EXPERIMENTAL INVESTIGATION ON CLAY BRICKS BY USING GRANITE SAW DUST

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ABSTRACT

The block is a building material, which is used to build up the structures. The aim of this project is to determine the compressive strength and other characteristic of the blocks. The blocks with clay and granite sawing powder waste, which will give a better understanding on the properties of blocks like compressive strength, water absorption and size and shape of block was good while comparing the other kind of blocks.

The scope of this project is to determine and compare the strength of the blocks by using different percentage of clay and granite sawing powder waste. The investigation was carried out by various mix ratio using the laboratory test likes compression test, water absorption. For strength characteristics, the results showed that a gradually increase in compressive strength, water absorption values in blocks was good while comparing the characteristics compressive strength of blocks.

INTRODUCTION

1.1 GENERAL

With the increase of construction materials costs such as cement, steel and timber are not enthusiastic to build these houses on a tight budget. Alternatives through using the Industrialized Building Systems (IBS) have to be sought and the government has been pressing the construction industry to use IBS for their projects. Projects using the IBS will be completed faster hence reducing construction completion time and cut the cost of manpower to more than half.

Based on structural aspects, IBS can be divided into five major types:-

- Type 1: Pre-cast Concrete Framing, Panel and Box Systems.
- Type 2: Steel Formwork Systems.
- Type 3: Steel Framing Systems.
- Type 4: Prefabricated Timber Framing Systems.
- Type 5: Brick work Systems.

Sustainability practices can enhance the cost reduction in construction. The following sustainability practices can be achieved such as by using Clay, Granite Sawing Powder Waste With Silica Fume as Clay replacement. Disposal of Granite Sawing Powder Waste is a major problem in Granite Factories. Reusing of Granite Sawing Powder Waste is a good alternative to solve the problem of disposal of Granite Sawing Powder Waste. The Use of Granite Sawing Powder Waste for the production of bricks is a well-known fact and is gaining popularity day by day.

1.2.OBJECTIVES OF THE STUDY

For the present study, the following objectives have been set.

1. To study the properties of bricks.
2. To determine the compressive strength of brick specimens (bricks with granite sawing powder waste and silica fume) using four mix ratio of clay, granite sawing powder waste and silica fume such as 50:45:5, 50:40:10, 50:35:15 and 50:30:20
3. To study the compressive strength and water absorption of brick specimens bricks with granite sawing powder waste and silica fume.

4. To study all kinds of materials used in bricks with granite sawing powder waste and silica fume.

1.3.BRICKS:

Fig 1.1 Typical bricks.

The artificial material in the form of clay blocks of uniform size and shape are known as bricks. The earths required for manufacturing of bricks are soil and clay. Clay is an earthen minerals mass. Purest clay consists of kaolinite with small quantities of minerals.

1.3.1.Composition of Brick Earth

Following are the constituents of good brick earth

1. Alumina
2. Silica
3. Lime
4. Iron oxide
5. Magnesia

1. Alumina:

It is the chief constituent of every kind of clay. A good brick earth should contain about 20% to 30% of alumina. This constituent imparts plasticity to the earth so that it can be moulded. If alumina is present in excess, with inadequate quantity of sand, the raw bricks shrink and warp drying and burning and become too hard when burnt.

2. Silica:

It exists in clay either as free or combined. As free sand, it is mechanically mixed with clay and in combined form, it exists in chemical composition with alumina. A good brick earth should contain about 50% to 60% of silica. The presence of this constituent prevents cracking, shrinking and warping of raw bricks. It thus imparts uniform shape to the bricks. The durability of bricks depends on the proper proportion of silica in brick earth. The excess of silica destroys the cohesion between particles and the bricks become brittle.

3. Lime:

A small quantity of lime not exceeding 5 % is desirable in good brick earth. It should be present in a very finely powered state because even small particles of the size of a pin head cause flaking on the bricks.

The lime prevents shrinkage of raw bricks. The sand alone is infusible. But it slightly fuses at kiln temperature in presence if lime. Such fused sand works as a hard cementing material for brick particles.

The excess of lime causes the brick to melt and hence it shape is lost. The lumps of lime are converted into quick lime after burning and this quick lime slakes and expands in presence of moisture. Such an action results in splitting of bricks into pieces.

4. Iron oxide:

A small quantity of oxide of iron to the extent of about 5 to 6 % is desirable in good brick earth. It helps as lime to dust sand. It also imparts red color to the bricks. The excess of oxide of iron makes the bricks dark blue or blackish. If, on the other hand, the quantity of iron oxide is comparatively less, the bricks will be yellowish in color.

5. Magnesia:

A small quantity of magnesia in brick earth imparts yellow tint to the bricks and decreases shrinkage. But excess of magnesia leads to the decay of bricks.

1.3.2. Manufacturing Process of Bricks:

The various process involved in the manufacturing of bricks are,

1. Clay Preparation.
2. Moulding.
3. Drying.
4. Burning or Firing of bricks.
   a) Kiln.

1. Clay Preparation:

Clay preparation methods may have to accommodate the physical characteristics of the raw material and special provision may have to be made to deal with certain impurities.

Preparation consists of transforming the clay rock into plastic mouldable material by a process of grinding and mixing with water. A typical factory might have a Primary crusher, these are used to break down large lumps of rock to manageable size, which can then be fed to a Secondary crusher, for example Pan mill, where the clay is reduced in size further. Water can be added here or if it is a dry pan the clay is reduced to dust and water added later. Further crushing takes place through conveyor rollers reducing the clay particles to about 1-2mm.

2. Moulding:

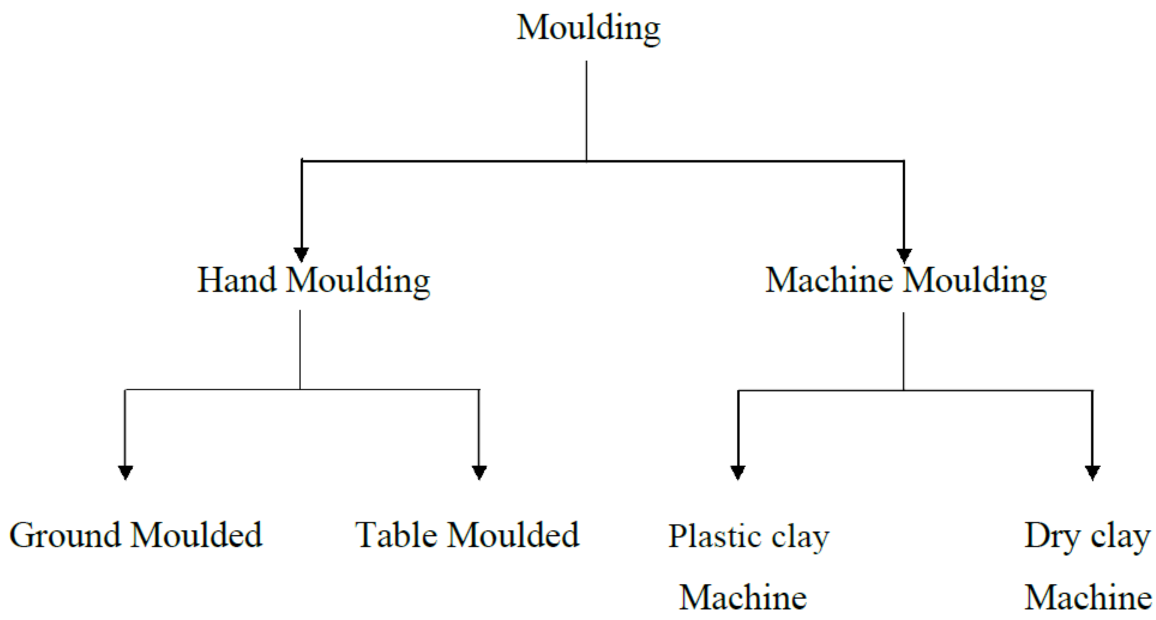


Fig 1.2 Flow Chart for various moulding methods

Clay, which is prepared form pug mill, is sent for the next operation of moulding. Moulding is done with the help of moulds. Moulds are rectangular boxes with openings at top and bottom. Wood and steel moulds are commonly used. Moulds are made slightly greater than the standard size of brick. Following are the two ways of moulding.

