Utilization of Vitrified Ceramic Tile Waste As Fine Aggregate In Cement Mortar

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Abstract- *Ceramic waste is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Ceramic waste tiles dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the ceramic waste tiles in various industrial sectors especially the construction, agriculture and glass industries would help to protect the environment. It is most essential to develop eco-friendly cement mortar from ceramic waste. In this research study the sand has been replaced by ceramic waste as fine aggregates accordingly in the range of 0%, 10%, 20% and 30% by weight of sand. Cement mortar mixtures were produced, tested and compared in terms of compressive strength to the conventional cement mortar. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. As a result, the compressive strength achieved up to 10% replacing sand with ceramic waste as fine aggregate. This research work is concerned with the experimental investigation on strength of cement mortar and optimum percentage of the partial replacement by replacing sand via 0%, 10%, 20% and 30% of ceramic waste as fine aggregate. Keeping all this view, the aim of the investigation is to study the behavior of cement mortar while replacing the ceramic waste as fine aggregate with different proportions in cement mortar.*

Keywords- ceramic waste, environmental pollution, cement mortar, fine aggregate, compressive strength.

I. INTRODUCTION

Earth, undoubtedly is the oldest building material known. Even though building with earth once fell out of popularity when the modern building materials and methods were discovered, but then it gains its revival time following the energy crisis. Moreover, growing concern and interest about environmental and ecological issue globally also increased the use of earth as a building material.

The compressed earth block is the modern descendent of the moulded earth block, more commonly known as the adobe block. The idea of compacting earth to improve the quality and performance of moulded earth blocks is, however, far from new, and it was with wooden tamps that the first compressed earth blocks were produced. This process is still used in some parts of the world. The first machines for compressing earth probably date from the 18th century.

Stabilised mud Blocks (SMB) represents a considerable improvement over traditional earth building techniques. When guaranteed by quality control, SMB products can very easily bear comparison with other materials such as the fired brick. Hence the allegiance it inspires amongst decision- makers, builders and end-users alike.

II. LITERATURE REVIEW

1. *"Studies on stabilized mud blocks as a construction material",* Vinu Prakash, Amal Raj et.al 2016

They have used materials like soil, lime, cement, coir, plastic fibre &straw fibre.

a) Compressive strength increased with increase in cement content. However, increase in lime content showed very little increase in strength.
b) Compressive strength increased by 43.39% for 10% cement content.
c) Compressive strength increased by 201.88% for 10% cement content & 3% coir.
d) Compressive strength increased by 169.811% for 10% cement & 3% plastic.
e) The average water absorption for blocks having 10% cement (C10),10% cement 3% coir (C10C) , 10% cement 3%
f) Plastic fibre (C10P) were less than 15% satisfying the IS recommendation.
g) Cost analysis of production shows that blocks with 10 % cement are about 55.7% cheaper than burnt bricks. Blocks having 10% cement 3% coir are about 17.14% cheaper than burnt bricks.
h) Use of OPC as a stabilizer in place of PPC gives more strength to the SMB with same proportions.

i) Use of lime in place of OPC at constant proportion increases the strength of SMB
j) Introduction of PPC in place of lime does not contribute to the increase in strength of the SMB, rather it decreases the strength

*2. "Stabilized lateritic blocks reinforced with fibrous coir wastes"*M.G.Sreekumar1, Deepa Nair et.al 2013

a) They have used the materials like laterate soil, sand cement and fiberous waste additives.
b) They have concluded that considerable improvement in the strength and durability characteristics were exhibited by fiber reinforced lateritic blocks on comparing with stabilized lateritic blocks without fibers.
c) Following conclusions were arrived from the research:

Strength characteristics

a. **Compressive strength:** 19% improvement was observed for the compressive strength of blocks stabilized with fibrous coir wastes @0.5%.
b. **Tensile strength:** An improvement of 9% was reported on tensile strength.
c. The compressive strength and tensile strength was found decreasing with the increases of the fiber content beyond 0.5%.
d. **Ductility:** Fibrous material addition improves ductility of the blocks making it suitable for earth quake resistant structures.

