ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 12, pp. 22626-22632, December, 2017

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

STUDY ON SILICA FUME MIXED CERAMIC WASTE AGGREGATE CONCRETE

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DOI: http://dx.doi.org/10.24327/ijrsr.2017.0812.1304

ARTICLE INFO

Article History:

Received 18th September, 2017
Received in revised form 10th October, 2017
Accepted 06th November, 2017
Published online 28th December, 2017

Key Words:

Conventional Concrete, Sustainable Concrete, Concrete Technology, Slica Fume, Ceramic Waste

ABSTRACT

To make a sustainable concrete technology, I used to introduced the new materials ceramic waste, Bottom ash, Silica fume and Replacing conventional Coarse aggregate (100%)-ceramic waste, Fine aggregate (50%) - bottom ash and Silica fume - Admixtures concrete are made. The properties are studied and compared with conventional concrete.

INTRODUCTION

Concrete is the mixture of cement, sand, stone ballast and water, which when placed in forms and allowed to cure, become hard like stone. The hardening is caused by the chemical reaction between the cement and water. The cement and water form a paste which upon hardening binds the aggregate to a permanent mass. Cement is called the binding material. In general, Stone and brick ballast is called course aggregate. Sand and mineral sand is called fine aggregate. The mortar in concrete is called "matrix" cement concrete when used by itself is known as Mass Concrete. The cement concrete has attained the status of a major building material in all branches of modern construction because of the following reasons:

1. It can be readily molded in to durable structural items of various sizes and shapes at practically no considerable labour expenditure.
2. It is possible to control the properties of cement concrete within a wide range by using appropriate ingredients and by applying special processing techniques mechanical, chemical and physical.
3. It is possible to mechanize completely its preparation and placing process
4. It possesses adequate plasticity for the mechanical working.

Concrete ingredients

The importance of the ingredients should be known before there are used in cement concrete.

Cement

Cement is binding material in the cement concrete. This concrete is used for different engineering works where strength and durability are of Prime importance.

Functions of cement

It fills up voids existing in the fine aggregate and makes the concrete impermeable. It provides strength to concrete on setting and hardening. It binds the aggregate into a solid mass by virtue of its setting and hardening properties when mixed with water.

Requirements

Good cement should satisfy all the requirements as per I.S. specifications

Aggregate

In the cement concrete, to provide good quality of concrete aggregate is used in two size groups:

Fine aggregate (sand) particle size less than 4.75mm
Coarse aggregate- Particle size more than 4.75mm

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Fine aggregate (sand)

Sand consists of small angular or rounded grains of silica. Sand is commonly used as the fine aggregate in cement concrete. Both natural and artificial sands are used for this purpose.

Functions of sand

1. It fills the voids existing in the coarse aggregate.
2. It reduces shrinkage and cracking of concrete.
3. By varying the proportion of sand concrete can be prepared economically for any required strength
4. It helps in hardening of cement by allowing the water through its voids.
5. To form hard mass of silicates as it is believed that some chemical reaction takes place between silica of sand and constituents of cement.

Requirements

1. Fine aggregate should consist of coarse angular sharp and hard grains.
2. It must be free from coatings of clay and silt.
3. It should not contain any organic matter.
4. It should be free from hygroscopic salt.
5. It should be strong and durable and chemical inert.
6. The size of sand grains should pass through 4.75mm IS sieve and should be entirely retained on 75 micron IS sieve.

Coarse aggregate

Functions

Coarse aggregate makes solid and hard mass of concrete with cement and sand.

It increases the crushing strength of concrete.

It reduces the cost of concrete, since it occupies major volume.

Requirements

Coarse aggregate used may be crushed stone, gravel and broken bricks.

Crushed stone: It is an excellent coarse aggregate provided. It is obtained by crushing granite, sandstone and close grained limestone.

Crushed granite chips are commonly and advantageously used in reinforced cement concrete.

Broken bricks well burnt and over burnt bricks are broken into suitable size and used as aggregate. It should be well watered before its use. Broken bricks are used as aggregate for concrete in foundations and under floors.

But generally crushed stone is only used as coarse aggregate.

Water

The water is used in concrete plays an important part in the mixing, laying compaction setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water is used in the mix.

