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PREPARATION OF CONCRETE BRICKS BY USING CERAMIC TILE WASTE AND QUARRY DUST

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ABSTRACT
The most of the building material for construction of houses is the normal brick. The rapid growth in today's construction industry has obliged the civil engineers in searching for more efficient and durable alternatives far beyond the limitations of the conventional brick production. This project presents the experimental investigation of partial replacement of tile waste as coarse aggregate and quarry dust as replacement of fine aggregate in the preparation of concrete bricks. In this study M10 grade of concrete was made for concrete bricks. Concrete mix of 10%, 20%, 30%, 40% & 50% ceramic tile waste as coarse aggregate and 50% replacement of quarry dust as fine aggregate constant replacement were made. The brick specimen was Casted a size of 100mm x 100mm x 100mm and the Shape and size test, Compression test, water absorption test, fire ignition, Soundness test, drop test, Efflorescence test, Color test and Structure test were conducted to analyze their suitability as a construction material.
Keywords: M10 grade of concrete, Quarry dust, ceramic tile waste, Shape and size test, Compression test, water absorption test, fire ignition, Soundness test, Drop test, Efflorescence test, Color test, Structure test.

I.INTRODUCTION

GENEREAL

Shelter is a basic human need and owing a house becomes a life long struggle as majority of Indians find housing costs prohibitively expensive. This problem becomes even more acute when considering the low - income families who accounts for about 60-70% of Indian population. This brings out the need to reduce the cost of the housing and make it affordable for the booming population. Burnt clay bricks are being used extensively and the most important building material is the construction industry. In India the building industry consumes about 20000 million bricks and 27% of the total natural energy consumption for their production. The higher water absorption, high efflorescence, etc. which have forced engineers to look for better materials capable of reducing the cost of construction. In this contest search for an alternative building material to clay bricks, various government agencies and research institutions have repeatedly recommended the use of waste materials such as Fly Ash, Red Soil, Quarry Dust etc., as an alternative building material in making bricks, blocks and tiles etc. Logically the unlimited use of clay is harmful to the society, as all the conventional clay bricks depend on good quality clay available from agriculture fields. Presuming a weight of 2kg per brick, the total clay is taken out from agriculture lands per year for such brick works out to over 300 million tons.

The development of the infrastructure the need of concrete has been increased at high rate. Concrete is important construction materials that have been widely used all over the world. The use of concrete has been increasing day by day. Due to this some negative impacts are there in production of concrete such as coarse aggregate extraction from natural resources, scarcity of river sand it leads to depletion of materials and ecological imbalance. Various researches have been found that replacement for coarse aggregate. The use of plastic, paper and pulp industry waste, textile waste, rice ash, recycled rubber tires, broken bricks are some examples for replacing aggregate in concrete. Coconut shell is an agricultural by product which can be used as coarse aggregate in concrete. According to report made in 2016 India is the third largest coconut producers in world. India produces of about 119 million tons of coconut every year. The coconut shells are accumulated in land and get degraded around 100-120years. Due to this, a serious environment problem of disposal of coconut shells occurs. So to minimize this coconut shell can be used as aggregate in concrete. The use of Fly Ash and other Agricultural wastes for making bricks is ecologically advantageous since apart from saving precious top agriculture soil, it meets the social objective of disposing industrial wastes otherwise are pollutants and nuisance.

Quarry stone dust

Igneous and metamorphic rocks cover about 90-95% of the earth's surface. In earth's crust, most abundantly available type of rock is igneous and due to its wide range of physical and chemical properties, enables its use in all different sectors of construction purposes. Most of the high-rise mountains, hills, plateaus and surface of the earth, even in oceanic crust consist of igneous rock. The leading manner of extracting rock or stone is through digging, quarrying and blasting. In India, most of the rocks are extracted through quarrying. Quarrying is the process of extracting rock using explosives. 15 The pieces of rock or stone obtained in quarrying are used in either stone masonry or aggregate in building or road construction. In this blasting process of rock, numerous small or fine particles of stones are transformed into dust particles in the atmosphere. These dust particles surround the environment throughout the quarry and get settled on the leaves and bark of trees, thereby killing the tissues of the tree. Hence to reduce air pollution, this quarry dust is used for construction purposes. It is used as a substitute for fine aggregate in concrete either partially or fully. As it is originated from rock, it offers better strength when compared with sand as fine aggregate in concrete. It can also be used in road construction and manufacturing of bricks and tiles. It is the cheap and best material available in the market for construction purposes.