3*".Cement Stabilized Soil Blocks Admixed with Sugarcane Bagasse Ash***".** Jijo James, P. Kasinatha Pandian, et.al 2015
They have used the materials like locally available soil, Sugarcane Bagasse ash(SBA)&OPC cement.

a) Cement stabilization of locally available soil can be used in the manufacture of stabilized soil blocks to meet the compressive strength and water absorption norms of BIS specifications. Cement stabilization of soil at 4% cement content meets the specifications of class 20 blocks whereas cement stabilization of soil at 10% cement content meets the specifications of class 30 blocks.
b) Addition of SBA to cement in stabilization results in an increased compressive strength of the blocks. However, SBA addition is more effective at lower cement content of 4% producing higher strength gains when compared to higher cement content of 10%.
c) Addition of SBA to cement in stabilization results in an increase in the water absorption of the blocks but is still comfortably within the norms stipulated by BIS. However, the addition of SBA produces more water absorption at higher cement content of 10% than lower cement content of 4% for similar SBA contents, again reinforcing the inference that SBA addition is more effective at lower cement content.
d) Addition of 8% SBA to 4% cement content increases its compressive strength to meet the strength requirements of class 30 blocks from the original category of class 20 blocks. Thus it can be seen that addition of 8% SBA can result in utilization of just 4% cement for achieving class 30 block specifications. This leads to saving of 6% cement in comparison with the other combination adopted in this study.

4.*"stabilized mud mortar".* Rashmi S1, Jagadish K S2, Nethravathi et.al

a) They have used the materials like clay, lime & brick dust.
b) It is evident from the studies that partial replacement of sand is viable as maximum strength of 4.25 MPa is obtained which clearly exceeds the limit (3MPa) established by I.S. 2250 code. The mortars containing lime may be used as low strength mortars. Therefore, the construction can be made economical as well as eco-friendly.

III. MATERIALS REQUIRED FOR STABILIZED SOIL BLOCK PRODUCTION

It includes classification, specifications, availability and properties of materials which are necessary for stabilized earth blocks production (such as soil, cement and Lime)

A. SOIL

Soil is a sediment or accumulation of mineral particles produced by the physical or chemical disintegration of rock, plus the air, water, organic matter, and other substances that may be included in the soil. In addition, soil is a non-homogeneous, porous, earthen material whose engineering behaviour is influenced by changes in moisture content and density.

<u>Classification of soil</u>

Soils are classified in many different ways: by their use, origin, grain size, texture, colour and density. Based on the origin of soil can be divided to two basic types.

a. Residual soils: These are caused by the weathering (decomposition) of rock by chemical or physical action. Residual soils are usually clayey, and their properties are related to the climate and the location of the soil. Residual soils are usually preferred to support foundations, and they have better, more predictable engineering properties.

b. Transported or deposited soils: These are derived by the movement of soil from one location to the other by natural means. The means are generally wind, water, ice, and gravity. The character of the resulting deposit often reflects the modes of transportation and deposition and the source.

Classification by particle size distribution

Soils are made up of varying proportions of materials such as gravels, sands, fine (silts and clays). Each of these has different characteristics

a) Gravels: These are made up of pieces of rock of varying hardness, and their size ranges between approximately>4.75mm.
b) Sands: These are made up of mineral particles, and their size ranges between approximately 4.75mm-2.36mm.
c) Silts: There are made up of particles the size of which range between approximately 0.002 and 0.06 mm
d) Clays: form the finest fraction of soils 0.002mm, and have completely different characteristics than those of the other particle types. They consist mainly of microscopic clay mineral particles, including kaolinites, illites and montmorillonites.

Classification by plasticity (Fine content)

Soil plasticity is the ability of a soil to undergo irreversible deformation when it is subjected to an increasing load. It is indicated by the plasticity index. The plasticity index is the amount of water required for a soil to pass from a plastic to a liquid state.

a. Cohesive soil: Cohesive soils are fine-grained materials consisting of silts, clays, and/or organic material. These soils exhibit from low to high strength when the air is dried in the voids.
b. Cohesion less Soil: Cohesion less soil is composed of granular or coarse-grained materials with visually detectable particle sizes and with little cohesion or adhesion between particles. These soils have little or no strength when they dry and little or no cohesion when they submerged. Strength occurs from internal friction when the material is confined. Apparent adhesion between particles in cohesion less soil may occur from capillary tension in the pore water. Cohesion less soils are relatively free-draining compared with cohesive soils.