Functions

1. Water is only the ingredient that reacts chemically with cement and thus setting and hardening takes place.
2. Water acts as a lubricant for the aggregate and makes the concrete workable.
3. It facilitates the spreading of cement over the fine aggregate.

Admixtures

While aggregate, cement, and water are the main ingredients of concrete, there are a large number of mineral and chemical admixtures that may be added to the concrete. The four most common admixtures will be discussed.

Air-entraining agents are chemicals that are added to concrete to improve its freeze-thaw resistance. Concrete typically contains a large number of pores of different sizes, which may be partially filled with water. If the concrete is subjected to freezing temperatures, this water expands when forming ice crystals and can easily fracture the cement matrix, causing damage that increases with each freeze-thaw cycle. If the air voids created by the air-entraining agent are of the right size and average spacing, they give the freezing water enough space to expand, thereby avoiding the damaging internal stresses.

Water-reducing admixtures, also known as super plasticizers, are chemicals that lower the viscosity of concrete in its liquid state, typically by creating electrostatic surface charges on the cement and very fine aggregate particles. This causes the particles to repel each other, thereby increasing the mix flow ability, which allows the use of less water in the mix design and results in increased strength and durability of the concrete.

Retarding admixtures delay the setting time, which may be necessary in situations where delays in the placement of concrete can be expected. Accelerators shorten the period needed to initiate cement hydration-for example, in emergency repair situations that call for the very rapid development of strength or rigidity.

Special concretes and recent developments

Con-crete is an engineered material, with a variety of specialty products designed for specific applications. Some important ones are described below.

Lightweight concrete

Although the heavy weight or large mass of typical concrete members is often an advantage, there are situations where this is not the case. For example, because of the large stresses caused by their own heavy weight, floor slabs are often made lighter by using special lightweight aggregate. To further reduce weight, special chemical admixtures are added, which produce large porosity.

Such high porosity (in either the matrix or the aggregate particles themselves) improves the thermal resistance of the concrete as well as sound insulation, especially for higher frequencies. However, because weight density correlates strongly with strength, ultralight weight concretes [1.1 g/cm^3(70 lb/ft3) and less] are used only for thermal or sound insulation purposes and are unsuitable for structural applications.

Heavy weight concrete

When particularly high weight densities are needed, such as for shielding in nuclear reactor facilities, special heavyweight aggregate is used, including barite, limonite, magnetite, scrap metal, and steel shot for fine aggregate. Weight densities can be achieved that are twice that of normal weight concrete.

Architectural concrete

Concrete surfaces that remain exposed may call for special finishes or textures according to the architect's desires. Textures are most readily obtained by inserting special form liners before casting the concrete. Sometimes the negative imprint of roughly sawn timber is considered attractive and left without further treatment.

Other surface textures are obtained by sandblasting, bush-hammering, and similar treatments. Ordinary Portland cement gives concrete the typical gray color. By adding color pigments to the mix, a large variety of colors can be produced, especially in combination with white Portland cement. Concrete mixed with specialty aggregate, such as marble, and ground smooth is known as terrazzo concrete, which is very popular for decorative surfaces on floors and walls.

Recently, crushed postconsumer glass has been used as aggregate for decorative applications because of the esthetic possibilities, provided suitable countermeasures against alkali-silica reaction are taken.

Fiber-reinforced concrete

The concrete matrix can be reinforced with short, randomly distributed fibers. Fibers may be metallic (primarily steel), synthetic (such as polypropylene, nylon, polyethylene, polyvinyl alcohol, and alkali-resistant glass), or natural (such as sisal, coconut, and rice husk). Such fibers are typically used in addition to conventional steel reinforcement, but in some applications exits replacement. For example, precast glass-fiber-reinforced building façade elements are widely used in the United States. By being uniformly distributed and randomly oriented, the fibers give the concrete matrix tensile strength, ductility, and energy absorption capacities that it otherwise would not have. In particular, when these fibers are engineered to optimize the fracture energy, so called high-performance fiber-reinforced concrete is obtained, which has remarkable deformational characteristics and extraordinary resistance to blast and impact loads. In the concrete industry, it is very common to add small amounts of polypropylene fibers to reduce the extent of shrinkage cracking.

