Project Report of

University Grants Commission Minor Research Project (MRP) 2018-2020

Title of the Minor Research Project

Quantum Leap in Low Cost Construction Techniques with Usage of Compash Brick Masonry for Rural Housing

(F.No.MRP-7093 (UGC/SERO)14.09.2018)

Submitted to

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Date: 09.02.2021

CERTIFICATE

The research Project embodied in the project report entitled **"**Quantum Leap in Low Cost construction Techniques with Usage of Compash Brick Masonry for Rural Housing" was sponsored by the University Grants Commission (UGC), New Delhi, under the minor research project scheme (F.No.MRP-7093(UGC/SERO) 14.09.2018). This work has been carried out at the Department of Civil Engineering, Mahendra Engineering College (Autonomous), Mallasamudram, Namakkal - 637503, Tamil Nadu, India.

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ACKNOWLEDGEMENT

I would like to thank **University Grants Commission, New Delhi** for granting me this project under Minor Research Scheme.

I am greatly indebted to thank **Chairman, University Grants Commission,** New Delhi for granting me this project. I take great privilege to thank **Finance Officer**, **University Grants Commission,** New Delhi for the successful completion of this project.

I take opportunity to express my since gratitude to **Shri.M.G.Bharathkumar,** the chairman and **Er.Ba.Mahendiran,** Managing Director, Mahendra Engineering college, Mahendrapuri, Mallasamudram, Namakkal for their kind encouragement and granting permission to do this research project.

I extend my heartfelt gratitude to **Dr. R.V. Mahendra Gowda** Principal, Mahendra Engineering College, for encouraging to execute this project. I express my sincere thanks to **Dr.R.Samson Ravindran,** Executive Director and **Dr.C.T.Sivakumar**, Executive Officer, Mahendra Engineering College, for motivating to do this project.

I would also acknowledge **ACC, Coimbatore and L&T Constructions, Chennai** for their support in executing this project successfully.

I am grateful to thank my **Research Scholars and Post graduate** students for their cooperation during the tenure of the project. I also thank all **Teaching and Non-teaching** staff members of Civil Engineering Department, Mahendra Engineering College for helping in completing this project successfully.

PREFACE

Bricks play a vital role in the construction industry and the major building elements is occupied with bricks. The research work is mainly focussed on utilizing industrial byproducts in brick manufacturing process. Compash brick is developed by utilizing industrial by products in an optimum manner. The research project deals with the solution for the environmental impact and also provides cost effectiveness in building construction.

The research work is reported in 9 chapters

Chapter 1 deals with the introduction to the research work. It deals with the outline of the work, basic qualities of brick, brick masonry and advantages of the compash brick over conventional brick.

Chapter 2 discusses on the literature review. This chapter gives an idea of the work carried by previous researchers pertaining to the utilization of industrial by products in brick. It also shows on the effect of mechanical and structural behavior of brick masonry with bricks manufactured by various materials.

Chapter 3 deals with manufacturing of brick. This chapter reveals on the various materials used for brick manufacture. It also deals with the various properties of materials, its chemical composition and material characterization. The procedure for casting of compash brick is discussed. Mix proportion of the compash brick is shown in this chapter. The casting of masonry prism and the testing procedure is also explained in detail.

Chapter 4 deals with experimental investigation. This chapter reveals on the mechanical properties, durability performance and structural behavior of brick masonry. The procedure for testing procedure is studied. The experimental testing setup is discussed. The casting of masonry prism , masonry wall and the testing procedure is also explained in detail.

Chapter 5 presents the results and discussion of the experimental work. The present chapter deals with the test results of compash bricks and the behaviour of compash brick masonry is discussed in comparison with the conventional clay brick masonry. The various tests conducted on the compash bricks are compression test, water absorption test, efflorescence test, weight density of brick. The stress strain behavior of brick, mortar and masonry is studied. The ultimate load bearing capacity of the masonry wall is also discussed. The results of durability studies are also reported.

Chapter 6 discusses on cost analysis. This chapter reveals calculation of material quantity and the corresponding cost of compash brick.

Chapter 7 outlines the conclusion of the research work. The research findings of compash brick are highlighted and the outcomes of the research work and merits are also presented.

Chapter 8 deals with recommendations minor research project of compash brick masonry and scope of the future work

Chapter 9 gives the list of reference articles studied while performing the research work.

Dr.K.Vidhya

Principal investigation

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Bricks is used most common material in building construction for centuries and they continue to still remain the dominate among the commonly used construction materials. A brick is block or a unit prepared by kneading clay, lime and sand, or concrete material, burnt and fired to harden and it's commonly used in masonry construction. Burnt brick are the most commonly used arranged in varies patterns with different bond types like English bond, Flemish bond etc, and are arranged in layers and , collectively known as brick work, and may be laid in various mortar proportions of mortar to hold the bricks together to make a long lasting structure. Brick are manufactured various types, various source of materials and sizes which vary with region and time period, and are produced in large quantities of bricks. Most common types of the bricks are fired clay brick and compressed brick. Fired brick are one of the long lasting and strongest building materials sometimes referred to as artificial stone and have been used since circa 5000 BC. Air dried bricks have a history older than fired bricks. The normal conventional clay bricks (CB) require more area of top soil to manufacture and its manufacturing potential is low. To solve the above problem and to reduce the pollution "Fly Ash and Pond Ash" materials are used. Sand is replaced by crusher sand because of cost consideration.

In this project, fly ash was partially substitute by pond ash and sand is replaced by Crusher sand, olivine sand and ecosand. Compash brick (CaB) is the mixture of ecosand, pond ash, olivine, fly ash, lime, gypsum, crusher sand and coal ash. The manufacturing process of the compash brick is similar to the fly ash brick. It is not yet used in field of construction. It is new innovative type of brick, which have property better than clay brick and fly ash brick. The properties of compash brick like compressive strength, weight density, water absorption, shape and size and efflorescence was brick was determined. In this present study of ultimate load and stress and strain behaviour of compash brick, cement mortar and compash brick masonry prism are determined and compared with clay brick.

1.2 QUALITIES OF BRICK

The good quality bricks should possesses the following properties:

- The bricks are classified based on the compressive into four classes like first class, second class, third class and fourth classes of the bricks.
- The good quality bricks should possessed uniform in size and shape.
- The clear metallic ringing sound should be heard for quality bricks.
- The water absorption for first class bricks is 15% and second class brick is 20%, when immersed in normal water for 24 hours time period.
- The quality bricks are hard when there is no impression found on the brick surface, while scratched with nails.
- The good quality bricks must not break when dropped from a one meter height from the ground.

1.3 USES OF BRICKS

- For highly important structures, multistory buildings, dams, roads, sewers, and tunnels etc., first class and second class bricks are commonly used.
- For temporary works third classes are widely used for the construction work.
- For pavement construction and foundation work, the fourth class bricks are commonly used.

1.4 BRICK MASONRY

Masonry is the assemblage of individual units laid in and bound together by mortar. Masonry is generally a highly durable from of construction. However, the materials used, the quality of the mortar and workmanship, and the pattern in which the units are assembled can significantly affect the durability of the overall masonry construction. There are many types of bond is available. In this project, stacked bond was used for construction of brick masonry wall. Masonry is commonly used for the construction of walls in buildings, retaining walls etc.

1.5 ADVANTAGES OF THE COMPASH BRICK OVER CONVENTIONAL BRICK:

The compash bricks have the following advantages:

Reduction in pollution

Clay is the commonly used ingredient for brick manufacture. Over exploitation of natural clay creates many environmental hazards as soil erosion, landslides etc. On the other hand many industries are generating large quantities of industrial wastes and it occupies vast land area and creates environmental pollution. The compash brick significantly utilize industrial by products and partially reduces the global warming.

Less energy consumption

More energy is used in burning clay bricks at refractory kilns. By manufacturing of compash brick less energy is consumed compared to conventional clay bricks.

Economy in construction

Compash bricks are at least 10-15% less than conventional clay bricks. The cost of the compash bricks is less compared to clay brick because compash bricks are manufactured by industrial by products. This compash brick may or may not require plastering so it may be taken as vital role to reduce the cost.

1.6 METHODOLOGY OF THE RESEARCH WORK

Stage 1: Feasibility study of the like crusher sand, fly ash, pond ash, eco sand, olivine sand and coal ash to make brick.

Stage 2: By using trial and error, Mix combination is arrived

Stage 3: Casting of the brick by various mix combinations

Stage 4: Testing of the compash brick for determine the mechanical properties of the brick

Stage 5: Assess the durability performance of the brick to predict the life span.

Stage 6: Investigate the structural behaviour of brick masonry using stress strain.

Stage 7 : Conclusion and recommendation

The methodology of the research work is shown in Figure 1.1.

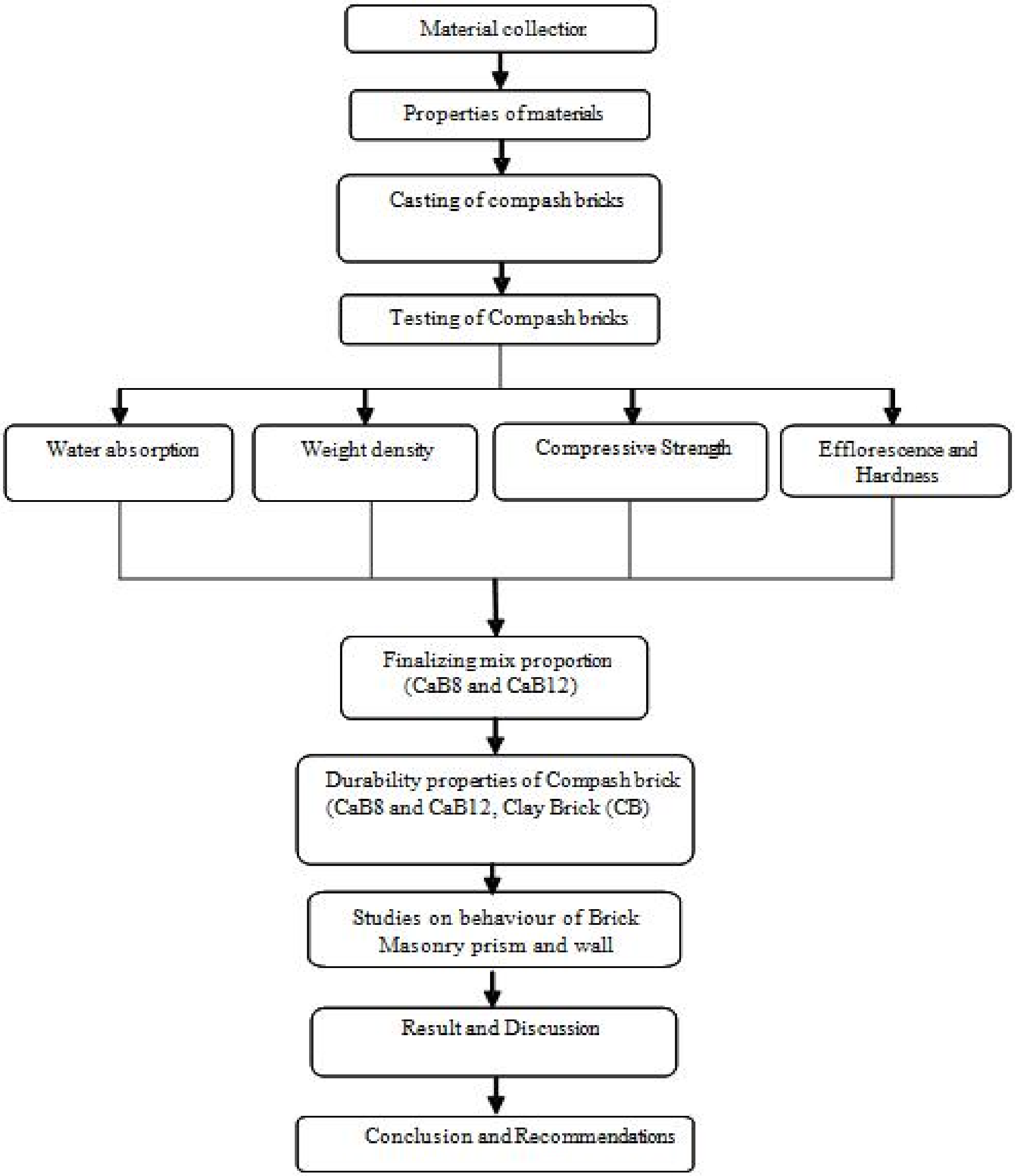

Figure 1.1 Methodology of the Research Work

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

The behaviour of brick masonry depends on their physical properties of brick and mortar. Many researchers studied on then the mechanical properties, behavior of masonry and numerical analysis on clay and fly ash bricks. Using pond ash and ecosand in the manufacturing of bricks has not been studied in detail. Very few literatures are available on this subject. Hence in the present study, focus has been made on using pond ash and ecosand in making of bricks and their properties are studied.