1) Hand Moulding:

Moulds are rectangular boxes of wood or steel, which are open at top and bottom. Steel moulds are more durable and used for manufacturing bricks on large scale as shown in fig 2.2. Bricks prepared by hand moulding are of two types.

a) Ground moulded bricks
b) Table moulded bricks

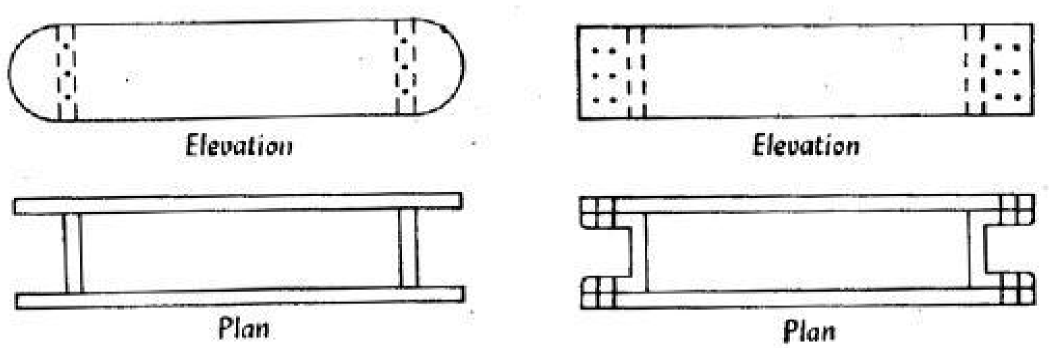


Fig 1.3 Wooden Mould & Steel Mould

2. Machine Moulding:

This method proves to be economical when bricks in huge quantity are to be manufactured at the same spot. It is also helpful for moulding hard and string clay. These machines are broadly classified in two categories.

(a) Plastic clay machines.
(b) Dry clay machines.

3) Drying:

The damp bricks, if burnt, are likely to be cracked and distorted. Hence moulded bricks are dried before they are taken for the next operation of burning. Bricks are laid along and across the stock in alternate layers.

(4) Burning:

This is very important operation in the manufacturing of bricks to impart hardness, strength and makes them dense and durable. Burning of bricks is done either in clamps or in kilns. Clamps are temporary structures and they are adopted to manufacture bricks on scale. Kilns are permanent structures and they are adopted to manufacture bricks on a large scale. A typical clamp is as shown small in fig 1.4

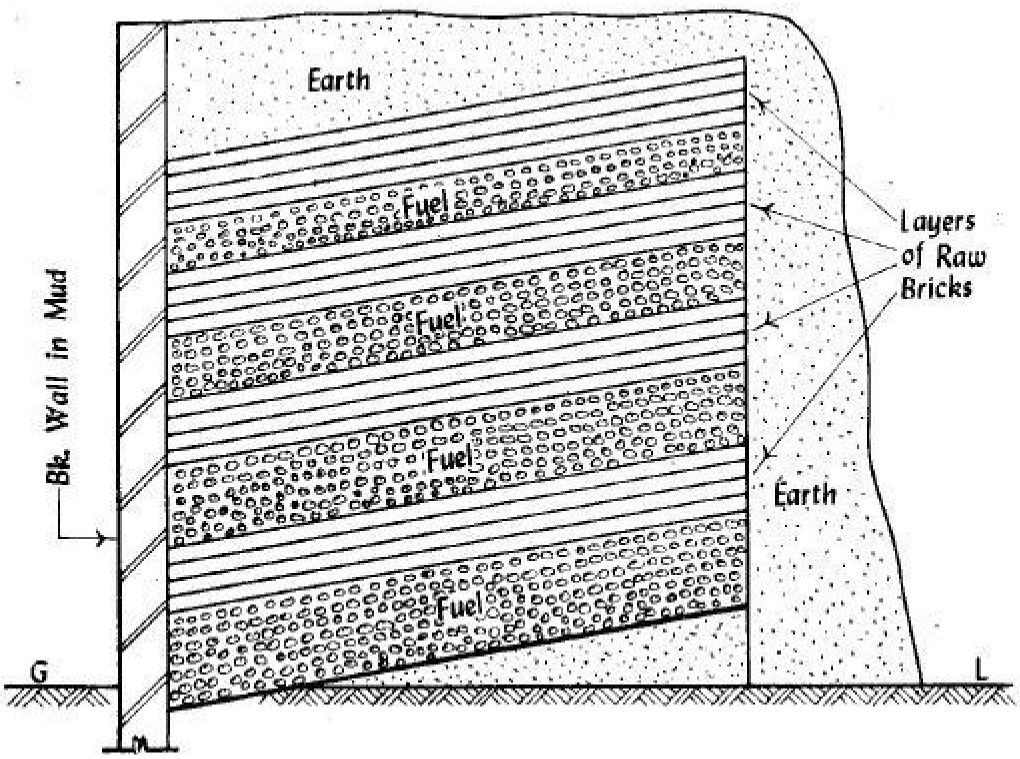


Fig 1.4 Clamp Burning

1. A trapezoidal shape in plan with shorter is slightly in excavation and wider end raised at an angle of $15^0$from ground level.

2. A brick wall with mud is constructed on the short end and a layer of 70cm to 80cm thick fuel (grass, cow dung, ground nuts, wood or coal) laid on the floor.

3. A layer consists of 4 or 5 courses of raw bricks laid on edges with small spaces between them for circulation of air.

4. A second layer of fuel is then placed, and over it another layer of raw bricks is putape. The total height of clamp in alternate layers of brick is about 3 to 4 m.

5. When clamp is completely constructed, it is plastered with mud on sides and top and filled with earth to prevent the escape of heat.

6. The period of burning is about one to two weeks or a month and allows the same time for coding.

7. Burnt bricks are taken out from the clamp.

a) Kilns:

A kiln is a large oven, which is used to burnt bricks by

1) Intermittent kilns.
   a) Intermittent up-draught kilns

b) Intermittent down-draught kilns
2) Continuous kilns.
a) Bull's trench kiln.
b) Hoffman's kiln.
c) Tunnel kiln.

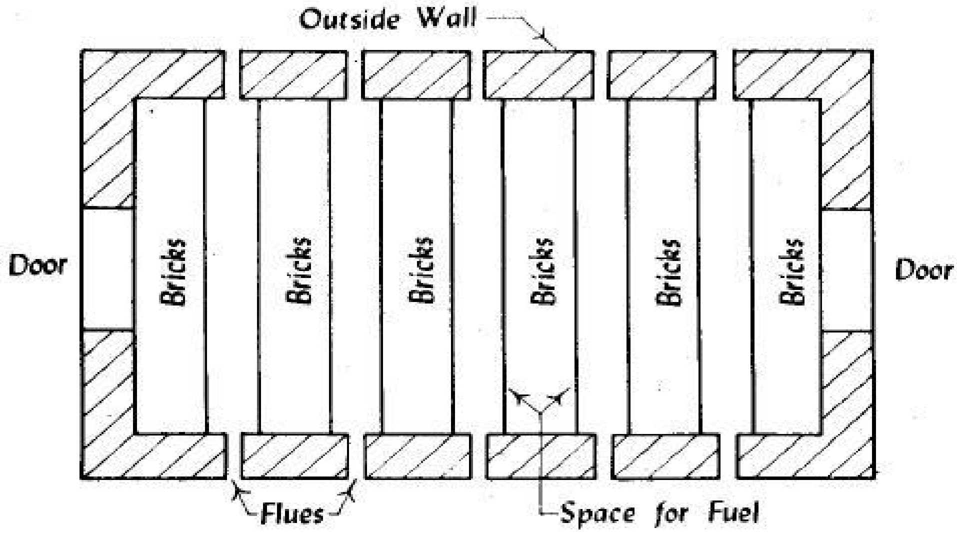


Fig 1.5 Intermittent kiln

1.3.3 Classification of bricks

Bricks can broadly be divided into two categories.

i) Un-burnt or sundried bricks.
ii) Burnt bricks.

i) Un-burnt or Sun dried bricks:

Un-burn or sun dried with the help of heat received from sun after the process of moulding. These bricks can only be used in the constructions of temporary and cheap structures. Such bricks should not be used at places exposed to heavy rains.

ii) Burnt Bricks:

The bricks used in construction works are burnt bricks and they are classified into the following four categories.

a) First Class bricks:

These bricks are table moulded and of standard shape. The surface and edges of the bricks are sharp, square, smooth and straight. The comply all the qualities of good bricks and used for superior work of permanent nature.

b) Second class bricks:

The bricks are moulded and they are burnt in kilns. The surface of bricks is somewhat rough and shape is also slightly irregular. These bricks are commonly used at places where is to be provided with a coat of plaster.

c) Third class bricks:

These bricks are ground moulded and they burnt in clamps. These bricks are not hard and they have rough surfaces with irregular and distorted edges. These bricks give dull sound when struck together. They are used for unimportant and temporary structures and at places where rainfall is not heavy.

d) Fourth class bricks:

These are over burnt briks with irregular shape and dark colour. These bricks are used as aggregate for concrete in foundation, floors, roads, etc because of the fact that the over burnt bricks have compacted structure and hence, they are sometimes found stronger than even first class bricks.

1.3.4.Properties of Good Bricks

The following are the required properties of good bricks:

(i) Colour: Colour should be uniform and bright.

(ii) Shape: Bricks should have plane faces. They should have sharp and true rightangled corners.

(iii) Size: Bricks should be of standard sizes as prescribed by codes.

(iv)Texture: They should possess fine, dense and uniform texture. They should notpossess fissures, cavities, loose grit and un-burnt lime.

(v) Soundness: When struck with hammer or with another brick, it should producemetallic sound.

(vi)Hardness: Finger scratching should not produce any impression on the brick.

(vii) Strength: Crushing strength of brick should not be less than 3.5 N/mm^2. A fieldtest for strength is that when dropped from a height of 0.9 m to 1.0 m on a hard ground, the brick should not break into pieces.