Properties and chemical composition of quarry dust

Even though the quarry dust is the product obtained from rock, it consists of different chemical components in it, which is helpful to use in aggregate. The chemical composition of quarry dust includes Silicon dioxide (SiO_2), Aluminum Oxide (Al_2O_3), Ferrous oxide (Fe_2O_3), Calcium oxide (CaO), Magnesium Oxide (MgO), Sodium oxide (Na_2O), Potassium oxide (K_2O), Titanium (TiO_2). As this is the product obtained from a rock, the shape of the particles is irregular when used in concrete as fine aggregate provides better bonding. The specific gravity of the quarry dust ranges between 2.4 to 2.8, and maximum size of the particle is 4.75 mm and absorption of quarry dust ranges between 0.4 to 0.8% depending upon the type of rock from which the quarry dust is produced.

Applications of quarry dust

There are many applications of quarry dust. Discussed below are applications in construction, processing, and landscaping and recreational applications: Application of quarry dust in construction in the construction industry, quarry dust is used as an aggregate substitute especially for sand in a concrete mixture. The application of quarry dust can reduce the cost of construction. In the Centre for Housing Planning and Building built a number of low-cost houses using quarry dust. The research done for the cost of construction proved that using quarry dust is cheaper than sand. Quarry dust is also used in the construction of sub base in highways. Application of quarry dust in processing In India, quarry dust is used to produce concrete blocks. It is mixed with chalk and gypsum to produce blocks. The used of quarry dust in producing concrete blocks is also applied in South Africa. Quarry dust is also used to produce tiles.

Ceramic waste

In concrete production, a large amount of natural aggregates, water and sand are being consumed. Consequently to minimize the use of natural aggregates researchers have concentrated on the use of various waste materials as alternatives in construction industry, especially in concrete construction. One of the prime research interests is utilization of waste material like slag, fly ash, plastics etc. in concrete construction to achieve the goal of sustainable development (construction). Aggregates consist of 70% to 75% of volume of concrete. So reduce the consumption of natural aggregates, waste ceramic tile or broken tiles as coarse aggregates can be a new scientific sobriety in the field of sustainable concrete.

History of Ceramic Industry

It is assumed that the first clay tiles were produced seven to eight thousand years ago in the area now known as the Holy Land in Egypt. It was then verified from the know history that actual source who produced clay tiles was in 4000 B.C. at Egypt. In those days, in Egypt, tiles were used to decorate various houses. Clay bricks were dried beneath the sun or baked, and the first glazes were blue in color and were made from copper. During that period ceramics were also known to be found in Mesopotamia. These ceramics bore decorations, which were white and blue striped and later possessed more varied patterns and colors. After that the China utilized white stoneware with the earliest Chinese glaze was produced during the Shang-Yin dynasty in 1028 B.C. The usage and the art of making decorating ceramic tiles had spread by 900 A.D. and had become widely used in Persia, Syria, Turkey and across North Africa. As transport and communication developed, tile usage and its penetration in other territories increased. By the end of the 12th century, use and manufacture of ceramic tiles had spread across Italy and Spain and into the rest of Europe. Today Ceramic tile throughout the world is not hand-made or hand-painted for the most part. Automated manufacturing techniques are used and the human hand does not enter into the picture until it is time to install the tile. They are used in an almost infinite number of ways. In commercial buildings, where both beauty and durability are considerations, ceramic tiles will be found, particularly in lobby areas and restrooms. In fact most modern houses throughout use ceramic tiles for their bathrooms and kitchens and in every vital area of the premise is more common. Ceramic tiles are also the choice of industry, where walls and floors must resist chemicals (1).

