AN EXPERIMENTAL AND COMPARATIVE STUDY IN UTILIZATION ASPECTS OF NATURAL AND ARTIFICIAL FIBER IN BOTH FLY ASH BRICK AND MORTAR

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By

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Abstract

In every year, there are millions of tonnes of fly ash produced from the thermal power plant. These fly ashes are already utilized to make economical Fly Ash bricks. But, these bricks are rarely used in house wall due to lower compressive strength as compare to burnt clay bricks. Also, the bonding strength in between mortar and fly ash bricks is not that strong enough to make it durable. Due to these reasons, it lowers the priority to choose a fly ash bricks. A feasibility study was undertaken to production of fly ash based bricks with clay, wood ash, lime, gypsum and to increase the compressive strength of the bricks as well as bonding strength in between the bricks and mortar. The mortar composition was modified to make it more efficient. The compressive strength of the bricks, shear and tensile strength in between the bricks and mortar. It is expected that the compressive strength of the bricks will increase and the bonding strength in between the bricks and mortar will improve. Thus their property will be modified.

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CERTIFICATE

I hereby certify that the work being presented in the dissertation entitled "An experimental and comparative study in utilization aspects of natural and artificial fiber in both fly ash brick and mortar" in partial fulfillment of the requirement of the award of the Degree of master of technology and submitted to the Department of Mechanical Engineering of Lovely Professional University, Phagwara, is an authentic record of my own work carried out under the supervision of (Puneet Sharma, Assistant Professor), Department of Mechanical Engineering, Lovely Professional University. The matter embodied in this dissertation has not been submitted in part or full to any other University or Institute for the award of any degree.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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The external viva-voce examination of the student was held on successfully _____

Signature of Examiner

Table of Contents

List of Figure

List of Tables

Chapter 1

Introduction

1.1 History

On 1975, a company named National Mineral Corporation was founded by Sir William R Collins. This company was founded to promotion and marketing of fly ash to use it in the construction industries. At that time, they came to know that the fly ash has very unique pozzolan property, which can make a cementitious product when water and lime added to it. As it is a wastage material, so usage if fly ash is economical. [w1, w3]

Earlier, the fly ashes from the industries were released to the atmosphere. But, it was known to scientist that releasing fly ash to the atmosphere make environment pollution. Then it was necessary to use some kind of filters to remove the fly ash from being escape from the chimneys. Fly ash were used as wastage until researcher found the pozzolan property to reuse it. [w2]

1.2 Fly Ash: An overview

Fly ash is the by-product from burning crumbled coal in the thermal power plants. This fly ash is in the form of fine powder. In generally, the fly ash is captured by an electrostatic precipitator or other filtration equipment, before flue gases move out from the chimneys. The fly ash contains different component depending upon the source and form of the coal being burned. But all fly ash contains some amount of SiO_2(Silicon Dioxide), Al_2O_3(Aluminium Oxide) and CaO (Calcium Oxide). [w3, w4]

Fig 1: Fly Ash Powder [F1]

Fly ash has pozzolanic property. It means when it mixes with lime and water, it forms a Portland cement like compound. As fly ash is a waste material from the thermal power plant, so it is almost free of cost. But there is some toxic material present in the fly ash particle, which are harmful for human health. To solve this issue, fly ash is used in different application such that waste material can be used in some productive cases due to its pozzolanic property. [w5, w6]

1.3 Properties of Fly ash

Fly ash is used for wide range of application such as manufacture of bricks, manufacture of cement, manufacture of blocks, tiles etc. The pozzolanic property of fly ash help to implement concrete or bricks when lime and water are added to it. [w5, w7]

The physical as well as chemical properties of fly ash plays a very important role in imparting the pozzolanic reactivity as well as in its interaction with the cement mortar and concrete. [w8]

1.3.1 Fineness: Fly ash contain very small particle mostly made up of some clear glass spheres. Thus, whenever a product is made from this, it will be highly dense. Thus, the strength will be increase. [w8]

1.3.2 Specific Gravity: In generally, the fly ash particles are lighter in weight as compare to the weight of cement particles. Specific Gravity of this fly ash particle vary depending upon the proportion of the cenospheres (a light weight hollow sphere made of Silica and Alluminaant filled with inert gas or air. [w8]

1.3.3 Pozzolan Property: The pozzolan property means when water and lime is added to the fly ash, it reacts and forms a cementitious product. With increase in time, the fly ash gain strength. The compressive strength of fly ash is less, but it can be increase by adding some materials like lime, gypsum etc. [w8]

1.3.4 Geo-technical property: It makes fly ash a good substitute of soil as well as the presence of desired Silica, Alumina, iron oxide etc make it suitable for different sintered application. [w8]

The following tables will provide the different properties of fly ash as well as different chemical composition of the fly ash.

