CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

A survey has been made of the informant, measures and methods of disposal of major mining, industrial and municipal wastes and byproducts available in the 48 conterminous states of the United States, while more than 3 \times 10^9 tonnes of waste materials and byproducts is generated annually and causes a serious threat to the environment. Only small amounts are being used by the construction industry. The low level of use does not yet reflect the advances being made in converting wastes into viable construction materials. Hence, increased utilization of wastes in concrete making is necessary to achieve the following goals.

i. To achieve economy

ii. To minimize environmental impact.

iii. To reduce the huge consumption of natural resources.

2.2 ALTERNATE AGGREGATE

The use of alternate aggregate is a natural step towards solving part of the depletion of natural aggregate, and the alternate aggregate processed from waste materials would appear to be an even more sensible solution (Neville 1981). The investigation on the alternative material for concrete-making started before half a century.

James Roger Clifton et al. (1980) stated that the use of industrial wastes as aggregate in concrete is the only hope for the utilization of (substantial) increased quantities of waste.
Rafat Siddique (2003), stated that 50 percent replacement of fine aggregate by power plant waste material in concrete indicates significant improvement in the strength properties of concrete such as compressive strength, splitting tensile strength, flexural strength and modulus of elasticity.

Senthamarai and Devadas Manoharan (2005), investigated the suitability of the ceramic industrial wastes as a possible substitute for conventional crushed stone coarse aggregate. They concluded that the properties of ceramic waste coarse aggregate are well within the range of the values of concrete making aggregates and respective strength characteristics are comparable to those of the conventional concrete.

Goo-Dae Kim and Tae-Bong Kim (2007), investigated the use of waste high strength concrete in making modified sulfur concrete. They found that modified sulfur concrete has superior physical properties and chemical resistance.

Isa Yuksel et al. (2007), stated that the combination of bottom ash (BA), and granulated blast furnace slag (GBFS) as fine aggregate in concrete making, leads to improvement in resisting high temperature and surface abrasion. But care should be taken to reduce capillarity and drying- wetting resistance of concrete.

Aminul Islam Laskar and Sudip Talukdar (2008), investigated the effect of rice husk ash, fly ash and silica fume as admixture on rheological behavior of high performance concrete. They observed that silica fume is a better material for moderate plastic viscosity needed for the design of high performance concrete.

Khalifa et al. (2009), reported the performance of high strength concrete made with copper slag as a fine aggregate. They stated that the water demand reduced by 22 percent, the strength and durability of high strength concrete improved with super plasticizer
addition. Therefore they concluded that super plasticizer is very important ingredient in high performance concrete production.

Pacheco-Torgal and Jalali (2010), stated that the replacement of cement with 20 percent ceramic power in concrete performs better than the control concrete mixtures concerning compressive strength, capillary water absorption, oxygen permeability and chloride diffusion. These lead to more durable concrete structures.

Roz-ud Din Nassar and Parviz Soroushian (2012), examined the use of milled waste glass as partial replacement for cement in recycled aggregate concrete. They found that due to pozzolanic reactions with cement hydrates, forming secondary calcium silicate hydrate (C-S-H), that results in improved microstructure of recycled aggregate concrete and increase in the later age strength.

2.3. RECYCLING

The use of recycled construction rubbles as aggregate for concrete occurred after the Second World War (Park 1999). Huge quantities of building rubble become available each year by way of demolition of old structures to make way for new and modern ones due to rapid urbanization. Disposal of such materials is difficult in view of the scarcity of suitable dumping grounds, and meeting the environmental requirements. Hence, the broken concrete is increasingly recycled (Gambhir 2009)

Ramamurthy and Gumaste (1998), stated that recycled aggregate concrete can utilize demolition material from concrete and masonry constructions. Most of the waste materials produced by demolishing structure are disposed by dumping them as land fill. Hence, reuse of demolition waste avoids the problem of waste disposal and is also helpful in reducing the gap between the demand and supply of crushed granite fresh aggregate.
Mannan and Ganapathy (2001), reported that the long term behavior of oil palm shells concrete is very similar to control concrete and there is no retrogression in strength due to practical curing condition or laboratory curing conditions.

Arvind et al. (2002), studied the incorporation of Ceramic micropheres as aggregate and suitable chemical additives in concrete. They found low and moderate density lightweight mixes with a high degree of resistance to water absorption.

Salomom Levy and Paulo Helene (2004), concluded in their study that concrete can be produced with recycled coarse and fine aggregates from old masonry or from old concrete posses the same durability properties as that of conventional concrete.