Muhammad J. Munir et al (2018) focused their research work on manufacture of Eco-Friendly Fired Clay Bricks with Recycled Marble Powder. This study investigates on development of brick with recycled waste marble powder (WMP) varying from 5 to 25% by replacement for clay. The mechanical properties and durability characteristics of bricks with WMP were investigated. The WMP possessed linear shrinkage and lighter weight bricks. From Scanning electron microscopy (SEM) analysis showed that bricks are pores in nature and hence the compressive strength is reduced. However, the optimum level of the WPM is maximum 10 %.

Gopinath. R (2018) reported on development of Bricks using foundary sand and Eco sand. An innovative approach in the manufacture of brick was done using industrial by-products like foundry sand and eco sand derived from dolomite lime stone with cement as key ingredients. Eco sand can be used as a replaced by river sand and M Sand. Compressive strength value of solid block masonry is 8.55 N/mm^2 to 14.62N/mm^2 which came out to be greater than compressive strength of brick (3.5 N/mm^2 to 5.5 N/mm^2).

Vidhya & Kandasamy (2016) conducted an Experimental Investigations on the Properties of Coal-Ash Brick Units as Green Building Materials. In this investigation, an attempt was made to devise ways for the optimal use of pond ash in manufacturing coal-ash bricks. This article presents the experimental results for coal ash brick made up of pond ash with fly ash, lime, gypsum, and crusher sand. The fundamental strength and durability tests were conducted to evaluate the basic properties of bricks.

Gaurav & Jayeshkumar (2013) made a comparative assessment of natural sand and pond ash. The fineness modulus, specific gravity, and water absorption of pond ash were compared with Indian Standard values. The natural sand has high density than pond ash value but within the IS code. It was concluded that the natural sand could be replaced by pond ash partially or fully in cement concrete.

Vidhya & Kandasamy (2013) studied the properties of brick units made from fly ash and pond ash. Mixes 4, 5 and 6 fell under the class designation 7.5. In mix combination 1 and 2, the water absorption value of pond ash brick was lesser than 10 %. The pond ash brick showed better durability performance compared to conventional clay brick.

Bharathi et al (2011) studied the engineering properties of pond ash for sustainable concrete production. Coal ash material is suitable for road and embankment works and also proves economical by partial replacement of cement and sand. Coal ash material shows better possibilities in geotechnical applications and specifications irrespective of its material properties.

Thomas et al (2012) studied the properties of mortar and structural behaviour of masonry. During the triplet shear test, four types of failure modes were observed. Shear strength of masonry was calculated based on normal stress from Mohr-Coulomb relationship

Imane Rouch et al 2020 studied that sewage sludge from waste water treatment process can be used as partial substitute for clay in brick production. The sewage sludge was tested in several properties to be used in brick production such as linear drying shrinkage, absorption by capillarity, bulk density, mechanical resistance strength and radiological properties. The brick specimens of 5%, 10%, 15%, 20%, and 25% proportions (by dry weight) of sewage sludge were tested. Bulk density and compressive strength were found inversely proportional to amount of sewage sludge of range 1882.81 to 1921.87 kg/m^3 and from 5.78 to 16.1 MPa respectively. The linear shrinkage value was found to be improved in the order of 38.01% with 25% sludge compared to the standard brick.

Henry et al (2009) studied the environmental values of fly ash bricks and compared the same with that of conventional clay bricks. The greenest fly ash brick mitigates air pollution and global warming problems caused by using fuel in kiln in the manufacturing of conventional clay bricks. Class C fly ash bricks represent superior structural properties including shear strength, compressive strength, bond strength, flexural strength, and freeze-thaw resistance. The study concluded that the long-term strength of fly ash is derived from carbonation caused by CO_2 in the atmosphere.

Rafat (2003) conducted an experimental study on the effect of fine aggregate replacement with Class F fly ash. Tests were conducted to determine properties of fresh concrete and its strength on five different percentages of fly ash replacing fine aggregate. The results showed that the addition of fly ash increases the strength properties of concrete. The research concluded that the maximum compressive strength and split tensile strength were observed with 50% replacement at all ages and Class F fly ash should effectively used in structural concrete effectively.

Freeda Christy & Tensing (2011) conducted experiments on fly ash bricks and conventional bricks. The bricks were tested for their mass, water absorption, compressive strength and flexural strength. The compressive strength of fly ash bricks was 40 % to 80 % higher than that of conventional clay bricks and the weight density of fly ash brick was 10 % lighter than conventional clay brick. The study concluded that the fly ash brick is cost efficient, energy efficient and environmental friendly.

Hakan et al (2013) conducted studies on the behaviour of masonry wall with reinforced plaster mortar. Masonry brick of size 100 mm x 50 mm x 30 mm were used to construct a masonry wall of size 400 mm x 400 mm x 100 mm. Masonry wall specimens constructed with steel fiber reinforced plaster and poly propylene mortars. In masonry wall, vertical load was applied at different angles such as 30, 45, 60 and 90 degrees. The stiffness and strength and ductility of masonry walls with and without reinforcement were determined. The performance of reinforced plastered mortar masonry wall was evaluated to determine the failure envelope.

2.2 SUMMARY OF THE LITERATURE

Based on the literature paper foundry sand, waste marble powder, ecosand, sludge waste etc., are commonly used as replacement materials for the conventional brick in the process of manufacturing of the brick. For binding propose the most of the researchers/Reviewers suggested that industrial by products pointed out fly ash, sludge ash, pond ash etc act as a binding materials for solidification. In this project, eco friendly, industrial by products are efficiently used for this research work. This research work the cost of the brick is reduced greatly by the usage industrial waste materials.

CHAPTER 3

MANFACTURING OF COMP ASH BRICK

3.1 GENERAL

The manufacturing process of compash bricks and the materials utilized are described in this chapter. Proper selection of the constituent materials and its properties is a major concern affecting the properties of brick masonry. The key ingredients used for the research work are pond ash, fly ash, sand, lime, gypsum, olivine sand, coal ash, crusher sand and ecosand.

3.2 MATERIALS USED

3.2.1 Cement

Portland Pozzolana cement was used for making brick and mortar. It acts as a bonding agent between two bricks. Figure 3.1 shows the sample of Portland Pozzolana Cement. It confirmed with IS1489:1991 part1.

Figure 3.1 Sample of Cement

3.2.2 Fly Ash

This type of ash is obtained from Electrostatic Precipitator in dry form obtained from thermal power plants. This fly ash is fine material and contains very good pozzolanic property. Figure 3.2 shows the sample of Fly ash.

Figure 3.2 Sample of Fly Ash

Fly ash obtained from Mettur Thermal Power plant, Mettur, Tamil Nadu was used in this study. The CaO percentage is less than 5%, so the fly ash is classified as class F.

3.2.3 Pond Ash

Fly ash and bottom ash or mixed together at any combination in large quantity of water and made into slurry form and it is deposited in ponds from where water is drained away. The settled ash is called as pond ash. Figure 3.3 shows the sample of pond ash.

Figure 3.3 Sample of Pond Ash

3.2.4 Lime

Lime is a more important ingredient used in the manufacturing of bricks. The lime should be stored in bags or silos or in covered bins as it has a tendency to respond with CO_2 present in the air in the being there of moisture and produces $CaCO_3$ that do not have good binding properties and it also spoils the quality of lime to be used for making bricks. Lime was collected from Kangeyam. Figure 3.4 shows the sample of lime.

Figure 3.4 Sample of Lime

3.2.5 Gypsum

The mineral gypsum can be used for making bricks. While the gypsum added in the manufacturing of brick, it leads acceleration of the hardening process and gains the early strength. Gypsum should be contained in bags and stored in bins. Locally available gypsum was used for the manufacturing of compash bricks. Figure 3.5 shows the sample of gypsum.

Figure 3.5 Sample of Gypsum

3.2.6 Crusher Sand

Crusher sand is used in various construction activities. Hence it is in high demand in market. It is available in a variety of colours and grades to suit various requirements. The properties of the crusher sand are its fine texture, good quality and bonding strength. Locally available crusher sand was procured and used. Figure 3.6 shows the sample of crusher sand.

Figure 3.6 Sample of Crusher sand

3.2.7 Accelerator

Accelerating admixture is added to increase the early strength development in brick and concrete to

- The period of curing is reduced. The structure can be placed in service in advanced time.
- The removal of formwork is earlier and the structure can be placed in service in advance time. The acceleration admixture can be used in emergency repair work.

Some types of accelerators produced in the recent days are so powerful that it early set the ingredients in to hard in a less time. Ethyl cyanoacrylate type of accelerator is used for this research work.

3.2.8 Ecosand

Eco sand is the collected from ACC Private limited, Coimbatore. It is secondary product of cement manufacturing unit. Eco sand can be used as an alternative for river sand and M Sand. Eco Sand has specific gravity of 2.1 and fineness modulus of 0.028. Figure 3.7 shows the sample of Ecosand.

Figure 3.7 Sample of Ecosand

3.2.9 Olivine Sand

Olivine is a raw material obtained as a residue during Magnesite extraction process. Salem has rich potential of Magnesite in many places. The olivine sand is collected from the Sail Refractory Company limited, Salem, TamilNadu. Figure 3.8 shows the sample of Olivine sand.

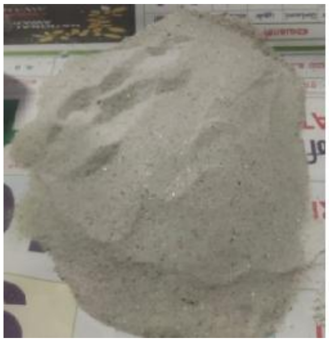

Figure 3.8 Sample of Olivine sand

3.2.10 Coal Ash

Coal ash produced from JSW, Salem, Tamil nadu. The ash generated from the coal based boiler will be disposed to ash brick manufacturers. It has good binding property. Figure 3.9 shows the sample of Coal ash.

Figure 3.9 Sample of Coal ash

3.3. CHEMICAL COMPOSITION OF MATERIALS:

The chemical composition of Ecosand, Olivine sand, and Coal ash is arrived. The test results are given in table 3.1.

Table 3.1: Chemical Composition of Ecosand, Olivine and Coal ash

S. No	Parameters	Composition in %		
		Ecosand	Olivine Sand	Coal ash
1	Loss of ignition (LOI)	22.5	2.25	5.25
2	Silica	43.83	51.80	56.5
3	Calcium oxide	25.4	1.60	16.85
4	Magnesium oxide	5.84	37.75	4.23
5	Iron oxide	0.42	4.15	13.2
6	Aluminium oxide	0.15	0.75	3.42
7	Alkali	Traces	Traces	0.45

3.4 MICROSTRUCTURE CHARACTERIZATION

The microstructure characterization is performed through Scanning Electron Microscopy (SEM) analysis and the morphology of fly ash, pond ash and compash brick powder is revelled. Figures 3.10, 3.11, 3.12 and 3.13 show the images of the fly ash, pond ash, ecosand and compash ash brick powder (CaBP) material.