Ceramic Tiles Industry in India

Ceramic tiles today have become an integral part of home improvement. It can make a huge difference to the way your interiors and outdoors look and express. The ceramic tiles industry in India has followed similar trends internationally which have been characterized by excess capacities and falling margins. Countries like Malaysia, Thailand, Indonesia, Sri Lanka and Vietnam are setting up their own plants. China has emerged as a major competitor. A major change that took over the ceramic tiles industry, was the introduction of vitrified and porcelain tiles. The Indian tile industry, grows at a healthy 15% per annum while the global industrial growth is 11% per annum. Investments in the last 5 years have aggregated over Rs. 5000 crores. India ranks in the top 3 list of countries in terms of tile production in the world. With proper planning and better-quality control it can increase significantly (1). Global scenario of top 10 ceramic tiles manufacturing countries as on year 2012-2013 is shown in Plate 1(2).

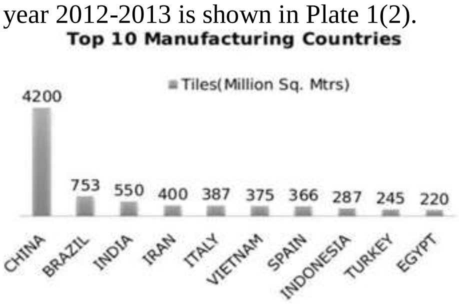

Figure:1 Global Scenario of Top Ten Ceramic Tiles Consuming Countries

Figure: 2 Geographical Presence of Ceramic Industries in India

The study focuses on producing concrete bricks of acceptable strength with ceramic tile waste as an alternative material for coarse aggregates and quarry dust as an alternative material for fine aggregates and determining the mix ratio of fine aggregates to achieve the required strength.

II.LITERATURE SURVEY

Concrete is an artificial material similar in appearance and properties to some natural lime stone rock. It is a manmade composite, the major constituent being natural aggregate such as gravel, or crushed rock, sand and fine particles of cement powder all mixed with water. The concrete as time goes on through a process of hydration of the cement paste, producing a required strength to withstand the load.

2.1 Quarry dust in concrete

Safiuddin et al., (2007) also have tried the partial replacement of sand with quarry dust in fly ash silica fume-based concrete and concrete having 20% sand replaced with quarry dust and 10% weight replacement of cement with fly ash and same 10% weight replacement of cement with silica fume by consideration. It was found that quarry dust as fine aggregate enhanced the slump and slump flow of the fresh concretes without affecting the unit weight and air content of the concrete. In hardened concretes, the compressive strength was decreased, the dynamic modulus of elasticity and initial surface absorption were marginally increased. However, the best performance was observed when quarry waste was used in the presence of silica fume.

Ilangovana et al., (2008) the strength and durability properties of concrete containing quarry rock dust as fine aggregate was studied. Based on the results, compared to the conventional concrete, the durability of quarry concrete under sulphate and acid action is higher. Nevertheless, the permeability of quarry concrete is less compared to that of the conventional concrete. At 100% replacement of sand by quarry dust strength values are same or better than the ones of the control concrete made with natural sand. Thus, the utilization of quarry dust in concrete is highly expected to give more strength and durability to the concrete production.

Jayawardena and Dissanayake, (2008) identified the most suitable rock types for manufacture of quarry dust in Sri Lanka, conducting laboratory tests on fresh rock samples from different quarries and determined the mineral composition and reactive forms of silica minerals. Charnockite and charnockitic gneiss and granitic gneiss because of having less than 5% mica are suggested to be suitable rocks to operate as quarries and supply quarry dust to use as an alternative source for river sand in the future. Hornblende biotite gneiss, biotite gneiss, migmatite and migmatite gneiss showed mica percentages higher than 5% (up to 20%) are not recommended. However, testing of quarry dusts for each quarry is needed while it is producing.

