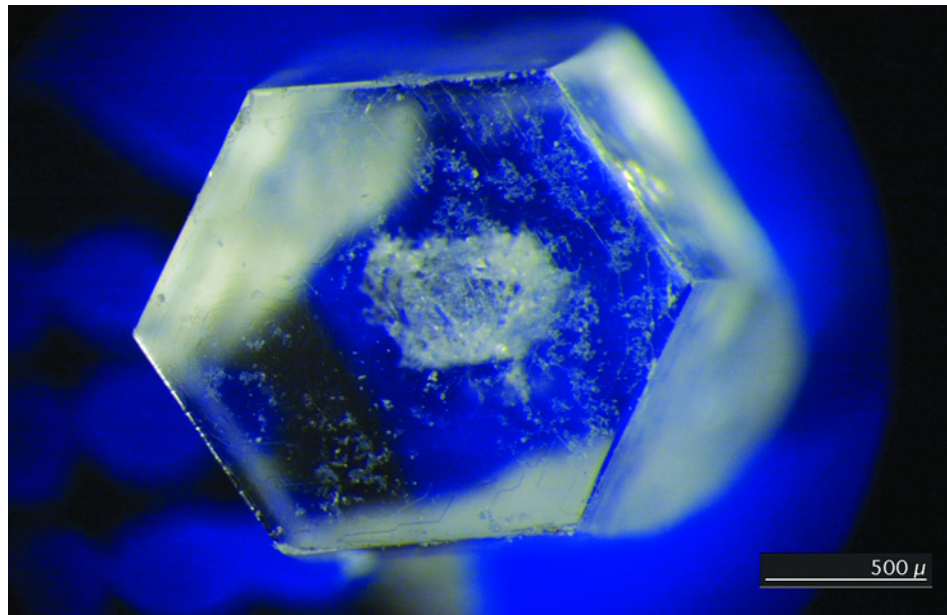


THE GCI Project
Bibliographies
SERIES

Preservation of
Lime Mortars and Plasters



Sorted by General Category



The Getty Conservation Institute

The Getty Conservation Institute works internationally to advance conservation and to enhance and encourage the preservation and understanding of the visual arts in all of their dimensions—objects, collections, architecture, and sites.

The Institute serves the conservation community through scientific research, education and training, field projects, and the dissemination of the results of both its work and the work of others in the field.

In all its endeavors, the Institute is committed to addressing unanswered questions and to promoting the highest possible standards of conservation practice.

GCI Project Bibliographies

Project bibliographies represent a distillation of many years of research by Getty Conservation Institute staff in support of a given project. The unique bibliographic resources available at the Getty Center and in the Los Angeles area make it possible for GCI staff to access and review literature that is not easily obtainable by many conservation practitioners. With this unique opportunity comes a unique responsibility to share the results of this research with the conservation community and other interested parties.

Lime Mortar and Plaster Research at the GCI

Lime-based mortars, plasters, and stuccoes are among the most common binding materials—as well as surface components on walls—found in archaeological and historical buildings. The Building Materials Section of the Getty Conservation Institute's Science Group is conducting research in three main areas related to these materials:

Preservation and Weathering

Insufficient cohesion and lack of adhesion are the most important weathering phenomena associated with mortars. Deterioration of the mortar can be a result of its original composition. This includes the type of aggregate used; the binder/aggregate ratio, which determines the physico-mechanical properties of the material; and the mineralogical composition that influences the durability of the mortar in the environment. Environmental factors, including salt contamination (sometimes a secondary effect of prior treatments), play an important role in the deterioration process.

Conservation and Treatment

During restorative interventions, such as grouting or filling of lacunae, it is important that the physical properties of the adhesive or replacement mortars closely match those of the substrate in order to minimize potential incompatibility between the materials. Modern materials such as cement or cement–lime blends often cause failure or lead to increased deterioration of the underlying brick or stone substrate, adjacent zones, or original lime based materials. Scientific investigations on test mixtures – manufactured and cured under standardized conditions – can lower the risk of failure and increase the durability of the restorative intervention.

Technology and Dating

In addition to providing valuable information for conservation purposes, the study of mortar technology can contribute to the scholarly interpretation of art and artifacts from the past. In some cases—especially when carried out in conjunction with conservation surveys—the results of mortar analysis can facilitate the dating and authentication of objects.

The Preservation of Lime Mortars and Plasters Bibliography, *Version 1.0*

The Lime Mortars and Plasters Bibliography had its origin in a collaboration between the Getty Conservation Institute (USA), the Katholieke Universiteit Leuven (Belgium) and the Universidad de Granada (Spain). It profited later from the input of the Institut für Steinkonservierung, Mainz (Germany) and other experts who reviewed the bibliography and provided additional citations.

