EXPERIMENTAL INVESTIGATION ON CONCRETE BRICKS BY REPLACING CEMENT WITH SUGAR CANE ASH AND COARSE AGGREGATE WITH MARBLE WASTE

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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 marble waste as coarse aggregate and Sugar cane bagasse (SCBA) as replacement of cement in the preparation of concrete bricks. In this study M15 grade of concrete was made for concrete bricks. Concrete mix of 10%, 20%, 30%, 40% and 50% replacement of coarse aggregate as marble waste and constant replacement of 10% of cement with Sugar cane bagasse were made. The brick specimen were Casted a size of 190mm x 90mm x 90mm 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, Sugar cane bagasse*, marble waste, Shape and size test, Compression test, water absorption test, fire ignition, Soundness test, Drop test, Efflorescence test, Color test, Structure test.*

1. INTRODUCTION

1.1 General

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, marble waste, scba, ggbs etc, as an alternative building materials 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 tonnes.

About180 billion tonnes of clay brick production per year consumes 540 million tonnes of clay, makes 26305 hectares of land barren, and consumes 30 million tonnes of coal equivalent, generates 26 million tonnes of Carbon Dioxide. A 10% switchover to fly ash bricks will use 30 million tonnes of fly ash every year, save environment and coal. There has been impressive increase in the power generation in India from a low capacity of 1362 MW in 1947 to about 112050 MW in 2004. Indian coal has high ash content around 35-45% and low calorific value 35004000 KCal/Kg as a result of which huge quantity of ash is generated. A typical 200 MW unit produce around 50-60 M.Tons of ash per hour in India. Generally 0.40 hectare land is needed per M.W. of power production. Power being considered as an engine of growth, has always been a focus area for most of the developing countries including India. The power generation in India has increased from 1362 MW in 1947 to 200000 MW in 2012 and ash generation will reach a figure of around 200 M. Tons per year. This would require about 40000 hectares of land for the construction of ash ponds. Further, Government of India has planned for enhancement of installed capacity to 3, 00,000 MW by 2017 (Vimal et al. 1995). Coal based power plants not only produce of millions of megawatts of power but also millions of tons of fly ash. Most of the coal based power plants were set-up with sole aim of power generation (Dhar, 2001). Environmentally safe disposal of large quantity of fly ash is not only problematic but also expensive. Keeping in view the gravity of the fly ash disposal problem, global efforts are mooted to utilize fly ash in bulk quantities.

1.2 SCBA

Now a days, Agricultural and industrial by-products are used in concrete production as cement replacement materials or as admixtures to enhance both fresh and hardened properties of concrete as well as to save the environment from the negative effects caused by their disposal. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties. A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement. Therefore, it is possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, concrete pavers, concrete roof tiles and soil cement interlocking block. Bagasse ash, which is considered as an industrial waste, if utilized to its maximum capacity in the construction industry, provides the benefits of reducing the Conventional cement generated CO_2 as well as saving precious land from becoming a landfill site. Hence, Bagasse ash based concretes have been gaining popularity as an eco friendly construction material and studies are being conducted on its suitability as an alternative to the much popular Portland cement concrete.

1.3 Marble waste

After the civil war, the colonies in Kansas found lowland without vegetation. As they dug it, they found a stone called Greenhorn named by them and which is now known as limestone. They built dugouts using this stone. Later, the settlers mined this for building materials, such as cages, hedges, and boundary or enclosures to fence in domestic animals, and so on. Generally, it weighs 135 to 220kgs. Over 64000 Kms of fence was built in 5 decades with black marble stone posts. Black marble stone is a sedimentary rock origin formed by solidification of debris beneath the sea or ocean for a long time. The residues of dead animal shells, bones, and other calciumcontaining materials lithify to form a rocky formation. Such depositions contain at least 50% calcium carbonate in the form of the mineral calcite ($CaCO3$), resulting in a hard rock known as limestone. As they contain a high percentage of calcium carbonate, they are used as decorative material and building stone.