Brito et al. (2005), reported that the abrasion resistance of concrete made with ceramic recycled aggregates is higher than that of concrete made with limestone aggregates.

Tsung – Yueh Tu et al. (2006), state that recycled aggregates are not suitable for use in the production of high performance concrete due to their relatively high absorption capacity. Such inadequacies can be overcome by proper mixture proportions through the applications of Densified Mixture Design Algorithm (DMDA) in the design of HPC.

Chi-Sun Poon and Dixon Chan (2007), investigated the allowable level of contaminating materials such as crushed clay bricks, crushed ceramic tiles, waste glass cullet, wood and chips in recycled aggregate concrete. The test results show that, it is feasible to allow a higher level of contamination in the recycled concrete aggregates for making the concrete by adopting proper mixing methods.

Hanifi Binic (2007), has stated that the crushed ceramic waste and basaltic pumice waste could be very conveniently used in concrete to achieve low water absorption and higher compressive strength.
Teo et al. (2007), investigated the structural bond properties of lightweight concrete incorporating solid waste oil palm shell as coarse aggregate. The structural bond strength was determined through pull-out test. The results show that concrete prepared from oil palm shell aggregates has much higher bond strength than the theoretical bond strength.

Lopez et al. (2007), reported that there is no much notable change in the properties of concrete with white ceramic powder as fine aggregate.

Andrade et al. (2009), investigated the influence of the use of coal bottom ash as a replacement for natural fine aggregates on the properties of concrete in the fresh state. They concluded that the behavioral tendencies of concrete are different in different bottom ash usages and the higher the percentage of bottom ash used as a natural sand replacement the lower the deformation through plastic shrinkage and also showed that the setting time is affected by the presence of bottom ash.

Angulo et al. (2009), have studied the analytical techniques for the characterization of construction and demolition (C&D) waste recycled aggregates based on the combination of X-ray diffraction (XRD) and X-ray fluorescence (XRF) analysis. Using these combined analysis estimation of the amount of cement paste, amount of clay and micas has been found. They concluded that the amount of measured soluble salts in C&D aggregates is lower than the usual limits for mortar and concrete production.

Baoshan Huang et al. (2009), reported that recycling a fired ware scrap, a waste ceramic material from automobile manufacturing is used in Portland cement concrete and hot-mix asphalts fine aggregate. The compressive test results indicated that the fired ware scraps can be potentially used in the Portland cement concrete and hot mix asphalt.
Guerra et al. (2009), investigated the use of sanitary porcelain as substitute for coarse aggregate in concrete production. The produced concrete has the same mechanical characteristics as conventional concrete and they concluded concrete made with porcelain debris as a substitute for part of the coarse aggregate is technically viable.

Joao Silva et al. (2009), reported that crushed debris of ceramic waste fines as aggregate for manufacturing of mortars can increase the compressive strength due to a micro filler effect of the superfine and to a pozzolanic effect presented by some components of crushed debris.

Padmini et al. (2009), stated that the water absorption of recycled aggregate increases with any increase in strength of parent concrete from which the recycled aggregate is derived. Higher water absorption of recycled aggregate necessitates adjustment in mix water content to obtain the desired workability and also the resistance of recycled aggregate to mechanical actions is lower than fresh crushed granite aggregate. Recycled aggregate concrete requires lower water-cement ratio and higher cement content to be maintained as compared to concrete with fresh granite aggregate.

Masahiro Suzuki et al. (2009), investigated the efficiency of internal wet curing of high-performance concrete made with recycled waste porous ceramic coarse aggregates with very low water/binder ratio of 0.15. The results show that internal curing has become completely eliminate autogenous shrinkage of HPC.

Luc Courard et al. (2010), have studied and presented an experimental investigation on the replacement of natural aggregates by concrete road recycled aggregates in the roller compacted concrete (RCC) road. They observed that RCC with natural and concrete road recycled aggregates are similar for compactness and the compressive strength is higher for recycled aggregates than natural aggregates.
Pincha Torkittikul and Amon Chaipanich (2010), investigated the feasibility of using 100 percent ceramic waste as fine aggregate in Portland cement concrete and fly ash concrete. They found the compressive strength of ceramic waste concrete was increases with increasing percent of ceramic waste content and was optimum at 50 percent for the Portland cement concrete. However, the compressive strength of fly ash concrete is increased with ceramic waste content up to 100 percent. Using ceramic waste as fine aggregate in fly ash showed good.