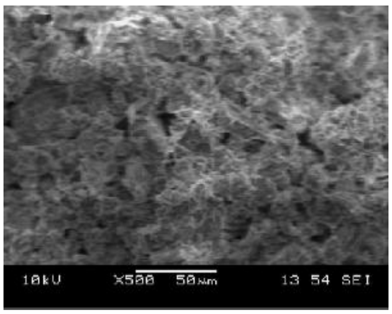

Figure 3.10 SEM analysis for fly ash

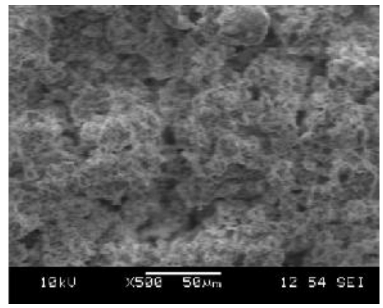

Figure 3.11 SEM analysis for pond ash

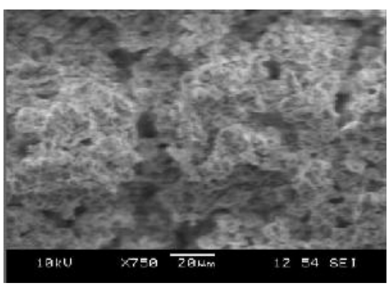

Figure 3.12 SEM analysis for Eco Sand

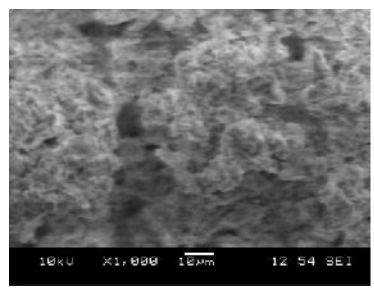

Figure 3.13 SEM analysis for CaBP

From figure 3.10 and 3.11, most of the fly ash and pond ash particles are combined together and looks like cushioned in nature. The spherical shape is identified in fly ash particles and also its shows amphorous and agglomerate materials. The pond ash fragments are irregular and honey comb structures. From figure 3.12 and figure 3.13, under the SEM analysis for Ecosand shows non absorbing nature and rough surface texture and for compash brick powder particles are spherical in shape and uniform structure. The particles of the compash brick exist impermeable.

3.5 MANUFACTURING OF COMPASH BRICK (CaB)

The raw materials such as fly ash, ecosand, pond ash, olivine sand, gypsum and lime, coal ash and crusher sand were mixed homogenously as per the mix proportions and required quantity of water was added for good bonding. Eco sand received from ACC, Coimbatore, Tamil Nadu. The preliminary study of 5 mix combinations are carried at Tech New Building Products, Coimbatore to reduce the transportation cost of the material.

The range of the fly ash is varies from 40 -70 percentage, lime is varied from 5 to 10 percentage, gypsum may used as around 5%, cement may be used as maximum of 3%, crusher sand or crusher sand may varied from 25% to be used to manufacturing the compash brick. The fly ash may be replaced by pond ash and coal ash and eco sand and olivine sand partially replaced by crusher sand.

3.5.1 Manufacturing Process of trail mix combination 1compash Brick

Proportioning of raw materials is an important aspect for making of compash bricks of desired quality. There is no specific method to find out the mix design of coal ah bricks. Fly ash, pond ash, lime, crusher sand, cement and accelerator are used to manufacturing the compash brick for trial mix combination 1. Four trial mixes was derived to manufacturing of compash brick with combination of fly, pond ash, lime crushed sand and cement. The trail mix combination 1 is represents in table 3.2. The flow chart of manufacturing of trail mix combination 1 compash brick is represented in figure 3.14.

Table 3.2 Trail mix combination - 1 of compash brick

Mix Id	In percentage of materials					Accelerator (5% of wt of cement)
	Cement	Lime	Fly ash	Pond ash	Crusher Sand	
CaB1	2	12	40	42	4	0.15
CaB2	2	12	40	40	6	0.15
CaB3	2	12	40	38	8	0.15
CaB4	2	12	40	36	10	0.15

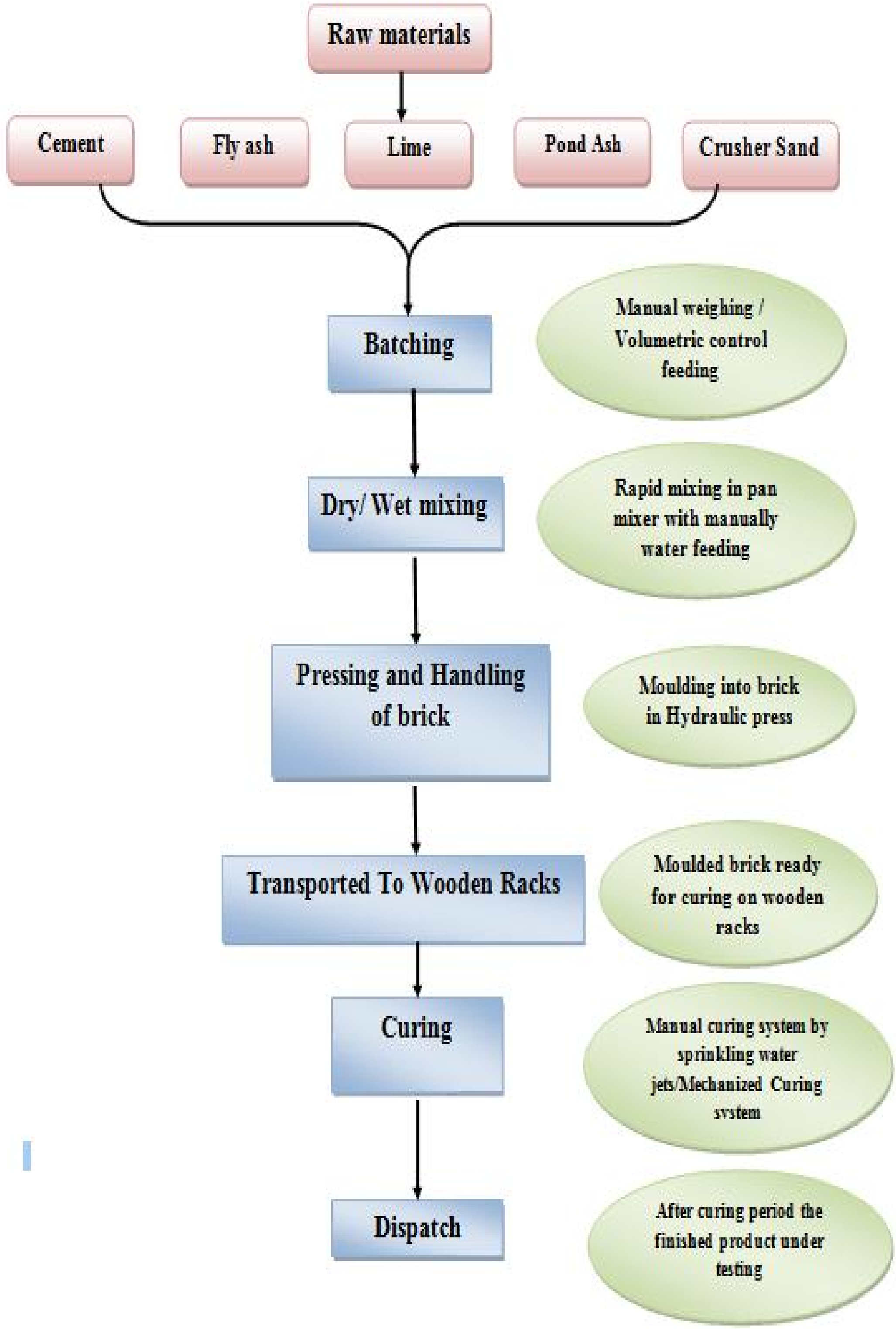

Figure 3.14 Flow chart of manufacturing of trail mix combination 1 compash brick

3.5.1.1 Mixing of raw materials

Mixer is used to mix the all ingredients with uniform mixing in dry form. Then the water is added to the dry mix and till the uniform consistency is attained. Then the mix is homogeneous. Figure 3.15 shows the pan mixer.

Figure 3.15 Pan Mixer

3.5.1.2 Moulding of brick

The brick making machine is purchased through the UGC- Minor Research grant. It possessed 3 brick moulder. Size of moulds can be placed with maximum size 230mm x 110mm x 75mm. Figure 3.16 shows the Brick Making Machine. The bricks are handled by tray for easy transportation of compash bricks.

Figure 3.16 Brick Making Machine

3.5.1.3 Curing of compash bricks

Compash brick should be cured 14 days by water. Water is sprayed manually over the compash bricks. The figure 3.17 shows the curing of cast specimen. Curing is recommended to be performed during cold or wet weather.

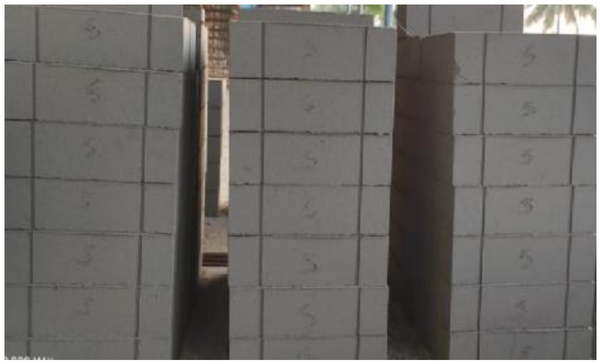

Figure 3.17 Curing of compash brick specimens

3.5.2 Manufacturing Process of trail mix combination 2 compash Brick

From the trial mix combination 1, it is found that the compressive strength is low due excessive usage of pond ash. And also the cost of the compash brick is high due to usage of the cement and accelerator. Hence, the research work extended to trail mix combination 2.

The fly ash, lime, gypsum, crusher sand and pond ash are used to manufacturing the compash brick for trial mix combination 2. Five trail mixes was derived to manufacturing of compash brick with combination of fly ash, lime, gypsum, crusher sand and pond ash. The trail mix combination 2 is represents in table 3.3. The flow chart of manufacturing of trail mix combination 2 compash brick is represented in figure 3.18.