Textile-reinforced concrete

Whereas in fiber-reinforced concrete the fibers are short [usually no longer than 2 in. (5 cm)] and discontinuous, textile-reinforced concrete contains continuous woven or knitted mesh or textiles. Conceptually, such reinforcement acts similarly to conventional steel reinforcing bars or welded steel wire fabrics. But these fabric materials are non corrosive and can have mechanical properties that are superior to those of steel. The fabrics can be pre manufactured in a wide variety of ways, Thereby lending themselves to new applications, Especially for repairing or strengthening existing concrete structures.

Polymer-modified concrete

In polymer-modified concrete, also known as latex-modified concrete, a polymer is added to improve the material's strength, imperviousness, or both. In applications such as highway bridge decks, often a layer of latex-modified Concrete is placed on top of a regular reinforced concrete deck for additional protection of the steel reinforcement. In polymer concrete, the hydraulic cement is replaced by an organic polymer as the binder.

Polymeric composite Roller-compacted concrete

This type of concrete is formulated with very low contents of Portland cement and water and therefore is of relatively low-cost. It is often used for pavements and dams. It can be transported by dump trucks or loaders, spread with bulldozers or graders, and compacted with vibratory rollers. Because the cement content is so low, the heat of hydration does not cause the kind of problems encountered in dams built with conventional concrete.

Ultra-high-strength concrete

Whereas concretes with compressive strengths of 6000 to 12,000 lb/in.(40to 85 MPa) can now be categorized as high-strength, a new technology has been developed that results in strengths of 30,000 lb/in.(200 MPa) and higher. The key ingredient of this ultra-high-strength concrete is a reactive powder; therefore, it is also known as reactive powder concrete. Other characteristics of this material are low water-cement ratios, carefully selected high-strength aggregates, and small steel fibers.

Self-leveling concrete

The need for good workability has been mentioned. The need for highly skilled workers who can properly compact concrete at the construction site prompted researchers in Japan to optimize the mix design such that the fresh concrete can flow into place without the need for further vibration. The main challenge was to obtain a low viscosity mix without the threat of desegregation. This innovation is particularly important in applications with dense steel reinforcement, which traditionally have caused severe difficulties of producing high-quality concrete.

"Green" concrete

Concrete is by far the most widely used building material. Well over 10 billion tons are produced worldwide each year, requiring enormous natural resources. Also, it has been estimated that the production of 1 ton of portland cement causes the release of 1 ton of carbon dioxide (CO_2) into the atmosphere, a gas that is known to contribute to global warming. Together with the large amounts of energy required to produce portland cement, the cement and concrete industry has a major impact on the environment worldwide. Efforts are underway to reduce this impact and transform the industry to conform to the principles of sustainable development. The most significant step is the replacement of portland cement by other cementitious or pozzolanic materials, preferably materials that are by products of industrial processes, such as fly ash (the by-product of coal-burning power plants) and granulated blast furnace slag (a by-product of the steel industry). To reduce the need for virgin aggregate, recycled concrete is the most promising approach, because construction debris, in particular demolished concrete, constitutes a major component of solid waste that fills up sparse landfill capacity. These recent developments are much more advanced in Europe and Japan than in the United States. But the "green" building movement is gaining momentum there as well, and for the concrete industry to maintain its dominant position.

Sustainable concrete

Sustainable concrete construction is a step towards green and eco friendly concrete construction practices to solve global environmental problems.

Concrete is a construction material which been used substantially all over the world. Regarding the amount of concrete that has produced, used and its impact are considered as an important part of the whole global environmental problems.

The effect of concrete is taking place in different stages from excavation of raw material until the end of structure life. Global warming due to emission of CO_2, increasing landfill sizes and pollution is the result of these impacts.

Rising population density and increasing demand for concrete have exacerbated the situation. Thus it is required to go for sustainable concrete construction practices.

Methods for Achieving Sustainable Concrete Construction

Following are the methods for achieving sustainable concrete construction:

Use of Blended cements

Most of CO_2 is being released during clinker production due to calcium calcinations and energy consumption. This emission can be reduced by using blended cement in which industrial by product like slag that replaces part of clinker.

Not only does the blended cement reduce greenhouse gas emission in calcinations, but also decrease energy consumption.

