# Experimental Studies on Ceramic Tiles used for Concrete

Jeniba.A
Anna University
Department of Civil Engineering
Udaya School of Engineering
Vellamodi, Kanyakumari Dsct.

***Abstract:-*** **The availability of coarse aggregate i.e. Stone is reducing day by day. So, in order to replace the stone aggregate, we used tiles which are also wasted 30% in Indian industry. We used M20 grade concrete with different % of tiles which are 20%, 40%, 60% and 80%.Compressive strength, splitting tensile strength, flexural strength and modulus of elasticity test has been conducted on concrete specimens which are cured for 28 days, 54 days, and 90 days. We also used 150mm cubes for testing compressive strength, 150mm diameter and 300mm length for tensile strength and for modulus of elasticity, a prism of size 500mm length 100mm wide 100mm thickness for flexural strength.**

## INTRODUCTION

### *1.1GENERAL*

The availability of coarse aggregate i.e. Stone is reducing day by day. So, in order to replace the stone aggregate, we used tiles which are also wasted 30% in Indian industry. We used M20 grade concrete with different % of tiles which are 20%, 40%, 60% and 80%.Compressive strength, splitting tensile strength, flexural strength and modulus of elasticity test has been conducted on concrete specimens which are cured for 28 days, 54 days, and 90 days. We also used 150mm cubes for testing compressive strength, 150mm diameter and 300mm length for tensile strength and for modulus of elasticity, a prism of size 500mm length 100mm wide 100mm thickness for flexural strength. And we compared with conventional concrete of grade M20 of same days of curing which is 28 days, 54 days and 90 days. Finally we got the safe value.

### *1.2 TYPES OF TILE*

There are several types of tiles used for residential and commercial applications, they are:

a) Ceramic tile
b) Quarry tile
c) Porcelain tile
d) Mosaic tile
e) Marble tile

Ceramic tile: ceramic comes from the Greek term Keramos, meaning "a potter" or "pottery". Since the infancy of ceramics, up to this very day, the process is still very much the same for the creation of all the ceramic materials, one need to bake a mixture of clays at a very high temperature. It is the most common tile used in the US in offices, stores and homes. Ceramic tile comes in two forms: glazed and unglazed. Ceramic tiles are made from clay and then heated. The glaze is added after the firing of clay tile, which creates the color of the tile. The glazing process allows for the creation of infinite color combinations.

Quarry tile: It is unglazed ceramic tile. It is an inexpensive, durable and natural option for industrials, commercial and residential tile applications. Quarry tile is used a lot in industrial settings because it is so durable and can also be used outdoors.

Porcelain tile: it is a ceramic tile. The difference between porcelain and ceramic is that porcelain is fired at a higher temperature, making it more dense and moisture-resistant. Porcelain tiles are also less porous, making them more stain-resistant. For these reasons, most porcelain tiles are suitable for both indoor and outdoor installations. Porcelain tiles are hard to cut due to their density and hardness, so the cost and labor involved is often higher.

Mosaic tile: it allow you to creative with your tile design. Mosaics are most commonly used for smaller areas, such as a bathroom or kitchen backsplash, or even small counter space areas. Mosaic tiles are usually less than six square inches and made of porcelain or clay composition.

Marble tile: marble is a versatile natural stone which has been used for centuries in homes to create a luxurious and unique look. Because marble is a natural stone, there are variations in the color of each tile. Many homeowners like this, as it creates a unique, one-of-a kind design, while others prefer a more consistent look, like ceramic tile. Marble is porous and must be sealed just like all other tile types.

### *1.2 MATERIALS AND MIX PROPORTION*

#### *1.2.1 Aggregates*

*1.2.1.1 Ceramic tile aggregate*

The ceramic tiles are collected and then break into pieces by hammering. The pieces tiles are sieved to get a 20 mm size.

*1.2.1.2 Stone aggregate*

A crushed granite stone of size 20mm are used for all the specimens.

*1.2.1.3 Fine Aggregate*

The fine aggregate used for the entire specimen were natural river sand complying with the requirement of IS383:1970.

*1.2.1.4 Water:*

Locally available potable water is used for mixing the concrete.

Fig: 1.1 materials.

*1.2.2 Mix proportion*

Table1.1: Mix proportion for M20 grade

| TRIAL NUMBER | UNIT | CEMENT | F.A | C.A | WATER | WATER CEMENT RATIO |
|---|---|---|---|---|---|---|
| 1 | VOLUME | 1 | 1.8 | 2.8 | --- | 0.5 |

*1.3 DURABILITY OF CONCRETE*

A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service. The materials and mix proportions specified and used should be such as to maintain its integrity and, if applicable, to protect embedded metal from corrosion. One of the main characteristics influencing the durability of concrete is its permeability to the ingress of water, oxygen, carbon dioxide, chloride, sulphate and other potentially deleterious substances. Impermeability is governed by the constituents and workmanship used in making the concrete. With normal-weight aggregates a low permeable concrete is achieved by having adequate cement content, sufficiently low water/cement ratio, by ensuring complete compaction of the concrete, and by adequate curing.