III.OBJECTIVE AND METHODOLOGY

3.1 Aim

The aim of study is to evaluate the performance and suitability of replacement of Tile waste with coarse aggregate and fine aggregate with quarry dust in concrete bricks manufacturing.

3.2 Objective

The objectives of experimental study are:

• Study on strength characteristics of M10 grade concrete bricks with replacement of 50% fine aggregate by quarry dust and replacement of 10%, 20%, 30%, 40%, and 50% coarse aggregate by Tile waste.

• To determine the Shape and size test, Compression test, water absorption test, fire ignition, Soundness test, Drop test, Efflorescence test, Color test and Structure test for concrete bricks.

3.3 Methodology

The present study requires preliminary investigations in a systematic manner

• Selection of type of grade of mix, mix design by an appropriate method, trial mixes, final mix proportions.

• Estimating total quantity of concrete required for the whole project work.

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• Estimating quantity of cement, fine aggregate, coarse aggregate, tile waste, quarry dust required for the project work.
• Preparing the concrete bricks with partial replacement of fine aggregate by quarry dust, coarse aggregates by tile waste and cement, water-cement ratio kept constants.
• Prepared bricks cure for 7days by sprinkling of water daily 2times.
Concrete bricks tested and concluded optimum dosage of waste material replacement.

IV.EXPERIMENTAL WORK

4.1 Materials Used

For the preparation of concrete bricks we are used Cement, tile waste, quarry dust, Coarse aggregates, Fine aggregates and water.

Cement

Cement is used right from ancient periods in construction industry. In the most general sense of the word, cement is a binder, a substance which sets and hardens independently, and can bind other materials together. The word "Cement "traces to the Romans, who used the term "opus caementicium" to describe masonry which resembled concrete and was made from crushed rock with burned lime as binder. The volcanic ash pulverized brick additives which were added to the burnt lime to obtain a hydraulic binder were later referred to as cementum, cimentum, cament and cement. Cements used in construction are characterized as hydraulic or nonhydraulic. The most important use of cement is the production of mortar and concrete – the bonding of natural or artificial aggregates to form a strong building material which is durable in the face of normal environmental effects. Cement used in the investigation was found to be Ordinary Portland Cement (53 grade) confirming to IS: 12269 – 1987. The properties of cement were given in below table.

Table 4.1 Properties of Cement

Property	Values
Fineness of cement	5%
Standard consistency	35%
Initial setting time	40min
Final setting time	400min
Specific gravity	3.06


Fig.3: Cement (OPC 53 grade)

Water

According to IS 456: 2000, water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. The pH value of water shall be not less than 6.

Fine aggregates

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification.


Fig.4: Fine aggregates

Coarse aggregates

It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification.


Fig.5: Coarse aggregates

Quarry dust

Fine aggregate is described as crushed rock particles with a size of less than 4.75mm. It is further divided into coarse, medium, and fine categories. Coarse grains range from 4.75mm to 2mm, medium grains range from 2mm to 0.425mm, and fine grains range from 0.425 mm to 0.075 mm.

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Fig.6: Quarry dust

Ceramic tile waste

The ceramic tile waste collected from C&D waste. The collected waste crushed into small pieces with passed from IS sieve 10mm.

• The specific gravity value is 2.28
• The water absorption value is 1.0%


Fig.7: Tile waste

4.2 Sample Production

Control mix: The cement, fine and coarse aggregates were weighted according to mix proportion of M10. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.55. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

Quarry dust based Concrete bricks: The cement, quarry dust (50% of sand weight replacement), fine and coarse aggregates were weighted according to mix proportion of M10. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.55. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix. A standard 100×100×100 mm brick specimens were casted for all above various types of concrete mixes. The samples were then stripped after 24hours of casting and are then be sprinkling of water for curing 7days (daily 2 times). As casted, a total of (40) 100x 100 × 100mm bricks specimens were produced.


