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Experimental analysis of the effect of lime addition on the properties of clay bricks (a thermomechanical study)

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Abstract:
The purpose of adding lime to clay bricks is to develop and improve their mechanical, physical, and chemical properties. Lime reduces shrinkage upon drying, thus reducing cracking. Furthermore, it improves the brick's resistance to compression and shape retention, increasing its long-term durability. In this context, tests were conducted on clay bricks with lime contents ranging from 5% to 30% at the University of Djelfa's research facility. A consistent increase in density was observed up to 15% lime. Lime also reduced water retention from 17% to 10%, thereby reducing the brick's vulnerability to moisture. Mechanically, compressive strength increased by 26%. Regarding the thermal aspect, thermal conductivity decreased between 5.71% and 30.28%. The results showed that a 15% lime rate is ideal for achieving a balance between durability and thermal insulation. In the field, lime may be a promising natural and economical option, contributing to reducing carbon emissions and construction costs while improving the maintainability of local assets.

Keywords:
building materials, physical properties, clay, lime, mechanical properties, thermal properties

1. Introduction

Natural clay is highly plastic and therefore unsuitable for construction use [1]. Therefore, when lime and other mineral additives are added, a more durable, water-resistant brick is formed, known as a clay-lime mixture [2]. Clay bricks are produced in various ways from natural clay deposits. Brick clay mixed with additives such as lime is pressed and then allowed to dry. Along with mineral and organic additives, water is also important, affecting the clay's plasticity and impacting the brick's setting, drying, sintering, and expansion during production [3]. Proper mixing and shaping are essential to avoid cracking, swelling, or excessive shrinkage, which results in increased sagging [4]. This paper presents an approach to determining the ideal lime ratio when producing clay-lime mixture bricks, based on compressive strength. The use of lime as a stabiliser in clay bricks is a historical practice that has been revived [5]. Although lime is available worldwide, its use in clay bricks has not been widely known. Lime reacts with clay to form a gel due to the presence of alumina [6]. Therefore, when lime is added to the clay, the particles bond together, which is desirable in clay bricks, unlike lime bricks and lime-sand mixtures [7]. A balanced mixture of clay and lime must be used in the production of clay bricks. Because lime reacts with clay, it cannot be added in quantities greater than those that provide a balanced material with the clay used. Information on the minimum and maximum lime content required for the various types of clay used would be very useful to manufacturers [8]. Clay soils are not suitable for construction because they have low bearing capacity and are difficult to work with due to their high plasticity [9]. Many soils with a clay content of 30% or higher are unacceptable for construction under any circumstances. However, the use of lime can improve the engineering properties of clay. Lime reacts with clay, increasing the workability of clayey soil [10]. Previous studies have demonstrated the importance of adding lime to clay bricks. However, they have often been limited to determining a single ratio or studying the effect of expansion in general, without delving into the different ratios that may have different effects. However, they often limited themselves to specifying a single ratio or analysing the effect of the addition in general without delving into the different ratios that may have diverse effects. In a study by Laouidji et al., the effect of adding lime at different ratios (2% to 10%) was evaluated on three soils in Algeria. The experiments showed a clear increase in compressive and flexural strength with the addition of 8% lime: compressive strength increased by 47% to 101%, and the flexural modulus improved. The results indicate that adding lime between 2% and 8% improves the performance of clay bricks, and the results confirm this [11]. In a study, the effect of lime use in the manufacture of lightweight, steam-cured bricks was investigated. The effect of water content was studied. The results showed that untreated bricks with 15% lime increased clay hardness and improved pozzolanic interaction and mechanical properties [12]. In another study, sustainable solutions were presented by incorporating lime powder and bentonite into pressed, unfired bricks. The results showed that the addition of lime and bentonite improved compressive and flexural strength and reduced water absorption and weight, resulting in a pressed brick with a strength of 10.40 MPa according to building standards. Bentonite also enhanced durability and reduced thermal conductivity by 31.91%, making the pressed bricks more energy-efficient and less environmentally impactful than traditional fired bricks [13]. In some studies, limited ratios were used, which improved some properties without reaching an optimal balance. Other studies indicated the need for comparative experiments to analyse mechanical properties when the lime ratio was gradually changed. Hence, a research gap emerges, necessitating a comprehensive, systematic study to measure the impact of adding lime.

This research aims to bridge the gap by conducting a systematic experimental study to compare the performance of clay bricks as the percentage of lime added varies from 5% to 30%, and to determine the ratio that achieves the ideal balance among mechanical, thermal, and physical properties. Mechanical properties are analysed by compressive strength testing, physical performance is evaluated by measuring moisture absorption and water absorption, and thermal performance is evaluated by measuring thermal conductivity, which directly impacts the sustainability and thermal efficiency of buildings.