1.3.5 Physical Properties:

Parameters	Fly Ash
Bulk Density(gm/cc)	0.9-1.3
Specific Gravity	1.6-2.6
Plasticity	Lower or non-plastic
Shrinkage limit (volume stability)	Higher
Grain size	Major fine sand/silt and small percent of clay size particles
Clay(Percent)	Negligible
Free Swell Index	Very low
Classification(texture)	Sandy Silt to Silty loam
Water holding capacity(WHC)(Percent)	40-60
Porosity(Percent)	30-65
Surface area(m2/kg)	500-5000
Lime reactivity (MPa)	1-8

1.3.6 Chemical Composition:

Compounds	% Amount
SiO_2	38-63
Al_2O_3	27-44
TiO_2	0.4-1.8
Fe_2O_3	3.3-6.4
MgO	0.01-0.5
CaO	0.2-8
K_2O	0.04-0.9
Na_2O	0.07-0.43
pH	6-8

The chemical composition and properties may be vary depending upon the type of fly ash. [w8]

1.4 Classification

When the exhaust gas, after burning the coal reach the electrostatic precipitator or filter equipment, the exhaust gases solidifies and form fly ash. But depending upon the type of coal that is burned, the fly ash is classified as follows:

1.4.1 Class C Fly Ash: When burning of younger lignite or sub-bituminous coal is done, class C fly ash is produced. Class C fly ash is often high calcium fly ash with carbon content less than 2%. Class C fly ash, when water added, becomes harder just like cement and gets stronger over time. [w9, w10]

1.4.2 Class F Fly Ash: When burning of harder, older, anthracite and bituminous coal is done, the class F fly ash is produced. Generally, class F fly ashes are low calcium fly ash with carbon content is less than 5%, but sometime it may be as high as 10%. Due to pozzolanic property, the glassy Silica and Alumina of class F fly ashes require a binding agent like Portland cement, lime and when mixed with water, it produces cementitious product. [w9, w10]

1.5 Fly ash: A Hazardous wastage

After burning the coal in power plant, the electrostatic precipitators or filter equipment capture the fly ash before it escapes from the chimney. But at the time of capturing fly ash, it is in the form of gas. After solidification, it forms fly ash. This fly ash contains some toxic substance that can be very harmful to human health as well as environment. It this fly ash waste is not properly controlled, the toxic substance may affect food, drinking water and air. [12, 13]

Fig 2: Fly Ash Wastage [F2]

Some common health problem from this toxic substance of fly ash are:

- When this toxic substance mostly Silica mixed with air, and after inhaled it, lung disease can develop. Furthermore, continuously inhaled Si can form lung cancer, poor oxygen circulation etc. [w11]
- Fly ash tends to remain in air for long time. So, it can enter the body, causes irritation to eyes, skin, nose and throat etc. [w11]

1.6 From wastage to cost effective green product

As fly ash is just a waste material from thermal power plant, it is free of cost. But this waste material contains toxic substance which can harm human health as well as environment. So, it is very important to reuse this material before it harm environment and human health. After go through the properties of fly ash, one more important property i.e. 'pozzolanic' found, which means this can form cementitious product when water and lime added to it. Thus, these fly ashes may be used to make some bricks or cement like product by adding different chemicals on it. [13,14,17]

Fig 3: Fly Ash Bricks [F3]

But the main problem is that fly ash has very low compressive strength. Thus, the product like bricks made from this will easily break during transportation or usage of the product. So, it is necessary to add some material which help to increase the strength. [13, 14, 17]

It is found that some material is available to help the fly ash to gain more compressive strength. For example: Hydrated lime, phosphogypsum, Silicon Sulphate, Sand, Clay, etc. These materials help to increase the bond in between fly ash particle. Thus, the compressive strength is increased. [13, 14, 17]

So, finally it becomes possible to transform a hazardous material to cost-effective green product. But when we consider the strength in between mortar and fly ash brick, it still fails to give enough bonding strength in between them. So, it is necessary to add some extra material to the mortar to give it good bonding strength.

1.7 Advantages of Fly Ash

Though it is a wastage material, still it has huge advantage which is enough to give it a shape of environment friendly product. The advantages of Fly ash are: [w12, w14]

- As fly ash is waste material, it is highly economical.
- The particle size of fly ash is very small, which make the product highly dense and also reduces permeability. Thus, it can provide greater strength to the structure.
- The fire insulation property of fly ash is very high.
- It has ability to gain strength over time.
- It can resist the cold weather when used in construction.
- It has great workability.
- It reduces the crack problems, permeability and bleeding.
- It is considered as non-shrink material.
- It reduces CO_2 emission.
- Due to light weight of the fly ash, the bricks manufactured from fly ash has low weight as compare to conventional bricks. Thus, the overall weight (dead weight) of a building or any construction reduces.
- The area covered by fly ash bricks is normally more than a clay bricks with same number of bricks.
- The fire insulation property of fly ash is very high.