Table 3.3 Trail mix combination - 2 of Compash brick

Mix Id	In Percentage of materials				
	Lime	Fly ash	Pond ash	Gypsum	Crusher sand
CaB5	10	10	50	5	25
CaB6	10	20	40	5	25
CaB7	10	30	30	5	25
CaB8	10	40	20	5	25
CaB9	10	50	10	5	25

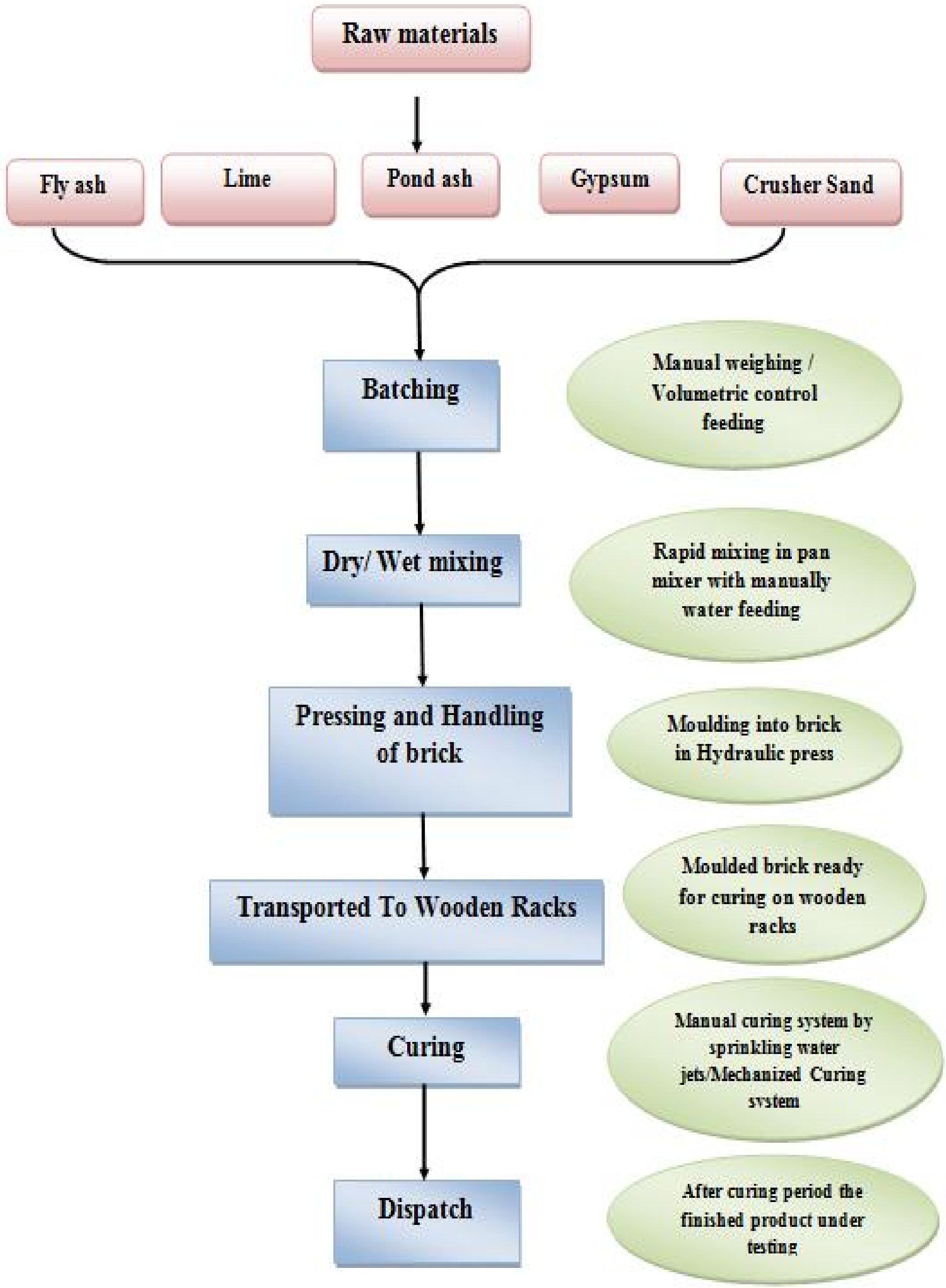

Figure 3.18 Flow chart of manufacturing of trail mix combination 2 compash brick

3.5.3 Manufacturing Process of trail mix combination 3 compash Brick

From the trial mix combination 2, it is found that the compressive strength is good and the cost is also reasonable. The cost of compash brick could be reduced further also industrial by product ecosand is available at free of cost and olivine sand is available at the nearby source. Hence, the research work extended to trail mix combination 3.

The fly ash, lime, gypsum, olivine sand, ecosand and coal ash are used to manufacturing the compash brick for trial mix combination 3. Five trail mixes was derived to manufacturing of compash brick with combination of fly ash, lime, gypsum, crusher sand and pond ash. The trail mix combination 2 is represents in table 3.3. The flow chart of manufacturing of trail mix combination 2 compash brick is represented in figure 3.19.

Table 3.4 Trail mix combination - 3 of compash brick

Mix Id	In Percentage of materials					
	Lime	Fly ash	Coal ash	Olivine sand	Ecosand	Gypsum
CaB10	10	10	10	15	50	
CaB11	10	20	10	15	40	5
CaB12	10	30	10	15	30	5
CaB13	10	40	10	15	20	5
CaB14	10	50	10	15	10	5

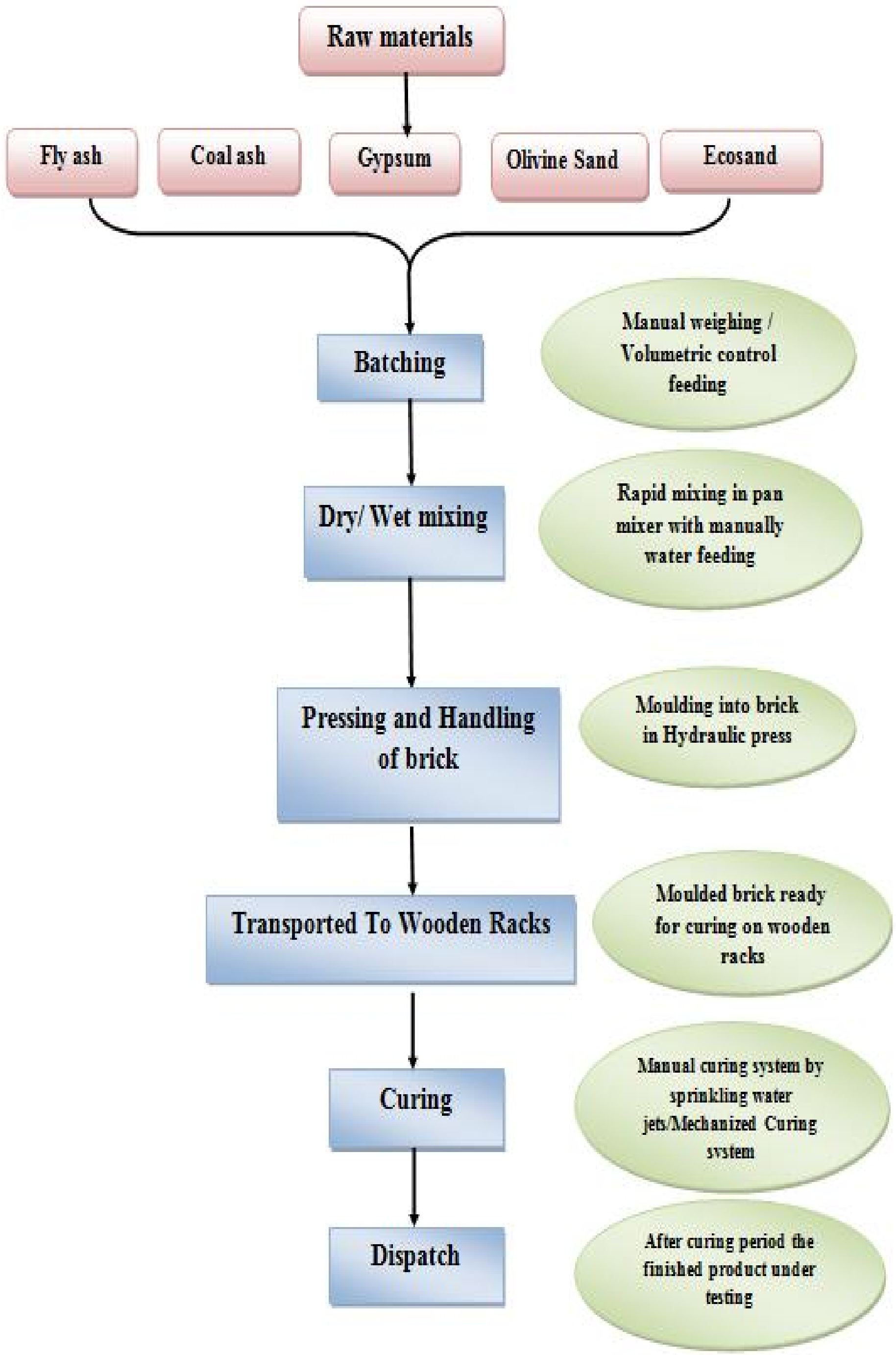

Figure 3.19 Flow chart of manufacturing of trail mix combination 3 compash brick

CHAPTER – 4

EXPERIMENTAL INVESTIGATION

4.1 GENERAL

This chapter details with experimental investigation on compash ash bricks and masonry. In the first stage of the investigations, the mechanical properties and durability characteristics of compash ash bricks were studied and compared with clay brick. In the second stage of the experimental study compressive strength and stress-strain performance of brick masonry prism were investigated. The ultimate load carrying capacity of compash ash brick masonry wall is determined through experiments.

A. EXPERIMENTAL STUDY ON PROPERTIES AND DURABILITY CHARACTERISTICS OF THE BRICK

In the first stage of the investigation, basic mechanical properties of bricks such as weight density, water absorption, compressive strength and efflorescence of compash ash bricks of various mix combinations were examined. The durability properties like resistance to chemical attack were analysed for compash brick on compash bricks (CaB8 and CaB12) and Clay bricks (CB).

4.2 MECHANICAL AND PHYSICAL PROPERTIES OF THE BRICK

4.2.1 Compressive Strength

As per the code IS3495:1992(Part 1) the compressive strength was conducted. For each mix combination a six numbers of brick was tested after 28days of curing period. By using Compressive Testing Machine the test was carried out. The compressive strength value is determined by applying a uniform rate of loading to the brick. The uniaxial load is applied on the brick until the failure is occurred. The maximum failure is noted. The compressive strength is the ratio of ultimate load to the cross section of the brick in N/mm^2. Figure 4.1 shows the compressive strength test setup for brick.

Figure 4.1(a) compash brick **Figure 4.1(b) clay brick**

Figure 4.1 Compressive strength of brick.

4.2.2 Water Absorption

The water absorption test was carried out as per IS 3495:1992 (Part 2). It is kept is oven at 105^{o}C and cool the specimen and measure the weight as W1. Again the same specimen is immersed in water for 24 hours. The saturated weight was noted as W2. The water absorption value is the ratio of difference in weight to the dry weight of the brick. The value is noted in percentage. Figure 4.2 and 4.3 Dry weight of brick and Water absorption test setup for brick.

Figure 4.2 (a) clay brick **Figure 4.2 (b) compash brick**

Figure 4.2 Dry Weight of brick W1.

Figure 4.3 (a) clay brick

Figure 4.3 (b) compash brick

Figure 4.3 Water absorption test setup for brick.

4.2.3 Weight Density

A six number of brick is tested for weight density for each combination of mix. The volume and weight of the brick is measured. The ratio of weight to the volume of the brick is weight density of the brick in N/mm^3. Figure 4.4 shows the weight density test setup for brick

Figure 4.4 (a) clay brick

Figure 4.4 (b) compash brick

Figure 4.4 Weight Density for brick.

4.2.4 Efflorescence

As per IS 3495 part 3 the efflorescence test was performed. For each mix combination a six number of specimen is used for the testing. The brick sample is immersed in water at the depth of 25mm from bottom and the water level is maintained. The presence of white patches is analysed in brick specimen. Figure 4.5 shows the efflorescence test setup for brick.

Figure 4.5 (a) clay brick

Figure 4.5 (b) compash brick

Figure 4.5 Efflorescence test setup for brick.

4.3 DURABILITY PROPERTIES

The durability properties of compash brick and conventional clay brick were investigated under various aggressive environments. The compash and clay brick specimens were immersed in potable water with 5% of Na_2SO_4 and potable water with 5% of NaCl. 60 brick specimens were immersed in potable water with 5% of Na_2SO_4 and another set of 60 brick specimens was immersed in potable water with 5 % of NaCl for a period of 90 days. The wet weight and compressive strength of each brick specimen was determined after 3, 7, 14, 21, 28, 56 and 90 days of chemical exposure. Simultaneously the physical observation and dimension changes were observed. Figure 4.6 shows the durability test setup for brick.