The need for such research stems from rapid developments in the construction sector and the growing technical requirements for higher standards in construction materials, especially in hot regions. Improving the properties of clay bricks with lime can positively impact the environment by reducing the use of expensive industrial materials and enhancing environmental sustainability through the use of locally sourced, low-impact materials. Furthermore, it represents a qualitative step towards developing local building materials that combine traditional benefits with technological modernity. This study also aims to provide practical solutions to construction challenges in different environments, emphasising the importance of environmental and economic sustainability. The results of this research will provide valuable data that will contribute to improving construction policies and developing quality standards, enhancing the credibility of traditional materials in the face of modern requirements, and advancing the future of construction on well-studied scientific foundations.

2. Materials and methods

2.1. Materials used

2.1.1. Clay

The properties of the clay used are shown in Table 1. Analysing Table 1, the following can be concluded:
Geotechnical Properties of Clay:

The soil is a very fine-grained loamy soil, which increases its compressibility and swelling capacity. Clay is highly plastic (according to USCS classification), making it sensitive to water, prone to cracking upon drying, and prone to swelling upon saturation. The USCS (Unified Soil Classification System) is an engineering system used to classify soils by their physical properties. It is one of the most widely used systems in infrastructure and foundation projects [14].

Clay is characterised by high plasticity and a low sand content, making it suitable for insulation and brickwork. However, it is not ideal for projects requiring high strength or significant compressive strength without prior treatment such as stabilisation with lime or cement.

Chemical Composition of Clay:

Clay contains a high percentage of calcium carbonate but a very low percentage of silica (SiO_2), which results in poor compressive strength. Other unspecified elements constitute a high percentage and may affect the final performance.

This clay can be used to make unfired bricks and clay insulation in foundations and traditional architectural decoration. It also requires improvement when used in load-bearing structures (such as adding lime or reinforcing materials).

2.1.2. Lime

The properties of lime used are shown in Table 2. We conclude the following:

Lime has an excellent chemical composition, containing a very high percentage of calcium oxide, which makes it highly effective at reacting with water and clay to improve cohesion and hardness. Low impurities indicate good purity, making it suitable for construction and architectural uses. Because of its high CaO content (excellent chemical activity) and very low impurities (high purity), it can be used to stabilise soil and clay in civil engineering projects because it improves the properties of highly plastic clay.

Table 1. Clay properties [15]

Geotechnical properties							
Sand (> 0,02mm)	Silt (0,02-0,002mm	Clay (<0,002mm)	Liquid limit WL	Plastic limit WP	plastic index IP	VB	Specific density γs
0.09	0.54	0.37	0.81	0.34	0.47	8	2.6 g/cm3
Chemical composition							
SO_4 -2	$CaCO_3$	Cl-	SiO_2	Al_2O_3	Fe_2O_3	MgO	Other
0.41%	3.6%	0.14%	0.63	0.16	0.07	2.4%	7.46%

Table 2. Chemical and physical properties of lime used [16]

Chemical composition								
Na_2O (%)	CO_2 (%)	$CaCO_3$ (%)	Al_2O_3 (%)	SiO_2 (%)	SO_3 (%)	CaO (%)	Fe_2O_3 (%)	Insoluble material (%)
0.4–0.5(%)	< 5(%)	< 10(%)	< 1.5(%)	< 2.5(%)	< 0.5(%)	< 83.3(%)	< 2(%)	< 1(%)
Physical properties								
Apparent density (g/l)			More than 90 µm (%)			More than 630 µm (%)		
600–900			< 10			0		

2.2. Methods

2.2.1. Sample preparation

Clay and lime are thoroughly mixed using an electric mixer, then water is gradually added. To obtain a consistent mixture, the water ratio must be 30% of the mixture volume. This ratio was determined based on previous studies [17]. In previous studies, the experimenters used 32% of the total soil volume by combining clay and lime [18]. Another study focused on the effects of natural fibres and water content in the mixture, as they play a major role in developing the mechanical properties of mud bricks. The water content of the mixture ranged between 25–35% [19]. In this work, clay was crushed and sieved through a 2 mm sieve. The clay and lime were weighed, and the water volume was determined to be 300 Cl. Samples were prepared according to Table 3. Figure 1 illustrates the test preparation strategy. The wet weight of the samples was determined to be 2000 g. The mixture was placed in a metal mould measuring 20 × 10 × 5 cm^3, and the mould was shaken slightly to stabilise the mixture. Six samples were made for each lime content and left to dry for 28 days in a natural environment.