- The fly ash bricks are made with uniform size, so mortar required for plaster and joints reduced by 50%.
- The fly ash bricks don't require any soaking in water for 24 hours. It is enough to sprinkle the water before use.

1.8 Disadvantage of Fly ash

All materials have advantage as well as disadvantage. But if we work on the disadvantage, then it can be solved by using some unique concept. The disadvantages of Fly ash are: [w12, w14]

- The mechanical strength (compressive strength) of fly ash is low. But by adding some other material it can be increase.
- By using fly ash, only modular parts can be produced. The breakage will be more on large size.
- The fly ash bricks have very low tendency to make a bond between mortar and itself.
- The quality of all fly ash is not that good. So, it is important to utilize the right one. Because poor quality has negative impact on the desired product.
- The poor quality of fly ash may increase the permeability, thus damaging the construction.

1.9 Application of Fly Ash

Due to different properties and advantages of the Fly ash, it is used in different applications. The applications are discussed below: [w12, w14]

- In concrete production: Fly ash work as a substitute material for cement and sand.
- In transportation road: Now a day's fly ash is used for road construction. The fly ashes are mixed with different material to construct road. As fly ash gains strength during time, it helps the road to increase its strength over time.
- In brick production: Fly ash is used in the production of bricks, which is economical and has plenty of advantages.
- In the mortar: The strength of the mortar increases over time by using fly ash in it.
- In the Agricultural use: Fly ash is used for soil stabilization, fertilizer etc. But for this the fly ash should have pure substance.

1.10 Mortar: An overview

To combine building blocks together, mortar is used. Mortar acts as a binder in between two. These building blocks can be bricks, stones or concrete masonry unit. The mortar doesn't only bind them together, but also fill as well as seal the gaps between these two. Now a day it is also use as a decorative colour in the wall. [w15, w16]

In generally, mortar is a mixture of sand, water and a binder. The binder can be different according to the type of use. In mostly, the binder is cement. But sometimes, different

Fig 4: Cement Mortar [F4]

binders like lime, recycled aggregate, etc are used. For house wall bricks, the ratio of the proportion of cement, sand and lime are 1:5:2. Water is added as desired. The ratio of the proportion is varied according to the use of the mortar. [w15, w16]

1.11 Classification of mortars

Depending upon the application, there are different mortars used. These mortar types are discussed below:

1.11.1 Ordinary Portland Cement Mortar: It is also known as OPC mortar or cement mortar. The mixture of this mortar contains Ordinary Portland cement, water and fine aggregate. When this mortar is used in the construction, it becomes hard quickly allowing fast construction rate. [w16]

1.11.2 Polymer Cement Mortar: When the cements binders are partially replaced with some polymers, then it becomes polymer cement mortar. It is mainly prepared for repairing the structure. [w16]

1.11.3 Lime Mortar: In the lime mortar, the mixture contains lime, sand and water. It is rarely used, because of slow setting and low compressive strength as compare to cement mortar. However, when it comes to use against softer material like natural stone, lime mortar is used. [w16]

1.11.4 Pozzolanic Mortar: Pozzolana is a volcanic ash. If pozzolana is added to the lime mortar, it allows the mortar quick set and more compressive strength as compare to the lime mortar. This mortar solidifies quickly even under water also. [w16]

1.12 Different technologies to produce fly ash brick

Though the fly ash is economical material, the other material required to produce bricks may not be economical. In some cases, due to depending upon the materials available other than fly ash, the methods to produce fly ash bricks is different. The different possible methods are discussed below: [w17]

1.12.1 Burnt Clay Fly Ash Brick: In this method, the local soil is mixed with fly ash. The amount of soil i.e. clay is more than fly ash. The rest making process is almost similar to normal clay brick making procedure. After mixing the soil and fly ash, water is added to it. Then keep it for some time, and give it a desired shape. After removing from the mould, keep it to dry. [w17]

1.12.2 High Fly Ash Content burnt clay Fly ash brick: In this method, the amount of fly ash is used is high, almost 60% fly ash is used along with soil containing clay. In this method, after mixing of fly ash and soil with high clay, keep it for 12 hours. Then these are keep in the mould box for desired shape. Rice husk can also be mixed along with the fly ash. [w17]

1.12.3 Flux bonded clay fly ash brick: The amount of fly ash used in this process is upto 80%. The soil with high clay, flux additive and water are added to make the mixture as required. Then with the help of mould box, the final shape is obtained. The final product is air dried and fired at 800-1000Degree C. [w17]