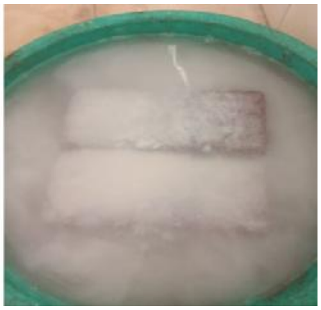

Figure 4.6 (a) clay brick

Figure 4.6 (b) compash brick

Figure 4.6 Durability test setup for brick

B.EXPERIMENTAL STUDY ON STRUCTURAL BEHAVIOUR OF BRICK MASONRY

In the second stage of the experiment, investigation was conducted out to determine compressive strength value and stress-strain behaviour of mortar, brick and brick masonry prism. The ultimate strength capacity of brick masonry wall was examined. Totally 18 prism specimens and 3 wall element were cast for the second stage of the experiment.

4.4 EXPERIMENTAL SETUP FOR STRESS STRAIN BEHAVIOUR OF BRICK

The stress - strain behaviour of clay brick and Compash brick was studied by using Universal Testing Machine (UTM) of capacity 200 tones. The dial gauge was fixed with respect through lateral and longitudinal direction of brick specimen. Two dial gauges were fixed in lateral direction and one dial gauge was fixed in longitudinal direction.

Figure 4.7 shows the experimental set up for brick. The experimental setup for stress strain behaviour test of bricks. Compressive load was applied gradually at uniform rate and at equal intervals of loading and the corresponding deflections were measured with the help of dial gauges. The dial gauges were removed before the failure was occurred in the specimen. The failure load was noted.

Figure 4.7 Experimental setup for brick unit

4.5 EXPERIMENTAL SETUP FOR STRESS STRAIN BEHAVIOUR OF MORTAR

The mortar cubes of size 70 mm x 70 mm x 70 mm were cast for determining stress - strain behaviour of mortar. The mortar proportion of 1:5 and 1:6 was used for determination of stress - strain behaviour using universal testing machine of capacity 200 tonnes. The mortar cubes are placed at the centre of the UTM without eccentricity.

The dial gauge was used to measure the deflection. The dial gauge was fixed with respective lateral and longitudinal directions of mortar specimen. Two dial gauges were fixed in the lateral direction and one dial gauge was fixed in the longitudinal direction. Figure 4.8 shows the experimental setup for stress - strain behaviour of mortar cubes.

Figure 4.8 Experimental setup for mortar cube

4.6 EXPERIMENTAL SETUP FOR STRESS STRAIN BEHAVIOUR OF BRICK MASONRY

4.6.1 Casting of Brick Masonry Prism

Brick masonry prisms are constructed by brick and vary combination of mortar. The prisms thus cast are shown in Figure 4.9 Size of brick specimen was 230 mm x 110 mm x 75 mm. The height of brick masonry prism is 400 mm with 10 mm thickness mortar joints for Compash and clay brick masonry prism. Totally 18 specimens were used for the study of stress-strain behaviour of Compash brick masonry prism compared with the conventional brick masonry prism. The test was conducted as per the codal provisions of IS1905:1987.

Figure 4.9 Sample of brick masonry prism

4.6.2 Testing Setup For Stress Strain Behaviour Of Compash Brick Masonry

The masonry prism was tested by the Universal Testing Machine (UTM) for stress-strain behaviour brick masonry prism. A five-layer height of masonry prism was used to find the secant modulus of the masonry prism. The prism was placed with the frame setup in which a compressometer was fixed at lateral directions to the frame. The whole assembly of prism with the compressometer was placed at the middle of the loading platform of UTM under uniaxial compression load without any deviation. The load was applied gradually at uniform rate and at equal intervals of loading and the corresponding deflections was noted from the compressometer till the failure occurred. The ultimate load or failure load of masonry prism was noted.

4.7 STRUCTURAL BEHAVIOR OF BRICK MASONRY WALL

4.7.1 Casting of Brick Masonry Walls

A masonry wall is constructed with brick units and mortar. The load carrying capacity of brick masonry wall is determined by using Loading frame. The compash brick masonry wall (CaBW) and Conventional Clay brick wall(CBW) are constructed with cement mortar thickness of 20mm with the mix ratio of 1:5 and 1:6. The stacked bond method is used for constructing brick masonry wall. The size of the compash brick wall is 0.9m x 0.9m x 0.07m.

4.7.2 Ultimate Load Bearing Capacity of Masonry Wall

By using loading frame the brick masonry wall is investigated for Ultimate load bearing capacity under cyclic loading using hydraulic jack. The geometry of the loading frame is shown in the figure 4.10. Determine the ultimate strength of the masonry walls loading frame of 2m height to 2m width was used. Under loading frame the walls were placed for testing with fixing of hydraulic jack. Above the masonry wall steel I section and bottom steel plate is provided to transfer the uniform load throughout the entire length of the wall. At uniform and regular intervals the compressive load is applied gradually and deflection is measured using dial gauges with least count of 0.01mm were fixed. The ultimate load is noted.

Figure 4.10 Experimental setup for Load Bearing Capacity of Masonry Wall

CHAPTER 5

RESULTS AND DISCUSSION

5.1 GENERAL

The present chapter deals with the test results of compash bricks and the behaviour of compash brick masonry is discussed in comparison with the clay brick masonry. The various tests conducted on the Compash bricks are compression test, water absorption test, efflorescence test, weight density of brick. The stress strain behaviour of the masonry element and load carrying capacity of wall is also discussed. The test was conducted as per the code IS3495:1992 (Part1 to 4) and IS1905:1987.

5.2 PHYSICAL AND MECHANICAL PROPERTIES OF COMPASH BRICKS

Table 5.1 shows the test result of compressive strength, weight density and water absorption of the trail mix combination – 1 of compash brick.

Table 5.1 Test results of trail mix combination - 1 of compash bricks

Mix Id	Compressive strength in N/mm^2	Water absorption in %	Weight Density in kN/m^3
CaB1	5.50	13.00	12.37
CaB2	4.03	12.50	12.88
CaB3	3.79	11.40	12.64
CaB4	3.50	10.00	13.73

From the result of compressive strength of the bricks various from 5.50 N/mm^2 to 3.50 N/mm^2 for trail mix combination1. The compressive strength value decreases with quarry dust content increases in the mix. The CaB1 possessed higher compressive strength than other mixes. The water absorption value various in percentage as 13.00, 12.50, 11.40 and 10.00. As per IS code the mix combination 1 satisfied the water absorption value of 15%. The weight density value in the range of 12.37 kN/m^3 to 13.73 kN/m^3. The presence of quarry dust increases the weight density of brick.

For the trail mix combination 2 the test result value of the compressive strength various in the range of 5.65 N/mm^2 to 8.65 N/mm^2. The mix CaB8 has higher compressive strength value than other mixes. The water absorption value of trail mixes various from 10.25% to 12.50%. The test results shows pond ash content is decreased the water absorption value is increased. The weight density value various from 11.75 to 13.75N/mm^3. When the flyash content increased the weight density of mix combination 2 is increased gradually. From the results, the flyash content of 40% and 20% which possess the good properties.

Table 5.2 Test results of trail mix combination - 2 of compash bricks

Mix Id	Compressive strength in N/mm^2	Water absorption in %	Weight Density in kN/m^3
CaB5	5.65	10.25	11.75
CaB6	6.21	11.25	12.12
CaB7	7.52	11.50	12.75
CaB8	8.65	11.75	13.25
CaB9	8.25	12.50	13.75

From the table 5.3, it is observed that compressive strength various from 6.25 to 8.35 MPa for the trail mix combination - 3. The combination CaB12 shows increased strength respectively from other combination mix of 3. The value of water absorption value in the various percentage of 11.15 % to 12.50 %.The percentage replacement of flyash increases the water absorption value decreases. The weight density in the range of 13.52 kN/m^3 to 14.25kN/m^3. The increase in percentage of Ecosand in mix has higher weight density.

Table 5.3 Test Result of Trail mix combination – 3 of compash bricks

Mix Id	Compressive strength in N/mm^2	Water absorption in %	Weight Density in kN/m^3
CaB10	7.65	12.50	14.25
CaB11	8.15	11.85	14.15
CaB12	8.35	11.65	13.90
CaB13	7.45	11.25	13.65
CaB14	6.25	11.15	13.52

The figure 5.1 shows the comparison of compressive strength of 3 trail mix combinations of compash brick by pie chart representation.

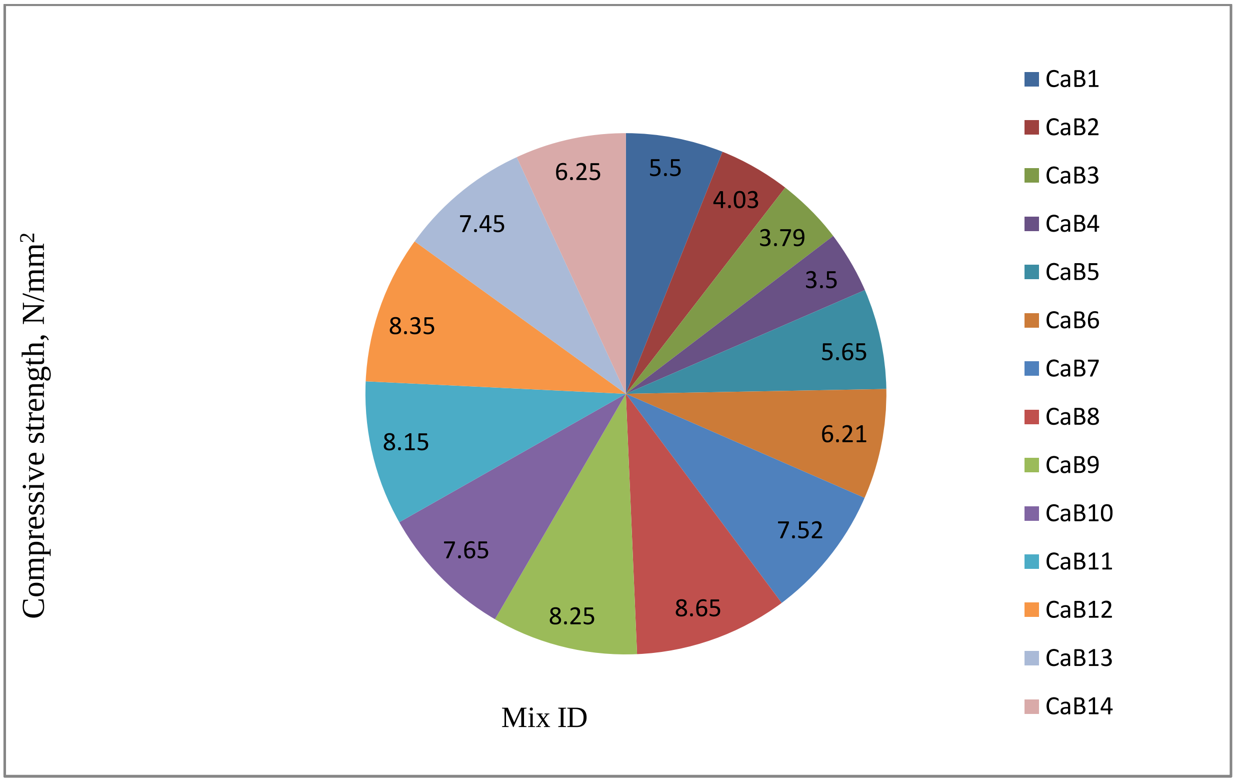

Figure 5.1 Comparison of compressive strength values of compash brick

From the result of compressive strength of the bricks various from 3.50 N/mm^2 to 5.50 N/mm^2 for trail mix combination1. The compressive strength value decreases with pond ash content and quarry dust increases. For the trial mix combination 2, the compressive strength value varies from 5.65 N/mm^2 to 8.65 N/mm^2. The Crusher sand percentage value is increased in mix proportion the compressive strength decreased.

The figure 5.2 shows the comparison of percentage of water absorption value of 3 trail mix combinations of compash brick by graphical representation.