Energy Efficiency Improvement

Decreasing emission from electricity and fuel utilization can be gained by improving energy efficiency which cause cost production reduction as well. Upgrading, modifying, and replacing of equipments to make them more efficient for producing of cement.

Large proportion of energy is used during cement production, and it comes from fuel combustion, so it is possible to obtain large reduction in energy employment by mitigating efficiency of fuel. Changing cement production technology is another way of improving energy efficient.

Carbon dioxide removal: decreasing CO_2 can be achieved by using CO_2 removal. In this method, during or after the process of production CO_2 is separated and then disposed out of atmosphere. Procedure of this technique is divided into three stages: drying and compressing of CO_2, transfer recovered CO_2, and storing or disposing it.

***Low carbon instead of high carbon fuel**:* using fuel which has lower CO_2 content is a method to reduce emission. Therefore, using waste derived fuel or natural gas instead of coal fuel decrease amount of CO_2 and minimizing waste disposal.

There are numbers of alternative fuels that could be used for that purpose such as refinery gases, mineral oil, and waste wood.

***Prolonged service life of concrete**:* how to extend the operational life of concrete is the most important factor because not only does it decrease the amount of demolition waste of current buildings but also save virgin materials. Durability is very significant which directly related to concrete service life.

***Waste recycling**:* it consists of rubble and masonry that can be used as coarse and fine aggregate. This strategy is economical especially in those countries where already raw material is depleted and using recycled waste is better than high cost raw material and expensive hauling.

It is estimated that 1 trillion L of water is used for concrete industry which most of it is drinkable. About 3% water on earth is fresh and it going to be rare in most of continents, so recycling water could be an answer for that problem.

By using textile that has water absorption property for curing, better aggregate grading, increasing the use of super plasticizer and admixtures the amount of utilized water can be reduced to half.

***Government, companies, and environmental activist responsibilities**:* clarification dangers of emission are very significant. This might lead to encourage producer and construction companies to implement methods toward lessening greenhouse emission.

Scope and objectives

- To characterize the ceramic waste, bottom ash and silica fume.
- To propose a mix design.
- To Study the,
- Mechanical properties and Durability
- properties of ceramic concrete

METHODOLOGY

- Utilizing ceramic waste (Electrical insulator scrap) as coarse aggregate (100%).
- Utilizing bottom ash (Lignite- base) as fine aggre gate (50%).
- Proposing 3 varies mix design for ceramic concrete Casting of
- cubes(0.1mx0.1mx0.1m),
- cylinder(0.15m Ø x 0.3m ht) and (0.1m Ø x 0.2m ht),
- Prism (0.1m x 0.1m x 0.5m).

Proposal of silica fume

Silica fume added on the basis of reaction take place between cement and water.

Hydration of cement:

2C3S + 6H ⟶ C3S2H4 + 3CH
(Tricalciumsilicate+water) (C-S-H gel+ calciumhydroxide)
2C2S +4H ⟶ C3S2H4 + CH

(Dicalcium silicate+water) (C-S-H gel+ calciumhydroxide)

CH formed in 1st reaction is 24.3%
CH formed in 2nd reaction is 5.40%

Reactions of silica fume with CH;
CH + Silica fume +water ⟶ $C_3S_2H_4$
(85% SiO_2) (C-S-H gel)

15% of Silica fume is added based on the above equation.

Procuring materials

(Ceramic waste into 20mm size aggregate)


Characterization of Coarse Aggregate

Properties	Ceramic waste	Crushed stone
Specific gravity	2.73	2.78
Maximum size	20	20
Finess modulus	6.05	6.34
Surface Texture	Smooth	Rough
Bulk density		
Loose	1410	1695
Compaction	1523	1935
Voids		
Loose	48	44
Compaction	44.32	39.81
Crushing value	17	18
Impact value	8	9

Characterization of Fine Aggregate

Properties	Ceramic waste	Crushed stone
Specific gravity	2.521	2.67
Maximum size	2.5	2.72
Finess modulus	6.05	6.34
Bulk desity		
Loose	1433	1695
Compaction	1628	1935
Voids		
Loose	43.2	36.52
Compaction	38.42	30.71

Characterization of Silica Fume

SiO_2(silicon dioxide, amorphous)	Min. 85.0%
H_2O (moisture)	Max. 1.0 % (when packed)
C (carbon)	Max. 2.5 %
LOI (Loss on Ignition)	Max. 4.0 %
Bulk density (Dense) (Kg/M3)	600 - 700 (when packed)