The literature assembled in this bibliography includes those references that were used or found relevant to the following specific research areas:

- The evaluation and verification of an analytical methodology for compositional identification (chemical and mineralogical) and physical characterization (hygric and mechanical properties) of historic materials that is specific for mortars and plasters; being often based on gypsum and lime mixes, and containing not only siliceous, but also calcareous, aggregate.
- The study of the compatibility parameters of historic lime mortars and new repair or replacement materials, as a guide for restorative intervention. Well-defined tolerances for the values of standardized physico-mechanical properties must be established as criteria for compatibility of mortars depending on their use for repointing, plastering, or as repair mortars.
- The elucidation of the effects of traditional practices (processing procedures and additives) in order to estimate the influence of the composition and formulation procedures for new repair and replacement materials.

Focusing on the scientific study of high calcium lime mortar, the selection criteria of the literature cited was based upon content related to lime hydrate as a binder. The original focus was a deliberate choice of the editors of the bibliography, in order to address systematically what literature was available on the topics of their studies. It has been widened as a reaction to comments from experts who reviewed the database. High calcium lime was also considered within the context of the full range of traditional and modern mortar binders, and therefore a limited number of references are included that provide scientific information on other types of lime (e.g., dolomitic lime), on hydraulic binders (e.g., hydraulic lime, pozzolanic mortars), on gypsum or gypsum mixes with lime, and also on ordinary Portland cement. In the same way, various processes and analytical procedures relevant to hydrated lime were augmented with information on similar processes in other areas of research.

The Lime Mortars and Plasters Bibliography will be posted on this site in subsequent iterations as the verification of citations for bibliographic accuracy and completeness continues, and the scope will gradually be enlarged to cover other types of lime and lime based binders. *Version 1.0* contains 1,561 references relevant to the field of lime mortar and plasters, with an emphasis on technical studies of ancient materials and modern, compatible materials for their conservation.

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Content, Selection Criteria and Arrangement

There has been an intense recent interest in the development of appropriate analytical tools and traditional materials and techniques for using lime-based materials in the conservation of artistic and architectural works. This has resulted in the publication of numerous bibliographies available in printed form and on the Internet. Although similar in many respects, the content of this bibliography covers not only articles and monographs on:

- analytical techniques
- case studies of materials from specific historic contexts
- studies of conservation treatments
- historical production and application materials and techniques
- the parameters and effects of variations in the production process of lime mortars (calcining, slaking, binders and aggregates, additives, application, drying and carbonation)

but also includes references on:

- the chemistry and mineralogy of calcium compounds (calcium hydroxide and calcium carbonates)
- the formation of compounds and reaction sequences in other classes of mortars (pozzolanics, natural hydraulic cements and ordinary portland cement)

In general, the available technical literature dealing specifically with high calcium lime for architectural purposes is minimal in comparison to these other classes of materials, but certain references may contain important or relevant information on the behavior of calcium compounds (e.g., solution properties, crystallization phenomenon) and these have therefore been included in the bibliography.

The subjective selection criteria thus has a broader scope than articles normally included in *Art and Archaeology Technical Abstracts*¹, (the bibliographic abstracting service for the field of conservation published by the GCI and the IIC) in that applied building materials studies are widely considered along with basic chemical and mineralogical research. The citations included follow the format for *AATA* with the exception that abstracts have not been included; however, abstracts of many articles from the conservation literature can easily be obtained by searching *AATA*.

This posting of the bibliography is available in two different versions. In the first version, the entire bibliography is sorted alphabetically by author, then by title and finally by date. In the second version, the bibliography is broken down into the categories of Conservation, History, Characterization and Analysis, Performance, and Technology. These categories are further divided into sub-groups based upon key terms. Within each category, citations are sorted first by date and then by author and finally by title. This allows the user to follow developments in a given area chronologically. Where applicable, multiple key terms have been assigned to citations as most references contain information relevant to several subjects (e.g., an analytical study of the components of an historical mortar might also contain information on the process of mortar preparation during a particular time period). These key terms were identified based upon both a review of the content of the bibliography to date and a consideration of the most important parameters of the technical study of high lime mortars and plasters. The citations have been grouped and subdivided in order to provide a limited guide to the content of the material in addition to that indicated by the title alone.

Please note that hard copies of the literature are not available from the Getty Conservation Institute, the Katholieke Universiteit Leuven or the Universidad de Granada. These need to be acquired through your local libraries or inter-library loan services.