2.3. Experiments

2.3.1. Density change measurement

Density is one of the key indicators for assessing how the lime ratio affects brick structure and mechanical quality. This assessment is part of a broader goal of improving brick performance, ensuring durability, and meeting the standards necessary for stable growth. The process of mixing clay with lime results in chemical reactions that alter how the clay particles bond together. Lime activates the clay components and forms chemical and physical bonds between the particles. ASTM C67 is used to measure the overall thickness and properties of clay bricks, including weight and volume. Samples are weighed and their dimensions measured according to eq. 1:

$$\rho = \frac{m}{v} \tag{1}$$

Figure 2 shows the change in bulk density as the lime ratio varies.

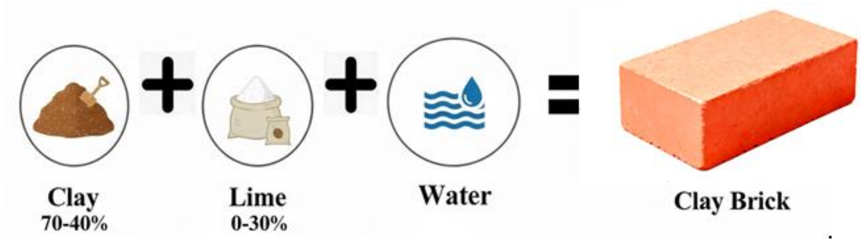
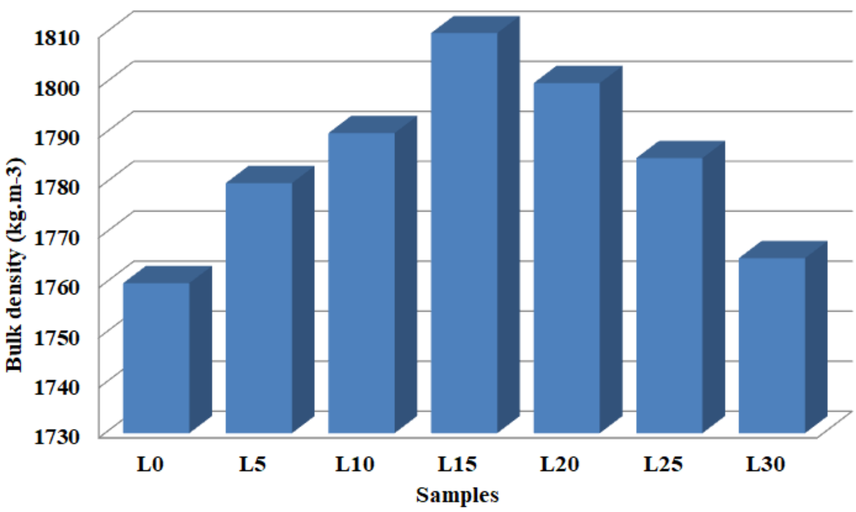


Fig. 1. Sample installation

Table 3. Sample preparation

Clay		Lime		Water (%) 600 cl	Samples
70(%)	1400g	0(%)	0g	30	L0
65(%)	1300g	5(%)	100g		L5
60(%)	1200g	10(%)	200g		L10
55(%)	1100g	15(%)	300g		L15
50(%)	1000g	20(%)	400g		L20
45(%)	900g	25(%)	500g		L25
40(%)	800g	30(%)	600g		L30



Sample L0: Contains 70% clay, 0% lime, and 30% water used in mixing.
Sample L5: Contains 65% clay, 5% lime, and 30% water used in mixing.
Sample L10: Contains 60% clay, 10% lime, and 30% water.
Sample L15: Contains 55% clay, 15% lime, and 30% water used in mixing.
Sample L20: Contains 50% clay, 20% lime, and 30% water used in mixing.
Sample L25: Contains 45% clay, 25% lime, and 30% water used in mixing.
Sample L30: Contains 40% clay, 30% lime, and 30% water used in mixing.

