

Comparative study of 6 types of lime for use in construction and architectural heritage restoration

Estudio comparativo de 6 tipos de cal para su uso en la construcción y restauración del patrimonio arquitectónico

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Abstract

All materials, to a lesser or greater extent, when in contact with the environment, undergo changes in appearance or in their properties. The sun, the rain, the winds, in general the weather causes the constructions to expand, contract, move and suffer deformations which causes their deterioration. The Architectural Heritage has great cultural importance due to the information it contributes to the historical study of society, it is a faithful reflection of the History of a place and for this reason it must be restored for its conservation. Quality assurance in any process is the total effort necessary to plan, organize, direct and control quality. In the construction industry, it is necessary to verify the characteristics of the materials used to guarantee improvement in their properties. This study aimed at the physicochemical characterization of 6 types of lime used in construction. The methodology used was based on the comparative determination of density, morphology and elemental composition. This study contributes to the knowledge of the characteristics of the different types of lime and serves as a basis for other studies related to the subject.

Lime (Calcium oxide), Restoration, Architectonic patrimony

Resumen

Todos los materiales en menor o mayor medida al estar en contacto con el medio ambiente sufren cambios en la apariencia o en sus propiedades. El sol, la lluvia, los vientos, en general el clima hace que las construcciones se dilaten, se contraigan, se muevan y sufran deformaciones lo cual provoca el deterioro de las mismas. El Patrimonio Arquitectónico tiene gran importancia cultural por la información que aporta al estudio histórico de la sociedad, es fiel reflejo de la Historia de un lugar y por eso se debe restaurar para su conservación. El aseguramiento de calidad en todo proceso es el esfuerzo total necesario para planear, organizar, dirigir y controlar la calidad. En la Industria de la construcción se vuelve necesaria la verificación de las características de los materiales empleados para garantizar la mejora en las propiedades de los mismos. Este estudio tuvo como objetivo la caracterización fisicoquímica de 6 tipos de cal utilizada en la construcción. La metodología empleada se basó en la determinación comparativa de la densidad, morfología y composición elemental. Este estudio contribuye con el conocimiento de las características de los diferentes tipos de cal y sirve como base para otros estudios relacionados con el tema.

Cal (Óxido de calcio), Reconstrucción, Patrimonio arquitectónico

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Introduction

Architectural heritage is of great cultural importance for the information it contributes to the historical study of society and for what it represents for people as a whole. It is a faithful reflection of the history of a place and for this reason it must be preserved. Heritage is a topical issue and is present in various fields, whether cultural, social or scholarly. Until well into the 20th century, heritage was the monopoly of the social elite, as was education. In the 21st century, in the context of a democratic and mass society, heritage is an element of consumption and an educational tool. The different public institutions, civil society and school curricula are responsible for the dissemination of heritage, recognizing its educational value, its capacity to generate wealth and create knowledge. In the construction industry, it is necessary to verify the characteristics of the materials used to guarantee the improvement of their properties.

Lime is one of the materials used in construction, which is used in the preparation of mortars or masonry mixtures to join the materials used to build walls, foundations, slabs, as well as to finish walls and ceilings (I, II, III). Lime is a material that has many advantages, as well as a great variety of applications, which makes it an indispensable element in construction and restoration works (IV).

Lime is a generic term that designates all the physical forms in which calcium oxide and magnesium oxide, (CaO and MgO) and/or calcium hydroxide and/or magnesium hydroxide, (Ca (OH)₂ and Mg (OH)₂) can appear (V, VI). The standard that defines the specifications, definitions and conformity criteria for construction lime is UNE EN 459.

This standard classifies lime into two types:

Class I lime or quicklime, Q, consisting mainly of calcium oxide (CaO), and magnesium oxide (MgO) produced by calcination of limestone.

Lime class II or slaked or hydrated limes, S, resulting from the slaking of quicklimes composed mainly of calcium hydroxide. [Ca(OH)₂]. The raw material used for the manufacture of lime is limestone or dolomite extracted from quarries, with a carbonate content of over 95%, which are decarbonated by calcination in kilns at 975°C + 25°C to produce the corresponding lime. Tables 1 and 2.

Characteristics	Grain
Calcium and magnesium oxide content in calcined sample (1)	> 90% by weight
Finesse, Accumulated percentage retained on Sieve UNE 6,3 mm Sieve UNE 0,2 mm	0% Less than 10%.
Reactivity. Minimum temperature Quicklime with MgO < 5%. Dolomitic lime MgO > 5%. The maximum time to reach the minimum temperature is, in both cases, 25 min.	> 60% > 50%

Table 1 Class I quicklimes

Source: Own elaboration

The determination will be carried out on a sample previously calcined in an electric furnace at 975°C + 25°C.

Characteristics	Grain
Calcium and magnesium oxides content on calcined sample	> 90% by weight
Carbon dioxide content, at the point of manufacture	< 5% weight
Finesse. Accumulated percentage retained on UNE 0.2 mm sieve.	< 10%

Table 2 Slaked or hydrated limes

Source: Own elaboration

The determination will be carried out on samples previously calcined in an electric furnace at 975°C + 25°C. The objective of this work was to characterize the physical and chemical properties of the different samples as a contribution to scientific knowledge and as a contribution to the conservation of the architectural heritage of the country. This study is presented in 6 sections, section 1 deals with the Introduction. Section 2 deals with the Methodology to be developed. Section 3 deals with the Results of the Study. In Section 4 the Acknowledgements. In Section 5 the Conclusions. Section 6 contains the References consulted.