1.12.4 Fly Ash Lime – Gypsum Brick: In this method, lime and gypsum are used as binders. These are added to fly ash and sand in the presence of moisture i.e. water. The

amount of the materials is: 50-65% Fly ash, 5% gypsum, 8-12% lime, 20-30% sand. Then the samples are keep it the mould box to obtain the required shape. After obtain the shape, it is air dried for 1-2 days and then water cured is done for 15-21 days. [w17]

1.12.5 Fly ash Cement Brick/Fly ash Cement Gypsum brick: The replacement of lime and gypsum by cement is done in this method. As cement is the one of the strongest binder, so it can be used instead of lime and gypsum with fly ash to make a brick. The amount of materials used in this method are: - 50-60% Fly ash, 8-10% Ordinary Portland cement, 30-40% sand. After mixing these materials, water is added to obtain a desire mixture. Then the final shape of the brick is obtained by using mould box. The air-dried time is 1-2 days. After that water cured is done for 20 days. [w17]

1.12.6 High fly ash content bricks (Through mineral polymerization): The amount of fly ash is used during this process is maximum as compare to previous method. About 90% fly ash is used in this process, liquid caustic soda, water and additive are mixed together in required proportion to make the complete mixture. Then the mixture is keep in the mould to give it a brick shape. After obtaining the brick, it is keep in air for 20 days to dry and gain the compressive strength. [w17]

1.13 Comparison between Fly Ash Bricks and Clay Bricks

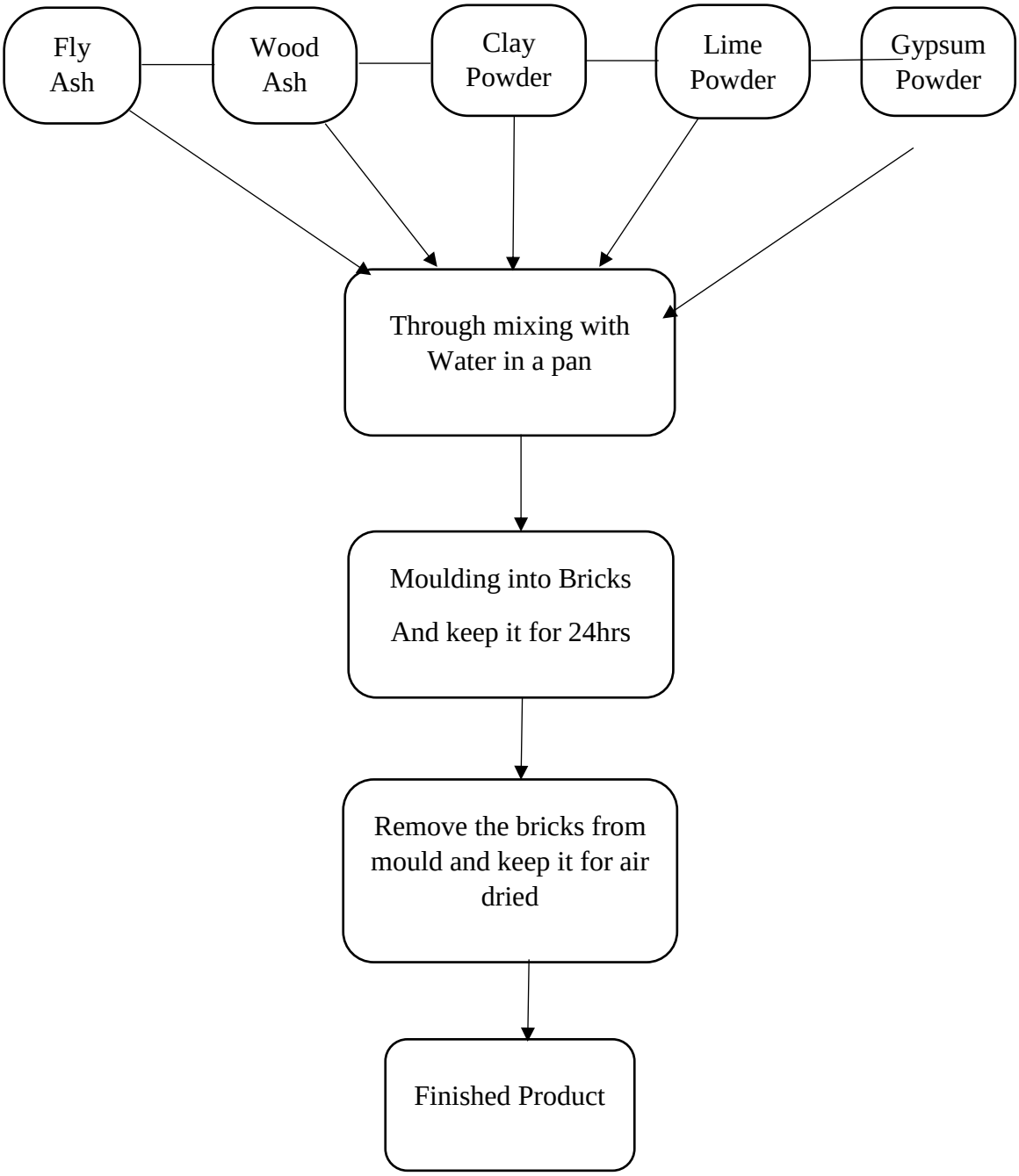
Though the fly ash has low compressive strength, but the strength can be increased by using different binder materials to stand it against normal clay bricks. The comparison between Fly Ash Brick and Clay bricks are discussed below: [w3, w4]

