

Importance of Lime in Construction: Properties and Applications

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ABSTRACT:

Since ancient times, lime has been an essential component of building materials, enhancing the resilience and sustainability of numerous constructions. This chapter examines the significance of lime in building by going through its main characteristics, uses, and environmental advantages. Because of lime's distinctive qualities such as its adaptability, durability, and propensity to encourage self-healing it is a crucial part of many building projects. Lime is also an environmentally favorable choice because of its abundant supply in nature, capacity to be recycled, and minimal carbon impact. Engineers and builders may use lime's potential to produce sturdy, environmentally responsible structures by knowing the role it plays in construction.

KEYWORDS:

Hardening Lime, Importance, Lime, Slaking, Thermal Properties.

I. INTRODUCTION

Lime, sometimes referred to as a citrus fruit, is a versatile and colorful ingredient that gives a variety of culinary creations a blast of tart taste and refreshing zest. Lime has gained popularity as a culinary component due to its unique flavor and energizing scent. Lime is incredibly versatile, working in everything from drinks to sweets [1], [2]. Within a thousand words, we will examine the history, health advantages, cultural importance, and several culinary uses of lime. Lime is a member of the Rutaceae family, which also contains lemons, oranges, and grapefruits as well as other citrus fruits. Lime is a fruit with a lengthy history that dates back to ancient times. It is native to Southeast Asia. They were highly prized for their purported therapeutic benefits in treating scurvy, a condition brought on by a lack of vitamin C. India, Egypt, and the Mediterranean area are just a few of the places in the globe where lime farming has spread over time. Lime's vivid green hue and rounded form are two of its distinctive features.

The zest, or outer skin of the fruit, is full of fragrant oils that are frequently employed to give food a zesty, lemony flavor. A lime's juicy, acidic flesh offers a strong, sour taste profile that goes well with a variety of dishes. Lime juice has several nutritional advantages for your health. They are a rich source of vitamin C, offering a significant quantity of this crucial component that strengthens the immune system and encourages the manufacture of collagen. Lime juice also contains trace levels of potassium, calcium, and the vitamins A and E. In addition, the natural acids in lime juice might help with cleansing and digestion. Lime has cultural importance in many areas in addition to being nutritious. Lime is a common component in Mexican and Southeast Asian cuisines, giving dishes like ceviche, guacamole, and Pad Thai a zingy flavor. In order to balance the sweetness of the other components, lime is also a crucial element in the production of classic cocktails like the Margarita and the Mojito [3], [4].

Lime is used in a wide range of culinary applications. Lime juice is a well-liked beverage component in cool summer cocktails like limeade and lemon-lime soda. Its acidity gives cocktails, mocktails, and even herbal teas a lively touch and enriches their tastes. Lime zest is frequently used in desserts as a garnish or flavoring, giving cakes, pies, and pastries a zesty aroma. Lime curd, a tart and creamy spread, makes a delicious pastry and pie filling. Lime juice functions as a natural tenderizer for meats, fish, and vegetables in savory meals. It can be added as a finishing touch or as a marinade to enhance tastes. Salads and grain bowls get a revitalizing boost from vinaigrettes and dressings with lime flavor. Lime is a key ingredient in Thai cooking and provides a balance of acidity and spice in the well-known Tom Yum soup. Lime is also useful for food preservation. It is the perfect component for pickling fruits and vegetables because to its strong acidity, which inhibits bacterial development and helps avoid spoiling. Lime juice may also be used to flavor and serve as a natural preservative for handmade jams and jellies. Lime is a colorful citrus fruit that infuses a variety of recipes with a blast of tart taste and

refreshing zest. Since its introduction to Southeast Asia and extensive use in international cuisines, lime has become a cherished ingredient that improves both sweet and savory dishes. The flexibility and distinctive flavor of lime make it a prized ingredient in culinary traditions all across the world, whether adding a squeeze to a drink or utilizing its zest to infuse a dessert with zesty undertones [5], [6].