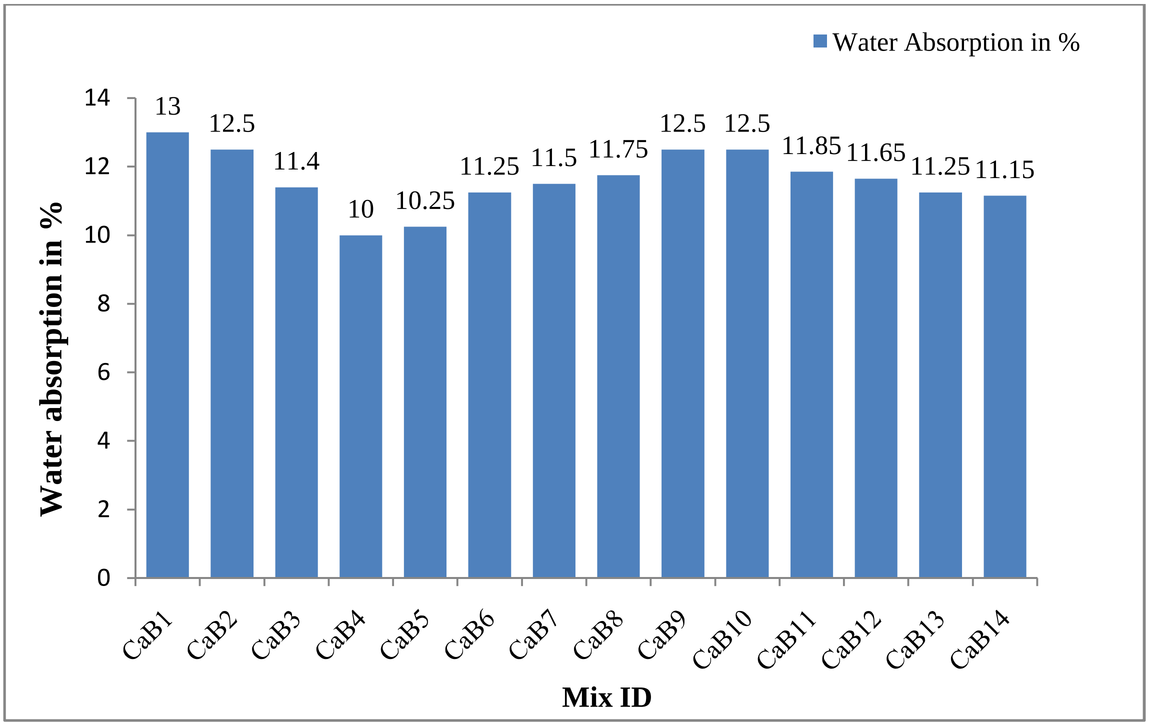

Figure 5.2 Comparison of Water absorption % of compash brick

Water absorption varies from 13 % to 10.00 % and weight density of the brick is varies from 12.37 kN/m^3 to 13.73 kN/m^3. The water absorption value of conventional clay is greater than compash brick.

The figure 5.3 shows the comparison of weight density value of 3 trail mix combinations of compash brick by graphical representation.

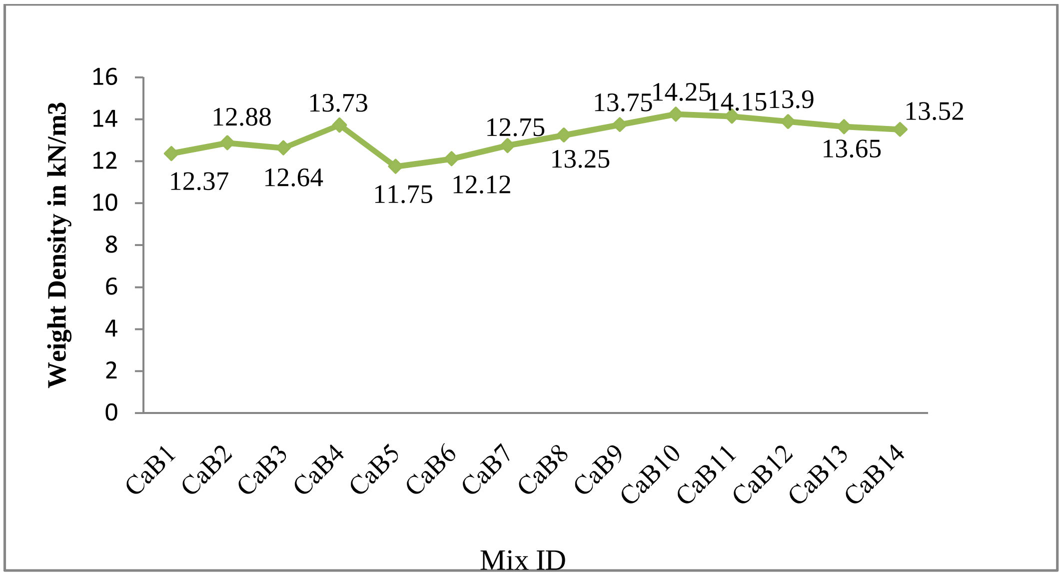

Figure 5.3 Comparison of Weight Density value of compash brick

The weight density value in compash brick decreased with increasing the pond ash percentage is increased in mix proportion 1and 2. The weight density increased with increase in eco sand percentage in mix combination 3.

The compressive strength, water absorption and weight density value of the conventional clay brick are 5.85 MPa, 16.5 % and 15.43 kN/m^3 are respectively. The weight density value is less compared to conventional clay brick. There is no white or grey batches found in compash bricks. By using this compash bricks, the self weight of the wall element decreased compared with conventional clay brick.

5.3 DURABILITY PERFORMANCE OF THE BRICK

Table 5.4 shows performance of the compash and clay brick after exposure to Na_2SO_4 and NaCl.

Table 5.4 Compressive strength and weight of bricks after immersion in Na_2SO_4, and NaCl solution for various periods (Days)

Mix ID	0 days	3 days	7 days	14 days	21 days	28 days	56 days	90 days
Average compressive strength in N/mm^2 in Na_2So_4 Solution								
CB	5.85	5.56	5.41	5.38	5.26	5.14	4.92	4.80
CaB8	8.65	8.57	8.48	8.37	8.29	8.21	7.84	7.52
CaB12	8.35	8.32	8.30	8.25	8.10	7.85	7.65	7.48
	Weight of the brick in kg							
CB	3.55	3.58	3.63	3.67	3.71	3.72	3.74	3.75
CaB8	2.80	2.92	2.98	3.11	3.13	3.15	3.16	3.18
CaB12	2.85	2.90	2.99	3.10	3.15	3.18	3.20	3.25
Average compressive strength in N/mm^2 in Nacl Solution								
CB	5.85	5.55	5.41	5.39	5.26	5.24	4.82	4.65
CaB8	8.65	8.58	8.48	8.37	8.31	8.21	7.74	7.62
CaB12	8.35	8.30	8.26	8.20	8.15	8.10	7.70	7.55
Weight of the brick in kg								
CB	3.55	3.58	3.65	3.69	3.71	3.72	3.74	3.73
CaB8	2.80	2.94	2.98	3.07	3.13	3.14	3.16	3.17
CaB12	2.85	2.92	3.00	3.09	3.15	3.19	3.20	3.24

The compressive strength values of clay bricks and compash bricks bricks were 4.80 N/mm^2 and 7.52 N/mm^2 respectively after 90 days of immersion in potable water with Na2So4 solution. The compressive strength values of clay bricks and compash bricks bricks were 4.65 N/mm^2 and 7.62 N/mm^2 respectively after 90 days of immersion in potable water with Na_2So_4 solution. Up to 28 days of immersion, micro cracks were formed due to presence of NaCl crystal growth in NaCl solution. This is the reason for the reduction in compressive strength of compash bricks and clay bricks after 28 days of immersion in NaCl solution.

5.4 STRESS–STRAIN BEHAVIOUR OF BRICKS

The compressive load and corresponding deflection data are recorded in the masonry prism element. Stress vs strain curves are drawn for two different types of bricks like compash and clay. In table 5.5 and figure 5.4 show this the values of ultimate load, ultimate compressive stress, failure strain and secant modulus of two different types of bricks used in this experimental investigation.

Table 5.5 Test results various brick with uniaxial loading

Mix ID	Ultimate load (KN)	Ultimate stress (N/mm^2)	Failure strain	Secant modulus (N/mm^2)
CB	122.85	5.85	0.0059	1727.2
CaB8	222.31	8.65	0.0066	2408.7
CaB12	221.26	8.35	0.0063	2350.5

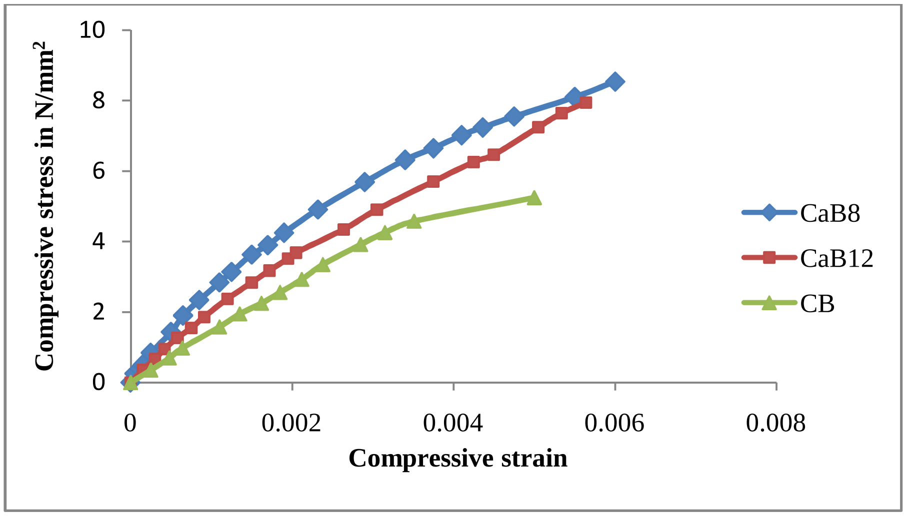

Figure 5.4 Stress strain curve for bricks

Ultimate compressive stress of Compash brick is 31.97% greater than the clay brick. Failure strain for Compash brick is 10.6% greater than clay brick. The young's modulus of Compash brick is 28.9% greater than the clay brick. Secant modulus is directly proportional to the compressive strength.

5.5 STRESS–STRAIN BEHAVIOUR OF MORTAR

The table 5.6 and figure 5.5 shows the values of ultimate load, compressive stress, and failure strain and young's modulus of mortar proportion 1:5 used for making prism in the experimental investigation.

Table 5.6 Test results various mortar grade with uniaxial loading

Mortar proportion	Ultimate load (kN)	Ultimate stress (N/mm^2)	Failure strain	Young's modulus (N/mm^2)
1:5	58.75	11.99	0.0264	5825.20
1:6	49.25	9.88	0.0243	5225.68

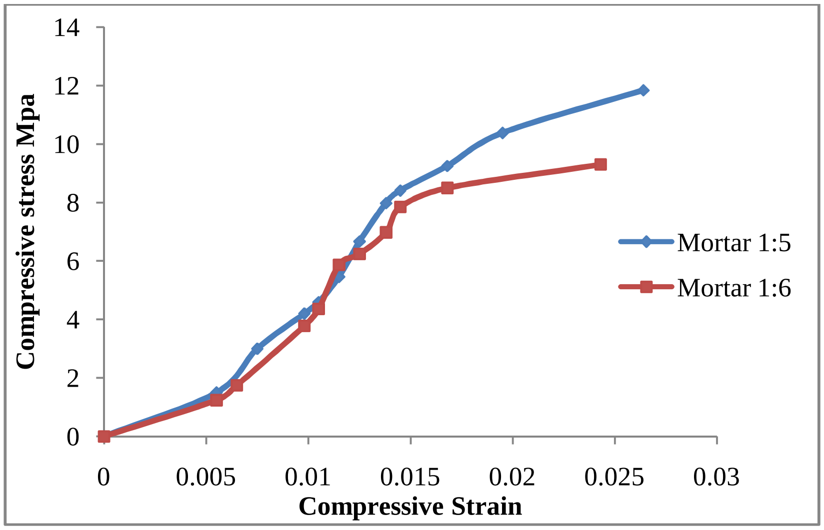

Figure 5.5 Stress strain curve for mortar proportion 1:5 and 1:6

The compressive strength of 1:5 and 1: 6 mortar proportions are 12 N/mm^2 and 9.88 N/mm^2 respectively. The failure strain and young's modulus of the 1:5 and 1:6 mortar proportions are 0.00264, 0.0243 and 5825.20 N/mm^2, 5225.68 N/mm^2. The 1:6 mortar proportion possessed the lower compressive strength and failure strain compared the mortar proportion 1:5.