2. LITERATURE SURVEY

In the study conducted by **A.D.V.S. Siva Kumar, K.V.G.D. Balaji, T. Santhosh Kumar,** Assistant Professors of Civil Engineering in GITAM University, Andhra Pradesh in 2014, bagasse ash is used as partial replacement of cement because it is one of the by product which can be used as mineral admixture due to its high content in silica (SiO2), it is also a waste product produced from Sugar manufacturing industry. In this study, sugarcane Bagasse ash is partially replaced in the ratio of 0%, 5%,10%,15% and 25% by weight of cement in concrete and exposed to different elevated temperature (i.e. 2000, 4000, 6000, 8000)C for 1 hour and immediately cooled with water. The result shows that the strength of concrete specimens increased at 2000C than room temperature for all percentage of replacement of cement with SCBA**.**

Experimental study on compressive strength of concrete by partially replacement of cement with sugar cane bagasse ash was conducted by **Jayminkumar A. Patel** and **Dr. D. B. Raijiwala** in the year 2015. Present study is to investigate impact of sugar cane bagasse ash in concrete. In this experimental work sugar cane bagasse ash which is taken from Maroli sugar mill, Navsari, Gujarat, is partially replace with cement at 0%, 5%, 10%, 15% and 20% by weight in concrete. The grade of concrete is M 25 and w/c ratio is 0.49 taken as a reference. 150x150x150 mm cubes are casted and tested for 7, 14, 28 and 56 days. Compressive strength result shows that up to 10% replacement of sugar cane bagasse ash in concrete gives comparable result with normal concrete without any admixture, but 5% replacement give maximum compressive strength. Also the amount of sugar cane bagasse ash increase, workability of concrete increases.

Muni Vishwakarma, R.K. Grover, Student M.E. Structural Engineering, Associate Professor, Civil Engineering Department, Jabalpur Engineering College, Jabalpur conducted study on the strength and cost analysis of concrete with Sugarcane Bagasse ash in the year 2015. The present work focuses on ash for partial cement replacement obtained from agricultural wastes, either by incineration in the laboratory or directly from industries where the waste has been incinerated for energy production. The Sugarcane Bagasse ash mixture provides strength equal to the nominal strength of the concrete and reduces the cost at a large scale. This paper is summarizes the experimental studies on strength of cement mortar with partial replacement of Ordinary Portland cement by Sugarcane Bagasse Ash (SBCA). Cement mortar paste were prepared with various percent of SCBA as partial replacement of OPC in range 5%, to 20 % by weight of cement.

The compressive strength test was carried out as per relevant Indian standard codes. The test results show that replacement of cement to the extent of approximately 10% by weight of cement was found to give the optimum results for the 28 days strength.

Kore Sudarshan Dattatraya (2016) In this work, the impact of marble waste as a partial replacement for conventional coarse aggregate on the properties of concrete mixes such as workability, compressive strength, permeability, abrasion, etc. was evaluated. Coarse aggregate (75% by weight) was replaced by aggregate obtained from marble mining waste. The test results revealed that the compressive strength was comparable to that of control concrete. Other properties such as workability of concrete increased, water absorption reduced by 17%, and resistance to abrasion were marginally increased by 2% as compared to that of control concrete.

Jay P. Chotaliya et al. (2015) The objective of this study is to provide a more scientific evidence to support the reuse of accumulated marbles waste in India by investigating into the following hardened properties of concrete with waste marble chips - compressive strength, split tensile strength and flexure strength. These properties were studied by casting cube specimens, cylindrical specimens and beam specimens. Waste marble chips are fully replaced with natural coarse aggregate. The water cement ratio used was 0.45% by weight.

Marble waste has been tested as a possible replacement of fine aggregate for the production of concrete mixes having w/c ratio in the range 0.4–0.6. Most of the studies have used calcite based marble waste for their studies. As in the case of replacing coarse aggregate by marble waste, Hanifi Binici here too was the pioneer in carrying out the research in this domain.