Importance of Lime in Construction: In the construction industry, the term lime refers to a flexible building material made from limestone. It has a long history of usage and is crucial for many different types of construction projects. In this post, we'll examine the value of lime in building while highlighting its traits, advantages, and particular applications. Lime, which is usually found as hydrated lime and quicklime, has numerous important qualities that make it useful in building. Its capacity to chemically react with other molecules, like as water and carbon dioxide, in a process known as carbonation, is one of its standout qualities. Due to this process, lime can harden and become stronger, extending the life of building materials. The adaptability of lime as a mortar or binder is one of the material's key advantages in building. Lime may be used to make a mortar that can be utilized for a variety of tasks, including plastering, rendering, and bricklaying when combined with aggregates like sand. Compared to cement-based mortars, lime mortar has certain significant advantages, especially when used for historic preservation and restoration work. It encourages the preservation of conventional masonry materials and is more flexible, allowing for little movements without breaking.

Lime is renowned for being extraordinarily workable. Lime mortar is easy to apply and shape because of its smooth, creamy consistency. This workability makes it easier to create decorative components and detailed details in architectural projects. Buildings' visual attractiveness is increased by the smooth and appealing surface provided by lime-based plasters and finishes. The compatibility of lime with various building materials is another important factor in construction. Lime-based plasters and mortars adhere well to a variety of substrates, such as brick, stone, and wood. Due to the lime mortar's role as a binding agent between various parts of the building, this compatibility guarantees the construction's integrity and lifespan [7], [8]. Lime has advantageous qualities from a sustainability perspective as well. Lime manufacture uses lower temperatures than cement production, which means less energy is used and less greenhouse gas emissions are produced. Lime is another naturally occurring substance that is abundant in many areas and may be obtained locally, minimizing its environmental impact even more. Additionally, lime-based mortars may be readily recycled or put to other uses, reducing waste in building projects. Lime has many purposes than only serving as a binder.

In the construction of roads and the development of soil, lime can be used as a stabilizing agent. The strength and load-bearing capability of soil are increased through lime stabilization, making it ideal for building. Road bases, foundations, and embankments frequently employ lime-treated soils because they offer stability and lower the chance of settlement or deformation. Lime is essential to building because of its special qualities and advantages. Its adaptability as a binder enables the construction of strong and beautiful buildings. The durability and integrity of construction projects are ensured by lime's compatibility with diverse building materials. Lime is moreover very useful in ancient preservation and restoration work because to its versatility and workability. Lime aids with resilient and sustainable building techniques, from mortar and plaster to soil stabilization. Its value in the construction sector stems from its capacity to deliver durability, environmental benefits, and strength to a variety of applications [9], [10].

II. DISCUSION

Historical Significance of Lime: Lime's historical relevance is firmly ingrained in human civilization, as seen by the fact that it has been used across many civilizations and millennia. Lime has been used extensively in architecture, agriculture, medicine, and cultural customs, among other areas of human life. Let's investigate lime's historical relevance in various fields.

a. **Construction:** Since ancient times, lime has been utilized in construction. When building gigantic constructions like the pyramids, the Egyptians used lime-based mortars and plasters. The lime mortar that the Romans, who are famed for their architectural prowess, employed extensively in their aqueducts, temples, and amphitheaters. Lime's strength, versatility, and compatibility with various materials helped ancient civilizations build long-lasting buildings. Because traditional lime-based mortars are still employed to preserve the authenticity and integrity of the structures, lime's historical relevance in construction is also seen in the preservation and restoration of historical sites and monuments.

b. **Agriculture:** For many years, lime has been used in agriculture. Agricultural lime, made from limestone, is used to raise the pH of acidic soils to neutralize them. Liming is a technique that increases crop output and soil fertility. Ancient civilizations like the Greeks and Romans, who valued employing lime as a soil supplement,

demonstrate the historical relevance of lime in agriculture. Lime is a crucial element in contemporary agricultural operations, helping to cultivate a variety of crops.

c. **Medicine:** Lime has a long history in conventional treatment. During lengthy sea journeys, sailors drank lime juice to stave against scurvy, a condition brought on by a lack of vitamin C. For instance, the British Navy required its men to drink lime juice, garnering them the moniker limeys. Due to their high vitamin C concentration, limes were used to treat scurvy and led to the understanding of this crucial nutrient. Other civilizations also recognized the therapeutic benefits of lime and employed it to cure a variety of illnesses, including skin issues and digestive problems.

d. **Cultural customs:** Lime is related with many different traditions and rituals and has cultural importance in many civilizations. Lime is revered and utilized in religious rites and celebrations in several civilizations. Lime is used in traditional offerings and purifying ceremonies, for instance, in Southeast Asia. In certain cultures, lime juice is applied to the skin to lighten and brighten the complexion. Lime has also been used as a cosmetic ingredient and a symbol of beauty. The cultural importance of lime is closely related to many groups' customs and values.

