

EXPERIMENTAL STUDY ON IRONIZED BRICK (I-BRICK)

Submitted in partial fulfilment of the requirement for the award of

**Bachelor of Engineering
in Civil engineering**

Submitted by,

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade “A” by NAAC

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SATHYABAMA

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **DRAVID KHANNAA .M** (Reg. No 39200015), **JAVADI DEVI VARA PRASAD** (Reg. No. 39200020) who carried out the project entitled "**EXPERIMENTAL STUDY ON IRON BRICK (I-BRICK)**" under our supervision from November 2022 to April 2023.

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1.



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ABSTRACT

Concrete is the second most commonly used material worldwide, and cement production is responsible for 8% - 10% of total carbon dioxide emissions. Our project involves conducting experimental research on an innovative iron-based binding compound known as I-Brick, which has the potential to be an exceptional replacement for cement in OPC brick, and produce a carbon-free building material. The primary objective of this project is to compare the environmental impact of I-Brick with that of ordinary Portland cement (OPC) blocks. Several active researchers have spent several days trying to reduce greenhouse gas emissions such as carbon dioxide.

I-Brick utilizes over 95% of recycled materials, and a compressive strength test was conducted to compare its performance with other materials. Additionally, the materials used in I-Brick are renewable. Hence It can be called as true eco-friendly material Materials like iron powder are the by products from the iron ore process to prevent the depletion for natural resource. This iron powder is used as binding material and other materials like silica fume and limestone are used as best alternative of cement. Three different mix proportion with four brick in each proportion are been prepared to find the optimum mix proportion. The mechanical properties like compressive strength are been conducted to find the perfect mix proportion.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Concrete is a highly consumed material globally, with India ranking as the second largest producer of cement in the world. However, the production process of clinker results in the formation of approximately 8%-10% of total carbon dioxide emissions. While historically concrete has been a vital factor in the growth of major cities worldwide, researchers are now primarily focused on reducing the environmental impact associated with concrete and cement production. The sustainable construction industry has seen an increase in the use of cement alternatives, such as the "I-BRICK." This innovative substitute for Ordinary Portland Cement (OPC) brick is made using more than 95% recycled materials, making it a truly eco-friendly material.

The production process of OPC Brick does not require heat for catalysation, and carbon dioxide is compressed to accelerate the curing process. The demand for cement and natural aggregates (NA) is expected to increase significantly worldwide, with the consumption of NA in the US alone exceeding 2 billion tons annually and projected to rise to over 2.5 billion tons by 2020. With an anticipated increase in natural aggregate demand to approximately 18 billion tons per year by 2050, I-BRICK presents a promising alternative. Additionally, the use of iron powder from the iron ore industry can effectively address several environmental issues, such as reducing CO₂ emissions and minimizing disposal areas.

This paper presents the feasibility of usage of iron powder, silica fume and metakaolin as substitutes for the cement in the conventional fly ash brick.

1.2 HISTORY

In the early 2000s, Ferrock was invented by chance when Dr. David Stone, the founder of Iron Shell Media Technologies and a former PhD student at the University of Arizona, was investigating methods to prevent iron corrosion and strengthening. During his research, he inadvertently developed Ferrock, which is five times more robust than standard Portland cement (a powdery building substance consisting of chalk, concrete, mortar, and clay) and has the ability to endure greater compression caused by seismic events.

Although alternative building methods are gaining popularity in Australia due to the unfavorable climate and heat conditions that traditional building materials are unable to withstand, the popularity of Ferrock in the country seems to be hampered by its production process which requires a considerable amount of silica and metal shavings. Since these materials are limited in supply, Ferrock is not a suitable option for many builders despite its benefits.

1.3 EXISTING PROBLEMS

1. According to the estimation of the global climate catastrophe, around 600kg of carbon dioxide is emitted per ton of cement production, as reported in 2016
2. According to Dathade et al. in 2014, there is a significant worldwide demand for cement and natural aggregates. In the United States alone, around 2 billion tons of natural aggregates are utilized in construction annually.
3. According to the UN report, it is projected that by 2030, emissions will reach 54 to 56 gigatons of carbon dioxide equivalent, exceeding the required level of 42 to have any possibility of limiting global warming to 2 degrees Celsius this century.
4. The demand for natural aggregates is on the rise and is projected to reach around 18 billion tons per year by 2050. In order to meet this level of consumption, I-BRICK would be a suitable substitute.

CHAPTER 2

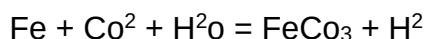
LITERATURE REVIEW

2.1 GENERAL

Vijayan D.S et al., (2018) All the material used in manufacture of concrete has to be tested and their characteristic behaviour should be noted using stipulated value. All the value and mix proportion are referred from this journal and the chemical reaction process is derived is noted as- $\text{Fe} + 2\text{Co}^2 + \text{H}_2\text{O} = \text{Fe}^2 + 2\text{HCo}_3 + \text{H}^2$



Net reaction



After complete curing, the sample contains approximately 8 to 11% captured CO₂ by weight, while the weight of cement can be substituted with 8% to 12% iron powder. From this journal we have noted the initial and final setting time of the ferrock and observed the mix ratio of 1:2.2:3:1 cement, fine aggregate, coarse aggregate respectively based on IS 516-1959.

Karupasamy. S et al., (2019) From this journal we got idea of flow chart for the process included in this project. In the brick, iron powder serves as a binding material, providing additional strength compared to standard Portland cement. and we should apply load increasingly at rate of 140kg/cm² per min, Until the cube collapse and ferrock compression test value get 35KN in 28 days where as in OPC brick get 38KN in 28 days. The entire process from quarrying the raw material to the casting and curing is noted from this journal and using of oxalic acid for maintain the Workability and resist the corrosion of iron powder and additional study by Rod Jones, Newlands was also utilized to obtain more comprehensive information on the environmental consequences of limestone, silica fume, and fly ash. Hence ferrock give an equal strength of OPC Conventional brick.

2.2 FERROCK

Alejandro, Lanuza Garcia et al., (2017) Life cycle analysis (LCA) is utilized to compare the environmental impact of Ferrock and ordinary Portland cement (OPC) from a cradle-to-gate perspective. This process-based LCA includes an extensive literature review and a comprehensive environmental assessment utilizing 60% iron powder, 20% fly ash, 10% limestone, 5% silica fume, and 5% metakaolin, with a water to solid ratio (W/S) of 0.21, ranging from 0.18 to 0.30. Ferrock exhibits typical strength in the range of 5000 to 7500 Psi, and in some cases, as high as 10,000 Psi. The formal structure of LCA is defined by the International Organization for Standardization in ISO 14040. The use of iron powder with a particle size of 19.03um, Class F fly ash conforming to ASTM C 618, and limestone with a particle size of 0.7um has been noted. Additionally, a system diagram of Ferrock has been provided. The iron-based binder required a shorter amount of time to cure than OPC, and Ferrock is less brittle compared to concrete. The shorter cure time of Ferrock allows for compressed project construction schedules. The primary objective of LCA is to compare Ferrock and ordinary Portland cement in terms of their impact on carbon emissions.