- The fly ash is lighter in weight. So, the bricks made from this is also light in weight. Thus, the overall weight to the construction is reduced as compared to clay bricks. So, the stress induced in the construction building reduces.
- The heat absorption rate of fly ash bricks is very less as compared to normal clay bricks. Thus, during summer the heat inside the room made by fly ash bricks is very less. So, it provides more comfort as compare to normal clay bricks.
- The shape of the Fly ash bricks is uniform in nature. Thus, the plastering doesn't require for making a compound wall of fly ash bricks. So, it becomes more economical.
- The Fly ash bricks are all made in same shape due to the same size mould. For this reason, the mortar required during the construction using fly ash bricks is very less as compared to mortar required for clay bricks construction.

- As fly ash has a pozzolanic property, it provides more compressive strength, when it mixed with lime and water as compare to normal clay bricks. Thus, it is economical as compare to the clay bricks.
- The clay bricks absorb more water than fly ash bricks. Thus, water required in construction of normal clay brick is more as compare to water required for fly ash bricks. Thus, saves money and usage of water in the construction. So, in the rainy season also, fly ash bricks keep the wall strong and durable.

1.14 Flow Chart of Fly Ash Brick Making Procedure

As there are different method to produce a fly ash bricks, the following flow chart shows the optimum method to make a fly ash bricks:



Chapter 2

Scope of the Study

The study of fly ash can make a wastage material beneficial. As there are too many thermal power plant, where the coal is used to generate the power. But this process generates some wastage material like Fly ash, which is harmful for human health. This waste materials are definitely free of cost. The fly ash has pozzolan property, which help to build a cementitious sample when water and lime is added to it. So, if there is a way to reuse this material and make a green product, it should be implement. This study helps to make an economical brick with high compressive strength with strong bond between mortar and bricks. This helps to reduce the waste material. As there are different process already available to make a fly ash bricks with high compressive strength, but somehow it has been using less in construction as compare to normal bricks. The fly ash material can be used in concrete, mortar etc. Thus, the effect of fly ash on human health as mentioned earlier will be less. So, finally a waste material can be converted to some good application.

Chapter 3

Objective of the Study

The fly ash particles have pozzolan property. So, it will be a great job if we use these materials to make an effective product. The objectives of this study are:

- To make a fly ash brick with optimum composition to obtain high compressive strength.
- To obtain strong bond in between mortar and bricks by changing the composition of the mortar.
- To make a cost effective durable fly ash bricks.
- To make the bricks with high shear and tensile strength.
- To make a light weight fly ash brick, so that the total weight of bricks in a building is minimised.

Chapter 4

Review of Literature

Sunil Kumar [2002] studied to develop low cost house by using low cost bricks and hollow blocks with the help of some bricks and hollow blocks, which are more economical and light weight. The material required to develop these bricks and hollow blocks are Fly Ash, Lime and Gypsum. The compressive strength, durability, water absorption test and density of the bricks and blocks were experimented. It was observed that these materials have enough strength to use in low cost development of house. It was concluded that the curing of bricks and hollow blocks by using hot water, increased the strength to the maximum values. [1]

Ashish Kumar Parashar, Rinku Parashar [2012] studied the compressive strength of different bricks. These bricks are made with different materials to clay bricks. The different materials are Wood Ash, Fly Ash, Rice Husk and Cement. After experimentation, it was observed that the bricks with wood ash has the maximum compressive strength as compare to others. The fly ash and rice husk show very less compressive strength. Though cement also shows high compressive strength, but it is not economical. [2]

Akshay Satish More, Ahad Tarade, Ashwani Anant [2014] studied the properties change in the burnt clay bricks when fly ash and rice husk are added to it. The compressive test, water absorption test and density of the bricks were experimented. It was observed that the clay bricks with fly ash shows the optimum performance as required. The compressive strength of the clay bricks with fly ash was 23% greater than normal bricks, also water absorption is below 20% as Indian Standard. [3]

