



# Earthen mortars from Cremona (Northern Italy): The evolution throughout centuries of a manufacturing tradition



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## HIGHLIGHTS

- Earthen mortars from Cremona are a mixture of soil and/or sand and lime.
- Three types of earthen mortars have been identified.
- Between the XVII and the XVIII centuries a technology change took place.
- Organic and inorganic additives were used to improve the performances of earthen mortars.

## ARTICLE INFO

### Article history:

Received 19 September 2015

Received in revised form 27 July 2016

Accepted 28 July 2016

### Keywords:

Earthen mortars

Lime

Organic additives

Neogenic phases

Hydraulic compounds

Archaeometry

## ABSTRACT

Earthen architectures were widespread in the town of Cremona (Northern Italy) until the first decades of the XX century. An archaeometric study of earthen mortars from buildings of different ages in Cremona allowed investigating the evolution throughout centuries of a well-established masonry tradition. Three typologies of earthen mortars were identified, differing in the amount of added lime. A two-step change in the technology of earthen mortars manufacturing has been inferred. Since the XVII century, lime was added in larger amounts to the mixtures. During the XVIII–XIX centuries, organic additives were employed to further improve the performances of the earthen mortars.

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## 1. Introduction

### 1.1. Earthen mortars of Cremona

Earthen masonries are widespread in architectures of different ages all over the world [1]. Despite the general belief that these materials were earmarked to rural and poor buildings, they were commonly utilised also in defensive and religious architectures, in noble residences and in institutional buildings [2–13].

Earthen masonries were employed since Roman times till the first decades of the XX century in the town of Cremona (Northern Italy, Fig. 1A) and its surroundings [4,6,8,14–17]. Their employment was reasonably due to a conscious choice by local craftsmen and was determined neither by lime shortage nor by time/costs savings [14,15]. Both aerial and hydraulic lime were indeed

available from the not-far towns of Piacenza, Lodi and San Colombano [18–22] (Fig. 1A).

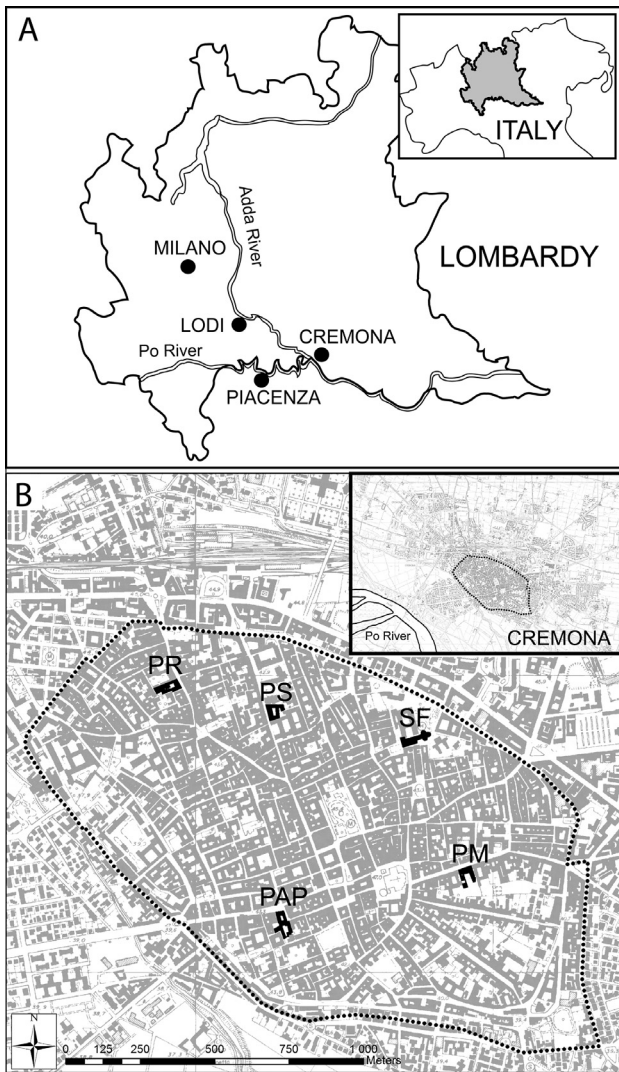
The common practice of building with earth is also testified by the local vocabulary [23]. The ancient terms *bazàna* and *robba* (the latter probably being a vernacular expression) refer to mortars made of sand, earth and lime mixtures. The term *mòlta* indicates a mixture of sand and earth without the addition of lime [8,14,15]. However, no indications on the amounts of components of the different mixtures are provided in ancient documents. Moreover, it is not clear why different recipes coexisted. Was it the evolution of a traditional recipe? Were different recipes devoted to different structural positions in the buildings? Or did it depend only on the master builder's expertise?