(viii) Water Absorption: After immersing the brick in water for 24 hours, waterabsorption should not be more than 20 per cent by weight. For class-I works this limit is 15 percent.

(ix) Efflorescence: Bricks should not show white patches when soaked in water for24 hours and then allowed to dry in shade. White patches are due to the presence of sulphate of calcium, magnesium and potassium. They keep the masonry permanently in damp and wet conditions.

(x) Thermal Conductivity: Bricks should have low thermal conductivity, so thatbuildings built with them are cool in summer and warm in winter.

(xi) Sound Insulation: Heavier bricks are poor insulators of sound while light weightand hollow bricks provide good sound insulation.

(xii) Fire Resistance: Fire resistance of bricks is usually good. In fact bricks are usedto encase steel columns to protect them from fire.

1.3.5.Tests for bricks

A brick is generally subjected to following tests to find out its suitability of the construction works.

i. Absorption.
ii. Crushing strength or compression strength.
iii. Hardness.
iv. Presence soluble salts.
v. Shape and size.
vi. Soundness.
vii. Structure.

i) Absorption:

A good bricks should not absorb not more than 20 percent of weight of dry brick.

ii) Compressive strength:

Crushing or compressive strength of brick is found out by placing it in compression testing machine. It is compressed till it breaks. Minimum crushing strength of brick is 3.5N/mm^2 and for superior bricks, it may vary from 7 to 14N/mm^2.

iii) Hardness:

No impression is left on the surface the brick is treated to be sufficiently hard.

iv) Presence of soluble salts:

The bricks should not show any grayer white deposits after immersed in water for 24 hours.

v) Shape and size:

It should be standard size and shape with sharp edges.

vi) Soundness:

The brick should give clear ringing sound struck each other.

vii) Structure:

The structure should be homogeneous, compact and free from any defects.

1.3.6.Grading of Bricks and Its parameters

As per IS: 1077-1957 and 1970 code specifications.

a) Bricks with compressive strength not less than 140kg/cm^2 – First class bricks - Grade A-A.

b) Bricks with compressive strength not less than 70kg/cm^2 – Second class bricks - Grade A.

c) Bricks with compressive strength not less than 50kg/cm^2 – Third class bricks - Grade B.

d) Bricks with compressive strength not less than 30kg/cm^2 – Fourth class bricks - Grade C.

Table 1.1 Grades of Bricks As Per IS 3102 -1971(BIS)

Class Designation	**Average compressive strength**	
	Not less	**Less than**

	than (N/mm^2)	(N/mm^2)
350	35	40
300	30	35
250	25	30
200	20	25
175	17.5	20
150	15	17.5
125	12.5	15
100	10	12.5
75	7.5	10
50	5	7.5
35	3.5	5

12

Parameters for the Bricks

Table 1.2 Parameters for the Bricks

Descriptions	Bricks
Use	External& Internal Walls / Boundary walls
Length	228mm
Height	82 mm
Breadth	102 mm
Weight	3.6 - 3.62kg approx

1.4.MATERIALS USED

1. Clay & Red Soil.
2. Granite Sawing Powder.
3. Silica Fume.

1.4.Clay Soil

Clay is a kind of material that occurs naturally and consists of very fine grain material with very less air spaces. Due to this it is difficult to work with this soil, because the drainage in this soil is low. Hence, there is possible for water logging to occur, which can harm the roots of the plant.

Fig 1.6 Clay soil

Clay soil becomes very heavy when wet and if cultivation has to be done, organic fertilizers need to be added to the soil. Clay soil is formed after years of rock disintegration and weathering. It is also formed as sedimentary deposits after the rock is weathered, eroded and transported. Clay soil due to its formation process is rich in mineral content.

The various types of soils found in india are discussed below-

1.4.2.Red Soil

It is the soil of the tropical regions of the country. This typical soil is found in those regions which receive heavy rainfall.

This soil is poor in lime content and hence it is more acidic. It is basically red in color because of the presence of iron oxides.

Fig1.7 Red Soil

Red soils are well developed in the southern region of Western Ghats and Orissa`s Eastern Ghats. This soil contains least moisture content. Red Soils are mostly found on the plateau in the east spreading partly over Orissa and Tamil Nadu, parts of Chhota nagpur and Meghalaya.

1.4.2.Granite Sawing Powder

The Granite stone industry generates different types of waste. Solid waste and stone slurry, where as solid waste is resultant from rejects at the time of cutting or at the processing unit. Stone slurry is a semi liquid substance consisting of particles originated from the sawing and polishing process and water used to cool and lubricate the sawing and polishing machines. The slurry is stored in tanks for evaporation. To conserve water the slurry is passed through filtration and slurry compacting machine.

The compacted granite fine cakes are transported and disposed in landfills. Its water content are drastically reduced (Approx 2%) and the granite fines resulting from this will have environmental impacts. The stone slurry generated during the processing will be around 40% of the final product.

Disposing of compacted granite fine slurry cakes is a major problem anywhere. The factories were use to dispose these granite fines around their own factories. These factories are situated very close to the residential areas. As per the government regulations, any disposable waste is to be disposed minimum 2 Km away from the industries. Since the cities are expanding the land around the cities are very expensive leading to disposal problems.

Disposal of these granite fines leads to health hazards like respiratory and allergy problems to the people around. It also decreases the fertility of soil and yield. It also causes Air and Water pollution. The high cost of brick used depends on the cost of the constituent materials.

Cost of bricks can be reduced through the use of locally available alternative material, to the conventional ones. This paper is on use of granite fines as an alternative to expensive and depleting sand. The worldwide consumption of clay as used in bricks production is very high, and several developing countries have encountered some strain in the supply of natural sand in order to meet the increasing needs of infrastructural development in recent years.

A situation that is responsible for increase in the price of clay, and the cost of bricks. Expensive and scarcity of clay which is one of the constituent material used in the production of conventional bricks was reported in India. To overcome the stress and demand for clay, researchers and practitioners in the construction industries have identified some alternatives materials namely as fly ash, limestone powder and siliceous stone powder etc.

In India the use of granite dust to replace clay was reported. The rejection of very fine materials like clay size particles passing through the 75 microns has been common practice in the past.

However, at the light of state of the art brick technology, the dimension of dust particles is compatible with the purpose of filling up the transition zone (measuring between 10 to 50microns) and the capillary pores (which range from 50nm to 10microns of diameter) this acts as micro filler. Hence various fine particles have been tried in the production of bricks.

Uses for Granite Sawing Powder:

- Granite is among the most plentiful rocks on earth. This intrusive igneous composite, formed by volcanic magma, makes up most of the continental crust.
- Anywhere you stand on dry land, granite is somewhere beneath your feet. It's also all around us in daily life.
- Granite has many uses in commercial construction and manufacturing, and has a long tradition in statues, headstones and carvings.
- The fabrication of granite produces large amounts of granite tailings, slurry and dust. These remainders are processed into powdered granite for several purposes.

1.4.3.Silica Fume

Silica fume (SF) is an inorganic waste material which is generated during the elemental silicon and ferro-silicon alloy production. Due to the unique properties, it is utilized in several industries. However, very little information is available on the utilization of potential Silica Fume in traditional clay brick industry.

In this study, the effect of different quantities of Silica Fume addition on the properties of fired clay brick was investigated. Test samples were produced by uni-axial pressing and fired at 800^oC, 900^oC, 1000^oC and 1100^oC. The microstructures of the samples were investigated by Scanning Electron Microscopy (SEM).

The strength of the fired samples at 1000^oC and 1100^oC were significantly improved with SF addition. It was concluded that the reactive amorphous nature of SF particles enhances the sintering action locally and this gives better strength behavior.

SF addition also improved the efflorescence behaviour of the bricks. It was concluded that the effect of SF addition on the fired clay brick mainly depends on the firing temperature. At low firing temperatures, SF addition has a tendency to decrease the bulk density. However at higher firing temperatures, SF addition allows better sintering action with a drastic increase in bulk density.

Sources of Silica Fume:

It is very fine no crystalline silica manufactured by electric arc furnaces as a by-product of the production of metallic silicon or ferrosilicon alloys. The raw materials are coal, quartz, and wood chips. The smoke that produced from furnace operation is stored and sold as silica fume rather than being land filled.

As the silica fume powder particles are hundred times finer than ordinary Portland cement, there might be problems arise when deals with silica fume, such as dispensing consideration, transportation, and storage that must be taken into account. To overcome some of these difficulties, the material is commercially divided in various forms.

The difference between these forms is the size of the particle which do not significantly affect the chemical make-up or reaction of material. This difference has effect on the different purposes of use. Thus, careful consideration is needed when choosing the type of silica fume for specific application.

Production of Silica Fume:

Silica fume is a byproduct in the carbo-thermic reduction of high-purity quartz with carbonaceous materials like coal, coke, wood-chips, in electric arcfurnaces in the production of silicon and ferrosilicon alloys.

1.5.SUMMARY

The locally available materials of granite sawing powder waste and silica fume are used for production of bricks. The environment is affected by the waste materials of granite sawing powder waste and silica fume. Hence these two waste materials can be reused for alternative production of bricks.