Shi-Cong Kou and Chi-Sun Poon (2010), suggested the properties of recycled aggregates can be improved by impregnation of recycled aggregates with polyvinyl alcohol (PVA) solution. The recycled aggregate was soaked in 6 percent, 8 percent, 10 percent, 12 percent, PVA solutions and optimal value 10 percent is determined. They suggested that the mechanical properties of concrete made with PVA solution soaked recycled aggregate improved and shrinkage reduced.

Chakradhara Rao et al. (2011), stated that the impact resistance of the recycled aggregate concrete reduced with the increase in percentage of recycled construction aggregate and the reduction is more with 100 percent RCA (recycled construction aggregate).

Kim and Lee (2011), reported that replacing fine and coarse bottom ash with normal sand and gravel varying in percentages (50 percent, 75 percent and 100 percent), the effect of fine and coarse bottom ash was found that the slump flow of fresh concrete was slightly decreased from 530mm to 420mm when coarse bottom ash was replaced 100 percent of normal coarse aggregates. While fine bottom ash did not affect the slump flow, moreover it also showed that both fine and coarse bottom ash aggregate had more influence on the flexural strength than compressive strength.
Martin-Morales et al. (2011), suggested immersing the construction and Demolishing waste aggregate in water to reduce chlorides before it fed in to the waste treatment plant for crushing process of C&D waste.

Benito Mas et al. (2012), presents the concrete made from mixed recycled aggregates from construction and demolition waste. Concrete wastes are suitable for manufacturing low and medium strength blending concrete. This paper focuses on the use of mixed recycled aggregates with different types of cements.

Benito Mas et al. (2012), stated that mixed recycled aggregate has very high water absorption rates resulting in more water is added to the mixes to compensate for absorption, and special precautions are required in the mix design.

Anna Halicka et al. (2013), investigated the reuse of ceramic sanitary wastes as both fine and coarse aggregates in concrete. The sanitary ceramic aggregate may be recommended for preparing special type of concretes such as high strength and high absorption resistant concrete. This paper presented also the results of examination of concrete in high temperature with alumina cement and ceramic sanitary ware wastes as aggregate in 1000°C temperature.

Manzi et al. (2013), report on the use of both fine and coarse recycled concrete aggregates which satisfy the time-dependent properties of concrete such as shrinkage and creep combined with porosity measurements.

Thomas et al. (2013), out to analysed the physical, mechanical and durability properties of concrete incorporating recycled aggregate. The results show the durability of concrete made with recycled aggregate is worse due to intrinsic porosity of aggregate.
Medina et al. (2013), stated that the use of recycled ceramic aggregate as coarse aggregate in concrete does not interfere in a negative way during the hydration process and also observed that the microstructure in the interfacial transition zone (ITZ) between recycled ceramic aggregate and paste was more compact than in the case of natural aggregate and paste.

2.4 INDUSTRIAL WASTE IN CONCRETE

Rasheeduzzafar and Ehtesham Hussain (1991), investigated the addition of microslica and blast furnace slag in plain cements. Initially they added 10 and 20 percent microslica and 60 percent and 70 percent slag. The behavior of microslica can be assessed by alkali-silica reaction generated expansions and the behavior of slag can be assessed by formation of hydroxide concentrations in the pore solution. The performance of 60 percent slag cement is comparable with that of 10 percent microslica cement, the expansions and hydroxide concentrations values are well below the allowable limit.

Natraja et al. (2001), emphasized the use marble quarry waste as coarse aggregate in concrete and concluded that a satisfactory concrete can be made from these waste with reference to the strength of concrete.

Guoqiang Li et al. (2004), has stated that waste tire rubber filled concrete has very high toungness and its strength decreases with increase in rubber content.

Mukesh Limbachiya et al. (2012), discussed the effect of both partial and full replacement of natural coarse aggregates by coarse recycled concrete aggregates in a fly ash concrete. The use of 30 percent fly ash as a partial substitute of portland cement for fly concrete production The results obtained from the experimental investigation showed that high amount of recycled aggregate concrete could lower the resistance to chloride penetration and carbonation of concrete.
Gunasekaran et al. (2013), stated that wastes are produced in large quantities from agro-based industries and the use of these waste materials in construction industry would contribute onwards and cleaner environment.

Zengqing Sun et al. (2013), presented a paper to study the thermal behavior of geopolymer-type material, where waste ceramic was activated. The thermal behavior of synthesized geopolymer was determined in terms of compressive strength. The test results indicate that waste ceramic material having favorable anti-thermal properties and waste ceramic could serve as a satisfying source material for thermos table geopolymer.