Fig.8: Mixing of all ingredients (quarry dust)


Fig.9: mixing of all ingredients (quarry dust + tile waste)


Fig.10: Casting of brick mould


Fig.11: Demoulded concrete bricks

4.3 Concrete Bricks Testing

Compression Test

• Brick specimen to be tested is placed on a horizontal surface and the specimen is to be centered between the plates on Compression testing machine.
• Apply the load at a uniform rate till the failure occurs.
• Note down the maximum load at failure.

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Fig 12 Compression Test

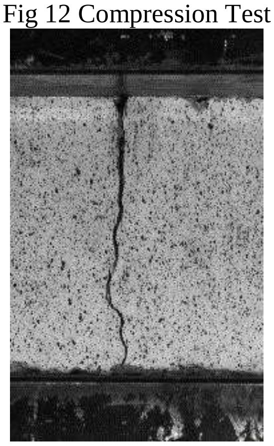

Fig 13 Compression Test after brick

Water Resistance Test

In this the bricks first weighted in dry condition and they are immersed in water for 24 hours. After that they are taken out from water and they are wipe out with cloth. Then the difference between the dry and wet bricks percentage are calculated.

The less water absorbed by bricks the greater its quality. Good quality bricks don't absorb more than 20% water of its own weight.

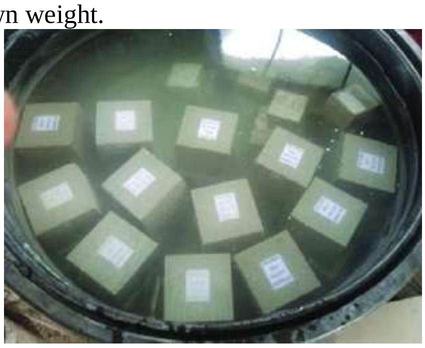

Fig 14 Water absorption Test

Efflorescence test

The presence of alkalies in bricks is harmful and they form a gray or white layer on the brick surface by absorbing moisture. To find out the presence of alkalis in bricks this test is performed. In this test, a brick is immersed in fresh water for 24 hours and then it's taken out of the water and allowed to dry in shade. If the whitish layer is not visible on the surface it proofs that absence of alkalis in brick.

If the whitish layer visible about 10% area of the brick surface then the presence of alkalis is in the acceptable range. If that is about 50% of surface area then it is moderate. If the alkali's presence is over 50% of the brick surface area, then the brick is severely affected by alkalies.

Shape and Size Test

Shape and size of bricks are very important consideration. All bricks used for construction should be of same size. The shape of bricks should be purely rectangular with sharp edges. Standard brick size consists length x breadth x height as 100mm x 100mm x 100mm.

V.RESULTS AND DISCUSSIONS

As per experimental programmed results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

5.1 Brick Test Results

Compression Test

Table 5.1 Compression test results

Mix No	QD – TW (%)	Compressive strength (Mpa)
M1	0 - 0	7.8
M2	50 - 0	9.8
M3	50 – 10	9.6
M4	50 -20	9.4
M5	50 – 30	9.0
M6	50 – 40	8.5
M7	50 - 50	8.0

The compressive strength is decreasing with increasing in the tile waste as coarse aggregate replacement in the concrete brick's preparation. The replacement of sand with quarry dust (50%) and coarse aggregate with tile waste (Up to 50%), the incremental concrete compressive strength comparison is mentioned below:

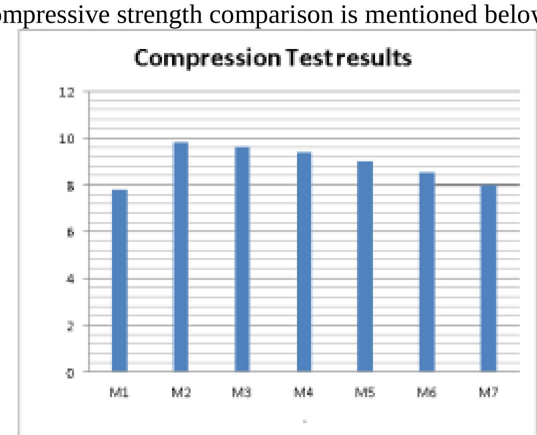

Fig 15 Compressive strength test results graph

Table 5.2 Compression test results comparison

Mix No	QD – TW (%)	Compressive strength (Mpa)	Increment / Decrement (%)
M1	0 - 0	7.8	0 (control mix)
M2	50 - 0	9.8	+ 25.64
M3	50 – 10	9.6	+ 23.07
M4	50 -20	9.4	+ 20.51
M5	50 – 30	9.0	+ 15.38
M6	50 – 40	8.5	+ 8.97
M7	50 - 50	8.0	+ 2.56

The compressive strength is higher for all different mixes from M2 to M7 as compare to the control mix of M1. The optimum dosage of QD – TW (%) is 50 – 10 (%).

Efflorescence test

No efflorescence visible on all bricks. All the bricks are good quality bricks.

Shape and Size Test

For all bricks are rectangular shape and size 10 cm x 10 cm x 10 cm. Proper shaped or uniformly shaped all the casted and cured concrete bricks. Then these bricks are good quality bricks.

Fire Resistance Test

There is no change in the structural properties of bricks up to 200°C above which visible cracks are seen and the bricks deteriorate with increase in temperature

Water Resistance Test

Table 5.3 Water Resistance Test results

Mix No	QD – TW (%)	Water absorption (%)
M1	0 - 0	2.2
M2	50 - 0	2.0
M3	50 – 10	2.6
M4	50 -20	2.8
M5	50 – 30	3.0
M6	50 – 40	3.3
M7	50 - 50	3.8

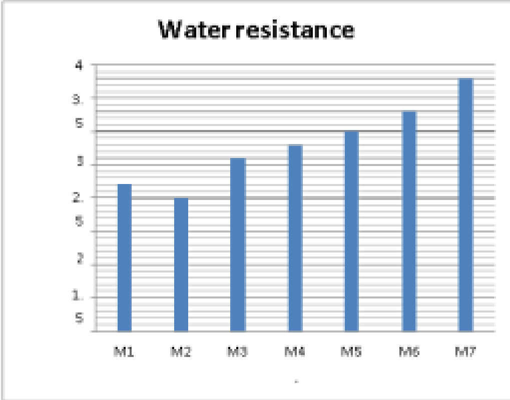

Fig 16 Water absorption test results graph

The water absorption value is going to increases with increasing the tile waste content in the preparation of concrete bricks.

CONCLUSIONS

1. The aggregates are vital elements in concrete Bricks. The usage of enormous quantities of aggregates results in destruction of hills causing geological and environmental imbalance. The environmental impacts of extracting river sand and crushed stone aggregates become a source of increasing concern in most parts of the Country. Pollution hazards, noise, dust, blasting vibrations, loss of forests and spoiling of natural environment are the bad impacts caused due to extraction of aggregates. Landslides of weak and steep hill slopes are induced due to unplanned exploitation of rocks.

2. Considering the depletion of natural sources and the effect on environment, the disposal problems involved in disposing Tile waste and quarry dust. This waste used in concrete bricks manufacturing gives good mechanical properties.

3. Trying to replace aggregate by tile waste partially to make concrete structure more economic along with good strength criteria. This can be useful for construction of low-cost housing society. Solves problems of disposal of C&D waste of tiles.

4. Up to 10% of coarse aggregate replaced by tile waste and 50% of sand replaced by quarry dust is good according to strength and cost wise.

5. Up to 10% of coarse aggregate replaced by tile waste and 50% of sand replaced by quarry dust gives higher compressive strength compare to control mix.

6. The water resistance value is increasing by increasing tile waste replacement by coarse aggregates. The structure test, soundness test, drop test, Color test, Size and shape test the properties are similar to good quality bricks. And these bricks are very lesser cost compare to normal concrete and fly-ash bricks.

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