Fig. 2. Change in bulk density value

2.3.2 Water absorption rate measurement

Measuring the water absorption rate of clay bricks after lime is added is an important step in understanding and improving their physical and mechanical properties, especially in construction applications that require moisture resistance and durability. Measuring the change in water retention rate of clay bricks when the lime material is changed is a key illustrative criterion for evaluating and improving the quality of building materials used in both traditional and modern construction. This is because the water absorption rate is a key indicator of a brick's properties, including hardness, physical strength, thermal performance, and mechanical quality. Bricks with a lower water absorption rate are less susceptible to moisture damage and hardening. Water absorption affects the brick's interaction with the mortar, which in turn affects the building's quality. The addition of lime changes the pore structure within the brick, affecting its water retention and, consequently, the standard used to calculate water absorption in clay bricks is: ASTM C67. Its thermal and mechanical properties. The retention rate is calculated using the following eq. 2:

$$\text{Water absorption rate (\%)} == \frac{m2-m1}{m2}\cdot 100\% \qquad (2)$$

m2 is a wet brick block after immersion in water. m1 is a dry brick block before immersion in water. Figure 3 illustrates how this test is performed. Figure 4 shows the change in water absorption rate with the addition of lime.

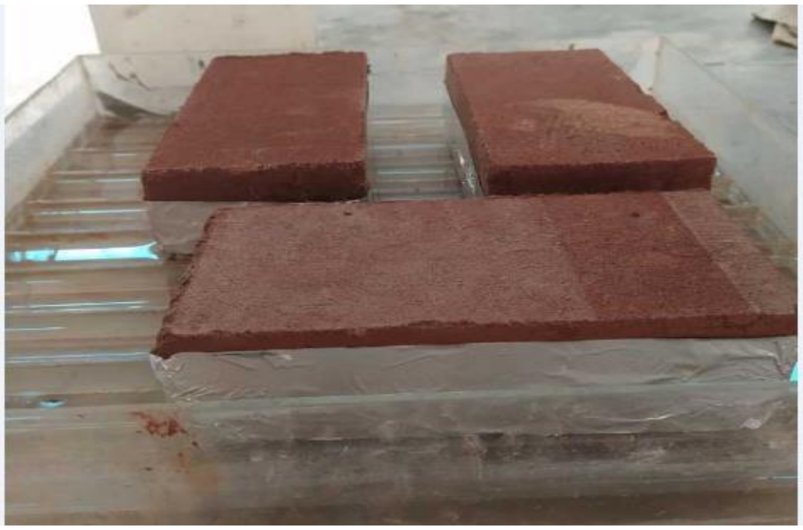


Fig. 3. Capillary water absorption experiment

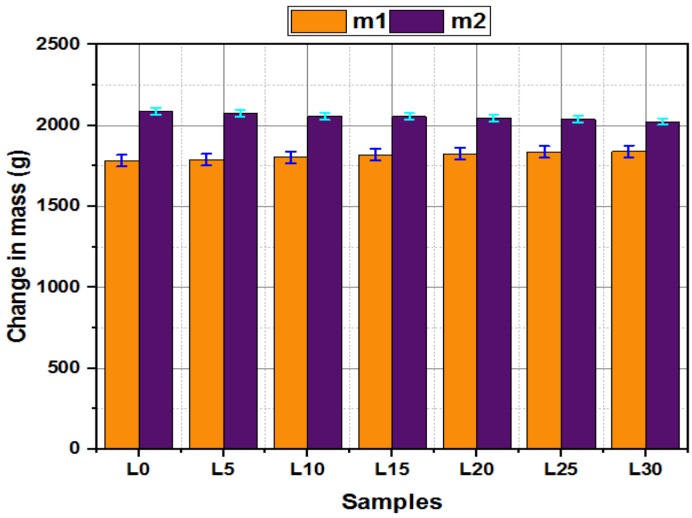


Fig. 4. Change in clay brick mass before and after immersion in water

2.3.3. Compressive strength measurement

Knowing the compressive strength value can ensure that the brick is capable of absorbing vertical loads in load-bearing walls without sudden collapse, enhancing the stability and safety of structures resistant to earthquakes and strong winds. The compressive strength test allows bricks to be classified into grades (residential, commercial, industrial) based on their resistance and ensures consistency in production. This classification facilitates the selection of the appropriate type for each construction application and reduces variation between different industrial batches.

Compressive stress values are related to the durability of bricks under repeated moisture and freeze-thaw cycles. Higher compressive strength reflects better uniformity in the firing of the clay and reduced porosity, resulting in longer service life and faster drying of the wall during service. ASTM C140 is used to determine compressive strength. Researchers used a 3000 kN hydraulic press. Stress values are calculated using the eq. 3:

$$\rho = \frac{F}{A} \tag{3}$$

F is the force applied to the brick. A is the area over which the force is applied

Figure 5 illustrates how the tests were conducted in the press. The results of compressive strength measurements are shown in Fig. 6.

