

DURABILITY STUDY ON LIGHT WEIGHT BRICKS USING PERLITE AND LIME MATERIAL

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Abstract— The aim of this study is investigation of brick reproducibility using expanded perlite aggregate as the main raw material. Engineering parameters such as weight per unit of volume, mechanical strength of produced control brick with a dimension of 190 x 90 x 90 mm were determined and optimized. The chemical composition of perlite are 70-75 % silicon oxide (SiO_2), 12-15 % Aluminium Oxide (Al_2O_3), 3-4 % Sodium oxide (Na_2O), 3-5 % Potassium oxide (K_2O), 0.5-2 % Iron oxide(Fe_2O_3), 0.2-0.7 % Magnesium oxide (MgO), 0.5-1.5 % Calcium oxide (CaO), 3-5 % loss on ignition (chemical / combined water). Its thermal, lightness, and acoustic insulation properties make perlite an excellent material to be used as lightweight aggregate in brick manufacturing. Binding materials such as cement, gypsum, lime, bitumen and clay were used for manufacturing perlite brick. These bricks were tested for compressive strength, water absorption, efflorescence, Density and sound test as per Indian Standards. Brick in standard sizes manufactured at different perlite–lime Ratios and unit weight, compressive strength, volume reduction and heat conductivity values were obtained. Then the mixture with the best combination of the properties was determined and cost optimization was described.

Keywords—Expanded Perlite,Lime Powder, Water; Specific gravity; bulk density, Water absorption.

1. INTRODUCTION

1.1 GENERAL

Perlite is used in various areas such as construction materials, agriculture, medical and chemical industry. Moreover, expanded perlite aggregate (EPA) has been used within the constructional elements such as brick, plaster, pipe, wall and floor block; however has not been industrially utilized in concrete yet. EPA is a heat and sound insulator, and lightweight material which ensures economic benefits in constructions. Such well burnt bricks do not breakdown when immersed in water. The temperatures in these kilns go 700 – 1100 degree celcius. In this chapter we will deal with the manufacturing of clay bricks and methods of testing them for use in building construction. The chemical composition of Perlite are: 70–75% Silicon Oxide: SiO_2 , 12–15% Aluminum Oxide: Al_2O_3 , 3–4% Sodium oxide: Na_2O , 3–5% Potassium Oxide: K_2O , 0.5-2% Iron oxide: Fe_2O_3 , 0.2–0.7% Magnesium oxide: MgO , 0.5–1.5% Calcium oxide CaO 3–5% loss on ignition (chemical / combined water). Perlite is used in industries,

agriculture, horticultural aggregate, vermiculite, refractory material, ladle topping, building construction products, fillers, filter aid and used in hot tops and risers. This paper summarizes the study of chemical and physical properties of Perlite and its application in India.

1.2 PERLITE:

Perlite is a type of volcanic rock with pearly lustre. It expands and becomes porous when heated. Colour of crude perlite is light grey to glossy black whereas, the colour of expanded perlite ranges from snowy white to greyish white. Distinguishing feature apart from other volcanic glasses is that perlite when heated to about 850-900 °C expands 4 to 20 times its original volume. This expansion is due to the presence of 2 to 5% combined water in crude perlite which when heated vaporises to form countless tiny bubbles. Expanded perlite is not only amazingly light weight, but also has exceptional physical properties. Unexpanded (raw) perlite has a bulk density around 1100 kg/m³ (1.1 g/cm³), while typical expanded perlite has a bulk density of about 30-150 kg/m³. Perlite is used in industry in both the forms- Crude Perlite and Expanded Perlite. Most perlite is expanded to produce ultra light perlite by heating. Crude perlite is prepared by crushing and screening to various size fractions.



Figure.1.1

1.2.1 EXPANDED PERLITE:

Expanded perlite aggregate EPA has been used in constructional elements such as brick, plaster, pipe, wall, and floor block, however, has not been industrially used in concrete yet. Perlite is a glassy form of rhyolitic or dacitic magma. It

contains 2–5% water. Upon rapid heating, perlite transforms into a cellular material of low bulk density. As the chemical water held within the perlite boils at temperatures of 900–1,100°C, the resultant steam forms bubbles within the softened rock to produce a frothy like structure. The formation of these bubbles allows perlite to expand up to 4–20 times of its original volume.