Mazloom .M et al., (2016) The focus of the research was on concrete mixes with a constant total binder content of 500 kg/m³ and a fixed water/binder ratio of 0.35. The study assessed the workability of fresh concrete and mechanical properties such as the development of compressive strength, secant modulus of elasticity, and strain caused by shrinkage, creep, swelling, and moisture movement, using silica fume replacement percentages of 0%, 6%, 10%, and 15% for cement. The findings of the research suggest that while the workability of concrete decreased as the proportion of silica fume increased, its short-term mechanical properties, such as 28-day compressive strength and secant modulus, improved.

Arabani .M et al., (2015) The examination of specific scenarios, such as incorporating blast furnace slag and metallic materials from discarded electronic devices, has significantly enhanced the fatigue resistance and ability of hot mix asphalt (HMA) to withstand repeated loading.

Em.O.Univ.Prof et al., (2017) In this paper, we take into consideration two conventional materials that are used in construction, Ordinary Portland cement and fiberglass insulation. And replace them with their green and sustainable alternatives Ferrocrete and Hempcrete. Hempcrete is a bio-composite material that consists of hemp hurds (shives), lime and sand. The lime-based binder undergoes a carbonation process in which CO₂ is absorbed.

Venkatesan.B and M. Venuga, (2018) Experimental study on concrete using partial replacement of cement by alccofine fine aggregate as iron powder. The compressive strength increases by 20.52% by adding 10% of alccofine in cement as a result after 28 days of curing it attain 38.14 N/mm². The study assessed several mechanical properties, including compressive strength development, secant modulus of elasticity, and strains caused by creep, shrinkage, swelling, and moisture movement.

Jones, R. et al. (2011) "Fly Ash Route to Low Embodied CO₂ and Implications for Concrete Construction". 2011 World of Coal Ash (WOCA) All the ingredients required for the production of Ferrocrete, except iron powder, are conventional industrial materials. A scientific report titled "Sustainability of Construction Materials" was the primary source of literature used for obtaining information about fly ash and metakaolin for this study. Chapter 17 of the report was specifically referred to due to its focus on clinker material production. This chapter provides a comprehensive review of the technical characteristics of composite cements and other low clinker cement mixtures, as well as their components, including a review of the emissions associated with these materials. The environmental impact of limestone was obtained from the limestone material fact sheet published by the Natural Stone Council, which includes a review of the products, applications, performance, physical properties, and environmental data of this material. Additionally, a study by Rod Jones, Michael McCarthy, and Moray Newlands was used to obtain more general information about the environmental impacts of limestone, metakaolin, and fly ash in terms of GWP, water, and energy use.

2.3 FLY ASH BLOCK

Deborah N et al., (2020) The cement manufacturing process not only generates significant amounts of CO₂ but also produces millions of tons of cement kiln dust (CKD) waste annually, posing respiratory and pollution health risks. This paper employs LCA to assess the environmental impact of four cement manufacturing techniques: (1) conventional Portland cement production, (2) blended cement with natural pozzolans, (3) recycling 100% of waste CKD into the kiln process, and (4) Portland cement produced by utilizing CKD to sequester a fraction of the CO₂ emissions. The recycling of CKD was found to offer little environmental benefit compared to the traditional process.

Magudeaswaran et al., (2018) The production of concrete, which relies heavily on natural resources, has raised concerns about its environmental impact. It is the most commonly used construction material globally, second only to water, and the cement industry is responsible for significant carbon dioxide emissions, accounting for up to 5-8% of human-made emissions worldwide. This gas is generated primarily from the chemical process and burning, with the cement industry being one of the largest producers.

Fera Al Adday et al., (2018) Recycled concrete aggregate (RCA) refers to the use of recycled aggregate (RA) as a partial or complete replacement for natural aggregate (NA) in a concrete mix. The demand for NA is steadily increasing and is projected to reach 1-8 billion tons per year by 2050. In order to investigate the properties of RCA, Tiuari and Nateriya utilized the Indian standard code to prepare concrete cubes with varying percentages of RA (0%, 50%, and 100%). They also used different percentages of iron powder and silica fume (10%, 15%, and 20%) in place of fine aggregate. The researchers used a cubic mold measuring 150x150x150mm to create bricks for infrastructure and residential building applications. Various percentages of superplasticizer (0.6, 0.8, 1.2, 1.8, and 2.5) were used, and it was observed that increasing the dose of superplasticizer led to an increase in the rate of performance.

Mihail CHIRA et al. (2012) In this paper, various materials used in construction, including natural, conventional, and innovative materials, are discussed. Future sustainable solutions such as Breathe Brick, which filters air from pollutants, Ferrock concrete that absorbs carbon dioxide, nanoparticle thermal insulating materials, and metamaterials used for acoustic insulation are also presented. The paper emphasizes the importance of sustainable development, which according to the definition given in the Brundtland Report, refers to development that meets current needs without jeopardizing future generations' ability to meet their own needs (Asdrubali, 2012).

Kumar, S Arun Prakash s, (2019) The study examines the impact of incorporating phase change materials (PCMs) into clay hollow bricks for use in building envelopes, aimed at managing thermal energy in energy-efficient buildings. Results show that the temperature decrease in a room with PCM is between 6 C to 2 C, compared to a room without PCM, and varies depending on the month.

Yoon-Ho Cho, Taeyoung Yun, In Tai Kim, and NyoungRak Choi. (2011) The use of recycled concrete aggregate (RCA) as a base layer aggregate for hot mix asphalt (HMA) is explored in the KSCE Journal of Civil Engineering. Sustainable mixes can be produced with RCA by crushing concrete aggregate into various sizes and adding fillers to improve its properties, given its high porosity and low specific gravity compared to conventional aggregate. To increase the strength of concrete mixes with recycled aggregate, various types of filler can be added. Junak and Sicakova experimented with improving the mechanical properties of RCA by preparing 24 standard cubes (100x100x100mm) with different percentages of coating filler, such as coal fly ash, liquid glass, and 8M NaOH solution.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

1. To find compressive strength and tensile strength of brick.
2. To make it cost effective compared to OPC brick.
3. To produce a carbon free conventional material.
4. To find the best ratio of mix proportion to attain the maximum strength.

3.1 SCOPE OF THE PRESENT STUDY

1. As the scope of the project, we aim to create a truly eco-friendly conventional material that can be compared to OPC blocks.
2. Although iron powder is currently being used as a raw material, it is also possible to use iron pellets instead.
3. While the cost of the brick may be higher than other options, the increased strength provided by the brick justifies the added cost.
4. The usage of metakaolin and limestone in this brick will help to maintain a consistent temperature and resist most of the heat, thereby helping to regulate the temperature inside.

CHAPTER 4

MATERIALS USED

4.1 MATERIALS AND PROPERTIES

4.1.1 Cements



Fig 4.1 Cement

Investigating the properties of cement is always desirable to ensure the most effective use in construction. However, it is important to note that the properties of cement can vary depending on the type of construction. Generally, a good quality cement should possess the following properties. The image of material is shown in Fig 4.1 and specification on Table 4.1.