2.1.REVIEW OF LITERATURE

2.1.1.GENERAL

Various literatures were collected to study and investigate to do project about bricks. Based on these collected literatures, the type of ingredients and the addition of ingredients were proportioned and moulded.

2.1.2.LITERATURES

J.N Akhtar & M.N Akhtar:

Bricks With Total Replacement of Clay By Fly Ash Mixed With Different Materials.

Fly ash is a powdery substance obtained from the dust collectors in the Thermal power plants that use coal as fuel. From the cement point of view the mineralogy of Fly ash is important as it contains 80% - 90% of glass. The impurities in coal-mostly clays, shale’s, limestone & dolomite; they cannot be burned so they turn up as ash. The Fly ash of class C category was used as a raw material to total replacement of clay for making Fly ash bricks. In present study the effect of Fly ash with high replacement of clay mixed with different materials were studied at a constant percentage of cement i.e 10%. Three Categories of bricks were to be studied namely Plain Fly ash brick (FAB), Treated Fly ash brick (TFAB) and Treated Fly ash stone dust brick (TFASDB).In all the above mentioned categories the quantity of Fly ash was kept constant as 80%. It is found that the compressive strength of plain Fly ash brick (15FAB) and Treated Fly ash brick (15TFAB) was found to be higher with 5% coarse sand and 15% sand combination at 10% cement. The gain in strength continues for Treated Fly ash Stone dust Brick (10TFASDB) and found to be higher with 10% stone dust and 10% sand combination.

A variation in the quantity of Fly ash was also attempted and it was found that the 25TFASDB with 50% fly ash, 25% stone dust and 25% sand combination at 10% cement achieved highest compressive strength.

- The addition of lime to the fly ash increases the cementitious properties of Fly ash and it was found that at 1.5% of lime, the OMC is minimum and dry density maximum.
- The compressive strength of Treated Fly Ash Brick (15TFAB) is more than Plain Fly Ash Brick (15FAB).
- The compressive strength of Treated Fly Ash Stone Dust Brick (10TFASDB) is more than 15FAB and 15TFAB.
- Treated Fly Ash Stone Dust Brick designated as (25TFASDB) achieved

highest compressive strength ($79 Kg/cm^2$) with 25% stone dust, 25% sand and 50% treated fly ash combination at 10 % cement as compared to15FAB, 15TFAB, 10TFASDB.

- Though the highest compressive strength ($79 Kg/cm^2$) obtained in case of 25TFASDB is less than the maximum strength ($105 Kg/cm^2$) of standard Ist class brick, even than the study is important as it replaces 50% of top soil by fly ash. More over the 25TFASDB bricks can be safely used in frame structure buildings as non load bearing walls and also as load bearing walls in case of single storey constructions.

Ramkumar, Swaminathan & Dhanapandian. Utilization of Granite and Marble Sawing Powder Wastes As Brick Materials.

The main objective of waste management system is to maximize economic benefits and at the same time protection of the environment. Granite and marble process industry generates a large amount of wastes mainly in the form of powder during sawing and polishing processes, which pollute and damage the environment. Therefore, this work aims to characterize and evaluate the possibilities of using the granite and marble sawing wastes, generated by the process industries from Salem District, Tamil nadu state, India, as alternative raw materials in the production of bricks. Samples of clay material and fired industrial bricks were collected from nearby District namely Namakkal, India. Their characterization was carried out with the determination of chemical composition, mineralogical and petrological analysis, particle size, plasticity, FTIR, and Mössbauer measurements. Secondly, technological tests were conducted on wastes incorporated brick specimens in order to evaluate the suitability of addition of wastes in the production of bricks. The results showed that granite and marble wastes can be added up to 50 wt. % into the raw clay material in the production of bricks.

- Red type clay out of which this brick has been made in industry.
- The physical property studies, records that the addition of granite and marble waste mixture imparts physical strength to the bricks when they are kilned at higher temperature.
- More specifically, bulk density, compressive strength, flexural strength was found to increase due to the addition of the above mixtures. This is because of the fact that the addition of the mineral matter especially quartz and feldspar to the clay, act as flux when they are kilned at higher temperature as evidenced by the physical test of the bricks.
- From the results of technological tests, it is suggested that granite and marble wastes can be incorporated up to 50 wt. % into clay materials for the production of bricks.
- The incorporation of granite and marble wastes has negligible effect on the mechanical properties during the entire process, anticipating no costly modifications in the industrial production line.
- The possibility to use the granite and marble wastes as an alternative raw material in the production of clay-based products will also induce a relief on waste disposal concerns.

Obada Kayali.
Performance of Fly Ash Bricks.

Bricks whose solid ingredients are 100% fly ash have been manufactured. The manufacturing process uses techniques and equipment similar to those used in clay brick factories. The bricks produced were about 28% lighter than clay bricks. The bricks manufactured from fly ash possessed compressive strength higher than 40MPa. This exceeds some of the best of load carrying clay bricks available by more than 25% and is several times better than acceptable commercially available common clay bricks.Other important characteristics of the fly ash bricks have been evaluated. These include absorption capacity initial rate of absorption, modulus of rupture, bond strength and durability. The values of these characteristics for fly ash bricks are excellent and have exceeded those pertaining to clay bricks. Moreover , fly ash bricks have been produced with a naturally occurring reddish colour similar to that of normal clay bricks. The new bricks and process have been patented and new bricks have been given the name Flash bricks. This paper presents the results of testing and the advantages gained by this type of bricks over conventional clay bricks.

- The results are indicative of the satisfactory performance of Flash bricks as load bearing elements. This type of bricks uses 100% fly ash without mixing with clay and shale. It, therefore provides a large venue for the disposal of fly ash in a very efficient, useful and profitable way.
- The mechanical properties of Flash bricks have exceeded those of the standard load bearing clay bricks. Notable among these properties are the compressive strength and the tensile strength. Compressive strength was 24% better than good quality clay bricks. Tensile strength was nearly three times the value for standard clay bricks.
- Comparison between the bond strength the bond strength of Flash bricks to mortar and that of comparable shaped and commonly used solid clay bricks showed that the Flash bricks have a bond that is 44% higher than the standard clay bricks.
- There is evidence that the microstructural features of the surface of Flash bricks is characterized by a rougher texture than that of clay bricks. This characteristics is belived to be responsible for the increased bond strength with mortar.
- The resistance of the bricks to repeated cycles of salt exposure showed zero loss of mass and indicated excellent resistance to sulphate attack.
- The density of Flash bricks is 28% less than that of standard clay bricks. This reduction in the weight of bricks results in a great deal savings amongst which are savings in the raw materials and transportation costs and savings to the consumer that result from increased number of units and reduction in the loads on structural elements.
- The processes of manufacture of Flash bricks indicate clearly that there is much savings to be done during the making of the bricks.
- These savings arise mainly from the uniformity of the raw materials and the reduction in firing time as well as from doing away with whole processes of mining, transporting, mixing and grinding, that are necessary in the case of the clay and shale based bricks.

Ahmed Mohammed Hassanain: Incorporation of water sludge, silica fume, and rice husk ash in brick making

The water sludge is generated from the treatment of water with alum. Disposing of sludge again to the streams raises the concentrations of aluminum oxides in water, which has been linked to Alzheimer's disease. The use of water treatment plant (WTP) sludge in manufacturing of constructional elements achieves both the economical and environmental benefits. Due to the similar mineralogical composition of clay and WTP sludge, this study investigated the complete substitution of brick clay by sludge incorporated with some of the agricultural and industrial wastes, such as rice husk ash (RHA) and silica fume (SF). Three different series of sludge to SF to RHA proportions by weight were tried, which were (25: 50: 25%), (50: 25: 25%), and (25: 25: 50%), respectively. Each brick series was fired at 900^{o}C, 1000^{o}C, 1100^{o}C, and 1200^{o}C. The physical and mechanical properties of the produced bricks were then determined and evaluated according to Egyptian Standard Specifications (E.S.S.) and compared to control clay-brick. From the obtained results, it was concluded that by operating at the temperature commonly practiced in the brick kiln, a mixture consists of 50% of sludge, 25% of SF, and 25% of RHA was the optimum materials proportions to produce brick from water sludge incorporated with SF and RHA. The produced bricks properties were obviously superior to the 100% clay control-brick and to those available in the Egyptian market.

- WTP sludge can be successfully used in brick manufacture incorporated with agricultural and industrial waste materials, which contain high silica content, such as RHA and SF.
- The results are limited to the study conditions such as mixing proportions, firing temperatures, and manufacturing methods used in this study.

- The chemical composition of water treatment plant sludge was extremely close to brick clay but higher sintering temperatures are required for sludge due to its lower silica and higher alumina contents.
- The maximum percentage of WTP sludge, which can be used in the mixture, should be determined by the practiced firing temperatures.
- Generally, the test results in the aspect of water absorption, efflorescence, and compressive strength showed that most of the research brick types were superior to both the research control clay brick types and commercial clay brick types available in the Egyptian market.
- A mixture consists of 50% of WTP sludge, 25% of SF, and 25% of RHA was the optimum materials proportions to produce brick from water treatment plant sludge incorporated with SF and RHA; by operating at the temperatures commonly practiced in the brick factories and based on the experimental scheme such as tested materials and testing procedures employed in this research.