Fig. 5. Applying compressive force to clay bricks

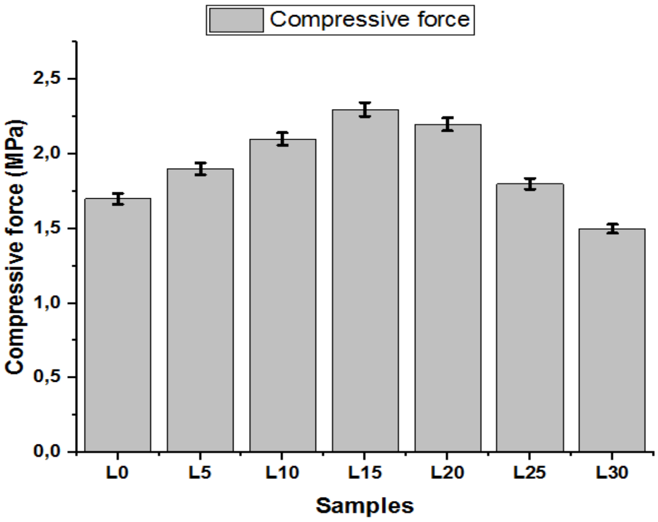


Fig. 6. Measuring compressive strength in clay bricks

2.3.4. Thermal conductivity measurement

Measuring the thermal conductivity of clay bricks is a design and operational necessity. This measurement provides insight into the comfort of building occupants, reduces energy consumption, and contributes to economic and environmental sustainability. With accurate data on the thermal coefficient, engineers can refine specifications and design more efficient, sustainable buildings. Measuring the thermal conductivity helps determine the ability of clay bricks to prevent heat transfer through walls. This indicator assesses the material's effectiveness in providing a thermally stable indoor environment. Choosing bricks with low thermal conductivity reduces heat emission in the summer and heat loss in the winter. This directly contributes to occupant comfort and reduces heating and cooling requirements. Thermal conductivity is measured using a Hukseflux device, which inserts a thermal needle equipped with a screen into the brick. ASTM D5334 is used to determine the thermal conductivity value.

An ointment is added that acts as a carrier between the probe and the sample, filling the microscopic gaps and preventing air ingress, thus improving heat transfer and ensuring measurement accuracy. It also secures the probe in place and minimises movement, in addition to protecting its surface from abrasion or scratching upon contact with solid materials.

Various measurements are taken every 5 minutes. The measurement results are shown in Fig. 7. Table 4 summarizes all the results.

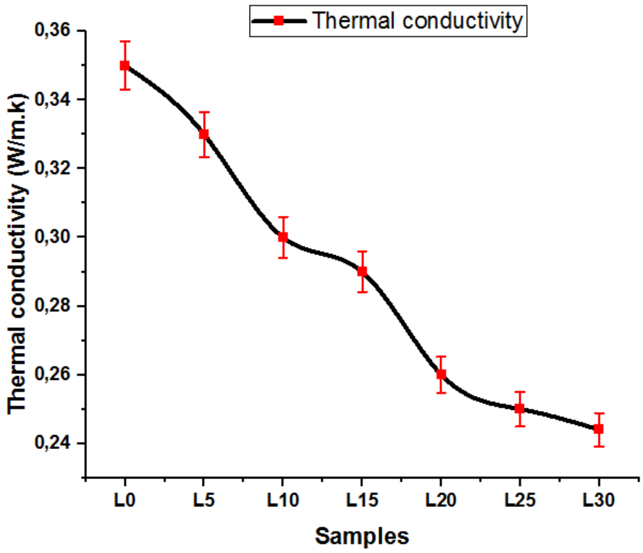


Fig. 7. Change in thermal conductivity

Table 4. Variations in all measured properties when the lime content is changed

Samples	Thermal conductivity ($W.m^{-1}k^{-1}$)	Compressive strength (MPa)	Water absorption rate (g)		Bulk density ($kg.m^{-3}$)
L0	0.35	1.75	1783	2086	1760
L5	0.33	1.95	1790	2076	1780
L10	0.3	2.10	1805	2057	1790
L15	0.29	2.30	1820	2056	1810
L20	0.26	2.20	1827	2046	1800
L25	0.25	1.85	1837	2040	1785
L30	0.244	1.50	1841	2025	1765

3. Analysis and discussion

3.1. Measuring density change

Analysis of Figure 2 reveals that the bulk density increases from 1780 $kg.m^{-3}$ to 1818 $kg.m^{-3}$ at 15% lime, then decreases from this value to 1765 $kg.m^{-3}$ at 30% lime.