B. CEMENT

Ordinary Portland Cements: OPC (53 Grade) can be used in all kind of Concrete constructions – such as RCC, precast concrete and pre-stressed concrete, Slip form constructions, all kinds of Masonry works, manufacture of cement based products such as pipes, tiles, blocks etc. OPC 53Gr. Cement is more suitable where high early strength is necessary viz. for production of High Strength/ High Performance Concretes and for Rehabilitation/ Retrofitting works.

Blended Cements can be used for all general construction works, especially for works in aggressive environmental conditions particularly in coastal areas to counteract chloride and sulphate attacks, water retaining structures, marine works, sewage pipes, mass concrete works such as dams, etc., substructures in sulphatic soils and structures in hot and humid climate.

C. LIME

Lime in the form of quicklime (calcium oxide – CaO), hydrated lime (calcium hydroxide –$Ca[OH]_2$), or lime slurry can be used to treat soils. Quicklime is manufactured by chemically transforming calcium carbonate (limestone – $CaCO_3$) into calcium oxide. Hydrated lime is created when quicklime chemically reacts with water. It is hydrated lime that reacts with clay particles and permanently transforms them into a strong cementitious matrix.

D. STABILIZATION OF SOILS

Soil stabilization significantly changes the characteristics of a soil to produce long-term permanent strength and stability, particularly with respect to the action of water and frost.

Lime, either alone or in combination with other materials, can be used to treat a range of soil types. The mineralogical properties of the soils will determine their degree of reactivity with lime and the ultimate strength that the stabilized layers will develop. In general, fine-grained clay soils (with a minimum of 25 percent passing the #200 sieve (74mm) and a Plasticity Index greater than 10) are considered to be good candidates for stabilization. Soils containing significant amounts of organic material (greater than about 1 percent) or sulphates (greater than 0.3 percent) may require additional lime and/or special construction procedures.

IV. EXPERIMENTAL TESTS FOR PROPERTIES OF MATERIALS

1. Specific gravity by Pycnometer method
2. Grain size analysis
3. Liquid limit test
4. Plastic limit test
5. Compaction test

1. SPECIFIC GRAVITY BY PYCNOMETER METHOD

a) This method covers the determination of the specific gravity of soils that pass 4.75 mm IS sieve.
b) When the soil is composed of particles larger than 4.75 mm, shall be used for the material retained on 4.75 mm IS sieve, and this test method shall be used for material passing the 4.75 mm IS sieve. The weighted average of the two values shall be the specific gravity value for the soil.

Table No. 5.1.1 SPECIFIC GRAVITY TEST

Observation	Trail-1 (gm)	Trail-2 (gm)
Mass of empty pycnometer (m1)	656	656
Mass of pycnometer + dry soil (m2)	956	956
Mass of pycnometer+soil+ water (m3)	1730	1726
Mass of pycnometer+water (m4)	1556	1550

1) The specific gravity of soil solids obtained = 2.4

2. GRAIN SIZE ANALYSIS

The value of Cc does not lie below 0.5, the soil is said to be poorly graded also, the soil sample consists of 90.2% of sand fraction and the value of Cu does not lie between 1&3, the sample is poorly graded soil.

3. LIQUID LIMIT TEST

Flow index = FI = 55%
Liquid limit = Wl = 18%

4. PLASTIC LIMIT TEST

Plastic limit of given soil sample = Wp =18.35
Plasticity index = IP = 37%.

5. COMPACTION TEST

Maximum dry density =1.72g\cc=16.44KN\M³
Optimum moisture content =17.5%

V. TRIAL MIX

Many stabilizers can be used. Cement and lime are the most common ones. Others, like chemicals, resins or natural products can be used as well.

The selection of a stabilizer will depend upon the soil quality and the project requirements:

Cement will be preferable for sandy soils and to achieve quickly a higher strength.

Lime will be rather used for very clayey soil, but will take a longer time to harden and to give strong blocks.

As we have taken the percentage of sand, cement and lime are listed below.