N.Vamsi Mohan, Prof. P.V.V Satyanarayanan & Dr.K.Srinivasa Rao: Performance of Rice Husk Ash Bricks.

In this study, rice husk ash has been utilized for the preparation of bricks in partial and full replacement of clay. Engineering properties like compressive strength, water absorption and size and shape have been studied. From the studies, it is observed that optimum proportion for (RHA + Clay) bricks was observed as 30% RHA and 70% Clay (Maximum of 30% RHA) as the bricks exhibited high compressive strength and low brick weight.

In full replacement of clay with 40% RHA, 40% Lime and 20% gypsum and 50% RHA, 30% lime and 20% gypsum gives more strength (41 kg/ cm^2) when compared to all other possible proportions after 28 days curing period.

- By the addition of RHA upto 40% to clay, the strength gradually decreased and beyond the addition of 40% RHA the compressive strengths decreased rapidly.
- Optimum proportion for (RHA + Clay) bricks was observed as 30% RHA and 70% Clay (Maximum of 30% RHA) as the bricks exhibited high compressive strength and low brick weight.
- As the percentage of RHA increased, water absorption of RHA-Clay bricks also increased.
- In full replacement of clay with 40% RHA, 40% Lime and 20% gypsum and 50% RHA, 30% lime and 20% gypsum gives more strength (41 kg/ cm^2) when compared to all other possible proportions after 28 days curing period. 50% RHA, 30% lime and 20% gypsum is optimum proportion due to its light weight at that proportion.
- As the percentage of lime and gypsum increased, water absorption of RHA+ Lime+ Gypsum bricks decreased.

2.1.3.SUMMARY

With the help of collected literatures, we came to know that the construction with bricks has environmental advantages and also enables speedier construction of high quality, aesthetic and affordable building. The usage of granite sawing powder waste with silica fume in the production of bricks is also possible from the literature which describes that the granite sawing powder waste with silica fume can be used as a clayey material with similar influence on the chemical soil properties as conventional clayey materials.

2.2.METHODOLOGY

2.2.1.GENERAL

This study was carried out for the purpose of having a detailed understanding of the effect and uses of utilizing granite sawing powder waste and silica fume in bricks and to determine its compressive strength. To achieve the objectives stated previously, several laboratory testing were conducted. By using appropriate apparatus and methods, testing was conducted on the required materials, standard bricks and the bricks with granite sawing powder waste and silica fume. The following steps were followed in this project study.

Step 1 Collection of literatures relevant to bricks.

Step 2 Selection of materials for brick from the literatures collected.

Step 3 Collection of materials for moulding the bricks (Clay, Granite Sawing Powder waste& Silica Fume) and mould.

Step 4 Preparation of mix proportions according to literature.

Step 5 Casting process of bricks with the help of Ground mould.

Step 6 Drying process of bricks.

Step 7 Burning process of bricks.

Step 8 Analysis of brick behavior on compression and water absorption test.

Step 9 Based on the results obtained from the above tests optimum mix proportion is to be recommended.

2.3.PROPERTIES OF MATERIALS

2.3.1.Chemical Composition of Clay

Class is obtained From“**CauveryImpex Stones (P) Ltd,Salem, Tamil Nadu**, **India**”. The physical and chemical properties of clay are given in the Table.

Fig.2.1. Clay

Table 2.1.Chemical Composition of Clay

Chemical Composition of Clay	In Percentage
SiO_2	68.76
Al_2O_3	10.20
CaO	3.36
TiO_2	0.02
Fe_2O_3	2.78
MgO	2.40
MnO	0.05
K_2O	1.25
Na_2O	0.67
P_2O_5	0.03
LOI	7.98

H_2O	2.63
Total	100

2.3.2.Physical Properties of Granite Sawing Powder Waste

The basic tests on Granite Sawing Powder Waste were conducted as per IS-383-1987 In terms of granites sawing powder waste physical properties, it is a unique material. These properties lend uniqueness to granite are

i) Co-efficient of expansion:

The co-efficient of expansion for granite vary from $4.7x10^{-6}$ – $9.0x10^{-6}$(inches x inches).

ii) Porosity/permeability:

Granite has almost negligible porosity range among 0.2 to 4%.

iii) Variegation:

Granite shows constancy in color and texture.

iv) Thermal Stability:

Granite is highly steady thermally, therefore shows no change with the change in temperature. It is impervious to weather from temperature and even from the air borne chemicals. Granite is the high confrontation to chemical erosion that makes it useful for making tanks to store highly caustic material.

v) Hardness:

It is the hardest building stone and hardness of it that lends it excellent wear.

vi) Specific Gravity

The specific gravity was around 2.74.

vii) Water Absorption

Water Absorption is found to be 0.60%.

Fig 2.2 Granite Sawing Powder Waste

Table 2.2 Chemical Composition of Granite Sawing Powder Waste

Chemical Composition	Standard range in Percentage	Tested Samples in Percentage
SiO_2	70 - 77	74.3
Al_2O_3	11 - 14	16.3
TiO_2	< 1	0.38
Fe_2O_3	1 - 2	0.19
MgO	0.5 - 1	3.36
MnO	< 1	0.08
Na_2O	3 - 5	1.24
P_2O_5	3 - 5	2.24
LOI	3 - 6	2.16
H_2O	< 1	0.03

2.3.3.Physical and Chemical properties of Silica Fume

Silica Fume powder obtained from**"Astraa Chemicals (P)Ltd''** Thousands Light, Chennai.Tamil Nadu, India.

Fig.2.3.Silica Fume

Table.2.3.Physical & Chemical Composition of silica fume

Property	Portland cement	Standard Range of Silica fume	Tested samples of Silica fume
SiO_2	21	85 to 97	87.50
Al_2O_3	5	-	11.20
Fe_2O_3	3	-	0.25
CaO	62	< 1	3.07
Fineness as suitable area, m^2/kg	370	15000 to 30000	24250
Specific gravity	3.15	2.2 to 2.6	2.54
General use in brick /concrete	Primary binder	Property enhancer	Property enhancer

2.4.METHODOLOGY CHART

The project methodology is shown in the below flowchart:

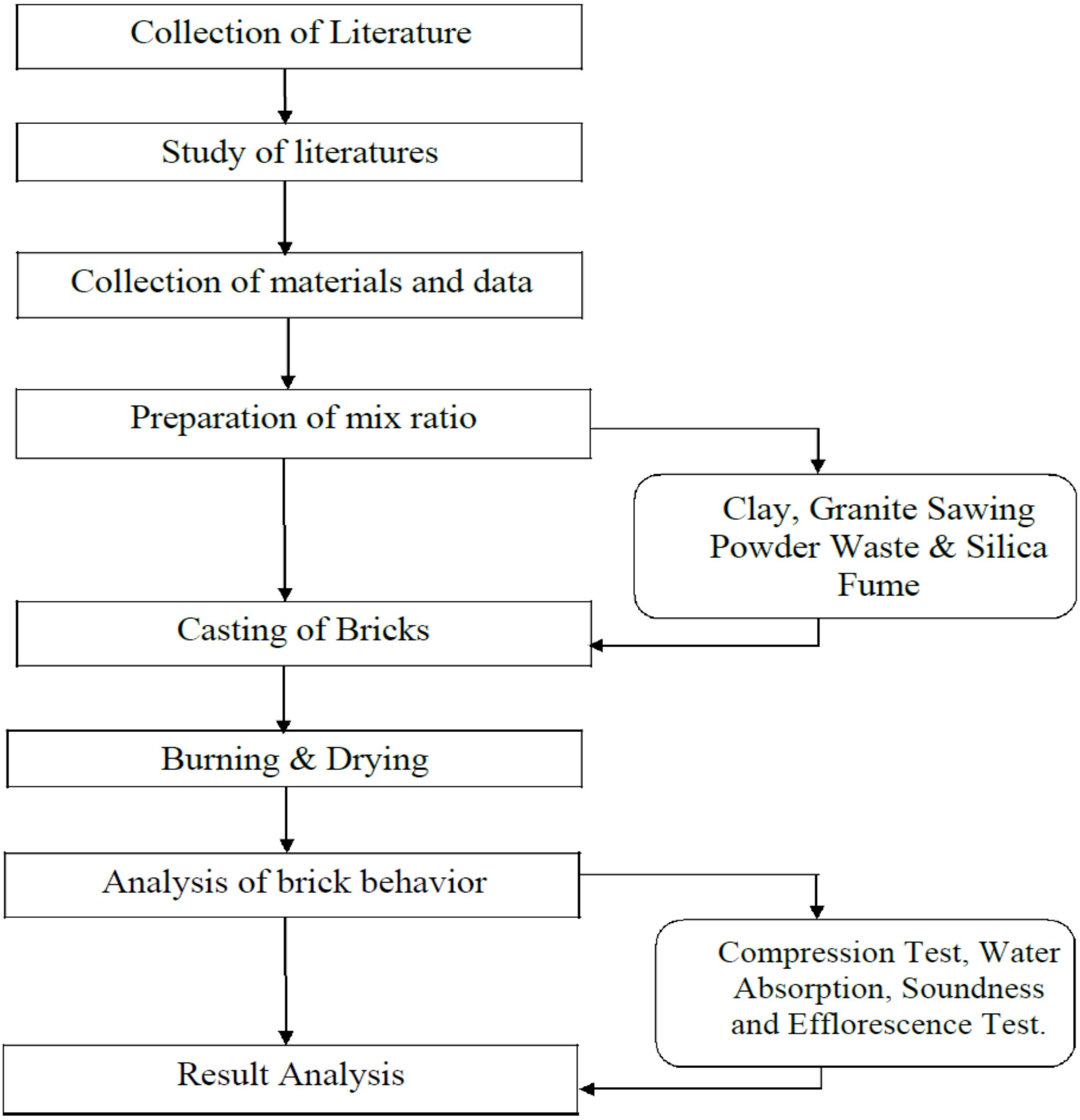


Fig Methodology Chart

2.5.SUMMARY

The bricks were moulded, dried, burned and tested according to the methodology mentioned above and also the analysis and discussion of the study are carried out in accordance with the object stated previously.