The factors influencing durability include:

i. The environment;
ii. The cover to embedded steel;
iii. The type and quality of constituent materials;
iv. The cement content and water/cement ratio of the concrete;
v. Workmanship, to obtain full compaction and efficient curing;
vi. The shape and size of the member.

The degree of exposure anticipated for the concrete during its service life together with other relevant factors relating to mix composition, workmanship, design and detailing should be considered. The concrete mix to provide adequate durability under these conditions should be chosen taking account of the accuracy of current testing regimes for control and compliance as described in IS 456.

*1.4 NEED FOR STUDY*

Nowadays M-sand is commonly used in the production of concrete due to the scarcity of natural river sand. The use of manufactured sand in concrete as fine aggregate may alter the strength and durability. Hence, an experimental investigation is necessary to predict the strength and durability of concrete made of manufactured sand.

*1.5 REVIEW OF LITERATURE*

*1.5.1 General*

*About 30% productions go as waste, which is not recycling at present. The workability of ceramic waste coarse aggregate concrete is good and the strength characteristics are comparable to those of the conventional concrete.*

*1.5.2 STUDIES ON EXPERIMENTAL INVESTIGATION*

***RM Senthamaraj, P Devadas Manhoharan*** *"Concrete with ceramic waste aggregate". Cementand concrete composites, No.(9-10), 27(2005)910-3.*

Experiment were carried out to determine the compressive, splitting tensile and flexural strengths and modulus of elasticity of concrete with ceramic waste coarse aggregate and to compare them with those of conventional concrete made with crushed stone coarse aggregate.

**F.Pacheco-Torgal, S.Jalali "**Reusing ceramic wastes in concrete**".** Construction andBuilding Materials 24(2010)832-838.

Solving the ceramic waste 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 aggregate and avoiding environmental problems related to land filled wastes. This paper examines the feasibility of using ceramic wastes in concrete. Results show that concrete mixtures with ceramic aggregates perform better than the control concrete mixtures concerning compressing strength, capillary water absorption, oxygen permeability and chloride diffusion thus leading to more durable concrete structure.

**Medina C, Frias M. "**Reuse of sanitary ceramic wastes as coarse aggregate in eco efficient concretes**".** Cement and concrete composites, 34(2012) 48-54.

The reuse of theses wastes as recycled coarse aggregate in partial substitution ( 15%,20% and 25%) of natural coarse aggregates in the manufacture of structural concretes. The results demonstrate the recycle, eco-efficient concerts present superior mechanical behavior compared to conventional concrete and it was moreover appreciated that the recycled ceramic aggregate does not interfere in the negative way during the hydration process.

**C.Medina, MIS de Rojas "**Properties of recycled ceramic aggregate concretes: Water resistance**".** Cement and Concrete Composites, 34 (2013) 23-26.

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 carries of aggressive substances.

**J.R.Correia , J.de Brito "**Effects on concrete durability of using recycled ceramic aggregates**"**. Materials and structures (2006) 39: 169-177

Ceramic waste from ceramic and construction industries is one of the most important parts in the global volume of construction and demolition waste. Ceramic waste may have several uses, one of which as coarse aggregate for concrete artifacts. Within a research campaign in coarse at Institutor Superior Tenino , concerning the reuse and the recycling of CDW, the visibility of replacing primary limestone aggregates with ceramic waste on the production of concrete payment slabs has been studied . compression and bending tests previously performed have shown the mechanical suitability of replacing at least partially limestone aggregate with ceramic recycled ones. In this paper the results of the water absorption tests, either by capillarity and the results of the abrasion resistance testes are presented all related to long term concrete durability.

**F.Puertas , Garcia-Diaz I, "**Ceramic wastes as alternative raw materials for Portland cement clinker production**"**. Cement and concrete composites, 30(2008) 798-805.

The cement industry has for some time been seeking procedures that would effectively reduce the high energy and environmental costs of cement manufacture. One such procedure is the use of alternative materials as partial replacements for fuel raw materials clinker. The present study expires the reactivity and burn ability of cement raw mixes containing fired red or white ceramic wall tile wastes and combinations of the two as alternative raw materials. The results showed that the new raw mixes containing this kind of waste to be technically viable and to have higher reactivity and burn ability than a conventional mix providing that the particle size of the waste used is lower than 90micrometer. The mineralogical composition and distribution in the experimental clinker prepared were comparable to the clinker manufactured with conventional raw materials. Due to the presence of oxides such as ZnO , ZrO2 and B2O3 in tile glazing the content of these oxides was higher in clinker made with such waste. The mix of red white ceramic wall tile waste was found to perform equally or better than each type of waste separately a promising indication that separation of the two would be unnecessary for thepurpose described above.