Tayfun Cicek, Mehmet Tanriverdi[2006] studied the properties change in the fly ash bricks when lime is used with steam autoclaved process. The materials required to produce this brick are Fly Ash, Lime and sand. These mixtures were autoclaved with different time and pressure to make the brick sample. It was observed that optimum mixture of the brick was Fly ash 68%, Sand 20% and lime 12%. The optimum autoclaved time and pressure was 6

hours and 1.5 MPa to produce highly effective bricks from fly ash with the autoclaved process. [4]

Xu Lingling, Guo Wei, Wang Tao, Yang Nanru [2004] studied the properties of the fired bricks when fly ash with low quality was used by replacing the clay. The compressive strength and water absorption property of fly ash was improved by using pulverised i.e. fine particle of fly ash. Maximum compressive strength and low water absorption rate were found in the fired brick with high fly ash volume ratio. [5]

Alaa A Shakir, Sivakumar Naganathan, Kamal Nasharuddin Mustafa [2012] studied the properties of the bricks made by using fly ash, quarry dust and billet scale. These materials were used along with cement and water to product the bricks by using non-conventional method. The mechanical properties such as compressive strength, water absorption rate and durability of the bricks were experimented. It was observed that the mechanical properties improved, when the ratio of the fly ash and the billet scale, the quarry dust and the biller scale was kept at 1:1. [6]

Nitin S Naik, B M Bahadure C L Jejurkar [2014] studied the strength and durability of the bricks made from fly ash, gypsum and cement. It was made by using different composition of these materials. The bricks were kept to dry in air for 2 days. The cementitious binding of fly ash, gypsum gave 90% better mechanical strength as compare to clay bricks. The durability was tested by using sulphate solution, and cementitious binding gave low water absorption rate. [7]

Neha Shreya, Biswajit Paul [2015] studied to find the environment management as well as effective use of fly ash to reduce the pollution. It was observed that by using fly ash in effective way, the pollution can be controlled and the waste material can be used as a geoliner constituent materials. [8]

Surender Malik, Bhavana Arora [2015] studied the properties change in the burnt clay bricks, when rice husk and fly ash are added to it. The addition of rice husk and fly ashes

were in different composition to check the change in properties. It was observed that the bricks with fly ash admixtures showed the maximum compressive strength as compare to others. The water absorption rate of fly ash bricks was below 20%. [9]

C Marthong, T P Agrawal [2012] studied the change in properties when fly ash was added to concrete. When fly ash is used as partial replacement of cement on concrete, the durability of the concrete increases. Different percent of fly ash was taken to analyse the best option for increase the strength, durability, etc. After experimentation, it was observed that upto certain limit of fly ash composition, the properties improved. But the limit was not stable for all grades of cement. It was finalized that it happened for all grade of the cement. [10]

Ranjit Kumar Panda, Jyoti Prakash Dhal, Subash Chandra Mishra [2012] studied the strengthening behaviour of the fly ash to make it more effective. The materials used to make the bricks were fly ash, sand, lime, gypsum and sodium silicate. The microstructure and compressive strength of the samples were experimented. It was observed that the compressive strength of the fly ash bricks was increased while a new binder was used i.e. Sodium Silicate. The micro particles were deviated from globular shape in the microstructure. [11]

Dr S L Patil, J N Kale, S Suman [2012] analysed that partial replacement of the fly ash in concrete to increase the strength of the concrete. The composition of fly ash was increased from 5% to 25% (by 5% step) as the replacement of the cement. It was observed that when the cement was replaced with any percentage of fly ash, the strength was decreased and the hardening time delayed. [12]

Nutan C Patel, Prof Jayeshkumar Pitroda [2013] studied an innovative concept to maximize the compressive strength of the fly ash bricks by using Glass Fibre. The bricks were made by using fly ash, sand, lime, kheda dust and glass fibre. From 0.2% to 1.0% of glass fibre was used in the bricks. The compressive testing and water absorption test was investigated.