2.6.MIX DESIGN

2.6.1.GENERAL

For manufacturing the bricks, most of the machine manufacturers suggest the following two mix ratio, we can choose profitable mix ratio to survive in the market if we are facing low availability of Granite sawing powder. At the same time we should maintain the quality too.

Normal Method

In normal method of manufacturing of bricks, the following are the ratios of materials used in bricks,

60%	Silica
30%	Alumina
2.5%	Lime
7%	Iron oxide
0.5%	Magnesia

Profitable Method

The profitable method is not good to produce a brick with essential strength but it gives profit. In profitable method of manufacturing the brick with granite sawing powder waste and silica fume, the following are the ratios of materials used in Granite Sawing Powder Waste with Silica Fume bricks.

50%	Clay
45%	Granite sawing powder
5%	Silica fume

Process of Manufacture

Clay, granite sawing powder and silica fumes are manually fed into a pan mixer where water is added in the required proportion for intimate mixing. The proportion of the raw material is generally in the ratio depending upon the quality of raw materials. After mixing, the mixture is shifted to the hand brick. The bricks are carried on wooden pellets to the open area where they are dried and burned. The bricks are tested and sorted before dispatch.

2.6.2.MIX PROPORTION

A variety of bricks have been developed during the past years, differing in shape and size, depending on the required strengths and uses. Our brick size are modular and rectangular is (228 mm x 102 mm x 82 mm) and having the following mix proportions.

Length of brick= 228 mm
Breadth of brick= 102 mm
Height of brick= 82 mm
Unit weight of brick masonry=19 KN/m^3
Mass of each brick= 3.623 kg

Table 4.1 Mix Proportion for Standard Brick (%)

Material	Silica	Alumina	Lime	Iron oxide	Magnesia	Total
Ratio (%)	60	30	4	5.5	0.5	100

Table 4.2 Mix Proportion for Bricks with granite sawing powder waste & silica fume (%)

S. No	Mix	Clay	Granite Sawing Powder Waste(GSP)	Silica Fume(SF)
1.	Mix 1	50	45	5
2.	Mix 2	50	40	10
3.	Mix 3	50	35	15
4.	Mix 4	50	30	20

2.6.3.SUMMARY

We are partially replaced the clay with granite sawing powder waste and silica fume in bricks. We gradually increase the % of silica fume powder. The mix ingredients are clay, granite sawing powder, silica fume and water. There is no particular Mix design for bricks hence the mix proportion of granite sawing powder waste and silica fume bricks is taken as mix proportions.

2.7.EXPERIMENTAL INVESTIGATIONS

2.7.1.GENERAL

Several laboratory testing were conducted for the purpose of having a detailed understanding of the effect of utilizing granite sawing powder waste and silica fume in bricks and to determine its compressive strength and as well as the other factors. By using appropriate apparatus and methods, testing was conducted on the required materials, standard blocks and the bricks with granite sawing powder waste and silica fume.

2.7.2.TESTING

There are several tests which are commonly used to obtain various properties of the brick. However in this study, only two bricks tests were required. The two bricks tests were the determination of compressive strength of the bricks and the water absorption of bricks. The procedures of the testing were based on British Standard Specification for Clay Brick, BS 3921: 1985.Hence, the bricks are tested as same as bricks with granite sawing powder waste and silica fume.

2.7.2.1.Determination of Compressive Strength

For the compressive strength testing of brick, the procedures were based on Appendix D, BS 3921: 1985. The required apparatus in this testing was compression machine. The test started by preparing 10 bricks which were chosen randomly from the brick stack. The bricks were immersed in water for 24 hours before undergo further testing. After 24 hours, each brick specimen was removed from the water. The overall dimensions of each brick were measured and the area of the bed face of the specimen was calculated.

For the compression machine, the bearing surfaces of all the platens were wiped clean. Any loose grit or other material was removed from the surfaces of the specimen which were to be in contact with the platens.

To ensure a uniform bearing for the brick specimen, the specimen was placed between 3 mm thick plywood sheets to take up irregularities. Then, load was applied onto the specimen without shock with some specified rate of loading and maintained this rate until failure.

Fig.2.5. Compressive Testing Machine

Failure occurred when the digital reading was observed. The maximum load (in kN) carried by the specimen during the test was recorded. To obtain the strength of each specimen, the maximum load obtained from the compressive strength test was divided by the area of the bed face determined earlier. The strength was recorded in N/mm^2 to the nearest

0.1 N/mm^2. Finally, the compressive strength was calculated by taking the average of the strengths of the 10 specimens of the sample to the nearest 0.1 N/mm^2 Figure 5.1 showed the machine used for compressive testing.

$$\textbf{Compressive Strength of bricks} = \frac{\textbf{Applied loadin N/mm}^2}{\textbf{Area of Bed Face}}$$

Average net area of flanged portion the compressive strength of any individual brick shall not fall below the minimum average compressive strength by more than 20%. (In accordance with IS 1725-1982).Brick dimension: 228mm x 102mm x 82mm.

2.7.2.2.Determination of Water Absorption Limit

The water absorption limit for the bricks were observed using the following procedure,

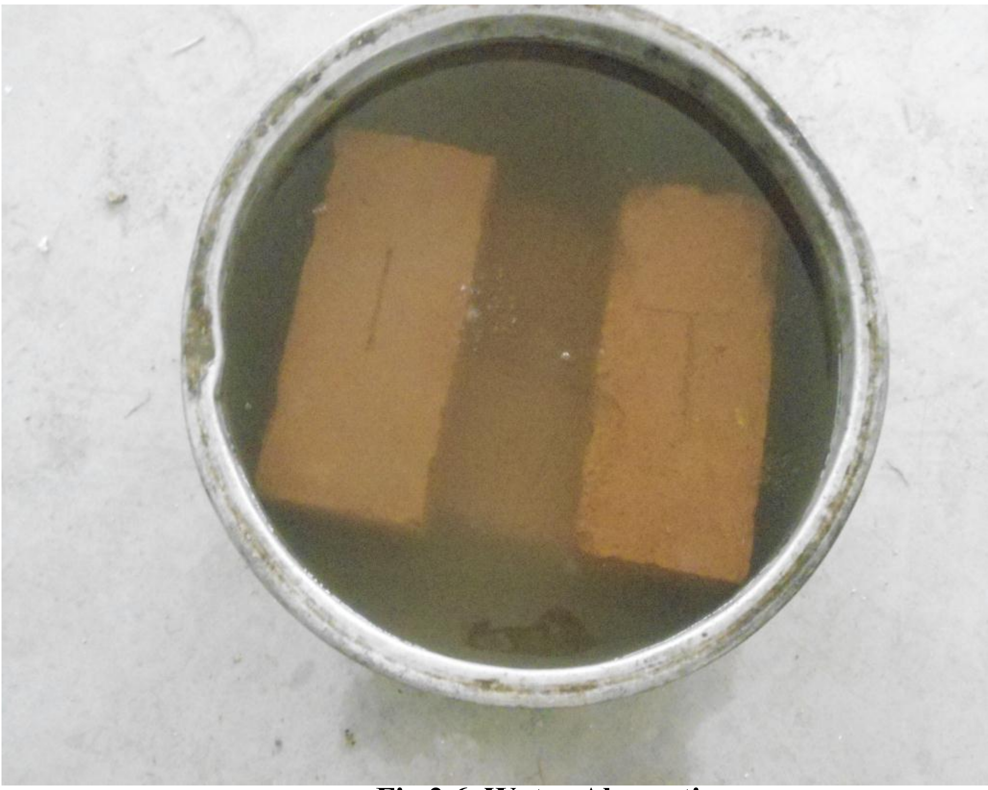


Fig.2.6. Water Absorption

1. Dry the specimen in a ventilated oven at a temperature of 105°C to 115°C till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (M_1).
2. Immerse completely dried specimen in clean water at temperature of 27+2°C for 24 hour. Remove the specimen and wipe out any trace of water with damp low and weigh the specimen (M_2).
3. Complete the weighing within 3 minutes the specimen has been removed from water.
4. Maximum permissible water absorption - 15% by weight after 24-hour immersion in cold water.