When lime is added to clay bricks at ratios ranging from 5% to 30%, its effect on density depends on several factors, including the type of clay, the type of lime (live or slaked), and the water-to-clay ratio used in mixing. At lower ratios (5-15%), the density increases slightly. This is explained by the lime filling the spaces between the clay particles, resulting in a more cohesive composition. This improves the chemical interactions between the components, forming more solid materials such as calcium carbonate. These results are consistent with research by Millogo et al., where the addition of lime (5%-12%) to clay bricks increased density due to pozzolanic reactions that formed calcium silicate gels (CSH) that fill the pores. While higher lime contents (above 12%) resulted in a slight decrease in density due to increased portlandite [20]. In a previous study, density decreased by 12% at lime contents of 5%-15% due to particle aggregation. This differs from our results because low-density polyethene (LDPE) does not absorb water, and as LDPE increases, the effective water content within the soil decreases during consolidation, weakening the compaction process and reducing density [21].

At higher concentrations (15%-30%), density begins to gradually decrease. This is explained by the fact that excess lime increases porosity and cracks during drying, thereby reducing overall density. These results are consistent with the findings of Ndjeumi et al., which indicate that increasing the lime content (greater than 14%) reduces the density due to the lower clay content and shrinkage during drying. This increases porosity through gas release (carbon dioxide during carbonation) and water evaporation [22].

3.2. Measuring the water absorption rate

When analysing Figure 4, which shows the change in mass before and after immersion in water, the experimenters observed that the water absorption rate decreased significantly as the lime content increased. Compared to the lime-free sample, the mass of the samples increased after immersion in water. Figure 8 shows the percentage increase in mass for each lime content.

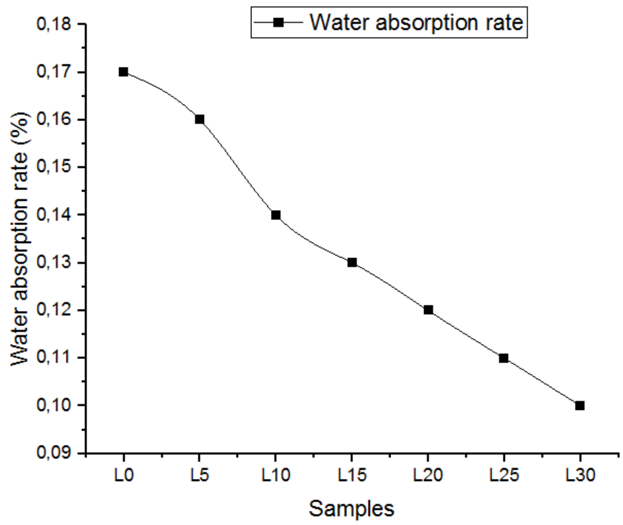


Fig. 8. Water absorption rate

It is noted that the water absorption rate decreased from 17% (2086 g – 1783 g) to 10% (2025 g – 1783 g). Lime reacts with the silica and alumina in the clay to form calcium silicate hydrate (CSH), which fills the microscopic spaces. As the capillary pores decrease, water penetration decreases, resulting in a lower absorption rate.

These results are consistent with several studies [23-25].

Mechanically, CaO first converts to $Ca(OH)_2$ upon mixing, then over time reacts with CO_2 to form $CaCO_3$.These microparticles act as an effective filler, blocking the pores.

Figure 9 shows how the lime ratio affects pore size reduction in clay bricks.

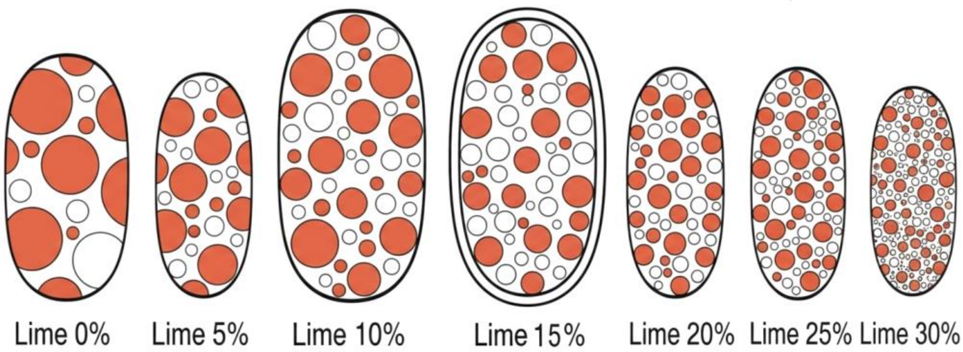


Fig. 9. Effect of lime ratio on pore size

3.3. Compressive strength measurement

Figure 6 shows the change in compressive strength of clay bricks with lime added at rates of 5% to 30%. It is noted that the compressive strength increases from 1.7 MPa to 2.3 MPa, an increase estimated at 10.5% to 26.08%. The compressive strength then decreases from 2.3 MPa to 1.5 MPa.

