, has decreased consistence, strength and strength development. Ceramic aggregate introduce risk than powder. Replacing cement by ceramic powder seems feasible especially for replacement ratios.

The expansion depends on the chemical composition, content and particle size of the ceramic and the alkali content of the concrete. Ceramic particle size has the most significant effect on ASR expansion .type and colour also affect expansion ceramic powder can suppress expansion aggregate can lead to adverse expansion in concrete ceramic powder is effective in reducing are depends on particle size.

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