**J. De Brito, A.S. Pereira, "**Mechanical behavior of non structural concrete made with recycled ceramic aggregates**"**. Cement and concrete composites 27 (2005) 429-433.

In order to reduce the volume of ceramic waste from the construction industry, it is possible, among other applications, to use it as aggregates in the production of non structural concrete artefacts. The main characteristics of such aggregates as well as those of the fresh and hardened concrete made with them are presented here and compared imental investigation to maximize the reuse and reutilization of construction and demolition waste. The results show that there is a strength and abrasion resistance, such as for concrete pavement slabs.

**R.Khaloo, "**Crushed tile coarse aggregate concrete **"**. Cement and concrete aggregate,No.2, 17(1995) 119-25.

The potential of crushed tiles as coarse aggregate in concrete. Test result of bulk, saturated surface dry and apparent specific gravities bulk unit weight water absorption resistance to abrasion percentage of voids and grading on two types of crushed tiles were compared with the results of the conventional crushed stone aggregate. Also included are results from tests on concrete cylinders under uniaxial compression split tension and beam under flexure to determine the influence of variables of test age on concrete strength type of tiles and ratio of volume of crushed tile to the total volume of coarse aggregate in concrete. Recommendation for use of crushed tiles as coarse aggregates in concrete.

**Hanifi Binici**" Effect of crushed ceramic and basaltic pumice as fine aggregates on concrete mortars properties"Construction and Building Materials,Volume 21, Issue6, June 2007, Pages 1191–1197

This study examines the suitability of ceramic industrial wastes and huge amounts of basaltic pumice as a possible substitute for conventional crushed fine aggregates. Experiments were carried out to determine abrasion resistance, chloride penetration depths and the compressive strengths of concrete with crushed ceramic waste and basaltic pumice fine aggregates and to compare them with those of conventional concretes. Test results indicated that ceramic wastes and basaltic pumice concretes had good workability. Furthermore, it was found that abrasion resistance of crushed ceramic (CC) and crushed basaltic pumice (CBP) concretes was lower than that of conventional concretes. Test results also showed that maximum abrasion rate was obtained from specimen control (Mo), while minimum abrasion rate is obtained from M3 (60% crushed ceramic concrete) specimens. Abrasion resistance was increased as the rate of fine CC was decreased. Abrasion resistance of concrete was strongly influenced by its compressive strengths and CC and crushed CBP content. The crushed ceramicaddition percentage decreased as the chloride penetration depthincreased. Results of this investigation showed that CC and CBP could be conveniently used for low abrasion and higher compressive strength concretes.

**J Yang, Q Du, Y Bao**, "Concrete with recycled concrete aggregate and crushed clay bricks"Construction and Building MaterialsVolume 25, Issue 4, April 2011, Pages 1935–1945

In the last two decades, a variety of recycling methods for construction and demolition wastes (CDW) have been developed. For instance, as one of the major components in CDW, concrete rubble has been used to replace natural aggregate after being treated. This is known as recycled concrete aggregate (RCA). The property and use of RCA for structural or non-structural concrete have been extensively studied and numerous findings have been adopted in engineering practice to produce sustainable concrete. Concrete rubble, however, is inevitably mixed with other wastes such as crushed clay bricks (CCB). The level of inclusion varies depending on the original construction materials of demolished buildings. The differing properties of CCB from RCA will affect the mix design as well as the physical and mechanical properties of the resulting new concrete when the inclusion level exceeds a certain limit. Separating CCB from RCA presents an operational difficulty in practice and also has huge cost implications. Therefore, it is important to study the effect of CCB with various inclusion levels on the properties of fresh and hardened concrete. This paper reports on a study conducted to investigate the physical and mechanical properties of recycled concrete with high inclusion levels of RCA and CCB and to explore the potential or the limitation of this type of mixed recycled aggregate in primary concrete structures

**César Medina**"Freeze-thaw durability of recycled concrete containing ceramic aggregate"Journal of Cleaner Production,Volume 40, February 2013, Pages 151–160
Abrupt temperature change (freeze-thaw cycles) is one of the most damaging actions affecting concrete, inasmuch as it induces micro cracking. The formation of this crack reduces the mechanical behavior 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, analyzing 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. Use of this waste as a construction material would yield substantial technical, economic and environmental benefits, in particular from the perspective of sustainable development.