Lime has a rich and varied historical importance overall. Its contributions to architecture, agriculture, medicine, and cultural traditions have affected many facets of life and altered human history. Lime has remained relevant and useful in many fields for a long time, demonstrating how valuable it has been as a flexible and important resource across time.

Properties of Lime: In terms of building and materials, lime has a number of significant qualities that make it a useful and valuable product. Its efficacy across a range of applications is facilitated by these qualities. Let's look at some of the main characteristics of lime:

a. **Chemical Reactivity:** Lime is chemically reactive, especially when it goes through the carbonation process. Calcium carbonate is created as a result of a chemical reaction that occurs when lime is in contact with water and carbon dioxide. Over time, this process causes materials made of lime to harden and become stronger. This characteristic is particularly significant when it comes to lime mortars and plasters since it enables the construction of strong, long-lasting buildings.

b. **Workability:** Lime has a reputation for being very workable. Lime turns into a smooth, creamy paste that is simple to work with and apply when combined with water. It is a popular choice for ornamental features in building because of its workability, which permits accurate details and detailed work. Complex architectural ideas are made easier to realize when using lime-based mortars and plasters since they are simple to shape, distribute, and sculpt.

c. **Compatibility:** Lime is well suited for use with a variety of construction materials. Mortars and plasters made of lime attach effectively to a variety of substrates, including brick, stone, and wood. This compatibility guarantees a solid link between the lime-based materials and the surrounding elements, adding to the structure's overall stability and durability. Due to its compatibility with existing materials, lime enables the restoration and preservation of old masonry.

d. **Flexibility:** Lime plasters and mortars are somewhat flexible, allowing for little expansions and movements without breaking. In regions where there is a high risk of earthquakes or structural movement, this feature is very important. Lime's elasticity helps to disperse stress and reduces the chance of damage from small movements, maintaining the construction's structural integrity.

e. **Breathability:** Materials made of lime are very permeable, enabling moisture vapor to move through. When moisture control is essential, like in older buildings or constructions with little ventilation, this trait is advantageous. Due to its breathability, lime prevents the formation of excessive humidity and lowers the danger of damage from moisture-related issues like mildew and rot.

f. **Sustainable and Eco-friendly:** Lime is regarded as a sustainable and environmentally beneficial construction material. Compared to the manufacture of cement, the production of lime uses less energy and produces less greenhouse gas emissions. Natural limestone, which is widely distributed and abundant, is the source of lime. Local sourcing can cut down on shipping expenses and carbon footprint. Materials made of lime may be recycled and reused, reducing waste in building projects.

The relevance and adaptability of lime in building are largely due to these qualities. Lime is a popular material for a variety of applications, including mortar and plaster work, historic restoration, and environmentally friendly

building techniques. These attributes include chemical reactivity, workability, compatibility, flexibility, breathability, and sustainability.

Thermal Properties of Lime: Lime is a desired material in construction and other applications where heat management is crucial due to its many thermal qualities. These thermal characteristics consist of:

a. **High Thermal Conductivity:** Lime is capable of efficiently conducting heat thanks to its comparatively high thermal conductivity. Due to its ability to efficiently transport heat from one location to another, lime is a good choice for applications requiring the dispersion or dissipation of heat. For instance, lime-based materials may be used in buildings as a thermal mass to absorb and disperse heat, assisting in the regulation of internal temperature and lowering energy consumption for heating and cooling.

b. **Fire Resistance:** Lime is a good material for fireproofing and building fire-resistant structures because of its strong fire resistance. High temperatures may be withstood by goods made of lime, such as lime mortar or lime plaster, without causing substantial structural changes. This asset gives more time for evacuation or fire control efforts and helps to slow the spread of fire.