Acknowledgements

We would like to acknowledge gratefully the following individuals for their help in compiling this bibliography, emphasizing that all errors, omissions or inconsistencies are entirely the responsibility of the editors.

For generously contributing several hundred references from her personal bibliography, we would like to thank above all Karin Kraus. For comments and suggestions, including additional pertinent literature, we thank Baerbel Arnold, Ernesto Borelli, Philippe Bromblet, Sharon Cather, Hans Erik Hansson, Rob van Hees, Christoph Herm, John Hughes, Isabel Kanan, Roman Kozlowski, Linda Krage, Urs Mueller, Margaret Thomson and Johannes Weber.

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¹ As of June of 2002 AATA was available on the Getty website as *AATA Online – Abstracts of International Conservation Literature*.

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Section Introductions

To make the citations accessible, the vast field covered by the bibliography has been arbitrarily divided into five thematic groupings with further division of each group into subgroups. Several basic aspects related to the production of lime and lime mortars (e.g., the steps of the lime cycle) helped us to subdivide the citations in a logical way that we hope will facilitate access for scholars in the field. Users of the bibliography should be aware that literature cited here will often be found in multiple categories or subgroups. This is due to the fact that individual texts often contain substantive discussions of multiple topics. When such is the case, they will be found in each appropriate category.

Within each category, citations are sorted first by date, then by author and finally by title. This allows the user to follow the developments chronologically.

Conservation

Citations related to the conservation of lime mortar and plaster have been further divided into three subgroups.

Diagnosis

This group of citations is concerned with the various types of information that guide the conservation process, and help to define the objectives and the guidelines of conservation interventions.

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Beckmann, P. Structural analysis and recording of ancient buildings. *The ARUP Journal*, 7, no. 2 (1972) pp. 2–5.

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Wenzel, F. Examples of methodical approach to structural consolidation of ancient buildings. In *Stable-unstable? Structural consolidation of ancient buildings.* Lemaire, R. M. and Van Balen, K., Editors. University Press, Leuven (1988) pp. 93–104.

Bonecchi, R.; Broglia, E.; Bugini, R.; Realini, M.; and Ferrari, S. L'arca scaligera di Mastino II (Verona). Le malte utilizzate nei restauri. In *Superfici dell'architettura: le finiture: atti del convegno di studi.* Bressanone, Italy, 26–29 June 1990 (1990) pp. 167–177.

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- Dettmering, T. and Kollmann, H.** *Putze in der Bausanierung und Denkmalpflege*. Verlag Bauwesen, Berlin (2001) 288p.
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Conservation and Treatment

This subgroup is concerned with the use of lime-based materials as a conservation treatment in itself (e.g. for repointing, plastering, or as binder for repair mortar for brick, stone or mortar) as well as with the conservation treatment of historic lime-based plasters with other materials. Practitioners must also be aware that lime mortars and plasters may need certain types of intervention, in order to retain the cultural values they represent. Citations in this section are intended to aid the understanding of these issues.

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History

Citations referring to ancient or historic building techniques, that were influenced by the local availability of materials and the traditions and habits of craftsmen in specific cultural contexts, are divided into two subgroups. Some citations describe historical and traditional techniques that may also be used to aid understanding of the possible current applications of lime mortar and plaster.

Historical Context

This subgroup contains information about chronological and geographical context of the use of lime (including scientific knowledge).

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Characterization and Analysis

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Additives

This subgroup covers literature that discusses additives, which are materials (both organic and inorganic) added to mortar and plasters –generally in minor quantity– that can considerably change their properties and durability. Additives may require special analytical techniques for their detection.

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Analytical Techniques

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Sample Preparation

This subgroup focuses on literature related to the preparation of mortar samples. Methods regarding how they can be subjected to the required analytical technique, or involving the making of test items to study the physico-mechanical properties of a material, are included in this subgroup.

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Texture

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Standards and Normatives

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Technology

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Calcination

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Carbonation – Curing

The reaction of lime hydrate with carbon dioxide leading to the hardening of the lime by the conversion of hydrate to carbonate is considered in literature in this section. Conditions (time, temperature, humidity, presence of CO₂, etc.) and their effects on the development or modification of the properties of mortars (primarily in relation to the binder) are also discussed.

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Mortar Preparation (mixing)

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Recipes and Formulations

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Slaking – Hydration – Aging

This subgroup includes literature on: slaking (mixing of the quicklime with water to convert it into lime hydrate); hydration (mixing of binders with water to achieve a (hydraulic) reaction with the binder); and, aging (storing and maintaining of the slaked lime under water before applying the mortar).

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