**F.Bektas K. Wang, H. Ceylan**"Effects of crushed clay brick aggregate on mortar durability" Construction and Building MaterialsVolume 23, Issue 5, May 2009, Pages1909–1914
This paper reports an experimental study that aimed to investigate the effects of recycled clay brick, used as a part of fine aggregate, on mortar durability. The brick, in crushed form, was from a local brick manufacturer that salvages its off-standard products. It was used to replace 10% and 20% (by weight) of the river sand in mortar. Effects of the brick replacement on the mortar flow, compressive strength, shrinkage, freeze–thaw resistance, and alkali–silica reaction potential were investigated. The results showed that as the brick replacement level increased, the mortar flowability reduced. The 10% and 20% brick replacements had no negative effect on the mortar compressive strength and very limited effect on the mortar shrinkage. The freeze–thaw resistance of the mortar was improved by the brick replacement. However, theuse of crushed brick as aggregate appeared not to reduce potential alkali–silica reaction. The microscopy study revealed the alkali–silica reaction product andassociated cracking in the mortar. Additional study indicated that the brick aggregate used in the study had pessimum proportion, 30%, for the alkali–silica reaction expansion.

**A Rao, KN Jha, S Misra**"Use of aggregates from recycled construction and demolition waste in concrete Resources" Conservation and RecyclingVolume 50, Issue 1, March 2007, Pages 71–81
Construction and Demolition (C&D) waste constitutes a major portion of total solid waste production in the world, and most of it is used in land fills. Research by concrete engineers has clearly suggested the possibility of appropriately treating and reusing such waste as aggregate in new concrete, especially in lower level applications. This paper discusses different aspects of the problem beginning with a brief review of the international scenario in terms of C&D waste generated, recycled aggregates (RA) produced from C&D waste and their utilization in concrete and governmental initiatives towards recycling of C&D waste. Along with a brief overview of the engineering properties of recycled aggregates, the paper also gives a summary of the effect of use of recycled aggregate on the properties of fresh and hardened concrete. The paper concludes by identifying some of the major barriers in more widespread use of RA in recycled aggregate concrete (RAC), including lack of awareness, lack of government support, non-existence of specifications/codes for reusing these aggregates in new concrete.

**D. Wattanasiriwech, A. Saiton , S. Wattanasiriwech**"Paving blocks from ceramic tile production waste"Journal of Cleaner ProductionVolume 17, Issue 18, December 2009, Pages 1663–1668

This paper presents the use of waste mud from ceramic tile production as the main component in paving blocks. Compressive strength values of the blocks werecompared with the standard value as prescribed by the Thailand Industrial Standard. The waste mud was first characterized using XRD, XRF, SEM, Laser diffraction particle size analyzer and sieve analysis. Paving blocks were subsequently prepared by mixing the waste mud with Ordinary Portland cement (OPC) and compacted using a hydraulic press. Water was added to the cement–mud mix to assist compaction and to strengthen the blocks by hydration of OPC. Effects of water and cement content, immersion in water, as well as compaction pressure on compressive strength were subsequently studied. Increasing compaction pressure and also immersion in water for 5 min every 24 h were found to enhance densification and thus compressive strength of the test samples. The blocks containing 15 wt% cement required a long curing period of up to 28 days for their compressive strength to reach the standard requirement while the compressive strength of the blocks containing 25–30 wt% cement exceeded the standard requirement after curing for only 7 days.

**Turhan Bilirİlker Bekir Topçu** " Experimental investigation of drying shrinkage cracking of composite mortars incorporating crushed tile fine aggregate"Materials

& DesignVolume 31, Issue 9, October 2010, Pages 4088–4097
Drying shrinkage is generally classified as an important hardened concrete property. It expresses the strain occurring in hardened concrete due to the loss of water. During the drying process, free and absorbed water is lost from the concrete. When the drying shrinkage is restrained, cracks can occur, depending on the internal stresses in the concrete. The ingress of deleterious materials through these cracks can cause decrease in the compressive strength and the durability of concrete. In this study, being as a fine aggregate in mortars, crushed tile (CT) effect on drying shrinkage and drying shrinkage cracking is investigated. Thus, compressive and flexural strength, modulus of elasticity, and free and restrained drying shrinkage tests are conducted on mortar specimens produced with and without crushed tile fine aggregate. The ring test has been used in order to investigate the cracks induced by restrained drying shrinkage. In this way, free drying shrinkage strain, along with the number and development of drying shrinkage cracks, of the crushed tile fine aggregate mortar composites are quantified and observed.

**P. Devadas Manoharan RM. Senthamarai D. Gobinath**"Concrete made from ceramic industry waste" Durability properties Construction and Building MaterialsVolume 25, Issue 5, May 2011, Pages 2413–2419
Concrete which contains waste products as aggregate is called 'Green' concrete. Use of hazardous waste in concrete-making will lead to green environment and sustainable concrete technology and so such concrete can also be called as 'Green' concrete. Concrete made with ceramic electrical insulator waste as coarse aggregate shows good workability, compressive, tensile and flexural strengths and modulus of elasticity. Further, study of its durability will ensure greater reliability in its usage. Permeation characters are used widely to quantify durability properties of concrete. This paper presents an experimental investigation on the permeation characteristics [volume of voids and water absorption (ASTM C642-06), chloride penetration (ASTM C1202-10), and sorption] of concrete with ceramic electrical insulator waste coarse aggregate (hereafter it is called recycled aggregate concrete) of six different water–cement ratios in comparison with those of corresponding conventional concrete mixes. From the results it has been observed that there is no significant change in the basic trend of permeation characteristics of this recycled aggregate concrete when compared to the conventional concrete. This recycled aggregate concrete possesses higher permeation characteristic values than those of conventional concrete. These values decrease with decrease in water–cement ratio for both the recycled aggregate concrete and the conventional concrete.