Thermal conductivity has been defined as “the rate of flow of heat per unit area per unit temperature gradient when heat flow is under steady state conditions” Tennent 1997. The thermal conductivity of porous materials depends on various parameters, such as the thermal properties of the constituent phases and the microstructure parameters, which include the volume fractions of the constituent phases, geometrical distribution of the phases, the size and size distribution of the particles, and the geometry of the individual papers.



Figure.1.2

1.2.1.1 PHYSICAL PROPERTIES OF EXPANDED PERLITE

Property of EPA	Determined limits
Color	White
Specific gravity	0.28
Unit weight kg/m ³	30–190
Porosity %	90
Specific heat kCal/kg °C	0.20–0.23
Melting point °C	1,300
Thermal conductivity W/mK	0.039–0.046
Thermal expansion mm/m °C	0.004–0.011

1.2.1.2 CHEMICAL PROPERTIES OF EXPANDED PERLITE

Component	Content in %
SiO ₂	70.68
Al ₂ O ₃	13.04
Na ₂ O	3.54
K ₂ O	4.34
Fe ₂ O ₃	1.04
CaO + MgO	3.78
Other	3.38

1.2.2 ADVANTAGES OF EXPANDED PERLITE:

Industrial applications for Perlite are the most diverse, ranging from high performance fillers for plastics to cement for petroleum, water and geothermal wells. Other applications include its use as a filter media for pharmaceuticals, food products, chemicals and water for municipal systems and swimming pools. Additional applications include its use as an abrasive in soaps, cleaners, and polishes; and a variety of foundry applications utilizing Perlite insulating properties and high heat resistance. This same heat resistant property is taken advantage of when Perlite is used in the manufacture of refractory bricks, mortars, and pipe insulation. Over half of all the Perlite expanded in the United States annually is

used to make —formed products. These products include ceiling tiles, pipe insulation, roofing board and fire-rated door cores, and are manufactured with a variety of binders. Perlite can safely be used over a wide range of temperatures. Being lightweight, non-combustible, and insulating, Perlite has been found to be useful in a wide variety of industrial applications, e.g., refractory brick, high temperature insulation, molten metal topping, cryogenic insulation, filtration, and lightweight fillers. Perlite and vermiculite are both used to improve moisture retention and aeration in soil. They are used in a similar manner, but they are not interchangeable. Perlite and vermiculite are quite different in composition and in how they improve your soil. Determining which is better for use in your garden depends on your plants and their needs. There are many uses for perlite. These uses can be broken down into three general categories: construction applications, horticultural applications, and industrial applications.

1.3 LIME POWDER:

Locally available Lime powder were used in this work. limestone is a general term for rocks that contain 80% or more of calcium or magnesium carbonates, including marble, chalk, and marl. lime has an adhesive property with bricks and stones, it is often used as binding material in masonry works.

Lime is a calcium-containing inorganic material in which [carbonates](#), [oxides](#), and [hydroxides](#) predominate. In the strict [sense](#) of the term, lime is [calcium oxide](#) or [calcium hydroxide](#). It is also the name of the natural [mineral](#) (native lime) CaO which occurs as a product of [coal seam fires](#) and in altered [limestone xenoliths](#) in [volcanic](#) ejecta.^[1] The word "lime" originates with its earliest use as building mortar and has the sense of "sticking or adhering".

The rocks and minerals from which these materials are derived, typically limestone or [chalk](#), are composed primarily of [calcium carbonate](#). They may be cut, crushed or pulverized and chemically altered. "Burning" ([calcination](#)) converts them into the highly [caustic](#) material "quicklime" ([calcium oxide](#), CaO) and, through subsequent addition of water, into the less caustic (but still strongly [alkaline](#)) "slaked lime" or "hydrated lime" ([calcium hydroxide](#), Ca(OH)₂), the process of which is called "slaking of lime". [Lime kilns](#) are the [kilns](#) used for lime burning and slaking.

When the term is encountered in an agricultural context, it usually refers to [agricultural lime](#), which is crushed limestone, not a product of a lime kiln. Otherwise it most commonly means [slaked lime](#), as the more dangerous form is usually described more specifically as [quicklime](#) or "burnt lime".