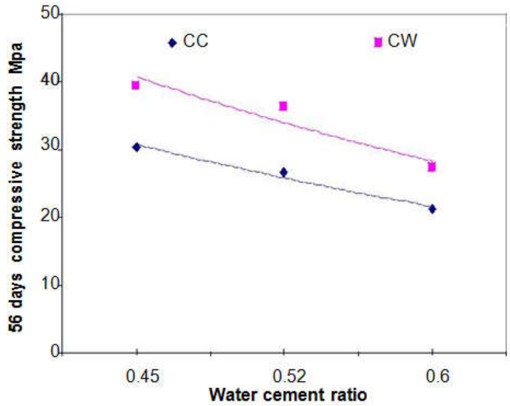
Mix Proportion

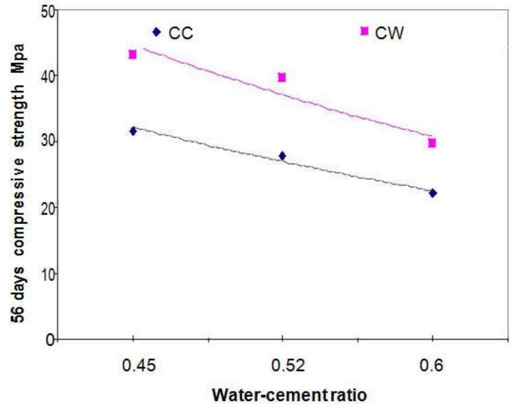
Mix No	W/C	CEMENT Kg/m3	Proportion by weight
CW1	0.58	300	1:2.41:3.73
CW2	0.50	350	1:1.93:3.19
CW3	0.44	400	1:1.56:2.79

Testing

All the tests were conducted using standard method. Mechanical properties and durable properties were found out for both the concrete and the results should be compared. Mechanical properties such as compressive strength, tensile strength and flexural strength were found out. Durability properties such as sulphate attack and chloride diffusion were done and results are highlighted.

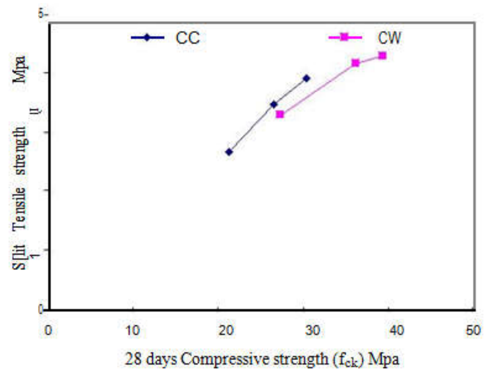
Compressive Strength Test

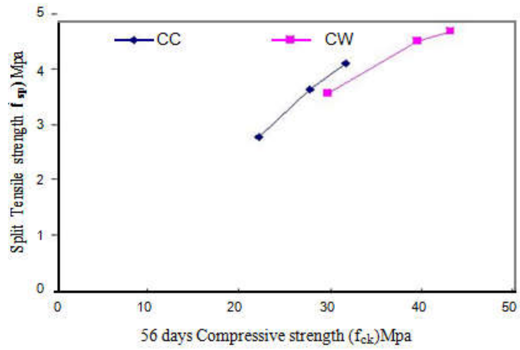




Relationship between Water-Cement ratio and Compressive strength @ 28 and 56 days of curing period