Cement with higher fineness tends to have higher strength, while uniformity in its properties results in greater consistency. Therefore, it is recommended to use cement with high consistency to achieve optimal performance.

Table 4.1 Cement properties

S.No.	Properties	value
1	Specific gravity	3.16
2	Consistency	32%
3	Initial setting time	45 min
4	Final setting time	480 min

4.1.2 Fly ash (IS-3812-1981)



Fig 4.2 Fly ash

Fly ash is a by-product material that is produced during the process of coal combustion in power stations, resulting in heterogeneous, spherical, glassy particles that mix with flue gases. The pozzolanic material components present in fly ash react with lime to produce cementitious material. The image of material is shown in Fig 4.2 and specification on Table 4.2.

Fly ash is composed mainly of silicon, aluminium, iron, and calcium oxides. Its use as a mineral admixture in concrete categorizes it into either Class C or Class F ash, based on its chemical composition.

Table 4.2 Fly ash properties

S.No.	Properties	value
1	Specific gravity	2.96
2	Finesse	45micron
3	Size	10 to 100 micron
4	Colour	Dark grey or brownish

4.1.3 Silica fume



Fig 4.3 Silica fume

Silica fume, which contains 90% silicon dioxide, is utilized to enhance the properties of concrete and cement by increasing bond strength, improving compressive strength, and reducing permeability. It aids in protecting steel against corrosion and binding limestone with iron powder. In addition, it improves the setting time of the mix proportion.

Silica fume in its condensed form is a highly reactive and finely grained mineral admixture that easily reacts with calcium hydroxide, which is generated during the hydration of Portland cement. The image of material is shown in Fig 4.3 and specification on Table 4.3.

By reducing the heat generated during cement hydration, improving resistance to sulphate and acidic waters, and enhancing strength, these measures can mitigate thermal cracking.

Table 4.3 Silica fume properties

S.No.	Properties	value
1	Particle size	0.1 - 0.2 micron
2	Surface area	30,000 m ² /kg
3	Density	150 – 700 kg/m ³
4	Colour	Black or dark grey

4.1.4 Metakaolin



Fig 4.4 Metakaolin

This pozzolanic material is produced by calcining high purity kaolin clay at temperatures ranging from 700°C to 800°C, and its reactivity in concrete is based on its chemical composition and reactive surface. Its particle size is smaller than that of cement particles. The image of material is shown in Fig 4.4 and specification on Table 4.4.

Metakaolin, which is commonly utilized in the production of ceramics, can also serve as a replacement for cement in concrete. Presence of metakaolin strengthens the matrix of pervious concrete thereby enhancing its mechanical properties.

An optimal replacement level of cement with metakaolin is found to be 15% for mixes with 12.5 mm and 20 mm sized aggregates. This replacement level results in a reduction in pore size, leading to improved strength, higher density, and greater resistance to acid.

Table 4.4 Metakaolin properties

S.No.	Properties	value
1	Specific gravity	2.60
2	Bulk density	0.3 – 0.4 g/cm ³
3	Density	1.8 – 2.1 g/cm ³
4	Colour	Half white

4.1.5 Limestone

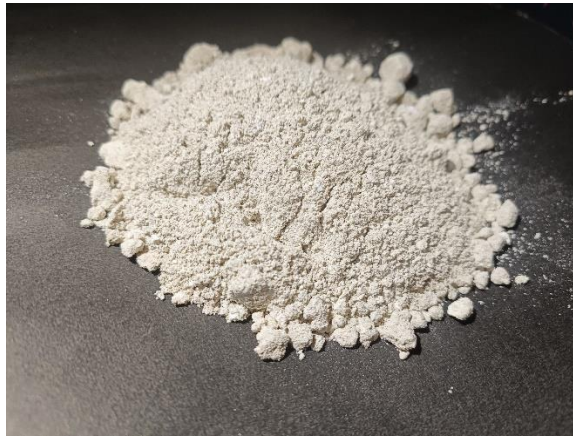


Fig 4.5 Limestone

The durability of Portland cement concrete is noteworthy, although it has lower resistance to freezing and thawing when compared to pure cement concrete. The presence of limestone, which constitutes about 20% of Portland cement, provides optimum protection against corrosion of reinforcement bars. Additionally, it aids in the binding of the mix proportion.

Lime also has major applications in the manufacture of glass and in agriculture. Additionally, limestones containing clay content which are utilised in the production of cement. The image of material is shown in Fig 4.5 and specification on Table 4.5.

Manufacturers are aware that incorporating ground limestone in Portland cement, instead of clinker, provides advantages, with the primary benefit being the reduction of the cement's embodied CO₂.

Table 4.5 Limestone properties

S.No.	Properties	value
1	Specific gravity	2.3 – 2.7
2	Bulk density	2709 kg/m ³
3	Density	2.71 g/cm ³
4	Colour	White or grey

4.1.6 Calcium Nitrate $\text{Ca}(\text{NO}_3)_2 \cdot 4(\text{H}_2\text{O})$



Fig 4.6 Calcium nitrate

Calcium nitrate can be utilized in various ways, including as a set accelerator, plasticizer, long-term strength enhancer, and antifreeze admixture. Its role as a binding material and the quantity added can impact the properties of the concrete mix. The image of material is shown in Fig 4.6 and specification on Table 4.6.

Table 4.6 Calcium nitrate properties

S.No.	Properties	value
1	Molar Mass	164.088 g/mol
2	Density	2.504 g/cm ³
3	Structure	Crystal
4	Colour	Colour less

4.1.7 Iron Powder



Fig 4.7 Iron powder

Calcium nitrate can be utilized in various ways, including as a set accelerator, plasticizer, long-term strength enhancer, and antifreeze admixture. Its role as a binding material and the quantity added can impact the properties of the concrete mix and the strength of the cured concrete. The image of material is shown in Fig 4.7.

4.2 CASTING OF SPECIMENS

4.2.1 Specification of Specimens

1. Each specimen weight between 2400-2800 grams. The material we brought for the project are shown in the table.
2. The quantities and cost of the total project are explained in detail in this table.
3. The dimension of brick is 230mmx110mmx70mm (Length x breath x depth).
4. The mould for the specimens is shown in fig 4.8.