Figure.1.3 Lime Powder

1.3.1 PHYSICAL PROPERTIES OF LIME

POWDER:

PHYSICAL APPEARANCE	WHITE POWDER
SPECIFIC GRAVITY	2.2
pH(1% solution)	12.4
SOLUBILITY@20°C(68°F)	0.165 g/100ml water
BULK DENSITY	2210.5kg/m ³ (138 lb/ft ³)

1.3.2 CHEMICAL PROPERTIES OF LIME

POWDER:

CHEMICAL PROPERTIES	
Chemically, both limestone and marbles are siliceous calcium carbonate rocks.	
Lime (CaO)	38-42%
Silica (SiO ₂)	20-25%
Alumina (Al ₂ O ₃)	2-4%
Other Oxides like Na, Mg	1.5 to 2.5%
Loss On Ignition (LOI)	30-32%

1.4 AIM

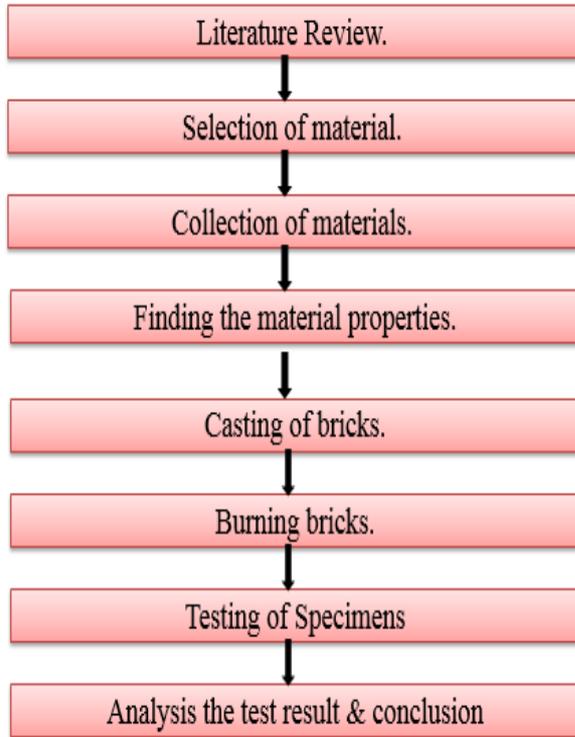
To Experimental study on light weight bricks using perlite and lime materials.

1.5 SCOPE :

- ❖ To reduce the weight of the bricks.
- ❖ Floating bricks.
- ❖ To avoid the accidents of fire industries.

2.METHODOLOGY:

2.1 FLOWCHART:



The methodology of the project involves collection of literature and necessary documents required for the experimental work. After the sufficient documents are collected, the materials required for the experimental work is collected, and tested for its originality against the project specifications. When the materials satisfy the project specifications, the specimens (bricks) are to be casted and are to be burned under normal bricks conditions.

When the materials are burned, the bricks are tested for their compression strength, and the water absorption test.

3. MATERIAL COLLECTION AND TESTING

3.1 MATERIAL PROPERTIES:

3.1.1 Specific gravity test of Expanded perlite:

The empty specific gravity bottle designed and was taken as (w1).The bottle was filled with perlite and the weight is taken as (w2).The specific gravity bottle was filled with perlite and water weighed which was

taken as (w3).Roll the bottle in the incline position until no further air bubble rise to the surface. Fill the bottle to the top with water and weight (w4).

$$\text{Specific gravity of EPA} = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

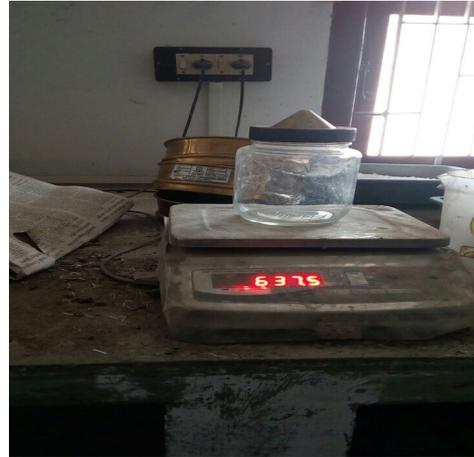


Figure:3.1.specific gravity test

3.1 Specific gravity of Expanded Perlite

Description	Weight in g		
	Trial I	Trial II	Trial III
Weight of empty mould (W ₁)	611	611	611
Weight of mould +EPA (W ₂)	630	620	629
Weight of mould + EPA +water (W ₃)	1450	1468	1465
Weight of mould + water (W ₄)	1510	1510	1510

4.EXPERIMENTAL PROGRAM:

This Indian Standard was adopted by the Indian Standards Institution on 17 November 1968, after the draft finalized by the Flooring and Plastering Sectional Committee had been approved by the Civil Engineering Division Council. These bricks are made of raw materials, such as clay or shale of suitable composition with low lime and iron content, felspar, flint or sand, and vitrified at high temperatures in ceramic kilns. These bricks are designed primarily for use in chemical and allied industries and are normally used with chemical resistant mortars.