Formula for,

$$\textbf{Water Absorption (In \%)} = \frac{(M_2 - M_1) \times 100}{M1}$$

The bricks when tested in accordance with the procedure laid down in IS 3495 Part II-1976, after immersion in water for 24 hours, the average maximum water absorption was noted.

2.7.2.3.Soundness Test

If two bricks are struck with each other they should produce clear ringing sound. The sound should not be dull.

2.7.2.4.Hardness Test

For this a simple field test is scratch the brick with nail. If no impression is marked on the surface, the brick is sufficiently hard.

5.2.5 Efflorescence in Bricks:

Usually sulphate of magnesium, calcium, sulphate and carbonate (and sometimes chloride and nitrates) of sodium and potassium are found in efflorescence. These salts may be traced to the brick itself, sand used in construction, the foundation soil, ground water, water used in the construction and loose earth left over in contact with brick work.

Bricks with magnesium sulphate content higher than 0.05 percent should not be used in construction. Soluble salt content in sand (chloride and sulphate together) should not exceed 0.1 percent. Water, if it finds access to brick work, moves along its pores by capillary action and carries with it dissolved salts. As the solution evaporates from the exposed surface of the brick work, the salts are left as deposit on the surface or on layers just below it.

Disintegration or flaking of the brick surface is caused by the mechanical force exerted by salts as these crystallize just below the exposed surface. Magnesium sulphate, in particular, disintegrates bricks and pushes out plaster.

Remedies

1. Well fired bricks should be used in construction.
2. Sand should be tested for its salt content.
3. Proper D.P.C. should be provided in the building.
4. Efflorescence on brick work traceable to salts in the materials can be removed by dry brushing and washing repeatedly. Such efflorescence may re-appear in dry season but usually are less in intensity. Finally these disappear as the salt content of the bricks is gradually leached out.

Testing Bricks for Efflorescence

Distilled water to be filled in a dish of suitable size. The dish should be made of glass, porcelain or glazed stone ware. Place the end of the bricks in the dish, the depth of immersion in water being 25 mm. Place the whole arrangements in a warm (for example, 20 to 30^{o}C) well ventilated room until all the water in the dish is absorbed by the specimen and the surface water evaporate.

Cover the dish with suitable cover, so that excessive evaporation from the dish may not occur. When the water has been absorbed and bricks appear to be dry, place a similar quantity of water in the dish and allow it to evaporate as before. Examine the bricks for efflorescence after the second evaporation and report the results as:

(a) **Nil** –when there is no perceptible deposit of efflorescence.

(b) **Slight-** not more than 10% area of the brick covered with a thin deposit of salt.

(c) **Moderate** - covering up to 50% area of the brick.

(d) **Heavy-** covering 50% or more but unaccompanied by powdering or flacking ofthe brick surface.

Serious- when, there is a heavy deposit of salts accompanied by powdering and/orflacking of the exposed surfaces.

2.7.4.SUMMARY

To determine the compressive strength of brick specimens (Bricks with granite sawing powder waste with silica fume) using various four mix ratio such as (Clay: GSP:SF) 50:45:5, 50:40:10,50:35:15 and 50:30:20 in % and to determine the percentage of water absorption of bricks with granite sawing powder waste and silica fume, the tests were conducted as mentioned procedure.

2.8.RESULTS AND DISCUSSIONS

2.8.1.GENERAL

The present chapter of this study, the difference between the experimental results and theoretical values was discussed based on the results obtained from the analysis of tests conducted on the standard bricks and the bricks with granite sawing powder waste with silica fume.

2.8.2.RESULTS AND DISCUSSIONS

For the tests that had been done on the bricks, several statements could be made based on the results obtained and observation done during the tests.

1.Compressive Tests on Bricks

Fig2.7.At Initial Crack

During the compressive tests on the bricks, failure could be seen occur along the horizontal middle axis of four sides of the bricks. The sides of the bricks were broken off in the form such that several layers were being peeled off from the sides of the bricks when loading was applied onto the specimens. The surfaces were broken off and got into crack at the middle of the bricks. Figure 6.1 shows the brick with crack. The characteristic compressive strength of the bricks obtained was 4.2N/mm^2

Table.2.6 Compressive Strength for Mix 1

Trial No	Dimensions of The Brick			Initial Crack		Final Crack		No of Specimens
	Length	Height	Breadth	Load in KN	Stress in N/mm^2	Load in KN	Stress in N/mm^2	
1	228	82	102	46	1.98	181	7.78	10
2	228	82	102	49	2.11	183	7.87	10
3	228	82	102	49	2.11	183	7.87	10
					Average	=	7.84	

Table.2.7 Compressive Strength for Mix 2

Trial No	Dimensions of The Brick			Initial Crack		Final Crack		No of Specimens
	Length	Height	Breadth	Load in KN	Stress in N/mm^2	Load in KN	Stress in N/mm^2	
1	228	82	102	38	1.64	171	7.35	10
2	228	82	102	38	1.64	172	7.40	10

3	228	82	102	41	1.76	174	7.48	10
					Average	=	7.41	

Table.2.8 Compressive Strength for Mix 3

Trial No	Dimensions of The Brick			Initial Crack		Final Crack		No of Specimens
	Length	Height	Breadth	Load in KN	Stress in N/mm^2	Load in KN	Stress in N/mm^2	
1	228	82	102	30	1.29	153	6.58	10
2	228	82	102	32	1.38	154	6.62	10
3	228	82	102	33	1.42	152	6.54	10
					Average	=	6.58	

43

Table.2.9 Compressive Strength for Mix 4

Trial No	Dimensions of The Brick			Initial Crack		Final Crack		No of Specimens
	Length	Height	Breadth	Load in KN	Stress in N/mm^2	Load in KN	Stress in N/mm^2	
1	228	82	102	20	0.86	133	5.71	10
2	228	82	102	24	1.03	136	5.85	10
3	228	82	102	26	1.12	138	5.93	10
					Average	=	5.83	

2.Water Absorption Limit:

From observing the Water Absorption Limit for bricks having different mix proportions, the dried brick was immersed completely in clean water at temperature of 27+2°C for 24 hour. This GSP & SF brick when tested in accordance with the procedure laid down in IS 3495 Part II-1976. The following table 6.5 shows the results obtained from the water absorption limit of blocks.

Table.2.10. Water Absorption Limit of Bricks.

Brick	Weight of Dry Bricks (M_1) in Kg	Weight of Soaked bricks for 24 hours (M_2) in Kg	Water Absorption Limit in %
MIX 1	3.62	3.81	7.18
MIX2	3.62	3.92	8.28
MIX3	3.62	4.01	10.77
MIX4	3.62	4.10	13.26

2.8.3.SUMMARY

Based on the discussion on results obtained, the optimum replacement level of granite sawing powder waste and silica fume as clay was found and from the compressive strength test, it was determined that the brick using granite sawing powder and silica fume as clay gives more or less compressive strength as the normal brick. From the water absorption test, it was found that the brick using granite sawing powder waste and silica fume as clay have more or less same water absorption limit.

2.9. STATISTICAL ANALYSIS

2.9.1.GENERAL

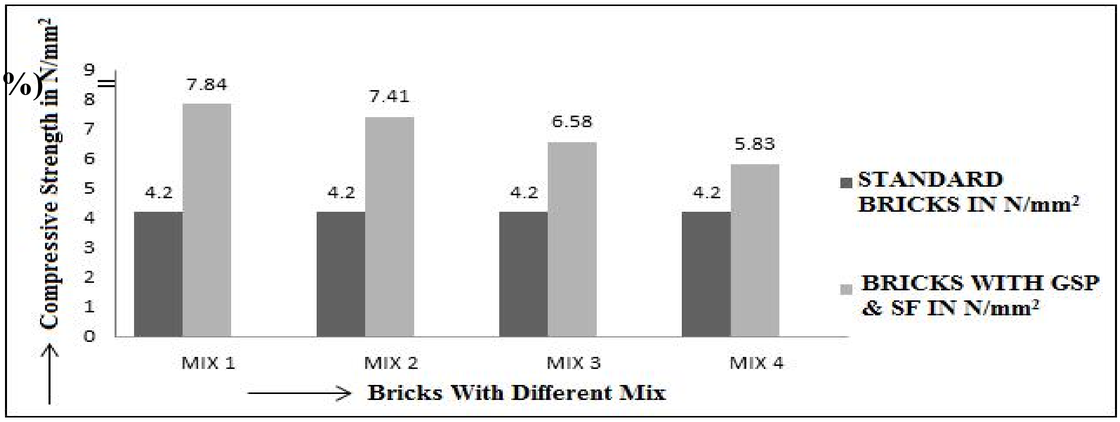
The study presents the results obtained from the experiment testing done on the standard bricks and the bricks granite sawing powder waste and silica fume. Analysis was done on the results obtained and presented them in the more appropriate formats, such as tables, charts or statements. Comparison among the results was also done for the purpose of evaluation.