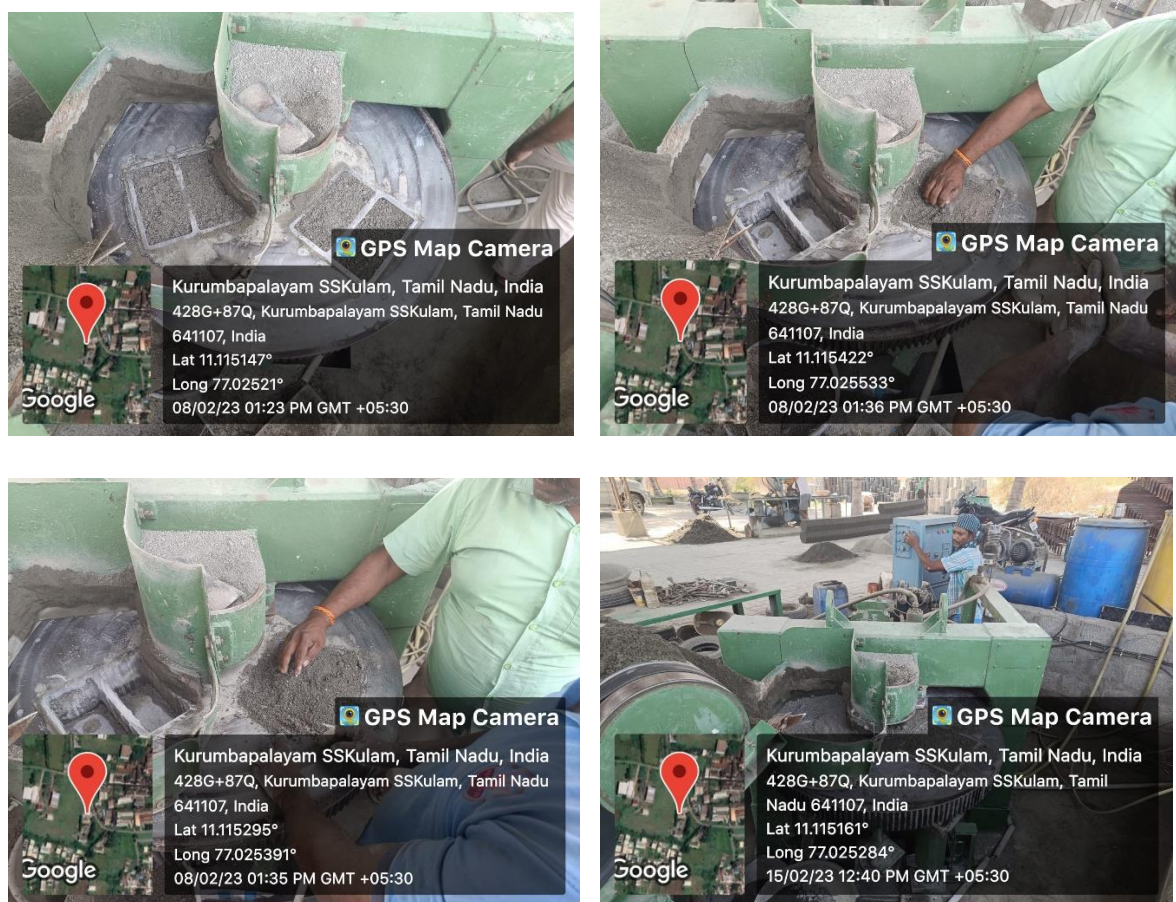


Fig 4.8 Casting of specimen

4.2.1 Total Cost and No of Specimen

Totally 32 blocks were casted and cured in room temperature. The mould was divided into four groups **MIX1, MIX2, MIX 2 and FLYASH BLOCK**. Based on the percentage of materials added in table detail quantities and cost of the project are shown in the table 4.7. From this we can roughly estimate the cost of the brick.

To determine the cost of producing these bricks, the percentages of materials added to each of the four groups would have been considered, along with the detailed quantities of these materials.

Table 4.7 No of specimen

MATERIALS	I-BRICK NUMBERS	FLY ASH BLOCK NUMBERS	QUATITIES /KG	COST /KG (rs)
M-SAND	24	8	40	7
LIMESTONE	24	-	30	10
GYPSUM	-	8	5	12
IRONPOWDER	24	-	6	300
CALCIUM	24	-	1	300
CEMENT	-	8	6	12
METAKAOLINE	24	-	7	60
SILICA FUME	24	8	7	70
			TOTAL =	3722

4.3 MIX DESIGN

4.3.1 Mix Design of “I-BRICK”

Let's consider the 3 different proportion as “mix 1”, “mix 2” and “mix 3”.

Table 4.8 Mix design of I-BRICK

MATERIALS	MIX 1	MIX 2	MIX 3
M- sand	40%	45%	55%
Limestone	18%	25%	20%
Metakaolin	15%	10%	7%
Silica fume	15%	10%	7%
Iron powder	10%	8%	10%
Calcium Nitrate	2%	2%	2%