This standard covers the requirements for bricks intended for use where minimum absorption is required and thermal shock and alkali resistance are not important service factors. In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

It is necessary to Check the quality of brick before using it in any construction activities. There are some field tests that we can conducting the field in order to check the quality of bricks. A Brick is generally subjected to the following tests to find for the Construction work. These tests are as follows.

Bulk Density Test,Water Absorption Test

4.1.BULK DENSITY TEST:

1.The brick is dried in a ventilated oven at a temperature of 105⁰ to 115⁰C till it attains substantially constant mass.

2.The brick is then cooled to room temperature and its mass is recorded.(M)

3.Then the dimensions of the brick is measured accurately and the volume is calculated.(V)

$$\text{Bulk density} = \frac{\text{Mass}(M)}{\text{Volume}(V)}$$



Figure.4.1.bulk density test

BRICK RATIO	TRIAL I	TRIAL II	TRIAL III	AVERAGE WEIGHT IN Kg	BULK DENSITY Kg/m ³
CONVENTIONAL BRICK	2.8	2.89	3.1	2.93	1465
B1 (70,30)	1.020	1.000	1.094	1.038	674.44
B2 (75,25)	0.990	0.987	0.984	0.987	641.32
B3 (80,20)	0.960	0.955	0.953	0.956	621.18
B4 (85,15)	0.850	0.866	0.853	0.856	556.20

Average bulk density of perlite bricks = 623.28 Kg/m³

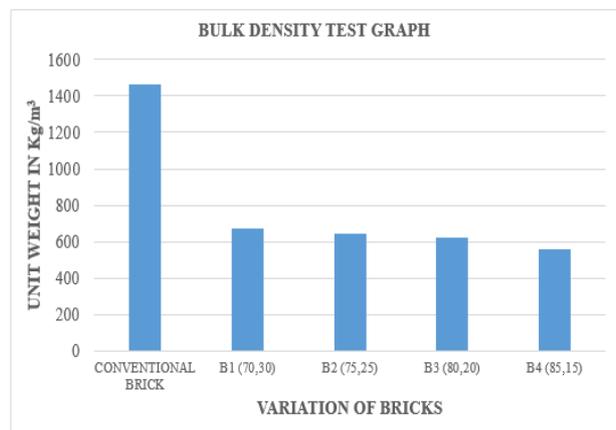


Figure:4.1. graph for bulk density test results

4.2. WATER ABSORPTION TEST:

In this test bricks are weighed in dry condition and let them immersed in fresh water for 24 hours. After 24 hours of immersion those are taken out from water and wipe out with cloth. Then brick is weighed in wet condition. The difference between weights is the water absorbed by brick. The percentage of water absorption is then calculated. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight.

$$\text{Water absorption} = \frac{M_2 - M_1}{M_1} \times 100$$

BRICK RATIO	TRIAL 1	TRIAL 2	AVERAGE WATER ABSORPTION
CONVENTIONAL BRICK	11.56	9.41	10.48
B1(70,30)	23.99	21.81	22.9
B2(75,25)	22.42	21.61	22.0
B3(80,20)	20.19	20.3	20.24
B4(85,15)	31.5	31.99	31.75

Average water absorption value in % = 24.7

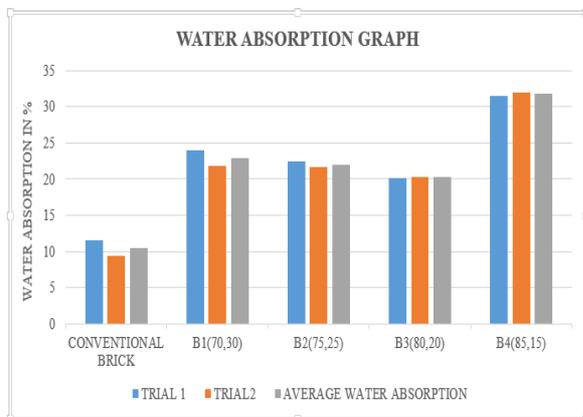


Figure 4.3 Graph of Water Absorption test

5. CONCLUSION:

The low unit weight is one of the most important features for the bricks and construction sector. declared that the low density of bricks is related with internal micropores and it reduces the load in buildings and finally reduces the logistical costs. Water absorption of B3 (80,20) Brick is ,compare to lower than other ratios. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight. This Brick is floating into the water.

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