Arnon ChaipanichPincha Torkittikul, "Utilization of ceramic waste as fine aggregate within Portland cement and fly ash concretes"Cement and Concrete CompositesVolume 32, Issue 6, July 2010, Pages 440–449
The aim of this research work was to investigate the feasibility of using ceramic waste and fly ash to produce mortar and concrete. Ceramic waste fragments obtained from local industry were crushed and sieved to produce fine aggregates. The measured concrete properties demonstrate that while workability was reduced with increasing ceramic waste content for Portland cement concrete and fly ash concrete, the workability of the fly ash concrete with 100% ceramic waste as fine aggregate remained sufficient, in contrast to the Portland cement control concrete with 100% ceramic waste where close to zero slump was measured. The compressive strength of ceramic waste concrete was found to increase with ceramic waste content and was optimum at 50% for the control concrete, dropping when the ceramic waste content was increased beyond 50%. This was a direct consequence of having a less workable concrete. However, the compressive strength in the fly ash concrete increased with increasing ceramic waste content up to 100%. The benefits of using ceramic waste as fine aggregate in concrete containing fly ash were therefore verified.

**C. Medina, M.I. Sánchez de RojasM. Frías**"Properties of recycled ceramic aggregate concretes" Water resistance Cement and Concrete CompositesVolume 40, July 2013, Pages 21–29
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.

**Hakan Kuşanİlker Bekir TopçuAbdullah Demir** "Modeling of some properties of the crushed tile concretes exposed to elevated temperatures"Construction and Building MaterialsVolume 25, Issue 4, April 2011, Pages 1883–1889
In this study, artificial neural network (ANN) and fuzzy logic (FL) models have been developed for predicting the compressive strength ($f_c$) and dynamic modulus of elasticity ($E_d$) of the crushed tile concretes (CTC) exposed to elevated temperatures. Some relationships are established between chosen inputs and outputs by developing and testing a multi-layered feed forward ANN and FL trained with the back-propagation algorithm. First of these relationships is established between the outputs as $f_c$ of CTC after being exposed to elevated temperatures and the inputs as exposed temperature ($T$), crushed tile aggregate (CT) and crushed stone II (CSII) contents of concrete. The second one is the relationship between $E_d$ of concretes and the same inputs. In this aim, concrete specimens are produced by CT replacing 16–31.5 mm coarse aggregate at the ratios of 0%, 10%, 25%, 50%, 75% and 100%. Concrete specimens are exposed to 20, 150, 300, 400, 600, 900 and 1200 °C high temperatures corresponding TS EN 1363-1 after an initial 28 day curing period. After heating, the specimens are slowly air-cooled to the room temperature and then $E_d$ and $f_c$ of concretes were determined. Experimental results are also predicted by

constructing models in ANN and FL methods. In the models, the training and testing results have shown that ANN and FL methods have strong potential for predicting the $f_c$ and $E_d$ of crushed tile concretes exposed to elevated temperatures

J.A. PolancoC. ThomasM.I. Sánchez de RojasM. FríasC. MedinaGas permeability in concrete containing recycled ceramic sanitary ware aggregate Construction and Building MaterialsVolume 37, December 2012, Pages 597–605
Non Destructive Techniques for Assessment of Concrete

Durability is a key property in concrete structures due to the economic, safety and environmental impact of repair and maintenance operations, or demolition, undertaken during their service life. The issue is particularly important when the concrete contains recycled materials. The present study explores the effect of the partial (20% and 25%) replacement of virgin aggregate with recycled ceramic sanitary ware waste on the gas permeability of structural concrete. The findings revealed that the slightly higher porosity in the recycled concrete obtained did not translate into greater gas permeability. These new concretes proved to be as durable as the conventional material, with good performance throughout their design service life.

**José NavasAlfredo GarcíaEsther MedelRamón Silvestre**"Using ceramic wastes from tile industry as a partial substitute of natural aggregates in hot mix asphalt binder courses" Construction and Building MaterialsVolume 45, August 2013, Pages 115–122

The technical feasibility of using recycled ceramic aggregates as a partial replacement of natural aggregates in hot mix asphalt was investigated. Recycled ceramic aggregates were obtained crushing stoneware and porcelain tile wastes from the ceramic industry. Both natural and recycled aggregates were characterized by suitability tests to be utilized in bituminous mixtures. Asphalt concrete binder course mixtures were designed through the Marshall method and the European CE marking standards. The mixtures were produced in both laboratory and asphalt plant, evaluating the influence of real production and scale factors. The addition of recycled ceramic aggregates increased binder, filler and air void contents, as well as the resistance to plastic deformation and the retained indirect tensile resistance after immersion. Nonetheless, worse moisture susceptibility with compressive strength and worse values of Marshall stability and deformation were observed. Up to 30% of natural aggregates were replaced by recycled ceramic aggregates with good mechanical conditions according to Spanish specifications. The main conclusion was that hot bituminous mixtures with a reasonable addition of recycled ceramic aggregates can satisfy binder course performance requirements for medium-low volume roads.