4.3.2 Mix Design of Fly Ash block

Table 4.9 Mix design of fly ash block

MATERIALS	MIX DESIGN
M-SAND	70%
FLYASH	15%
Cement	10%
Gypsum/Quarry dust	5%

CHAPTER 5

METHODS USED AND TESTING

5.1 METHODOLOGY

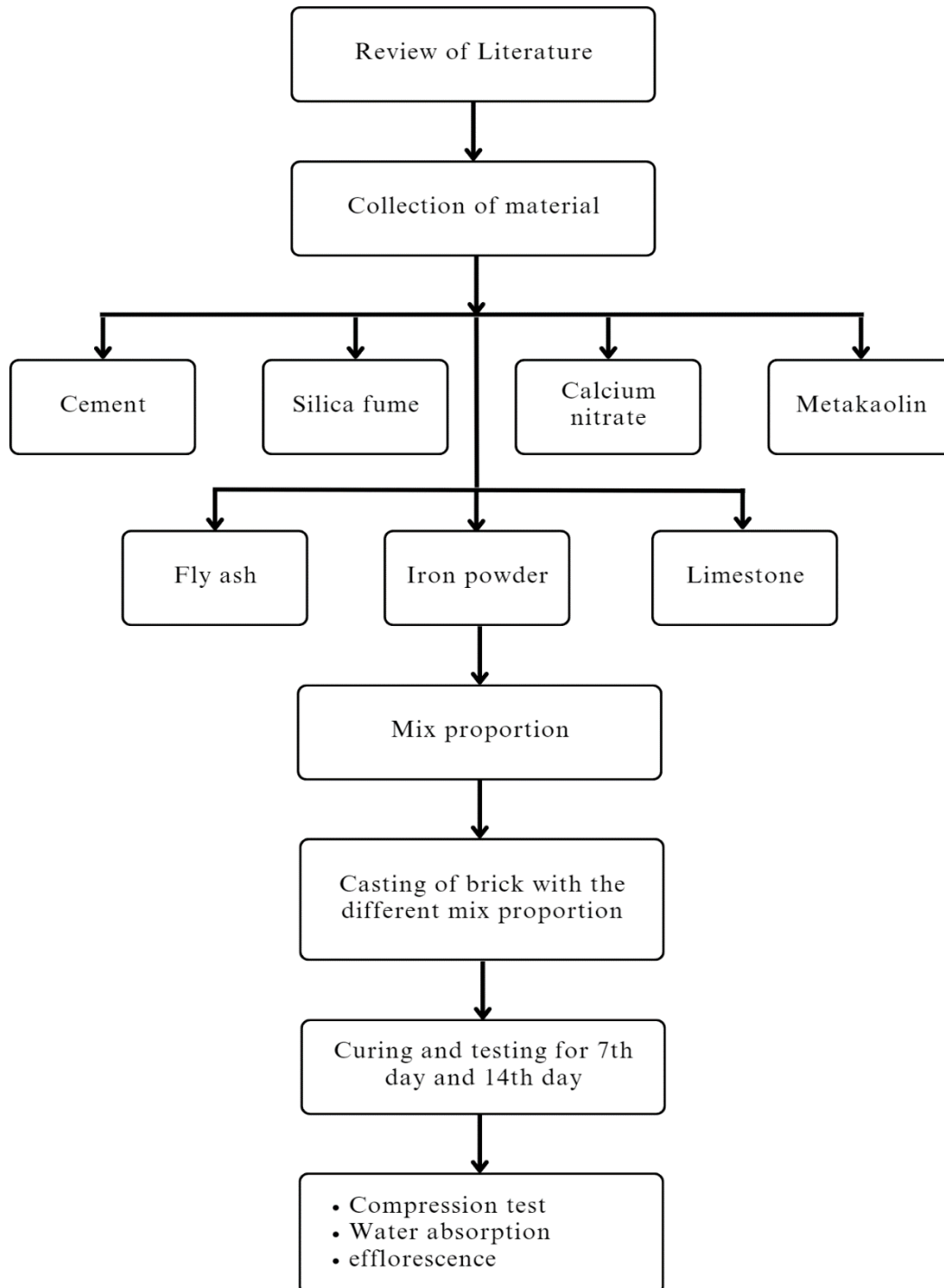


Fig 5.1 Methodology Flow chart

5.1.1 'I-BRICK' Methodology

1. Raw materials like iron ore and limestone are collected by quarrying in mining areas
2. By-products such as silica fume and fly ash are collected from factories for use in various industries.
3. The raw materials collected from quarrying are processed by crushing them to the required size and properties.
4. Iron powder is collected from the waste of iron and steel industries for use in various applications.
5. The limestone, fly ash, iron ore or iron pellets are ground to facilitate blending and mixing in the industry.
6. The subsequent stage is to combine the essential elements, including iron powder, fly ash, limestone, silica fume, and metakaolin, in the prescribed ratios.
7. Silica fume and Metakaolin are added to the mixture for their ability to resist corrosion, increase durability, and reduce carbon emissions.
8. We use a cubic mould measuring (230x110x75mm) to mould the brick mortar.
9. Moulded brick is kept dry for curing process and further test will be done.
10. As a step of the curing process, we make sure the water is sprayed every 12 hours all over the surface of the brick.
11. The methodology flow chart is shown in Fig 5.1

5.1.2 'I-BRICK' Methodology Flow chart

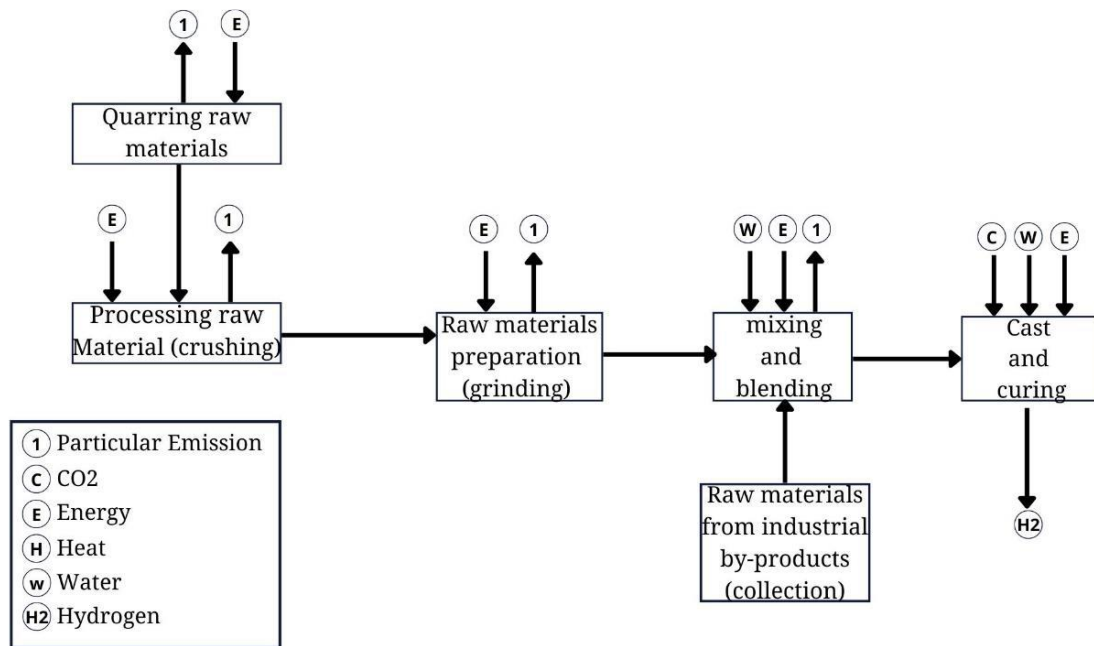


Fig 5.2 I-BRICK Flow chart

5.1.3 Fly Ash block Methodology

1. Raw materials like m- sand and limestone are collected by quarrying in mining areas.
2. By-products such as quarry dust and fly ash are collected from factories for use in various industries.
3. By-products such as quarry dust and fly ash are collected from factories for use in various industries.
4. cement is collected from the waste of cement industries for use in various applications.
5. The limestone and fly ash from the industry are ground for the purpose of blending and mixing.
6. The next step involves mixing the raw materials, such as cement, fly ash, quarry dust, and fine aggregate, in the required proportions.

7. We use a cubic mould measuring (230x110x75mm) to mould the brick mortar.
8. As a step of the curing process, we make sure the water is sprayed every 12 hours all over the surface of the brick.
9. Moulded brick Is kept dry for curing process and further test will be done.
10. The methodology flow chart is shown in Fig 5.1