c. **Insulating Properties:** Lime has insulating characteristics, which can aid to lessen heat transmission. Materials made of lime can function as thermal insulators to stop heat gain or loss. For instance, lime plaster can act as a thermal barrier between a building's interior and outside, maintaining a suitable inside temperature and consuming less energy.

d. **Thermal Stability:** Lime has strong thermal stability, which enables it to survive temperature fluctuations without significantly degrading. Due to this characteristic, lime-based materials can continue to function thermally and with structural integrity over time, even in conditions with temperature swings or thermal cycling.

e. **Reflectivity:** Lime has a high solar radiation reflectivity. Lime may reflect a large percentage of the heat from the sun when applied as a coating or finish to external surfaces, lowering solar energy absorption and limiting heat gain in structures. In warmer areas, this characteristic helps with energy efficiency and thermal comfort.

f. **Thermal Expansion:** Lime expands when heated and compresses when cooled, like the majority of materials. Due to the possibility of structural stress and probable damage caused by differential expansion and contraction, this feature must be taken into account when building. Building long-lasting, sturdy buildings requires an understanding of the thermal expansion characteristics of lime.

In applications where heat management, fire resistance, insulation, and thermal stability are crucial factors, lime's thermal qualities make it a desirable material. Its strong thermal conductivity, fire resistance, insulating qualities, thermal stability, reflectivity, and thermal expansion features help create safe, long-lasting structures that are both energy-efficient and thermally comfortable.

Application of Lime in Construction: Due to its distinct qualities and adaptability, lime has a wide variety of uses in building. It has been used for ages and is still appreciated in many different construction techniques. Let's look at some of the main uses for lime in building:

a. **Lime Mortar:** One of the most popular and significant uses of lime in building is in lime mortar. Lime mortar is made of lime, water, and aggregates (like sand). In masonry building, such as bricklaying, stone masonry, and plastering, it serves as a binding substance. Over cement-based mortars, lime mortar has a number of benefits, including better workability, compatibility with older and softer masonry materials, and enhanced moisture control. To preserve the authenticity and integrity of old structures, it is frequently employed in restoration and preservation projects.

b. **Lime Plaster:** Another widely used method of using lime in building is lime plaster. It is used as a coating for walls, ceilings, and other surfaces and is made of lime, aggregates, and water. Lime plaster gives structures a smooth, appealing texture that improves their architectural appeal. Additionally, it provides ventilation, enabling moisture to dissipate and a buildup of retained moisture that can cause mildew and rot to form. Lime plaster is frequently utilized in traditional and historic structures as well as in environmentally friendly building techniques.

c. **Limecrete:** A substitute for conventional cement-based concrete is limecrete, sometimes known as lime concrete. It is made of lime, aggregates, and water. Since the manufacture of lime uses less energy and emits fewer greenhouse gases than the production of cement, limecrete presents a more sustainable and ecologically friendly alternative. Excellent thermal characteristics, such as effective insulation and moisture management, are

provided by limecrete. It is frequently utilized in situations where controlling heat and managing moisture is crucial, such as in flooring, foundations, and environmentally friendly construction techniques.

d. **Soil Stabilization:** Lime is used in the soil stabilization process to enhance the engineering qualities of the soil. In order to increase the strength, stability, and load-bearing capability of soil, lime must be added to it. Construction of roads, building foundations, and embankments frequently employ soils that have been lime-treated because they increase stability and lessen the possibility of settlement or deformation. In locations with weak soil, lime stabilization is especially beneficial since it enables more efficient and economical building.

e. **Lime Wash:** For outdoor surfaces like walls and facades, lime wash is a time-honored and environmentally beneficial finish. A thin, permeable coating of hydrated lime that has been diluted with water is used to create it. Lime wash has a number of advantages, including as resistance to weather, durability, and defense against the growth of algae and fungi. As it progressively weathers and acquires a patina over time, it further offers a distinctive, organic aesthetic aspect. Historic structures and green building techniques both frequently utilize lime wash.

f. **Insulation made of lime:** Hemp-lime is one type of insulation made of lime that is both environmentally and energy-efficiently friendly. These substances are used to make insulating panels or renders by mixing lime, natural fibers (like hemp or flax), and aggregates. Excellent thermal performance, moisture control, and breathability are all features of lime-based insulation. It is frequently utilized to increase energy efficiency and interior comfort in passive and sustainable house building.