It was observed that when percent of glass fibre increased, the compressive strength also maximized, and the water absorption rate was decreased. [13]

Rinku Kumar, Neveen Hooda [2014] studied the properties of the fly ash bricks. The compressive strength, water absorption rate, hardness, soundness, efflorescence was studied and compared with the conventional clay bricks. It was observed that the properties of fly ash bricks were far better than normal clay bricks. [14]

Som Nath Sachdeva, Vanita Aggarwal, S M Gupta [2014] studied on Fly Ash Concrete to find the suitability of fly ash in concrete paver block. The fly ash composition was changed as 20% -40% and the experiment was done to find out the compressive strength as well as flexural strength of the concrete. It was observed that all the composition of fly ash obtained the required properties in the concrete. The strength of the fly ash composition was more when they cured it for 90 days. [15]

G Moriconi, V Corinaldesi, R Antonucci [2003] studied to improve the bonding strength between the bricks and the mortar. The materials used in the mortar were fly ash, ground bricks powder and recycled aggregate. The bonding strength in between mortar and bricks were tested. It was observed that the mortar with recycled aggregate showed stronger bonding strength in between brick and the mortar as compare to other form of mortar. Also, the mortar with fly ash or the ground brick powder showed better adhesion property, but the bonding strength was lower as compare to recycled aggregate mortar. [16]

J Paya, J Monzo, M V Borrachero [1999] studied to increase the early bond strength of the mortar by using mineral by product. The mineral by product was FC3R: Fluid Catalytic Cracking Catalyst Residue. The workability of the FC3R was increased by using some superplasticizer. The compressive test was done to check the bonding between mortar and the brick. It was observed that the compressive strength was improved a lot, when cement was replaced by FC3R in the mortar. It was concluded that ground FC3R can be used to increase the mechanical properties in between the mortar and the bricks. [17]

M Zhu, D L Chung [1997] analysed to increase the bonding strength in between bricks and mortar by using a special material. The main material to increase the bonding strength was Carbon Fiber. But, Carbon fiber is not economical material. The bond strength in between the mortar and bricks was improved by 110% under shear, 150% under tension, when carbon fiber of 0.5% of the cement weight was used. It was observed that by adding excess amount of carbon fiber gave less strength due to porosity increased in the mortar. [18]

Masao Kuroda, Tomohide Watanabe, Nariaki Terashi [1999] studied to increase the bond strength at interfacial transition zone with the help of fly ash. When Silica Powder, fly ash, silica fume, gypsum was added to the interfacial zone of new to old paste, the bonding strength developed in between them were experimented. The bonding in the interfacial zone was increased when SiO2 kept high and CaO kept low. It was observed that the interfacial zone structure was varied depending upon the chemical component used. [19]

Min Hong Zhang, Jahidul Islam [2011] studied to increase the early strength of the concrete by reducing settling time with high volume of the fly ash or slag. By using nano-silica, analysed the effect of using it on settling time, rate of cement hydration, strength development with 50% fly ash or slag. It was observed that the nano silica with 12nm particle size showed increased in rate of the cement hydration as compare to Silica fume with particle size 150nm. [20]

Sivakumar Naganathan, Tan Linda [2013] studied the effect of fineness particles of the fly ash on the performance of the cement mortar. The fly ash was grinded to make it finer. The percent of fly ash replaced was from 10% to 40%. The compressive strength, water absorption test was tested experimentally. It was observed that with the increase in fineness of the fly ash particle, the strength was increased and water absorption was decreased to 15%. To improve the strength and limit the water absorption rate, fineness was a very good option. [21]

Sarath Chandra Kumar Bendapudi, Purna Saha [2011] studied to increase the bonding strength in the concrete and mortar by using fly ash. The fly ashes were added as an admixture in concrete and mortar. It was observed that due to pozzolan property, the properties of the concrete and mortar was improved. [22]

Amarnath Yerramala, Rama Chandurdu C, Bhaskar Desai V [2012] studied the influence on strength of the cement mortar, when fly ash is worked as replacement of cement. The various composition of fly was taken, and replaced with cement. The compressive strength was investigated in the different sample. It was observed that 10% replacement of fly ash in the mortar was the optimum one. [23]

Chapter 5

Equipment, Materials and Experimental Setup

5.1 Material for bricks

The study to find the materials to increase the strength of the fly ash bricks has been done. The materials required for making the bricks are Fly Ash, Wood Ash, Clay Powder, Lime, Gypsum. There are total 5 compositions of these material is decided to make bricks and do the testing. These compositions are:

Number/Name	Fly Ash	Wood Ash	Clay Powder	Lime	Gypsum
1	50%	10%	15%	10%	15%
2	55%	10%	15%	15%	5%
3	50%	20%	15%	5%	10%
4	50%	5%	10%	20%	15%
5	65%	0	0	25%	10%

5.2 Material for mortar

The bonding strength of mortar with fly ash brick is not that good. Due to this, breakage in the wall, or many such type of issues developed. Thus, it is important to increase the bonding strength between mortar and the fly ash brick. So, the composition of the mortar has been redefined as follows:

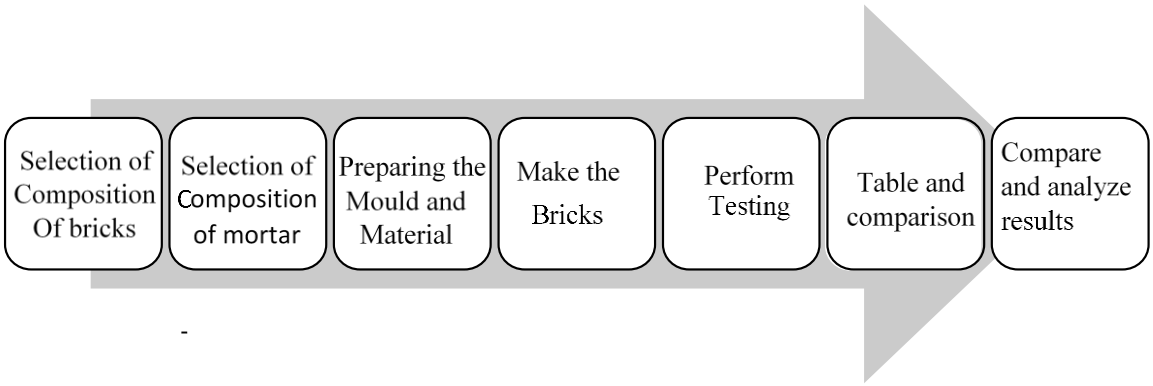
Number/Name	Cement[Ratio]	Sand[Ratio]	Lime[Ratio]
1	1	5	0
2	1	5	2

Chapter 6

Research Methodology

There are tonnes of fly ash produces over a year. As this is waste material and harmful for human health, it is necessary to reuse this material to produce an economical product. Due to pozzolanic property of the fly ash, it becomes harder when water and lime added to it. After done the research on various possible application of fly ash, it is finalized to reuse this material in making fly ash bricks. But, when compared to conventional clay bricks, it shows less strength. To overcome this problem, some other materials are needed. These materials are: gypsum, lime, wood ash. By following moulding process, the sample of these bricks will be produce.

In generally, the bonding strength of mortar and bricks is less. So, to overcome this problem, the composition of mortar has been changed as listed earlier. The complete methodology is listed below:



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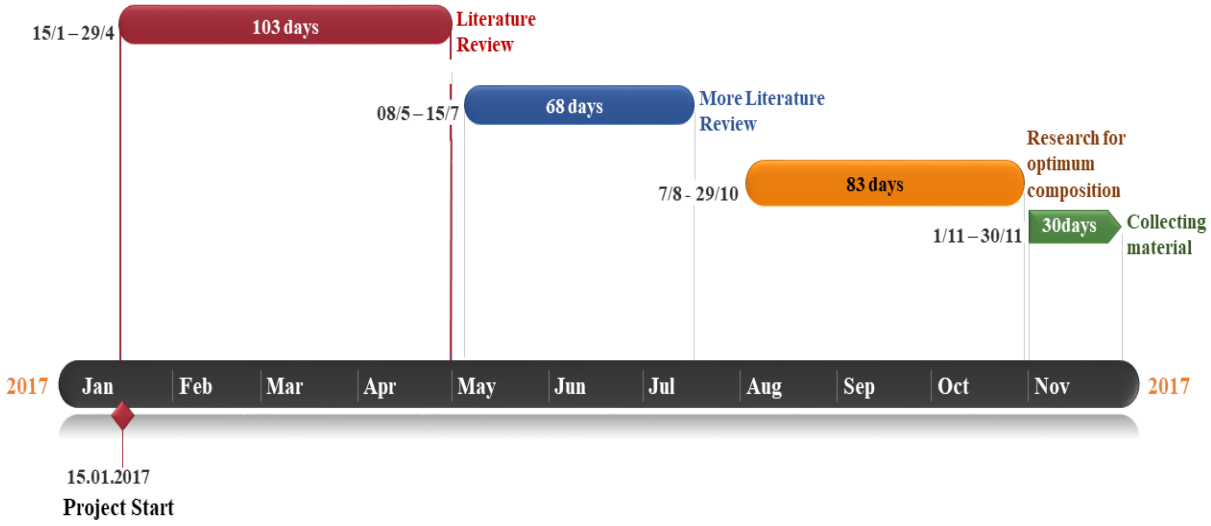
Chapter 7

Proposed work with timeline



Chapter 8

Expected Outcomes

It is expected that the waste material: Fly ash can be used to make a high strength, low cost and light weight bricks. Though the strength of the fly ash bricks is usually lower than the conventional bricks, but by adding some binders, it can be improved. It is finalised that 30 sample will be prepared to perform different test on it.

The bonding strength in between fly ash bricks and the mortar is not that good. Due to which cracking of wall appears. It is expected that the bonding strength can be improved by using binding materials in the mortar.

These are just expected outcomes. The final result will be found after doing the experiment.

Chapter 9

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