5.1.4 Fly Ash block Methodology Flow chart

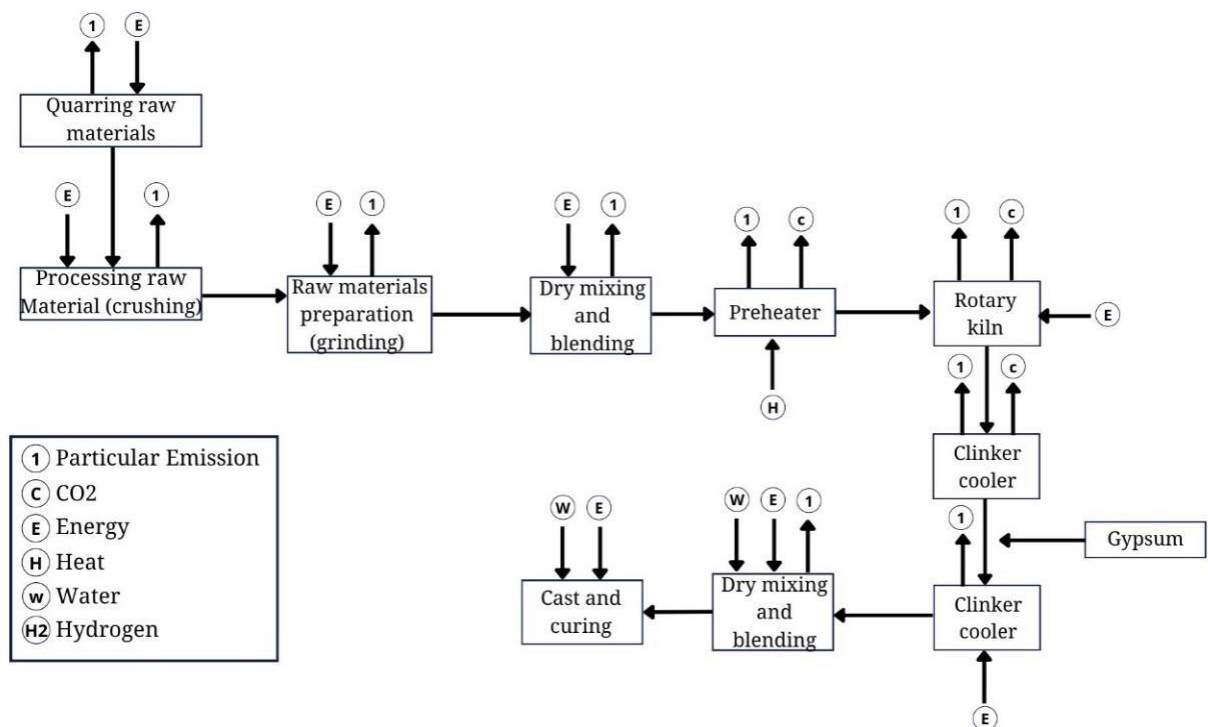


Fig 5.3 Fly ash Flow chart

5.2 TESTING PROCEDURE

5.2.1 Compression test

According to the testing procedure specified in IS 3495 (Part 2), the bricks must be immersed in cold water for 24 hours and should not have an average water absorption exceeding 20 percent by mass for class 12.5 or 15 percent by mass for higher classes.

If any of the wet compressive strength test results exceed the upper limit for the class, they will be considered as the upper limit of the class while averaging. The test machine is shown in the fig 5.4.

PROCEDURE

To conduct the compressive strength test, position the perforated sides of the brick in the center of two 3-ply plywood sheets, each with a thickness of 3 mm. Then, place the sample between the plates of the testing machine, ensuring that it is centered. Apply an axial load uniformly at a rate of 14 N/mm² (140 kg/cm²) per minute until failure occurs, and record the maximum load at failure. The maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine shall be considered the load at failure.

Compressive strength in N/mm sq. (kg/cm sq.) =

$$\frac{\text{Maximum load at failure in N (kg.)}}{\text{Average net area of the two faces under compression in mm sq. (cm sq.)}}$$



Fig 5.4 Compression test machine

5.2.2 Water Absorption test

When subjected to the testing method outlined in IS 3495 (Part 2) after being immersed in cold water for 24 hours, bricks should display an average water absorption of no more than 20% by mass for classes up to 12.5 and 15% by mass for higher classes.

To precondition the specimen, it should be dried in a ventilated oven at a temperature ranging from 105°C to 115°C until it reaches a substantially constant mass. Afterward, allow the specimen to cool down to room temperature and measure its weight, denoted as M1. Do not use a specimen that feels warm to the touch for this purpose. The image of the water absorption test is given in Fig 5.5.

PROCEDURE

1. Submerge the thoroughly dried specimen entirely in fresh water maintained at a temperature of $27 \pm 2^{\circ}\text{C}$ for a duration of 24 hours.
2. After removing the specimen from water, use a damp cloth to wipe off any remaining moisture and obtain its weight (M2) by completing the weighing process 3 minutes after the specimen has been removed from the water.
3. The percentage of water absorption by mass, after 24-hour immersion in cold water, can be calculated using the following formula.

$$\frac{M_2 - M_1}{M_1} \times 100$$



Fig 5.5 Water absorption test apparatus

5.2.3 Efflorescence test

The bricks, upon testing in accordance with the procedure specified in IS 3495 (Part 3), must have an efflorescence rating not exceeding moderate up to Class 12.5 and 'slight' for higher classes. The image of efflorescence test is given in Fig 5.6.

PROCEDURE

1. Measurements of dimensions shall be taken with an accuracy of 1 millimetre.
2. Calibration of all equipment and testing apparatus must be carried out regularly.
3. The selection of the number of specimens for the test shall be in accordance with the guidelines specified in IS 5454: 1976.



Fig 5.6 Efflorescence apparatus

CHAPTER 6

RESULT AND DISCUSSION

6.1 TEST RESULT

The results obtained by conducting experiment are presented here.

6.2 COMPRESSION TEST

The casted brick blocks have been tested and the compression test result are listed in table 6.1 and fig 6.1.

The test report of both 7th day and 14th day are shown in fig 6.2.

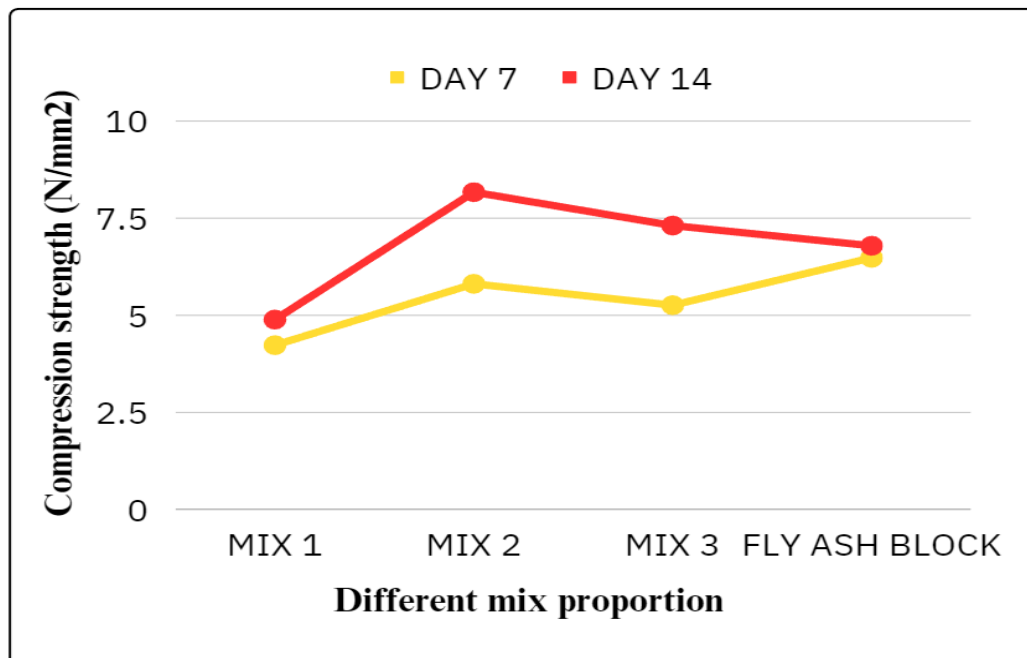


Fig 6.1 Compression Strength Test

Table 6.1 Compression Strength Test result

PROPORTION	DAY 7	DAY 14
Mix 1	4.23	4.89
Mix 2	5.81	8.17
Mix 3	5.26	6.79
Fly ash block	6.48	7.31



Fig 6.2 Compression Test

6.3 WATER ABSORPTION

The casted brick blocks have been tested and the water absorption result are listed in table 6.2 and fig 6.3.