Methodology to be developed

1. The specific mass was determined according to the method of the pycnometer Standard (NMX-C-165-ONNCCE-2004).Table 3
2. The morphology, as well as the elemental composition was determined with a scanning electron microscope JEOLJSM IT-100. Tables 4 and 5.

Analysis of results

As can be seen in Table 3. The density of the lime ranged from 1.05 to 4.53 grams per cubic centimeter, which indicates a great variety of chemical composition of the material, which is understandable since it depends on the origin of the rocks from which the lime was extracted.

It was also observed that the stone slaked lime compared to the slaked purchased natural lime showed a small variation in density, due to the fact that the slaked purchased natural lime has a higher percentage of calcium compared to the stone slaked lime.

The unslaked purchased natural lime has a higher amount of magnesium compared to the other types of lime. Powdered slaked lime, on the other hand, has calcium and magnesium in its composition.

Textlex lime has the highest density, which may be because it contains calcium, sodium, magnesium and also the highest carbon content compared to all the other samples studied. On the other hand, the slaked Textlex lime had the lowest density, which may be due to the fact that it did not contain carbon compared to when it was not slaked.

No. of sample	Type of lime	Density g/cm ³
1	Slaked lime (in stone)	2.586
2	Natural Lime (purchased, not slaked)	1.168
3	TEXTLEX lime (not turned off)	4.53
4	Lime (powdered slaked)	1.13
5	Natural lime (purchased, slaked)	2.64
6	TEXTLEX Lime (Off)	1.05

Table 3 Density of the different types of lime in g/cm³
Source: Own elaboration

%	1	2	3	4	5	6
Ca	81.81	0	35.06	81.81	94.86	26.21
S	1.12	0	0.62	1.12	1.18	0
P	0	6.62	0	0	0.61	0
Si	0	82.96	0.82	0	3.35	0.76
K	0.6	0.87	0	0.6	0	0.54
Na	0	4.73	0.22	0	0	0
Mg	1.85	4.73	0.82	1.85	0	0.72
O	13.61	42.73	0	13.63	0	0
C	0.99	0.08	20.54	0.99	0	0

Table 4 Elemental chemical composition of the 6 types of lime
Source: Own elaboration

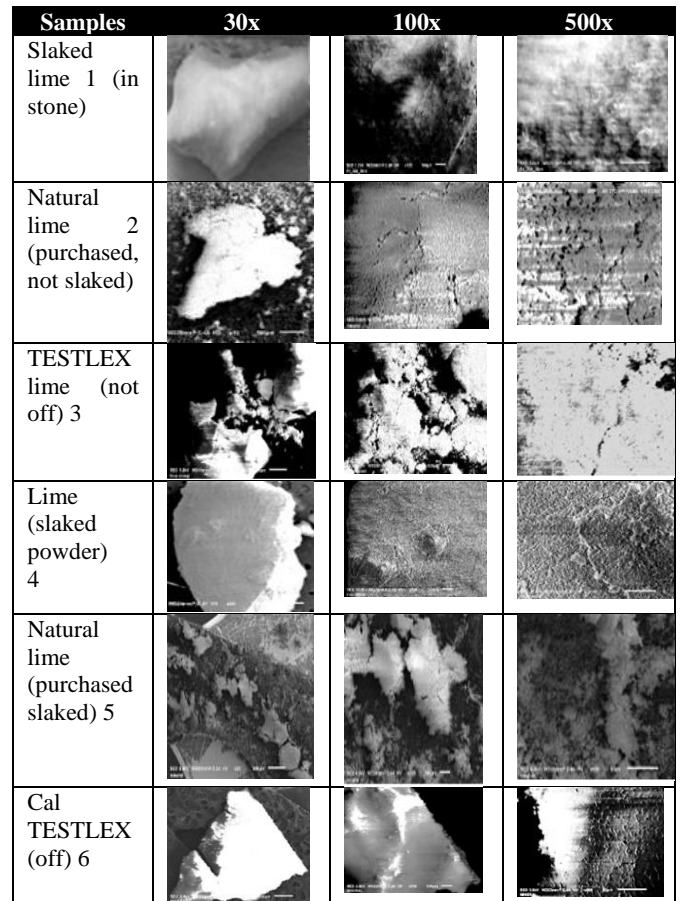


Table 5 Morphology of the 6 Cal samples at 30, 100 and 500 magnifications (30X, 100X, 500X)
Source: Own elaboration

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Conclusions

As can be observed in Table 3, the slaked lime in stone and the purchased slaked natural lime showed similar densities of 2.59g/cm^3 and 2.64g/cm^3 due to their chemical composition.

Textlex lime was the one that gave the highest density 4.53 g/cm^3 because it has carbon in its chemical composition.

The slaked Textlex lime gave the lowest density, which may be due to the fact that during the slaking process the carbon was converted into CO_2 , so it no longer had carbon in its elemental composition.

In calcium content, sample 1 and sample 4 had the same content, while sample 5 had the highest calcium content, sample 3 and sample 6 had the lowest calcium content.

Table 6 shows that all types of lime presented fine grain, which is good because the homogeneity of the grain is of vital importance for a good performance of the material when it is mixed with other construction materials.

This study will help those working in the construction and restoration process to see the need to ensure the quality of the materials they buy by verifying their chemical composition in order to reduce variability in the product of the works they carry out. This study also lays the foundation for subsequent studies.

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