Ramon Silvestra et al. (2013), investigated the feasibility of using porcelain and ceramic stoneware tile wastes as aggregate replacement in hot bituminous open graded wearing courses. The results obtained from experimental investigation gave up to 30 percent replacement of natural aggregate by recycled ceramic aggregates were to be adequate.

2.5 PROPERTIES OF CONVENTIONAL AND NON CONVENTIONAL CONCRETES

Bharatkumar et al. (2001), stated that the major difference between conventional concrete and HPC is essentially the use of chemical admixtures to reduce the water content. The mineral admixtures as cement replacement materials act as pozzolanic materials as well as fine fillers and also the combined use of super plasticizer and cement replacement material can lead to economical high performance concrete with enhanced durability and lower permeability.

Padmini et al. (2002), in their study described the relative permeation characteristics of concrete. The experimental study evaluates the measurement of water absorption, volume of permeable pore space (voids), and absorption of concrete. The test results indicate the difference between parent concrete and recycled aggregate concrete.
Rashid et al. (2002), have found that the effect of the type of coarse aggregate on the modulus of elasticity is obvious for high strength and normal strength concretes.

Wenzhong Zhu and Peter Bartos (2003), have stated that the prestation properties which include permeability, absorption, and diffusivity have been widely used to quantify the durability characteristics of concrete. They also pointed out that the relative volume of paste matrix, the pore structure of the bulk matrix and interfacial transition zone (ITZ) around the aggregate are the main factors control the permeation properties.

Chetan et al. (2011), presented the reports on the effect of variations in the cement content on roller compacted concrete mixture, on the basis of physical, mechanical properties and freeze-thaw resistances. The physical and mechanical properties indicated a significant deviation from the conventional concrete.

2.6. NEED FOR THE PRESENT STUDY

Ceramic waste (rejected ceramic insulator scraps) produced by the ceramic industries in Cuddalore District, Tamilnadu, is not recycled at present. The pollution control board does not permit the disposal of the waste in the open land. So the waste is placed inside the industry premises and thus gets piled-up every day and there is a pressure on the industries to find a solution for its disposal. In the ceramic electrical insulator industry a waste of 3 tonnes per day is produced. Bottom ash is produced by Neyveli Lignite Corporation in Cuddalore District.

If the ceramic waste can be used as coarse aggregate in concrete-making, it will be an ideal solution for disposal and a scientific study is necessary for the effective bulk utilization of waste in concrete production. Bottom ash is a by-product of Neyveli Lignite Corporation in Cuddalore District. Nearly 20 percent of it goes as ashes and it will be in the form of landfills. In this study bottom ash is used partially as a replace of river sand fine aggregate.
In this study the mineral cementation material silica fume which is widely available is added to concrete as binder as well as micro filler. This composite mineral admixture and multiple types of aggregates in the same mix may be used to get the desirable performance. Thus the use of different types of composite and hybrids can be used for getting tailor-made properties of concrete.

2.7 OBJECTIVES AND SCOPE OF THE PRESENT STUDY

Taking into consideration of above demand, it is proposed to use ceramic waste as coarse aggregate and bottom ash (50 percent) as fine aggregate in concrete-making.

The main objectives and scope of the study are:

i. To study the properties of ceramic waste coarse aggregate and bottom ash fine aggregate and comparing the respective properties with conventional crushed stone coarse aggregate and river sand for its suitability as coarse and fine aggregate in concrete.

ii. To study the engineering properties of fresh and hardened concrete made with ceramic waste coarse aggregate, bottom ash fine aggregate for a range of water-cement ratio.

iii. To propose a suitable guideline for mix proportioning of ceramic waste coarse aggregate and bottom ash fine aggregate concrete.

iv. To study the durability characteristics of ceramic waste coarse aggregate, bottom ash fine aggregate concrete for different water-cement ratios.

v. To study the flexural behavior of reinforced ceramic waste bottom ash (CWBA) aggregate concrete beam.

vi. To develop a regression model in terms of strength and elasticity based on the experimental results.
2.8 SUMMARY

Literature review makes public that the conventional concrete constituent materials are replaced by industrial waste and there is very insignificant information available on durability properties of concrete with industrial waste materials.

For this reason a categorized – investigation on the ceramic waste coarse aggregate and bottom ash fine aggregate concrete is proposed.