The test report of Water absorption in the brick are shown in fig 6.4.

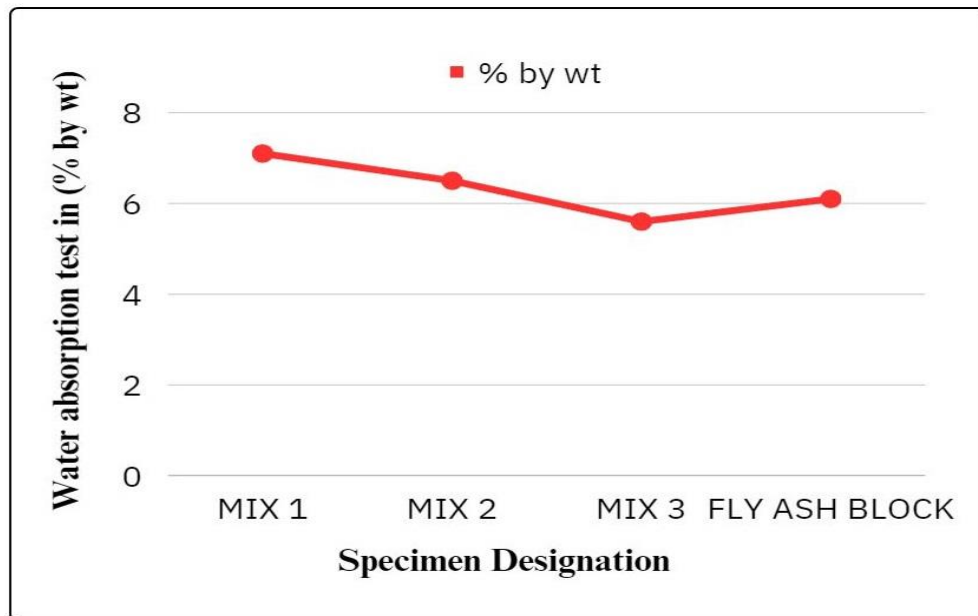


Fig 6.3 Water Absorption Test

Table 6.2 Water absorption Test Result

PROPERTIES	% BY WT
Mix 1	7.10
Mix 2	6.50
Mix 3	5.60
Fly ash brick	6.10



Fig 6.4 Water absorption Test Result

6.4 EFFLORESCENCE TEST

The casted brick blocks have been tested and the efflorescence result are listed in table 6.3 and fig 6.5.

The casted brick blocks have been tested and the efflorescence result are listed in table 6.3 and fig 6.5.

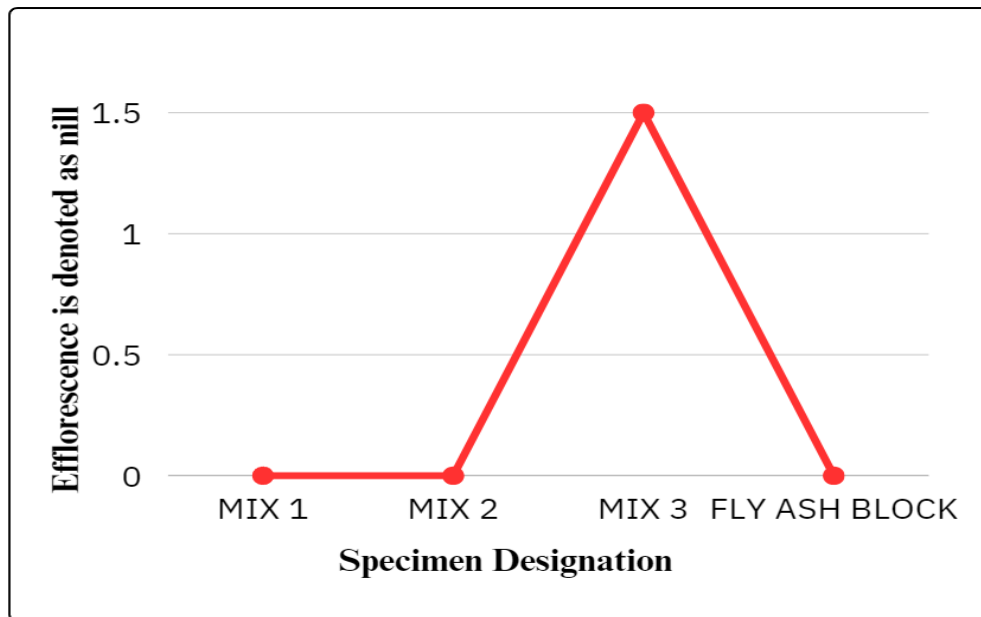


Fig 6.5 Efflorescence of specimen

Table 6.3 Efflorescence of specimen result

PROPERTIES	INDICATION
Mix 1	Nil
Mix 2	Nil
Mix 3	Slightly
Fly ash brick	Nil



Fig 6.6 Efflorescence test Result

6.5 ECONOMIC AND COST ANALYSIS SPECIMEN

Estimation refers to the anticipated or probable cost of a project, and it is typically determined before construction begins. Knowing the estimated cost of a project is essential before undertaking any work. This estimate is derived by calculating the quantities required and determining the cost at appropriate rates. By doing so, it is possible to obtain an accurate projection of the expected expenses that will arise during the construction of the work.

Economy is a significant consideration in construction. From the engineer's point of view, the cost of I-Bricks is slightly higher than conventional fly ash bricks. However, the compressive strength results are as expected, with I-Bricks exhibiting more strength compared to fly ash bricks. The use of Iron powder is slightly more expensive and we can also use iron pellets from iron ore industries and the cost of the brick is shown in fig 6.4.

The total cost of the project and cost of the materials are already shown in table 5.6. The total weight of each brick is between 2400 and 2800 grams. The cost of each mix proportion is shown in the tables below. The cost of each brick with detailed quantity and cost is shown in table 6.4, 6.5, 6.6, 6.7. The image of each proportion I-Brick and fly ash brick is shown in fig 6.7, 6.8, 6.9, 6.10 and as the result and I-Brick higher in cost.