José NavasAlfredo GarcíaEsther Medel Ramón Silvestre "Utilizing recycled ceramic aggregates obtained from tile industry in the design of open graded wearing course on both laboratory and in situ basis"Materials & DesignVolume50,September 2013, Pages 471–478

The purpose of the research was to evaluate the technical feasibility of using porcelain and ceramic stoneware tile wastes as aggregate replacement in hot bituminous open graded wearing courses. It is believed that it would reduce the environmental effects of wastes disposal and the natural aggregate demand. The investigated bituminous mix course was an open graded wearing course. Ceramic tile industry wastes were treated to obtain recycled aggregates. These aggregates were characterized and tested to see their suitability to be utilized in bituminous mixtures. The design process of mixture consisted on the study of mixtures prepared with natural and recycled aggregates. The mixtures were produced in both the laboratory and an asphalt plant basis, evaluating the influence of in situ production and scale factors. Recycled ceramic aggregates content was established to obtain appropriate mechanical and superficial characteristics, besides maximizing re-utilization of recycled materials. Up to 30% of recycled ceramic aggregates content by aggregates weight was found to be adequate. However, the partial substitution of natural aggregate by recycled ceramic aggregates involved higher water sensitivity in the mixture. The open graded wearing course with recycled ceramic aggregates was considered to be suitable for medium to low traffic volume roads, though further research is deemed to be necessary for technical and economical viability.

**Jianping Zhai ,Qin Li·Yan Xu, Dejing Tao, Hao An, Hao Cui, Zengqing Sun**"Synthesis and thermal behavior of geopolymer-type material from waste ceramic"Construction and Building MaterialsVolume 49, December 2013, Pages 281–287
Waste ceramic was activated by alkali hydroxides and/or sodium/potassium silicate solutions to synthesize geopolymer-type material in this study. The synthesized geopolymer pastes were characterized by mechanical test, TG-DSC, SEM, XRD, as well as FT-IR analyses. And the thermal behavior of synthesized geopolymer was determined in terms of compressive strength evolution by exposure to 100, 200, 400, 600, 800, and 1000 °C. The synthesized geopolymer pastes exhibited a maximum 28-day compressive strength of 71.1 MPa and favorable anti-thermal properties byshowing a higher compressive strength of 75.6 MPa after heat treatment of 1000 °C. The results indicate that waste ceramic could serve as a satisfying source material for thermostable geopolymer.
**Bartosz ZegardloPawel Ogrodnik ,Anna Halicka**" Using ceramic sanitary ware waste as concrete aggregate"Construction and Building MaterialsVolume 48, November 2013, Pages 295–305
Sanitary ceramic ware waste is classified as belonging to group of non-biodegradable industrial waste. The paper presents the studies on possible reuse ceramic sanitary wastes as the aggregate (both fine and coarse) in concrete.
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.
J.R. Correia , J. de Brito, T.F. Vieira, A.V. Alves, "Mechanical properties of structural concrete with fine recycled ceramic aggregates" Construction and Building MaterialsVolume 64, 14 August 2014, Pages 103–113
The objective of this research is to evaluate the effect of the incorporation of recycled ceramic fine aggregates, obtained from crushed bricks and crushed sanitary ware, on the mechanical properties of concrete. The effects of such incorporation on properties such as compressive strength, splitting tensile strength, modulus of elasticity and abrasion resistance were investigated and are discussed. Seven different concrete mixes were cast to test these hardened properties: a conventional reference concrete and six concrete mixes with replacement ratios of 20%, 50% and 100% of natural fine aggregates by either fine recycled brick aggregates or fine recycled sanitary ware aggregates. All mixes were prepared with the same workability and the same aggregates' size gradation to allow for a valid comparison of results. Results obtained show that concrete with recycled crushed bricks exhibits adequate structural performance. Conversely, concrete with recycled sanitary ware performed poorly compared to the reference concrete, even though this limitation may be offset by the use of super plasticizers.

## CHAPTER 2

## AIM AND SCOPE

The main scope of the project is to find out the strength variation of concrete on addition of different % of tiles in different tests they are

1) Compressive strength test
2) Tensile strength test
3) Modulus of elasticity test
4) Flexural strength test.

The main objective is to find out the exact % of tiles to replace stone aggregate.