Binici, Kaplan and Yilmaz (2007) used marble waste finer than 1 mm to replace sand of the same size, in proportions of 5%, 10% and15%. They stated that with inclusion of marble waste, com-pressive strength of the concrete mixes improved by 24% at15% substitution level. After exposure to a 7% sulphate solu-tion the compressive strength of the same mix reduced by only15% when compared to control concrete which lost 58% of original compressive strength. This mix had the best resistance to abrasive wear and water penetration also. These improve-ments were credited to marble wastes' porefilling ability but at the expense of reduced workability. Hence a superplasticizer had to be used to compensate this loss.

Ural, Karakurt and Cömert (2014) repeated the above exer-cise, but with the use of pozzolana-based cement as the binder and without any superplasticizer. They could achieve equiva-lent performance to that of control concrete at 10% sub stitu-tion despite a marginal increase in water content to achieve necessary workability.

Kırgız(2016a) also reiterated the same claims when he replaced sand by marble waste finer than0.075 mm. He could achieve maximum compressive strength (higher by 8% when compared to control concrete) at 20%replacement level. Additionally he evaluated flexural strength, Schmidt surface hardness and resonant frequency which were very much in line with the variation in compressive strength. These improvements however were largely insignificant.

Demirel (2010) used dolomitic marble slurry of size smaller than 0.25 mm to replace sand of the same size. Concrete properties like compressive strength, modulus of elasticity, unit weight and ultrasonic pulse velocity (UPV) were enhanced because of reduced porosity. Most significant varia-tion was noticed for the change in modulus of elasticity was which about 24%, whereas for the remaining parameters the increase was limited to only 10%.

In this project work we are going to utilise the marble waste as coarse aggregates replacemenet and cement with SCBA replacement in the preparation of concrete bricks.

3. OBJECTIVE AND METHODOLOGY

3.1 Aim

The aim of study is to evaluate the performance and suitability of replacement of marble waste with coarse aggregate and cement with SCBA in concrete bricks manufacturing.

3.2 Objective

The objectives of experimental study are:

- Study on strength characteristics of M15 grade concrete bricks with replacement of 10% cement by SCBA and replacement of 10%, 20%, 30%, 40% and 50% coarse aggregate by marble 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 SCBA- MW 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.

- Estimating quantity of cement, SCBA, fine aggregate, coarse aggregate, marble waste required for the project work.
- Preparing the concrete bricks with partial replacement of cement by SCBA, coarse aggregates by marble waste and fine aggregates, water-cement ratio kept constants
- Prepared bricks cure for 7days by spinkling of water daily 2times.

4. EXPERIMENTAL INVESTIGATION

4.1 Materials Used

For the preparation of concrete bricks we are used Cement, SCBA, Coarse aggregates, Fine aggregates, Marble waste, and water.

4.1.1 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. Te 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 (43 grade) confirming to IS : 12269 – 1987. The properties of cement was given in below table.

Table 4.1 Properties of Cement

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

4.1.2 SCBA

Sugarcane Bagasse ash is the residue from an in-line sugar industry and the Bagasse biomass fuel in electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties. A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement. Therefore, it is possible to use sugarcane Bagasse ash (SCBA) as cement replacement material to improve quality.

The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO_2). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests. For this project, sugarcane bagasse ash was prepared by manual incineration process. The specific gravity of SCBA up-tained is 2.2.

4.1.3 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.

4.1.4 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. According to source fine aggregate may be described as:

- Natural sand-it is the aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies.
- Crushed stone sand-it is the fine aggregate produced by crushing hard stone.
- Crushed gravel sand-it is the fine aggregate produced by crushing natural gravel.
- The specific gravity value is 2.43
- The water absorption value is 0.8%

4.1.5 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. According to source, coarse aggregate may be described as:

- Uncrushed Gravel or Stone– it results from natural disintegration of rock
- Crushed Gravel or Stone– it results from crushing of gravel or hard stone.
- Partially Crushed Gravel or Stone– it is a product of the blending of the above two aggregate.
- Hard crushed granite stone, coarse aggregates confirming to graded aggregate of size,10mm as per IS:383-1970 was used in the study.
- The specific gravity value is 2.67
- The water absorption value is 1.2%

4.1.6 Marble waste

Crushed Black Marble stone waste aggregate of maximum size 20 mm, confirming to IS 383-1970 was used. The specific gravity and fineness modulus were found to be 2.75 and 3.49 respectively. Grading analysis is presented in table 4.2. Different properties of the BMSWA used in this experimental work are given in Table 4.3.