6.5.1 Cost of single I-Brick in mix 1

Table 6.4 Cost of single I-BRICK in Mix 1

MATERIAL	QNT IN (%)	QNT IN (g)	COST IN (Rs)
M- SAND	40%	1000 gr	7
LIMESTONE	18%	450 gr	4.5
METAKAOLINE	15%	375 gr	22.5
SILICA FUME	15%	375 gr	26.25
IRON POWDER	10%	250 gr	75
CALCIUM NITRATE	2%	50 gr	15
		TOTAL =	150.25

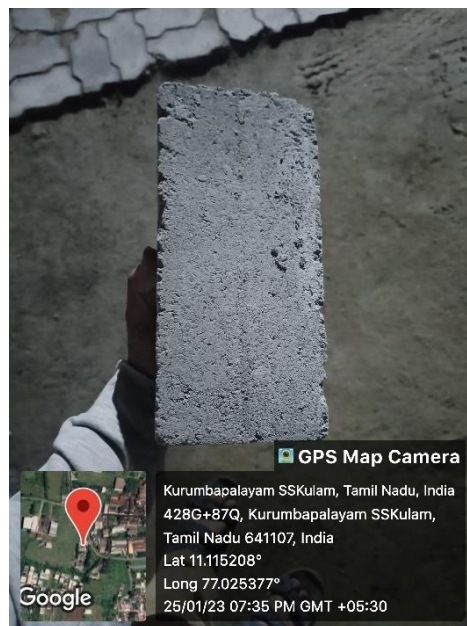


Fig 6.7 Image of I-BRICK Mix 1

6.5.2 Cost of single I-Brick in mix 2

Table 6.5 Cost of single I-BRICK in Mix 2

MATERIAL	QNT IN (%)	QNT IN (gr)	COST IN (Rs)
M- SAND	45%	1170 gr	8.20
LIMESTONE	25%	650 gr	15.6
METAKAOLINE	10%	260 gr	15.6
SILICA FUME	10%	260 gr	18.2
IRON POWDER	8%	208 gr	62.4
CALCIUM NITRATE	2%	52 gr	15.6
		TOTAL =	126.50



Fig 6.8 Image of I-BRICK Mix 2

6.5.3 Cost of single I-Brick in mix 3

Table 6.6 Cost of single I-BRICK in Mix 3

MATERIAL	QNT IN (%)	QNT IN (gr)	COST IN (Rs)
M- SAND	55%	1350 gr	9.50
LIMESTONE	20%	490 gr	4.90
METAKAOLINE	7%	172 gr	10.25
SILICA FUME	7%	172 gr	12.10
IRON POWDER	10%	245 gr	73.5
CALCIUM NITRATE	2%	55 gr	7.40
		TOTAL =	117.60



Fig 6.9 Image of I-BRICK Mix 3

6.5.4 Cost of single Fly ash brick

Table 6.7 Cost of Single Fly ash

MATERIAL	QNT IN (%)	QNT IN (gr)	COST IN (Rs)
M- SAND	70%	1890 gr	13.25
FLY ASH	15%	410 gr	11.35
CEMENT	10%	270 gr	3.25
GYPSUM	5%	140 gr	1.65
		TOTAL =	30.0

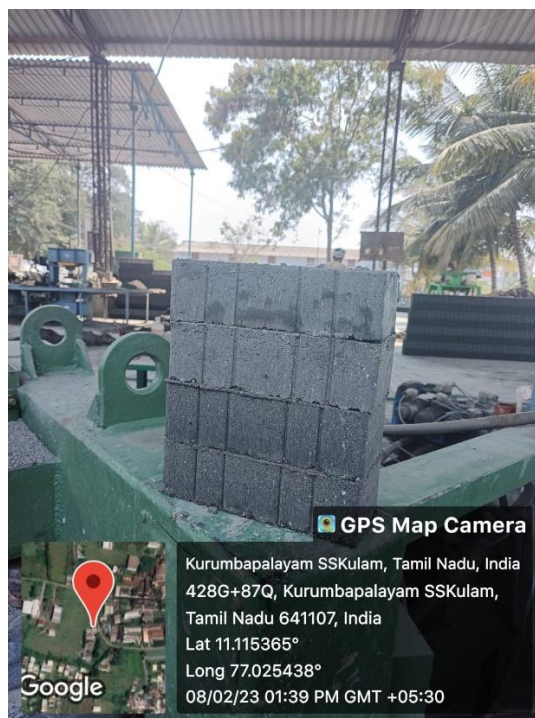


Fig 6.10 Image of Fly ash

6.6 Cost comparison

The figures shown below is the estimated values of “I-BRICK” and FLY ASH BLOCK.

Table 6.8 Comparison of cost

SPECIMEN	COST
MIX1	150.25
MIX2	125.60
MIX3	117.60
FLY ASH BLOCK	30.00

From table 6.8, we learned the final cost of each brick, which showed cost difference of approximately 80-90 Rs. Additionally Mix 2, with a cost of 117.60 Rs, exhibited greater strength than the fly ash brick, making it a successful proportion. However, we still need to refine our cost estimation.

The cost comparison here is expressed from the normal commercial product cost. so this might be quite expensive but collecting the material as bulk may reduce the most of the cost and the product may be manufactured at very less price.

CHAPTER 7

SUMMARY AND CONCLUSION

7.1 CONCLUSION

In order to sustain proportional growth without disrupting social order, innovative development solutions are essential in the face of increasing global population and industrial expansion. It is necessary to regulate ecological systems and ensure economic prosperity while considering their impact on human health. Cement production is one of the critical development factors that require innovative solutions due to its adverse environmental effects. The energy-intensive manufacturing process of OPC BRICK is responsible for a significant amount of greenhouse gas emissions and continued depletion of natural resources.

The compression test reveals that I-BRICK is stronger than Fly ash brick. By utilizing these materials, the construction industry can achieve sustainable development, and replacing fly ash block with I-BRICK can contribute to environmental conservation.

7.2 SCOPE FOR THE FUTURE STUDY

Additional investigation is required to establish the practicality of incorporating this novel material on a large scale, given its nascent state. The durability and reliability of i-brick in different environmental conditions over a long period of time are not yet fully understood. While the use of Ordinary Portland Cement in civil engineering has been improved to accommodate environmental variability, more research is needed to determine the durability and resilience of i-brick throughout its entire life cycle, including its environmental impacts. However, the production of hydrogen gas as a by-product of i-brick manufacturing presents new opportunities for its utilization. As the energy industry explores alternative fuel sources, hydrogen gas's clean-burning properties make it a promising candidate to aid the shift away from fossil fuels.

The preliminary report provides valuable insights into the technical characteristics and strength properties of I-BRICK, but it is important to note that it only examines a portion of these properties. Therefore, it is necessary to conduct further research and investigation on the by-products of I-BRICK manufacturing process to fully understand their potential uses and benefits. Moreover, it is equally important to estimate the cost of production and distribution to ensure that the brick can be made available at every construction site at an affordable price. This would help to increase the adoption of I-BRICK in the construction industry and promote sustainable building practices.

In conclusion, while the preliminary report offers a solid foundation for understanding the properties of I-BRICK, additional investigation is required to fully realize its potential as a construction material. By exploring the by-products and costs associated with its production, I-BRICK can become an accessible and viable alternative to traditional building materials.

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