Adding lime at a rate of 5% to 15% increases the hardness of clay bricks. However, its effect becomes negative after 15%. This is explained by the fact that lime fills the spaces between clay particles, reducing porosity and increasing cohesion within the material [26]. In addition, the pozzolanic reaction between calcium hydroxide (from the lime) and silica in the clay leads to the formation of a hydraulic calcium silicate gel, which enhances strength. New chemical compounds also mature during drying, creating stronger bonds between the particles, increasing compressive strength. The research results are consistent with other studies on the addition of lime to clay [27,28].

The decrease in compressive strength at a 15% lime content is explained by the fact that excess lime remains unreacted with water and becomes porous upon drying, reducing density. The shrinkage resulting from moisture loss in excess lime also causes microcracks in the brick, weakening it under pressure. It can be concluded that the optimum lime content is 15% to achieve the highest compressive strength. Exceeding this percentage increases material costs without any mechanical benefit and may even lead to long-term durability problems.

3.4. Thermal conductivity measurement

Analysing Figure 7, which represents the change in thermal conductivity in clay bricks when lime is added, it is clear that the thermal conductivity decreases from 0.35 $Wm^{-1}K^{-1}$ to 0.244 $Wm^{-1}K^{-1}$. A significant increase in thermal conductivity is also observed between 5% and 15% lime content, estimated at 5.71% to 17.17%, while a slight increase is observed between 20% and 30% lime content, estimated at 25.7% to 30.28%.

This is explained by the fact that adding lime to the clay mixture alters the microstructure and physical structure of the bricks, leading to a gradual decrease in thermal conductivity as the lime content increases from 5% to 30%.

The higher the lime content, the higher the total porosity of the brick. The more internal air-filled voids there are, the less capable the material is of transferring heat.

Air voids also act as a natural insulator; Therefore, the air produced by the decomposition of lime reduces thermal conductivity.

Here we discuss the role of lower density in increasing thermal insulation. Lime is lighter than the basic clay minerals, reducing unit volume and reducing heat transfer paths. Lime reacts with the silica and alumina in the clay to form compounds such as calcium silicate hydroxide, which have lower thermal conductivity than conventional silicates.

- From 0% to 15%: Significant improvement due to the formation of new pores and changes in mineral composition.
- From 15% to 30%: The decrease continues but slows, as the porosity begins to saturate.

The study results are consistent with previous research on heat transfer in lime-stabilised clay [29,30].

4. Significance of research results

4.1. Soil mechanics

The importance of determining the ideal lime-to-clay ratio lies in achieving a delicate balance between mechanical strength and thermal insulation. Pozzolanic reactions between calcium hydroxide and silica and alumina compounds lead to the formation of solid hydrates that increase compressive strength and reduce shrinkage and cracking. Meanwhile, reorganising the pores in the clay structure reduces thermal conductivity, improves specific heat capacity, and reduces moisture transfer without increasing weight. To adjust this ratio so that it does not become brittle under load and does not lack pozzolanic interaction, we rely on Atterberg fluid and plasticity limits tests, single-compressive strength tests, thermal conductivity measurements, microscopic analysis, and multi-criteria optimisation modelling. This ensures the highest mechanical performance and thermal insulation at the lowest environmental cost and compliance with building codes [31].

4.2. Environmental geotechnics

Determining the ideal lime-clay ratio is a critical step in ensuring optimal mechanical strength and natural load-bearing capacity in construction soil applications. Lime, thanks to its anti-acid and pozzolanic properties, reshapes the clay structure through interactions with silica and alumina. This occurs through the precipitation of silicate and calcium hydrates, which improve mechanical properties. Meanwhile, the porosity control resulting from lime expansion reduces the soil's thermal conductivity and moisture retention, reducing energy requirements for heating and cooling, and thus reducing the carbon footprint of buildings and structures constructed with these mixtures [32].

4.3. Stress resistance:

Determining the ideal lime ratio results in increased resistance to single-compressive forces due to its cohesive internal structure, which prevents fracture upon repeated impacts. Lime also contributes to reducing dry shrinkage and wet swelling associated with changes in water content, minimising the appearance of surface and internal cracks often caused by climate changes or sudden compaction. This improved stiffness extends the life of structures using these clay mixes, while ensuring long-term stability for backfilling and foundation reinforcement.