These are just a handful of the numerous uses for lime in building. Lime is a vital component in a variety of construction processes, from historic preservation to contemporary sustainable building methods. This is because of its adaptability, compatibility with other materials, and favorable qualities.

Environmental Benefits of Lime: Due to its numerous environmental advantages, lime is a sustainable and environmentally friendly material for a variety of uses. These advantages are a result of the product's manufacturing procedure, material qualities, and contributions to carbon and energy efficiency. Let's look at some of lime's advantages for the environment:

a. **Lower Carbon Footprint:** When compared to the manufacturing of cement, lime has a much lower carbon dioxide (CO₂) footprint. Calcination, often known as high-temperature heating of limestone (calcium carbonate), is the method used to make lime. Compared to the decarbonization of limestone used in the manufacturing of cement, this technique needs lower temperatures and produces less CO₂. Construction projects may lower their carbon emissions, aiding in the fight against climate change, by using lime instead of cement-based products.

b. **Energy Efficiency:** Lime manufacture uses less energy than cement production, in terms of energy efficiency. Low temperatures are used for the calcination of lime, which uses less energy. Due to this energy efficiency, the manufacturing of lime leaves a reduced ecological imprint and emits less greenhouse gases.

c. **Local Availability:** Lime is produced locally from naturally occurring limestone, which is prevalent in many parts of the world. Lime may be obtained locally, reducing transportation distances and related carbon emissions. Local accessibility fosters regional economies and lessens reliance on international supply networks.

d. **Recyclability and Usability:** Materials made of lime, such as lime plaster and mortar, are both recyclable and usable. Lime-based materials can be carefully removed, processed, and reused in new building or restoration work during remodeling or demolition projects. This recyclable nature lessens the demand for resource extraction and trash production.

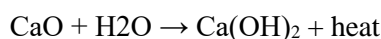
e. **Breathability and Moisture Regulation:** Lime-based construction materials, such lime plaster, provide qualities that allow for both breathability and moisture management. They permit moisture vapor to flow through, avoiding the accumulation of trapped moisture and lowering the danger of mold development and related health problems. This moisture control helps create healthier interior climates and lessens the demand for power-hungry mechanical ventilation systems.

f. **Preservation of Historic Buildings:** Lime has been utilized for centuries in the construction of historical structures like monuments, which helps to preserve them. By preserving and restoring ancient structures using lime, it is possible to preserve their historical integrity while also preserving cultural legacy for future generations. The compatibility of lime-based mortars and plasters with conventional masonry materials reduces the danger of damage and maintains the structural integrity of older buildings.

g. Sustainable Construction Practices: Lime plays a part in environmentally friendly construction methods including green building and sustainable architecture. Lime-based building solutions like hemp-lime insulation and limecrete help to make buildings more ecologically and energy-friendly. These materials support energy efficiency, provide thermal insulation, and improve indoor air quality.

Builders and designers may create a eco-friendlier built environment, contribute to sustainable development, and decrease carbon emissions by taking into account the advantages of lime for the environment and implementing it into construction processes. Please be aware that while lime has positive environmental effects, the precise impact might change based on things like production processes, transportation distances, and the entire lifespan of the building project.

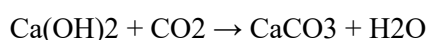
Slaking of Lime: Slaking of lime describes the chemical process that takes place when water is introduced to quicklime, resulting in the creation of hydrated lime calcium hydroxide. The term hydration also refers to this procedure. In a number of sectors, including building, agriculture, and water treatment, the slaking of lime is a crucial phase. It entails the transformation of quicklime, a highly reactive and caustic chemical, into hydrated lime, a more stable and practical form. An exothermic reaction occurs when water is introduced to quicklime, producing a considerable quantity of heat. The quicklime's crystal structure is damaged by the water molecules, which causes it to breakdown and turn into a fine powder. The following is a representation of the chemical equation for the slaking of lime:



One molecule of calcium oxide (CaO) and one molecule of water (H₂O) combine in this reaction to form one molecule of calcium hydroxide (Ca(OH)₂). The exothermic aspect of the hydration process is what causes the heat to be emitted during the reaction. There are various useful uses for lime slaking. Hydrated lime is frequently used in the building industry as a component of plaster and mortar. It increases the mixture's workability and flexibility, boosting its bonding abilities and general strength. Additionally, useful as a soil stabilizer, hydrated lime can raise the quality and fertility of agricultural land. Slaked lime is used in water treatment to change the pH values of the water. By increasing the pH of acidic water, it can neutralize the acidity, making it less corrosive and better suited for use in a variety of industrial operations or for human consumption.

Additionally, hydrated lime has coagulant properties that can help remove particles and pollutants from water by promoting flocculation. Since the reaction may be quite exothermic and generate a lot of heat, slaking lime is a regulated operation. To avoid the release of too much heat, which can result in splattering or even burns, it is crucial to gradually add water and completely mix it with the quicklime. In conclusion, the term slaking of lime describes the hydration process that takes place when water is introduced to quicklime, creating hydrated lime. This reaction is crucial for a number of sectors, including building, agriculture, and water treatment, where hydrated lime is used for its advantageous qualities. Industries may safely and efficiently use lime's adaptability by comprehending the slaking process.

Hardening of Lime: In most cases, the phrase hardening of lime refers to the carbonation process, in which hydrated lime (calcium hydroxide) takes up carbon dioxide (CO₂) from the air and changes into calcium carbonate. The lime becomes harder and more durable as a result of this reaction. Hydrated lime eventually interacts with carbon dioxide when it is exposed to air, a process known as carbonation or carbonation curing. This reaction's chemical equation is as follows:



In this process, one calcium hydroxide molecule interacts with one carbon dioxide molecule to form calcium carbonate and water molecules. Calcium carbonate, a crystalline substance, is created during the carbonation process when the calcium hydroxide molecules in the lime combine with carbon dioxide. The interlocking of the calcium carbonate crystals creates a sturdy, hardened structure. This technique is comparable to how limestone naturally forms over time. Lime may be hardened in numerous real-world situations. Carbonation is a process that gives lime-based building materials like lime plaster and lime mortar their strength and longevity. For instance, hydrated lime is combined with sand and water to create lime mortar. Carbon dioxide from the environment combines with the hydrated lime throughout the curing process, eventually converting it into calcium carbonate. The carbonation procedure enables the lime mortar to gradually harden and strengthen. Lime hardening is a gradual process that takes weeks, months, or even years to complete, depending on a number of variables like temperature, humidity, and the presence of carbon dioxide.

For materials made of lime to work at their best, carbonation needs to occur for a long enough period of time. Materials made with lime have the benefit of being self-healing. The presence of carbon dioxide in the atmosphere enables the lime to continue carbonating and fill in the damaged regions, essentially self-repairing whenever a break or damage arises in the lime-based construction. Lime hardening by carbonation is used in historical preservation and restoration in addition to applications in building. Since they gently carbonate and self-heal, lime-based materials have been utilized for centuries in historical constructions, making them ideal for preserving the structural integrity of ancient buildings. In conclusion, the process of carbonation, in which hydrated lime absorbs carbon dioxide from the air and changes into calcium carbonate, is referred to as the hardness of lime. The structure becomes hardened and durable as a result of this reaction, which happens gradually. This carbonation process gives lime-based products like lime plaster and lime mortar their strength and capacity for self-healing. To properly use lime-based materials in building and cultural preservation, one must understand how lime hardens.

III. CONCLUSION

In conclusion, lime's outstanding qualities and wealth of advantages make it an essential component in building. Its adaptability enables a variety of uses, such as concrete, mortar, and plaster, boosting the endurance of constructions. Building lifetime and upkeep are aided by lime's durability and capacity to encourage self-healing. Lime also has a low carbon footprint, is plentiful, recyclable, and offers substantial environmental benefits. Lime may be used in building projects to produce strong, long-lasting structures as well as to promote environmentally friendly, sustainable business practices. For a more sustainable future in building, engineers, architects, and builders must understand the significance of lime and take use of its possibilities.

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