2.9.2.STATISTICAL ANALYSIS

Based on several past researches, some of the properties of the bricks (bricks with granite sawing powder waste and silica fume) which required in the calculation for the compressive strength and water absorption could be obtained. The properties obtained and other required information was obtained from the results of experiment.

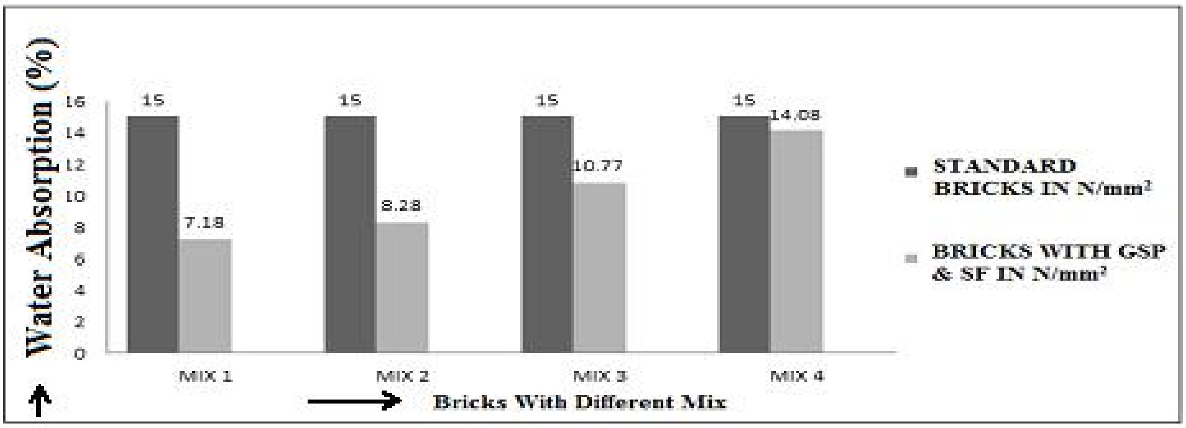
By using the various collected literatures, the compressive strength of standard bricks was obtained and compared. The information obtained from the experimental study was shown below

Compressive Strength of Standard Bricks Vs Bricks with GSP & SF

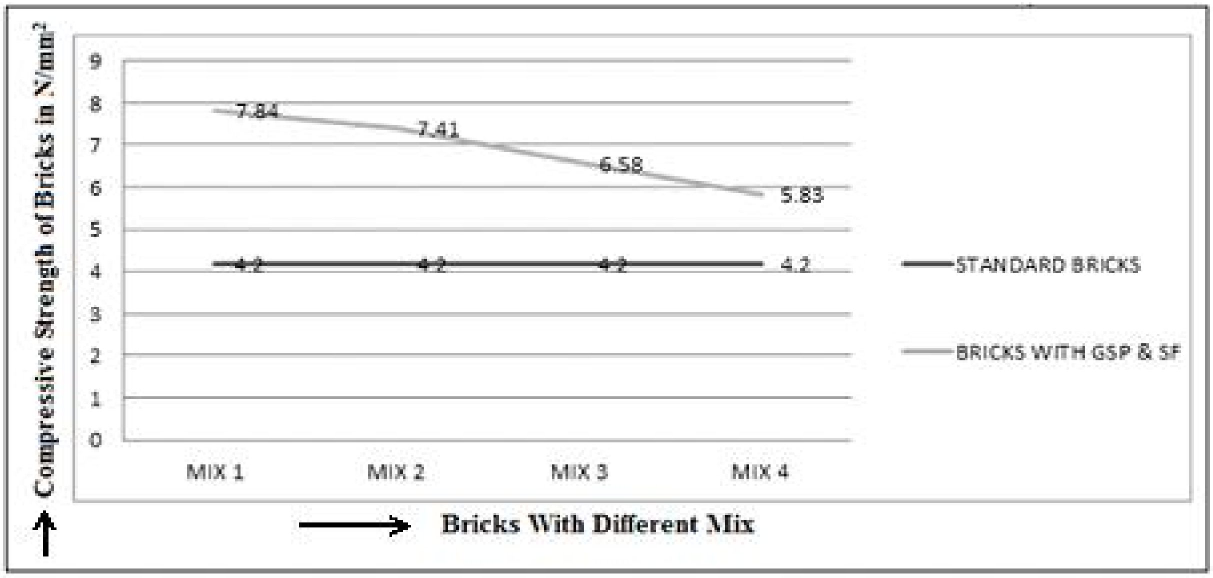


2.9.2.1.Water Absorption Limit of Standard Bricks Vs Bricks with Granite Sawing Powder Waste & Silica Fume.

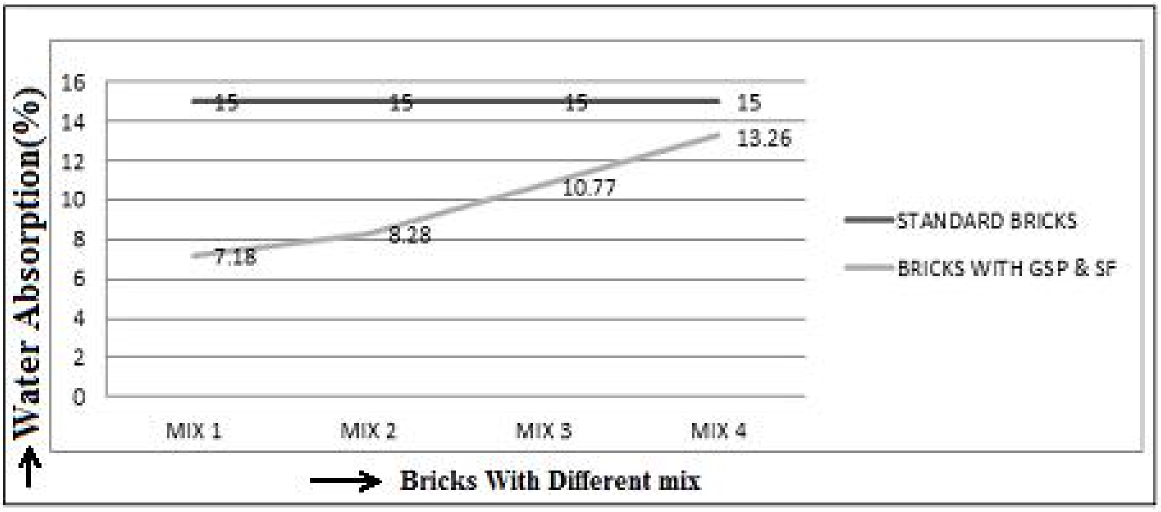
From the theoretical studies, it was observed that the water absorption limit for the standard bricks was not more than 15 % by weight. The water absorption limit for the bricks using granite sawing powder waste & silica fume was obtained as 7.18 to 13.26% by weight taken after 24 hours.



Compressive Strength Variations Graph



Water Absorption Test Value Variations Graph



2.9.3.SUMMARY

In our project study, we made statistical analysis between standard bricks and bricks With Granite Sawing Powder & Silica fume. There is major difference between standard bricks & bricks With Granite Sawing Powder & Silica fume like compressive strength value,water absorption and amount of salts presents in bricks etc.

3.1. CONCLUSIONS

GENERAL

Based on the scope of the investigation, the following conclusions can be drawn:

- Clay was found to be partially replaced by granite sawing powder with silica fume as into 50%.
- From the compressive strength test, it was determined that the brick using granite sawing powder waste and silica fume as clay gives more compressive strength as comparing the standard brick, i.e., 5.83 to 7.84 N/mm^2
- From the water absorption test, it was found that the brick using granite sawing powder waste and silica fume as clay gives less percentage of absorption as comparing the standard brick, i.e., 7.18 to 13.26 % by weight.
- From the results of technological tests, it is suggested that granite sawing powder waste and silica fume can be

incorporated up to 50 wt. % into clay materials for the production of bricks.

- The incorporation of granite wastes has negligible effect on the mechanical properties during the entire process, anticipating no costly modifications in the industrial production line.
- Less percentage of silica fumes only required for increasing the strength of the bricks.
- This kind of bricks with granite sawing powder waste and silica fume can widely used to build the structures like walls, parapet walls and etc.

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Bureau of Indian Standards for relevant standards as under:

1	IS : 1077 – 1992	Common burnt clay building bricks.
2	IS : 1200 (Part-III) – 1976	Methods of measurement of buildings and civil engineering works – Brick Work
3	IS : 2212 – 1991	Code of practice for brick work.
4	IS : 3102 – 1971	Classification of burnt clay solid bricks.
5	IS : 3495 (Part I to IV) 1992	Methods of tests on burnt clay building bricks
6	IS : 6042 – 1969	Code of practice for construction of light weight concrete block masonry.

7.IS 2110: 1980	Code for practice for in situ construction of wall in building with soil cement.
8 IS 1725:1982	Specification for soil-based blocks used in general building Construction.
9 IS 4326: 1983	Earthquake resistant design and construction of building code of practice.
10 IS 13759: 1993	Fly ash building bricks specification.