4.4. Thermal insulation

Lime regulates thermal insulation by distributing micropores within the clay mass, increasing the area of micro-voids that act as natural barriers against heat exchange. This simple change increases the thermal capacity of the prepared soil, meaning its ability to retain and store heat during the day and continuously release it at night. This significantly impacts internal building temperatures and reduces energy and heating consumption. Furthermore, the improved structure reduces moisture transmission and reduces condensation and the resulting corrosion, prolonging the life of building materials and reducing maintenance costs. Determining the ideal lime-to-clay ratio enables a coordinated system for balancing load-bearing capacity with the building's load-bearing capacity. It reduces emissions by minimising heating and cooling requirements, conserves natural resources by using direct quantities of lime, and adheres to local and international geotechnical and environmental standards. This technology ensures the durability and longevity of buildings, reduces operating and maintenance costs, and maintains a safe and secure environment for future generations [33].

5. Applications in the construction field

Mixing lime with clay to make bricks is a traditional method with positive effects on building performance and durability. This mixture has various applications in improving the physical and mechanical properties of clay materials, in addition to achieving advances in thermal and sound insulation and moisture resistance.

5.1. Improving mechanical properties

When lime is added to clay in specific proportions, the pozzolanic reaction between calcium hydroxide and silica and alumina compounds is activated. These reactions produce hard, strong crystals that increase the brick's hardness and enhance its resistance to unidirectional compression, improving its ability to withstand heavy loads in structures and load-bearing walls.

5.2. Increasing thermal insulation

Adding lime to clay contributes to the reorganisation of the pore structure within the brick, increasing the volume of air-filled, thermally insulating micro-voids. This reduces the thermal conductivity of the clay matrix, thus reducing heat transfer between the interior and exterior of the building. This improvement translates into investments in energy use for heating and cooling.

5.3. Sound insulation

The finer the pores, the fewer sound waves are transmitted through the clay wall. Lime-reinforced bricks provide effective barriers against external noise, making them suitable for private and commercial buildings located near noise sources.

5.4. Resistance to moisture and natural factors

Lime reduces water retention in clay bricks by helping to fill microscopic cracks and cavities. This significantly reduces the brick's tendency to swell or shrink due to changes in its hygroscopic composition. It also increases its resistance to weathering and micro-erosion caused by rain and wind.

5.5. Improving environmental sustainability

Mixing lime with clay is a more suitable alternative to Portland cement, as lime consumes less energy to manufacture and produces fewer carbon emissions. Regular local lime can also be used, reducing factories' reliance on imported materials.

6. Conclusion

This study discussed the effects of adding lime to clay bricks. The results showed that adding lime between 5% and 30% to clay bricks causes significant changes in their mechanical, physical, and thermal properties. Regarding the bulk density, we observe a gradual increase from 1780 $kg.m^{-3}$ for the lime-free sample to 1818 $kg.m^{-3}$ when 15% lime was added. However, after this percentage was exceeded, the density began to decrease, reaching 1765 $kg.m^{-3}$ at 30% lime. A change in the water absorption rate was observed, as lime controls the distribution of capillary pores within the brick. The water absorption rate decreased from 17% to 10%. Mechanically, an increase in compressive strength was observed with the addition of lime up to 15%, rising from 1.7 MPa to 2.3 MPa, then gradually decreasing at higher ratios to stabilise at 1.5 MPa at 30%. Thermally, the data indicate variations in thermal conductivity with the addition of lime; it decreased from 0.35 $W.m^{-1}k^{-1}$ to 0.244 $W.m^{-1}k^{-1}$ as the lime ratio increased from 5% to 30%. The rate of decrease ranged from 5.71% to 30.28%. The results highlight that the optimum lime addition ratio for clay bricks is 15%. At this ratio, the best balance is achieved between increasing density, reducing water absorption, and enhancing compressive strength, with a significant improvement in thermal insulation. This study demonstrates that the addition of lime to clay bricks contributes to improving their performance on several levels. With 15% lime, compressive strength increases to 26%, enhancing the brick's ability to withstand long-term loads and cracks. Water absorption is also reduced, reducing wall damage from moisture and salt deposits and reducing reliance on additional insulation. Lime also lowers thermal conductivity, making buildings more energy-efficient. Furthermore, lime is a partially environmentally friendly alternative to traditional building materials, reducing carbon footprint and cement costs and enhancing reliance on local resources, supporting economic and environmental sustainability in the construction sector.

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