### *EXPERIMENTAL INVESTIGATION*

### *3.1 MATERIALS USED*

The quality of material plays a vital role in the manufacture of High Strength Concrete. The various materials used to produce the HSC are:

i. Cement (PPC)
ii. R-Sand
iii. Coarse aggregate
iv. Water
v. Tiles

### *3.2 MATERIAL PROPERTIES*

The properties of each materials used to produce High Strength Concrete are discussed below in the following sub-section.

#### ***3.2.1 Cement***

The Portland pozzolana cement is a kind of blended cement which is produced by either intergrading of OPC clinker along with gypsum and pozzolanic materials separately or thoroughly blending them in a certain proportions. Pozzolana is a natural or artificial material containing silica in a reactive form. It may be further discussed as siliceous and aluminous material which in itself possesses little or no cementations properties, but it chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementations properties. Portland pozzolona cement produces less heat of hydration and offers greater resistance to attack of aggressive waters than ordinary Portland cement.Pozzolona cement shall comply the requirements of IS 1489. 53 grade Portland pozzolona cement with brand name Shankar Cement was used in this project and is shown in Fig. 3.1.Cement was purchased from Shakti Enterprisers in vijayanagar at Erode.The properties of cement used are given in table3.1.

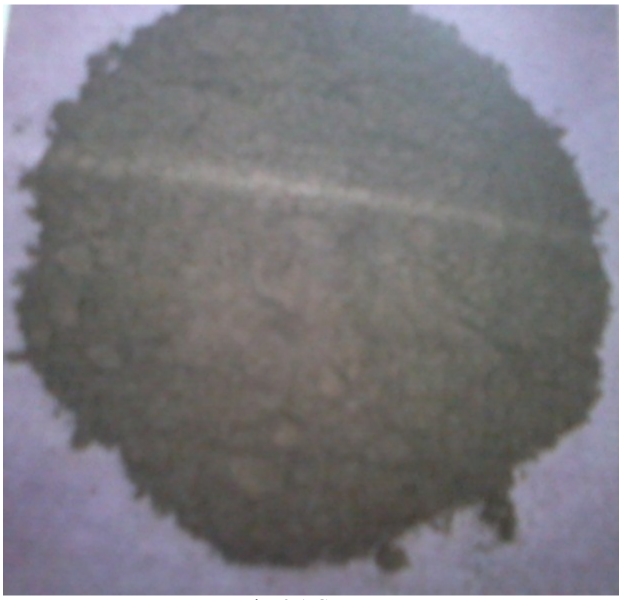

Fig: 3.1 Cement

Table 3.1 Properties of cement

| PROPERTY | VALUE |
|---|---|
| INITIAL SETTING TIME | 35 MINUTES |
| FINAL SETTING TIME | 8 HOURS |
| SPECIFIC GRAVITY | 3.15 |
| CONSISTENCY | 30% |

### *3.2.2 River sand*

The sand from river due to natural process attrition tends to possess smoother surface texture and better shape. It also carries moisture that is trapped in between the particles. These characters make concrete workability better. However, silt and clay carried by river sand can be harmful to the concrete. Another issue associated with river sand is that of obtaining required grading with a fineness modulus of 3.8. It has been verified and found, at various locations across south India, that it has become increasingly difficult to get river sand of consistent quality in terms of grading requirements and limited silt/clay content. It is because we do not have any control over the natural process. The river sand used in this project is shown in Fig. 3.2. River sand was purchased from a sand quarry in Bavani river at Erode.The properties of cement used are given in table3.2.

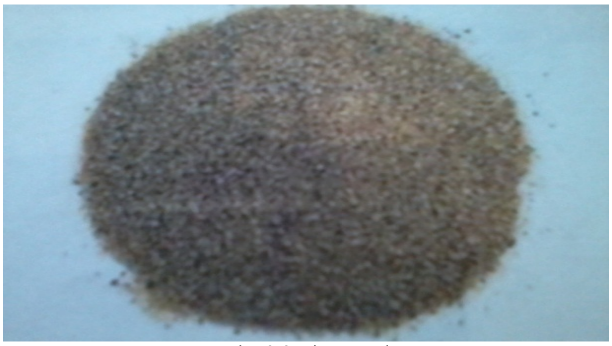

Fig: 3.2 River sand

Table: 3.2 Properties of river sand

| Property | Value |
|---|---|
| Specific gravity | 2.68 |
| Water absorption | 1.0% |
| Free moisture content | 0.2% |
| Fine modulus | 3.89 |

### *3.2.3 Coarse aggregate*

Aggregate shall comply the requirements of IS 383. As far as possible preference shall be given to natural aggregates. The nominal size of coarse aggregate should be large as possible within the limits specified but in no case greater than one-fourth of the minimum thickness of the member. However for most of the work 20mm and 12mm sizes in the combination of 70% :30% respectively were selected as coarse aggregate because this particular combination had minimum voids. The coarse aggregate used in this project is shown in Fig.3.4.Coarse aggregate was purchased from Ayyanar rock quarry at Kumarapalayam in Namakkal. The properties of coarse aggregate used are given in table3.4.