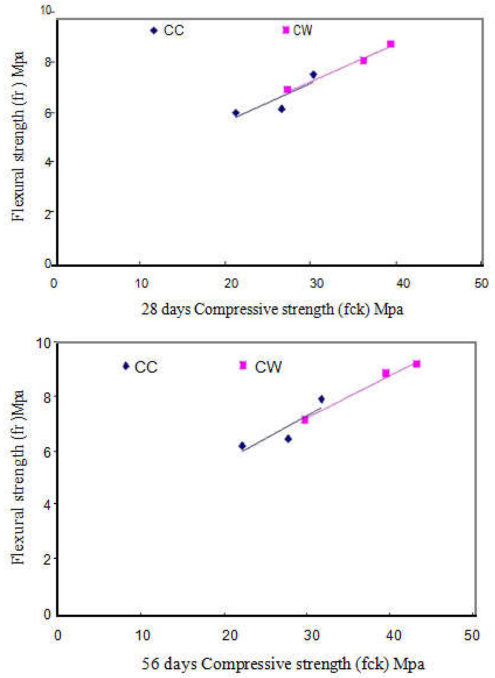
Split Tensile Strngth





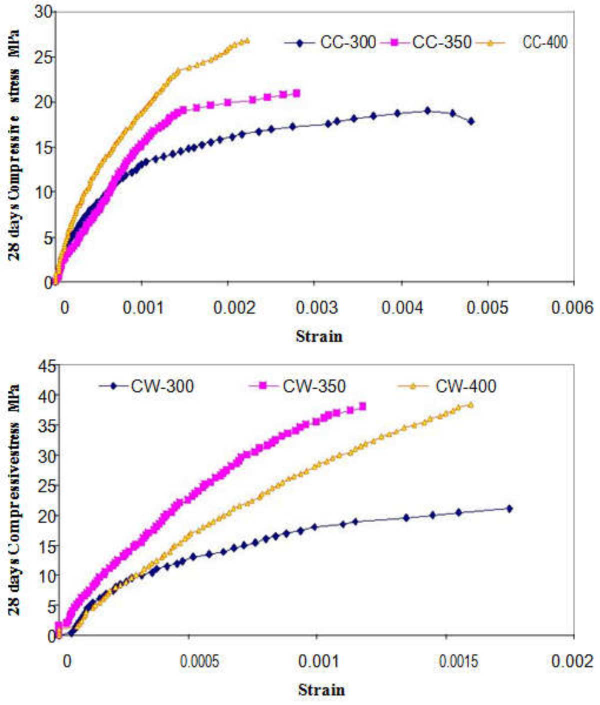
Relationship between Compressive strength and Split tensile strength @ 28 and 56 days of curing period

Flexural Strength



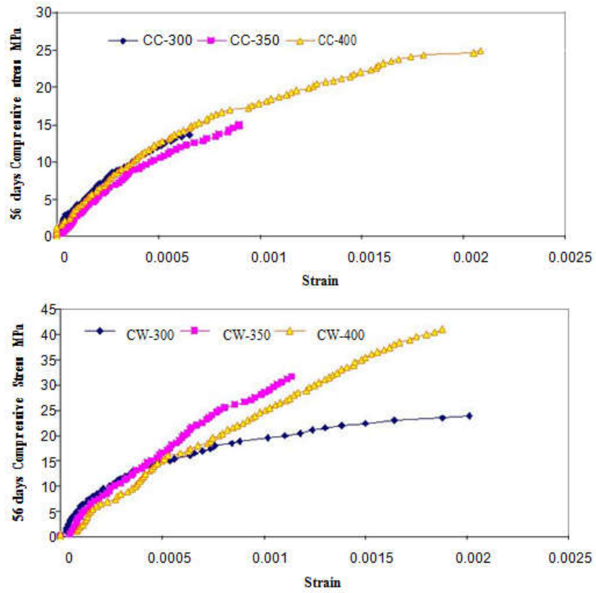
Relationship between Compressive strength and Flexural strength @ 28 and 56 days of curing period

Modulus of Elasticity



Relationship between Compressive stress and strain @ 28 days of curing period for both concrete

Modulus of Elasticity



Relationship between Compressive stress and strain @ 56 days of curing period for both concrete

CONCLUSION

The properties of Ceramic waste (Electrical insulator scrap) and Bottom ash are nearer to the properties of conventional aggregate. Hence it suited for concrete making.

The Mechanical properties of Ceramic concrete are higher than that of conventional concrete, this due to the replacement of sand by Bottom ash and an addition of admixtures (highly reactive Silica fume).

The Durability properties of Ceramic concrete are comparatively higher than that of Conventional concrete, this is due to presence of less pores in concrete.

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How to cite this article:

Venkadesan T *et al*.2017, Study on Silica Fume Mixed Ceramic Waste Aggregate Concrete. *Int J Recent Sci Res.* 8(12), pp. 22626-22632. DOI: http://dx.doi.org/10.24327/ijrsr.2017.0812.1304

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