SL.NO	% OF SAND	% OF CEMENT	% OF LIME
1	92%	8%	0%
2	92%	6%	2%
3	92%	4%	4%

CASTING OF STABILIZED MUD BLOCKS

The soil containing predominately non-expansive clay mineral is suited for cement stabilized blocks. The selected soil should be red soil. The collected soil sample should be dry and it should not contain any roots, stones, foreign materials etc if such types of materials are present in soil sample it is removed through sieving of soil. The collected soil sample should pass through 5mm IS sieve. The specific gravity of the selected soil for the preparation of mud blocks is 2.4

Hydraulic Press

The stabilized mud blocks production machines are available in mechanised as well as manually operated form. The machine weighs 170-200kg depending upon different moulds. Manually operated machines are ideal in rural areas for decentralized production. Mardini soil block press is one of such manually operated machine. A team of 6-7 persons can produce 200-500 numbers of blocks per day from a single machine depending upon their personal efficiency. For the production of 500 blocks 2 tonnes of soil and sand each along with 275kg of cement is required.

Block Size

Two block sizes (305x143x100mm and 230x190x100mm) have been standardized. These two sizes can be used to construct walls of thickness 305mm, s230mm, 190mm, and 143mm or100mm. These blocks are 2.5to2.8 times bigger in volume when compared with conventional bricks.

Block strength

Compressive strength of block greatly depends on the soil composition, density of the block and %of stabilizer (cement\lime). Sandy soils with 7% cement can yield blocks having wet compressive strength of 3- 4Mpa. This kind of strength will be sufficient to construct 2 storey load bearing buildings with span in the range of 3 - 4m

TESTS CONDUCTED FOR STABILIZED MUD BLOCKS

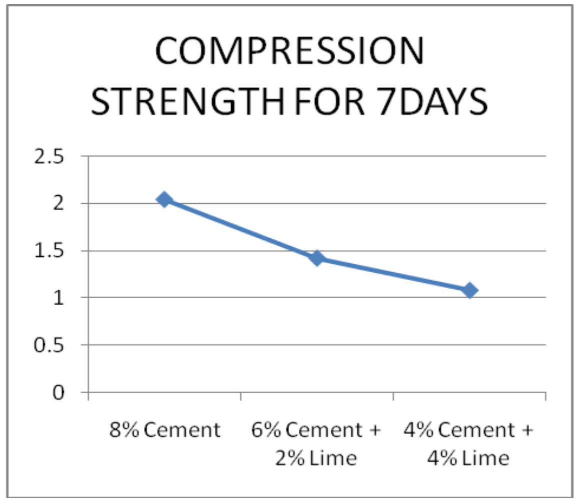
COMPRESSION TESTS

7 Days Dry Compressive Strength

SL.NO	NAMES	STRESS (MPa)
1	8% C	2.13
		2.30
		1.71
2	6% C + 2% L	1.5
		1.33
		1.43
3	4% C + 4% L	1.22
		0.94
		1.1

Average of 2%lime stress = 1.42Mpa
Average of 4%of lime stress = 1.08Mpa
Average of 8% of cement stress = 2.04Mpa

GRAPH FOR COMPRESSION STRENGTH TEST OF 7 DAYS

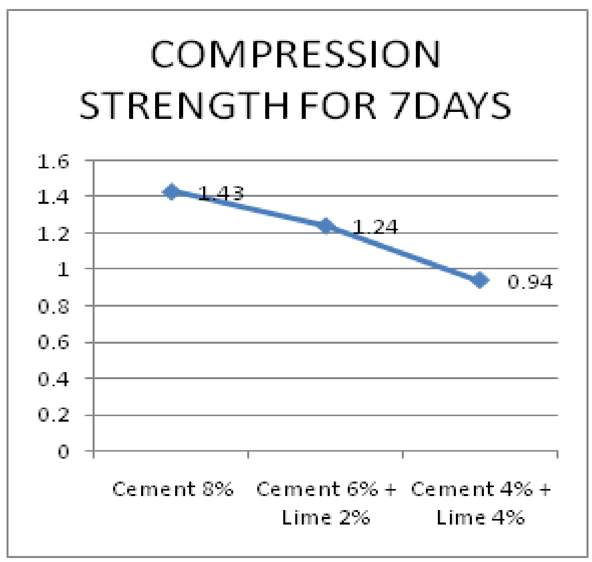


7 Days Wet Compressive Strength

SL.NO	NAMES	STRESS (MPa)
1	6%C+2%L	1.17
		1.24
		1.20
2	4%C+4%L	0.99
		0.87
		0.93
3	8%C	1.34
		1.43
		1.38

Average of 2%lime stress =1.24Mpa
Average of 4%of lime stress = 0.94Mpa
Average of 8% of cement stress = 1.43Mpa