Fig: 3.3coarse aggregate

Table: 3.3 Properties of Coarse aggregate

| Property | Value |
|---|---|
| Specific gravity | 2.78 |
| Water absorption | 0.5% |
| Free moisture content | 0 |
| Fine modulus | 0.5225 |

### *3.2.4 Water*

Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salt, sugar, organic or other substance that may be deleterious to concrete. Portable water generally considered satisfactory for mixing and curing. Tests will be performed to find the various physical& chemical properties of all the materials.Portable water available in the laboratory was used in this project for mixing and curing of HSC.

### *3.2.5 Tiles*

Ceramic tile: ceramic comes from the Greek term Keramos, meaning “a potter” or “pottery”. Since the infancy of ceramics, up to this very day, the process is still very much the same for the creation of all the ceramic materials, one need to bake a mixture of clays at a very high temperature. It is the most common tile used in the US in offices, stores and homes. Ceramic tile comes in two forms: glazed and unglazed. Ceramic tiles are made from clay and then heated. The glaze is added after the firing of clay tile, which creates the color of the tile. The glazing process allows for the creation of infinite color combinations.

Table: 3.4 properties of ceramic tiles

| Properties | Ceramic tiles |
|---|---|
| Specific gravity | 2.45 |
| Maximum size (mm) | 20 |
| Fineness modulus | 6.88 |
| Water absorption 24 h (%) | 0.72 |

Fig: 3.4 ceramic tiles

*3.3 MIX PROPORTION*

Table: 3.5 Mix proportion of M20 grade.

| TRIAL | CEMENT (KG/M3) | F.A (KG) | C.A (KG) | WATER (L) | W/C | TILE (KG) |
|---|---|---|---|---|---|---|
| CONVENTIONAL | 394 | 743.08 | 1114 | 197 | 0.5 | -- |
| TILE 20% | 394 | 743.08 | 891.2 | 197 | 0.5 | 222.8 |
| TILE 40% | 394 | 743.08 | 668.4 | 197 | 0.5 | 445.6 |
| TILE 60% | 394 | 743.08 | 445.6 | 197 | 0.5 | 668.4 |
| TILE 80% | 394 | 743.08 | 222.8 | 197 | 0.5 | 891.2 |

***3.3.1 Mixes Adopted***

Mix ratio as per IS method is adopted for the design mix. Plain concrete cubes cylinders prism were cast, cured and tested in UTM. M20 Grade of Concrete is chosen and the design mix adopted for the Test Specimens is 1:1.8:2.8, water cement ratio is 0.5.

*3.4 SPECIMEN CASTING*

Table: 3.6Number of specimens cast for the experimental program

| SL. NO. | TEST | SPECIMENS SIZE (MM) | TOTAL NUMBER OF SAMPLE |
|---|---|---|---|
| 1 | COMPRESSIVE | 150x150x150 | 39 |
| 2 | TENSILE | 150x150x300 | 39 |
| 3 | FLEXURAL STRENGTH | 500x100x100 | 39 |
| 4 | MODULUS OF ELASTICITY | 150x150x300 | 39 |
| | TOTAL NUMBER OF SAMPLES | | 156 |

***3.4.1 Casting of concrete***

*150 mm moulds should be filled in three approximately equal layers (50 mm deep). A compacting bar is provided for compacting the concrete. It is a 380 mm long steel bar, weighs 1.8 kg and has a 25 mm square end for ramming. During the compaction of each layer with the compacting bar, the strokes should be distributed in a uniform manner over the surface of the concrete and each layer should be compacted to its full depth. During the compaction of the first layer, the compacting bar should not forcibly strike the bottom of the mould. For subsequent layers, the compacting bar should pass into the layer immediately below. The minimum number of strokes per layer required to produce full compaction will depend upon the workability of the concrete, but at least 35 strokes will be necessary except in the case of very high workability concrete. After the top layer has been compacted, a trowel should be used to finish off the surface level with the top of the mould, and the outside of the mould should be wiped clean.*

***3.4.2 Testing of concrete***

*3.2.4.1 Compression Test*

The Compression Test is a laboratory test to determine the compressive strength of the concrete.

*3.2.4.2 Tensile Test*

The splitting tensile test is a much used method to determine the tensile strength of concrete. The conventional test procedure is known to have a number of limitations related to size effect and boundary conditions.

*3.2.4.3 Modulus of Elasticity Test*

Young's modulus is a measure of the stiffness of an elastic material and is a quantity used to characterize materials. It is defined as the ratio of the stress along an axis to the strain along that axis in the range of stress

*3.2.4.4 Flexural strength test*

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending

Fig: 3.5Casting

Fig: 3.6Curing