5.6 STRESS–STRAIN BEHAVIOUR OF BRICK MASONRY

As per the IS code - IS 1905:1987 – 'Codes of practice for structural use of unreinforced masonry' was used for this study. The ultimate stress, failure strain and Secant modulus of the compash and clay brick masonry prism was determined and tabulated in 5.7 and figured in 5.6 and 5.7.

Table 5.7 Comparison test result of brick masonry prisms

Mortar grade	Brick masonry type	Ultimate stress (N/mm^2)	Failure strain	Secant modulus (N/mm^2)
1:5	CB	2.53	0.0048	1612
	CaB8	3.22	0.0056	1711
	CaB12	3.15	0.0052	1680
1:6	CB	1.85	0.0063	1125
	CaB8	2.52	0.0068	1546
	CaB12	2.25	0.0065	1425

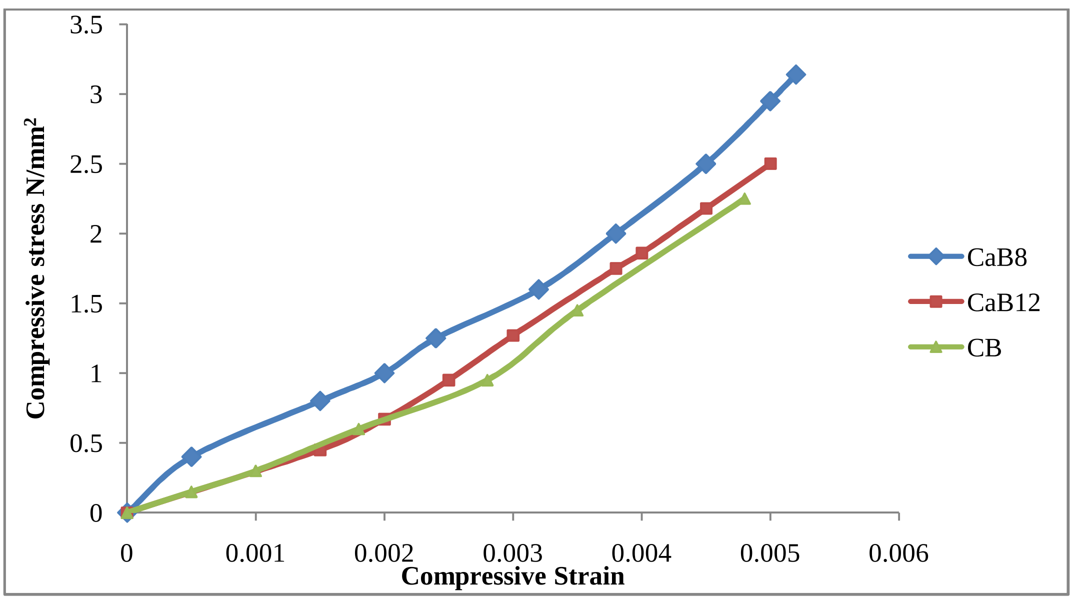

Figure 5.6 stress strain curve for brick masonry prism for 1:5 mortar

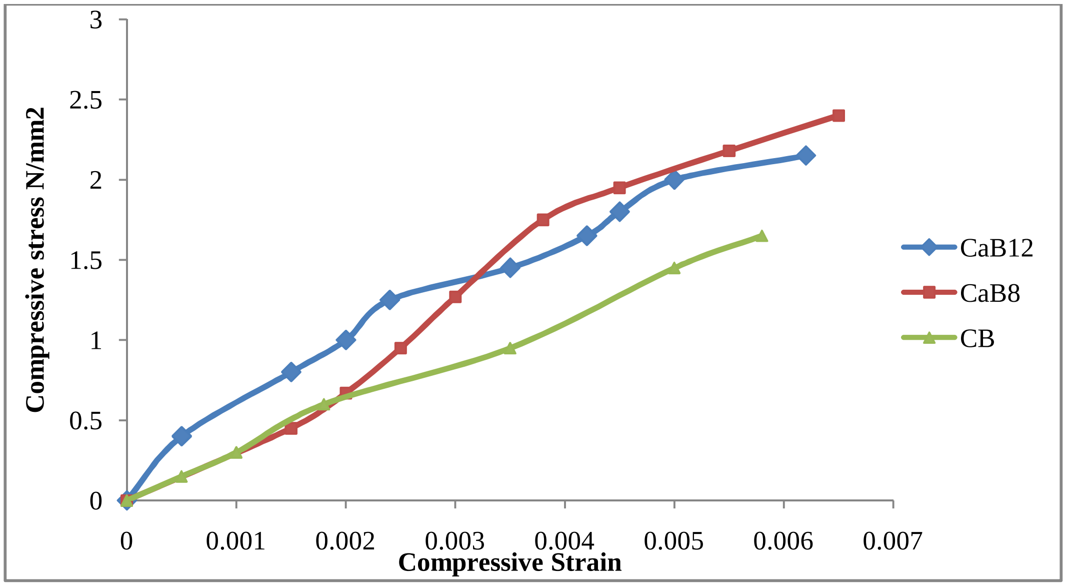

Figure 5.7 Stress strain curve for brick masonry prism for 1:6 mortar

The compressive strength value of the Compash brick masonry prism was higher compared to conventional clay brick. The failure strain value of the clay brick masonry prism was 14.28 % lower than that of Compash brick masonry prism in 1:5 mortar proportions. The secant modulus of the Compash brick masonry prism of 1:5 mortar proportions is 6.20 % higher than the conventional clay brick masonry prism. The brick masonry prism made up of the 1:6 mortar proportion possessed lower ultimate stress, failure strain and secant modulus compared to 1:5 mortar proportion.

5.7 ULTIMATE LOAD CARRYING CAPACITY OF WALL

Table 5.8 shows the ultimate load and ultimate stress of the brick masonry wall. The ultimate load value is higher in the ratio of 1:5 mortar proportions. The ultimate stress of compash brick masonry wall is higher than the conventional clay brick wall. The ultimate value of compash brick masonry wall for the ratio of 1:5 and 1:6 are 8.3N/mm^2 and 7.44 N/mm^2. The compash brick masonry wall with ratio of 1:5 and 1:6 has higher ultimate stress value than conventional brick wall. The compash brick masonry wall (CabW) with mix ratio 1:5 shows higher ultimate stress than the 1:6 mix ratio compash brick masonry wall.

Table-5.8 Ultimate load and stress obtained for walls

S. No	Cement mortar	Mix Id	Ultimate load (kN)	Ultimate stress (N/mm^2)
1	1:5	CaBW	941.50	8.38
2	1:5	CBW	645.50	5.75
3	1:6	CaBW	835.45	7.44
4	1:6	CBW	545.9	4.86

5.7.1 FAILURE MODES

From the figure 5.8 it clearly shows the crack pattern is propagate from top to bottom. The width of the crack pattern gradually decreases from top to bottom. The crack width of compash brick masonry wall is less when compared to conventional brick masonry wall.

Figure 5.8 Failure mode in brick masonry wall

CHAPTER 6

COST ANALYSIS

6.1 ANALYSIS OF BRICK MANUFACTURING COST

The cost analysis is important in acceptance of the product in practical usage. Pond ash is waste material but it includes the transportation cost. The cost of the brick is depends on the following criteria.

1. Brick making Machine
2. Varies material like olivine sand, coal ash, eco sand, fly ash, pond ash, cement, crusher sand.
3. Labour cost and transportation charges
4. Maintenance and electricity.

6.2 CALCULATION FOR QUANTITY AND COST OF THE MATERIALS FOR COMPASH BRICK

6.2.1 Cost analysis of CaB8

The cost analysis of the mix CaB8 is arrived. The materials for the 1000 nos of the brick are mentioned in the table 6.1. Quantity and cost of the material are represented in Pie chart 6.1 and 6.2.

Table 6.1 Quantity and cost of the materials required for mix CaB8 of compash brick for 1000 Nos

Materials	Percentage of materials	Quantity of the material in kg	Approximate Cost of the material in Rs.
Crusher sand	25	1000	800
Lime	10	400	650
Gypsum	5	200	975
Fly ash	40	1600	1050
Pond ash	20	800	350
Total	**100**	**4000**	**3825**

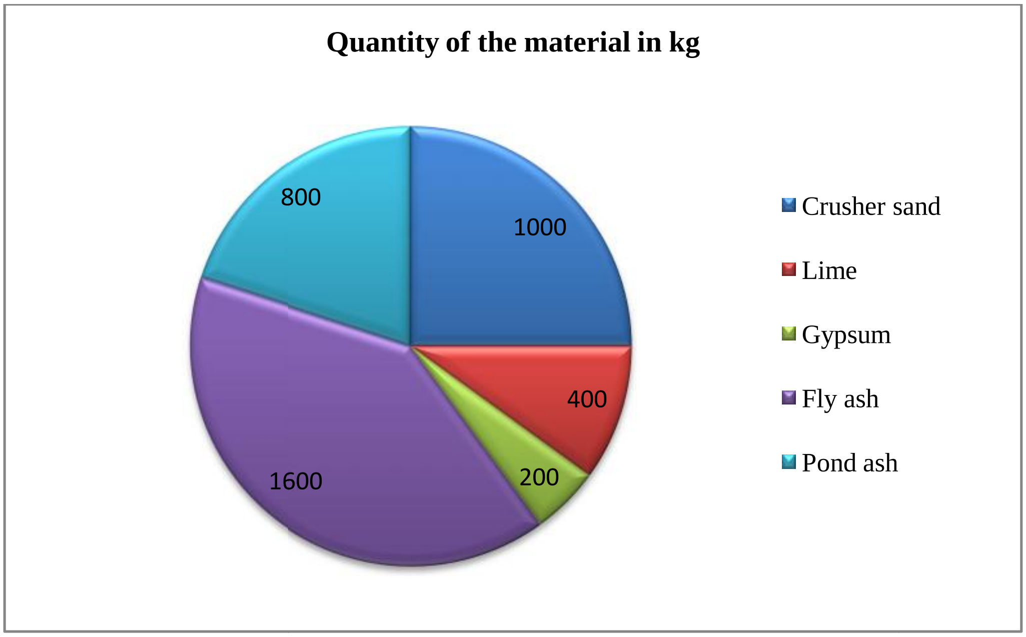

Figure 6.1 Quantity of the materials required for mix CaB8 of compash brick for 1000 Nos