GRAPH FOR WET COMPRESSION STRENGTH TEST OF 7 DAYS

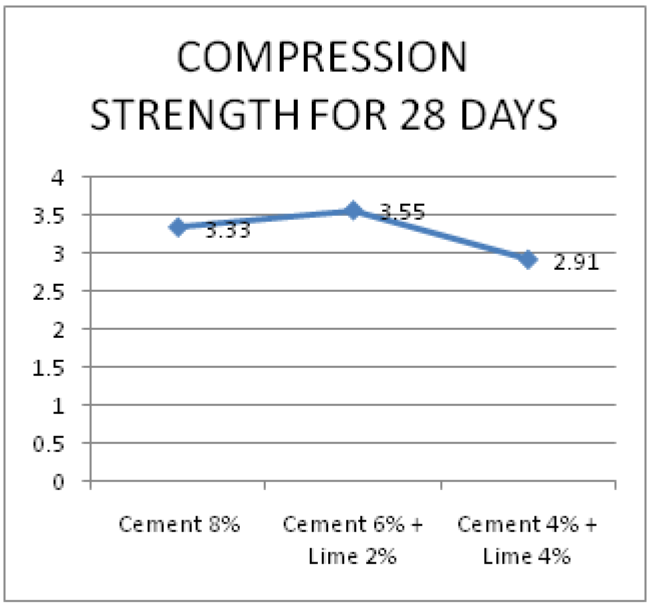


28 Days Dry Compressive Strength

SI.NO	NAME	STRESS (Mpa)
1	2%L+8%C	3.63
		3.61
		2.78
2	4%L+4%C	2.78
		2.984
		3.03
3	8%C+0%L	3.26
		3.47
		3.36

Average of 2%lime stress = 3.33Mpa
Average of 4%of lime stress = 2.91Mpa
Average of 8% of cement stress = 3.55Mpa

GRAPH FOR WET COMPRESSION STRENGTH TEST OF 28 DAYS

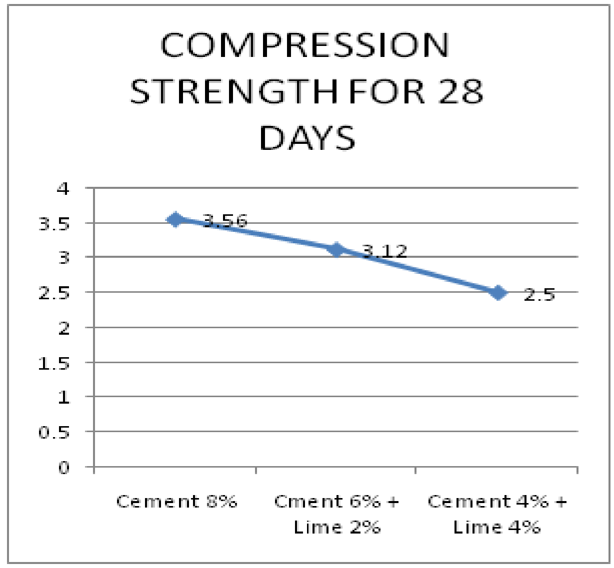


28 Days Wet Compressive Strength

SI.NO	NAME	STRESS (Mpa)
1	2%L+8%C	3.17
		3.152
		2.97
2	4%L+4%C	2.60
		2.41
		2.47
3	8%C+0%L	3.58
		3.50
		3.56

Average of 2%lime stress = 3.09Mpa
Average of 4%of lime stress = 2.49Mpa
Average of 8% of cement stress = 3.54Mpa

GRAPH FOR WET COMPRESSION STRENGTH TEST OF 28 DAYS



VI. CONCLUSION

a) Compressive strength increases with increase in cement content. However, increase in lime content showed very little increase in strength for 7 days test.
b) The 6% cement and 2% lime attained compressive strength of 3.59Mpa.
c) The only addition of 8% cement attained the compressive strength of 3.15Mpa
d) Cost analysis of stabilized mud blocks for 8% cement is 77% cheaper, 6% cement & 2% lime is about 70% cheaper and 4% cement &4% lime is about 60% cheaper when compared to concrete blocks.

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