Table 4.2 Grading analysis for BW – Sample - 5000gms

S.No	IS Sieve size (mm)	Weight of retained (gms)	Cumulative weight retained (gms)	Cumulative % retained	% Passing
1	80	-	-	-	100
2	40	-	-	-	100
3	20	2930	2930	58.6	42.4
4	10	1620	4550	91	9
5	6.3	450	5000	100	-
6	4.75	-	-	100	-
	total	5000		349.6	251.4

Fineness Modulus=349.60/100 = 3.49

Table 4.3 Properties of MW

S.No	PARTICULARS	RESULTS	BIS SPECIFICATIONS (IS

			2386-2013
1	Specific gravity	2.77	2.4 – 2.6
2	Fineness modulus	3.49	5 – 8
3	Flakiness index	2%	<40%
4	Elongation index	0%	<40%
5	Crushing value	9%	<45%
6	Impact value	13%	<45%
7	Water absorption	0.6%	<2%

4.2 Mix design

Adopted Grade was **M15** for prepararion of concrete bricks

4.2.3 For standard modular size

FOR 190*90*90mm size brick

Volume = 190*90*90 = 0.001539m^3

Assume 10% wastage, n = 1 brick

Final volume of brick = n*[1+wastage] *0.001539

= 1*[1+10/100] *0.001539

= 0.0016929m^3

Weight of cement = 0.00169290*[316.8] = 0.536kg

Weight of sand = 0.0016929*[704] = 1.192kg

Weight of aggregates = 0.0016929*[1584] = 2.68kg

Weight of water:

w/c = 0.55 (assume)

w = 0.55 * 536 = 300ml

4.2.4 SCBA – marble waste used in concrete bricks

For 1 Brick making (10% Replacement of cement with SCBA and 0% to 50% replacement of coarse aggregates with Marble waste)

- Weight of water = 300ml
- Weight of SCBA = 0.3 x 536 = 53.6gm
- Weight of cement = 536-53.6= 482.4 gm
- Weight of sand = 1192gm

Table 4.3 Material weights requirement for making 1 brick

SCBA % - MW %	Cement (gms)	SCBA (gms)	Fine aggregates (gms)	Coarse aggregates (gms)	Marble waste (gms)	Water (ml)

0 – 0	536	0	1192	2680	0	300
10 – 0	482.4	53.6		2680	0	
10 – 10				2412	268	
10 – 20				2144	536	
10 – 30				1876	804	
10 – 40				1608	1072	
10 - 50				1340	1340	

4.3 Sample Production

Control mix: The cement, fine and coarse aggregates were weighted according to mix proportion of M_{15}. 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.

SCBA based Concrete bricks: The cement, SCBA (10% of cement weight replacement), fine and coarse aggregates were weighted according to mix proportion of M_{15}. 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.

SCBA – MW based concrete bricks: The cement, SCBA (10% of cement weight replacement), fine aggregates, coarse aggregates and marble waste (0% - 50% with interval of 10% replacement of coarse aggregates) were weighted according to mix proportion of M_{15}. 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.

Standard 190×90×90 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 (42) 19×90×90mm brikcs specimens were produced.