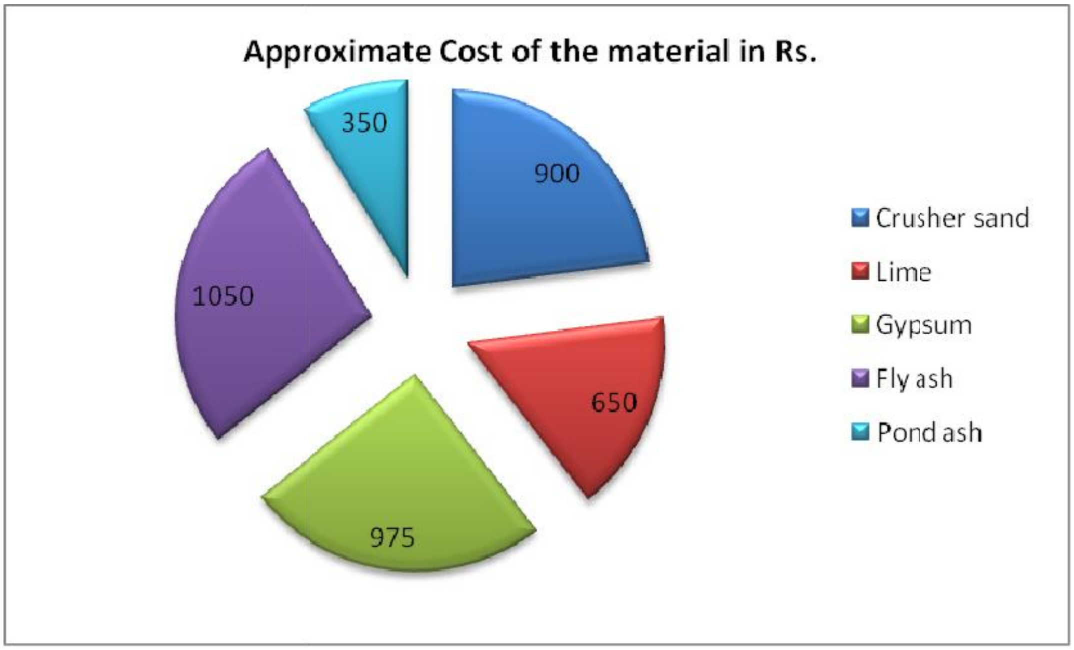

Figure 6.2 Cost of the materials required for mix CaB8 of compash brick for 1000 Nos

The cost for machinery, labour, and electricity charges for making 1000 nos of brick are given below table 6.2.

Table 6.2 Cost of machinery, labour and electricity for 1000 nos of the compash bricks

Sl. No	Description	Cost in Rs. per brick	Cost of 1000 nos of brick in Rs.
1	Labour	0.05	170
2	Electricity	0.05	
3	Machinery	0.07	
Total		0.17	

Total cost of the 1000 nos of the CaB8 = Material cost + Cost of other expenses

= Rs. 3925 + Rs.170 = Rs. 4095

The cost of one CaB8 brick = Rs. 4.10

6.2.2 Cost analysis of CaB12

The cost analysis of CaB12 is arrived. The materials for the 1000 nos of the brick are mentioned in the table 6.3 and represented in Pie chart 6.3 and cost of the material represented in Pie chart 6.4.

Table 6.3 Quantity and cost of the materials required for mix CaB12 of compash brick for 1000 Nos

Materials	Percentage of materials	Quantity of the material in kg	Approximate Cost of the material in Rs.
Olivine sand	15	600	600
Coal ash	10	400	360
Lime	10	400	650
Gypsum	5	200	975
Fly ash	30	1200	1050
Ecosand	30	1200	250
Total	**100**	**4000**	**3885**

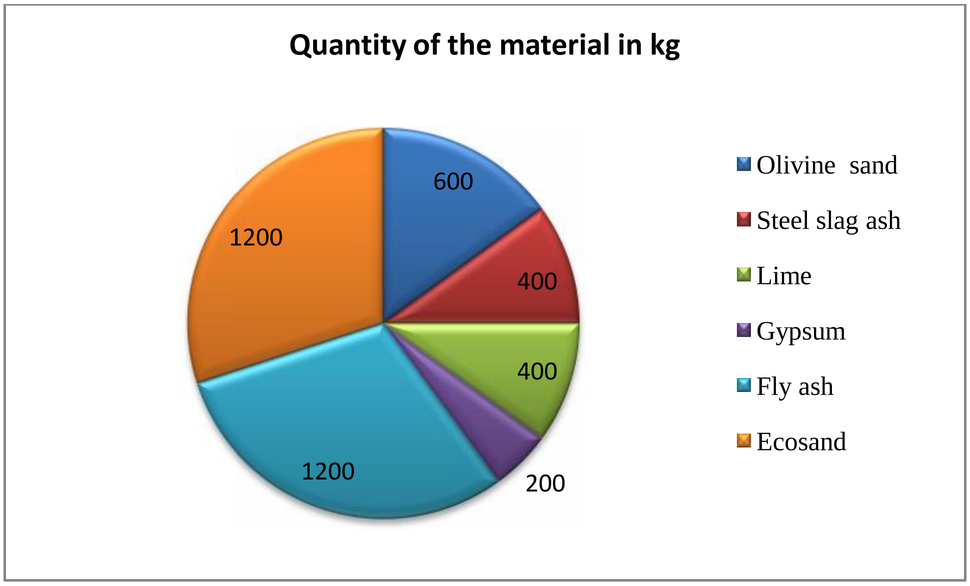

Figure 6.3 Quantity of the materials required for mix CaB12 of compash brick for 1000 Nos

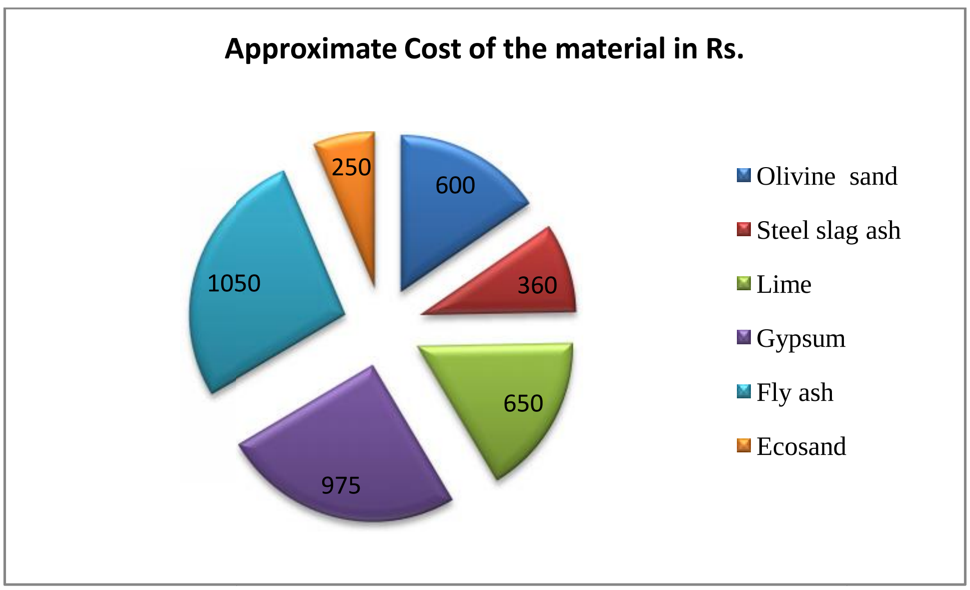

Figure 6.4 Cost of the materials required for mix CaB12 of compash brick for 1000 Nos

Total cost of the 1000 nos of the CaB12	=	Material cost + Cost of other expenses
	=	Rs. 3885 + Rs.170 = Rs.4055.00
The cost of one CaB12 brick	=	Rs. 4.06

CHAPTER 7

CONCLUSION

The following points of the research work are presented below,

A. MECHANICAL AND PHYSICAL PROPERTIES OF BRICK

1. The compressive strength of compash brick varies between 3.50 to 8.65 N/mm^2 for 14 mix combinations.
2. The water absorption percentage range is 10.10 to 13.00 from Mix CaB1 to Mix CaB14.
3. The mix combination of 10 has higher weight density value of 14.25 kN/m$^{3.}$ This is due to the higher percentage of the Ecosand.
4. The compressive strength value is decreased with increase of the crusher sand and pond ash.
5. All mix combinations of compash bricks should possesses the compressive strength of brick greater than 3.5 N/mm^2. So, all types of mix combination are used for load bearing structures.
6. The mix CaB8 and mix CaB12 are found to be optimum and possessed good compressive strength and water absorption value compared to all other mixes.

B. STRUCTURAL BEHAVIOUR OF BRICK MASONRY

7. The Secant modulus of the Compash brick is 31.97 % greater than the clay brick. Failure strain for Compash brick is 10.60 % greater than clay brick. The 1:6 mortar proportions possessed the lower compressive strength and failure strain compared the mortar proportion 1:5.
8. The secant modulus of the Compash brick masonry prism of 1:5 mortar proportions is 6.20 % higher than the conventional clay brick masonry prism.
9. The ultimate load carrying capacity and stress value of compash brick masonry wall is higher than conventional clay brick.

C. COST ANALYSIS OF BRICK

10. The polluting materials like eco sand, fly ash, pond ash, olivine sand, coal ash and crusher sand are effectively used in manufacturing of compash bricks.
11. The cost of the compash brick is significantly low compared to conventional clay brick because of usage of the industrial by products.
12. The cost of compash brick with mix CaB8 and mix CaB12 is Rs. 4.10 and Rs.4.06 respectively.
13. The cost of the compash brick is approximately around 35 percent lower than the conventional clay brick.
14. Entrepreneurship for construction related labours / brick manufacturing units are developed and also increase the employability.

CHAPTER 8

RECOMMENDATIONS AND SCOPE OF FUTURE WORK

8.1 RECOMMENDATIONS OF RESEARCH WORK

I thank UGC for granting me the research project on **"**Quantum Leap in Low Cost construction Techniques with Usage of Compash Brick Masonry for Rural Housing" to explore on various eco friendly industrial by products and convert the same into useful building products.

I herewith highlight the recommendations of the research project.

- ❖ The polluting materials like eco sand, fly ash, pond ash, olivine sand, coal ash and crusher sand are effectively used in manufacturing of compash bricks thereby environment pollution is reduced to a certain extent.
- ❖ From the research findings it is observed that utilization of flyash and pond ash upto 30% each in a mix and usage of ecosand upto 30% resulted in good compressive strength and other mechanical properties. It is also suggested that the overall cost of the compash brick prepared with the locally available materials is which is significantly less compared with traditional clay brick.
- ❖ The mix combination of mix CaB8 containing crusher sand, lime, Gypsum, fly ash and pond ash are 25 %, 10%, 5%, 40% and 20 % respectively. And mix CaB12 containing olivine sand, Coal ash, lime, gypsum, flyash and eco sand are 15, 10, 10, 5, 30 and 30% respectively are identified to be superior mix combinations of compash brick. The cost of this mix is Rs.4.10 and Rs.4.06. The cost of this compash brick is less compared to conventional bricks.
- ❖ The dumping of such industrial by products consumes lot of land resources and is creating an unhealthy way of living to the public. The innovative brick addresses this issue greatly.
- ❖ The cost of the brick is low compared to conventional clay brick because of usage of the industrial by products.
- ❖ This project transfers technology from research to engineering, industrial and societal practices.

- Entrepreneurship for construction related labours / brick manufacturing units are developed and also increase the employability.
- Through this proposed project we would encourage and motivate women in rural areas to actively engage in this project area and thereby developing employability potential for women. With support from NGO’s, resource persons, Industry and R&D organization this project would be a great success benefiting the environment, construction industry, etc ultimately contributing for the nations growth.
- The project shall also support Micro, Small & Medium Enterprises and contribute towards India’s rural employment.

Dr.K.Vidhya
Principal Investigator

8.2 SCOPE OF FUTURE WORK

- The numerical analysis of the compash brick and masonry wall element can be performed.
- The earth quake resistance behavior of the compash brick masonry under cyclic loading can be studied.
- Addition of industrial by products in mortar by partial replacement of cement and fine aggregate can be explored.
- The statistical analysis of the compash brick and masonry can be studied.
- Study of the thermal properties of the compash brick and masonry can be investigated.

CHAPTER 9

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ANNEXURE – A

BRICK MAKING MACHINE