Fig.4.7: Mixing of dry material

Fig 4.7: Fresh concrete

Fig 4.8: concrete bricks moulds

Fig.4.9: Sprinkling water curing of Bricks

5. RESULTS AND DISCUSSIONS

As per experimental programme 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

5.1.1 Compression Test

Table 5.1 Compression test results

SCBA % - MW %	Compression(N/mm2)
0 – 0	6.5
10 – 0	8
10 – 10	8.7
10 – 20	9.2
10 – 30	**10.4**
10 – 40	10
10 - 50	8.7

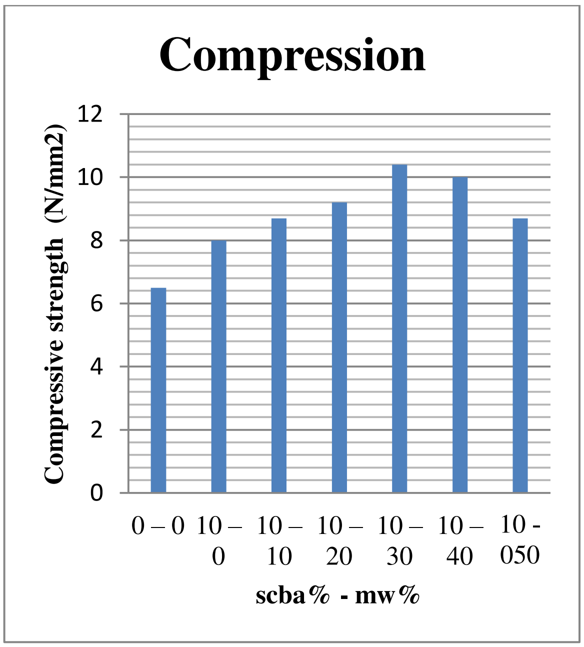

Fig 5.1 Compressive strength test results graph

5.1.2 Efflorescence test

No efflorescence visible on all bricks.

5.1.3 Shape and Size Test

For all brick is rectangular shape and size 19 cm x 9 cm x 9 cm.

5.1.4 Fire Resistance Test

Concrete bricks, presence of sand impart insulation. There is no change in the structural properties of bricks up to 180℃ above which visible cracks are seen and the bricks deteriorate with increase in temperature.

5.1.5 Water Resistance Test

Table 5.2 Water Resistance Test results

SCBA % - MW %	Water Resistance (%)
0 – 0	2.1
10 – 0	2.0
10 – 10	1.8
10 – 20	1.78
10 – 30	1.7
10 – 40	1.68
10 - 50	1.63

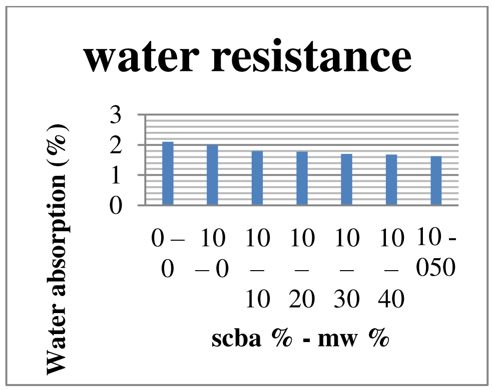

Fig 5.2 Water absorption test results graph

5.1.6 Color Test

All bricks having the uniform color for entire structure.

5.1.7 Soundness test

For all the bricks ringing sound produced and bricks were not breaked. Then the bricks are good quality bricks.

5.1.8 Drop test

For all the bricks did not breaked while performed drop test, then the bricks are good quality bricks.

5.1.9 Structure of Bricks

There are no flaws, cracks or holes present on that broken face then that is a good quality bricks.

5.1.10 Hardness test

Little bit scratch visible on all bricks except concrete bricks.

6. 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 SCBA. Marble waste shows good mechanical properties (Impact value 13%) as seen in the above investigation, a particular attention may be focused on the usage of SCBA, Marble waste aggregates in concrete.
3. Trying to replace aggregate by marble 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 marble waste.
4. Up to 30% of aggregate replaced by marble waste and 10% of cement replaced by SCBA is good according to strength and cost wise. Up to 30% of aggregate replaced by marble waste and 10% of cement replaced by SCBA gives higher compressive strength compare to control mix.
5. The water resistance value is decreasing by increasing marble 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 this bricks are very lesser cost compare to normal concrete and SCBA – MW based bricks.
6. Utilization of Bagasse ash and marble waste in concrete bricks solves the problem of its disposal thus keeping the environment free from the pollution.

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