Historical treatises and recent scientific literature do not help answer these questions.

In fact, XIX century treatises report contrasting information on the type of mortars (lime, terrigenous or mixed) to be adopted in architectures. The adoption of lime mortars was highly

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**Fig. 1.** A) Geographical position of the town of Cremona (Lombardy, Italy); modified after Cantù et al. [8]. B) Geographical setting of the studied buildings. PAP: Ala Ponzone Palace, PM: Magio Grasselli Palace, PS: Pallavicino Soldi Palace, PR: Raimondi Palace, SF: San Francesco Basilica. Dotted line indicates the boundaries of the historical town. It corresponds to the medieval walls built between 1169 CE and 1189 CE. These walls enclosed the ancient Roman village and all the buildings until the beginning of the XIX century.

recommended (at least for basements) in some documents, but treatises advising the employment of earthen mortars were found as well [22,24].

Recent investigations by Cantù et al. [8] evidence the use of earthen mortars with nearly identical compositions in all structural positions of Pallavicino Soldi Palace. Mortars mixtures consisted of sediments/soils of eolian origin and small amounts of quicklime (<5 wt.%). Intentional or involuntary additions of wood and/or agricultural waste ashes were hypothesised based on geochemical evidences. It is still not clear whether the terrigenous components of mortars consisted only of raw materials as they are (soil/sediment) or they were handmade mixtures (soil/sediment + sand). Moreover, considering the extremely little clayey fraction content (<1 wt.%), it is more appropriate to refer to these materials as “earthen mortars” [8] than “clay mortars” [14,25].

The emerged discrepancies highlight a gap of knowledge relative to the production and use of earthen mortars throughout centuries in the town of Cremona.

On this basis, an extensive archaeometric study of earthen mortars collected at Cremona is here proposed following the method-

ological protocol adopted by Cantù et al. [8]. The proposed analytical protocol consists of petrographic, mineralogical and geochemical investigations (by OM, SEM-EDS, XRPD, FTIR) supported by a statistical data processing. Samples collected in buildings of different ages were investigated in order to assess the evolution of a well-established technique in this town.

## 1.2. Studied buildings

Among the many historical architectures in Cremona, preserving original earthen masonries, five buildings (Fig. 1B) were chosen because of their comparable size, typology and construction techniques and the availability of historical documents also related to recent restorations and maintenance. Sampling was preceded by diagnostic investigations and archaeometric surveys in order to avoid portions of buildings subjected to continuous remaking.

The oldest building considered is Raimondi Palace, which was built by master builder Bernardino de Lera between 1493 CE and 1496 CE. The construction of the building was based on existing structures unified behind a eurythmic façade of Botticino marble in rusticated diamond form. Despite the building was subjected to invasive restorations since the first half of the XIX century, it was possible to identify walls and, locally, plasters belonging to the late XV century construction phases.

Magio Grasselli Palace, which nowadays appears as a unique construction, is the result of significant building restorations that have incorporated older structures, sometimes dated to the middle ages. Around the middle XVII century, the marquis Nicolò Magio bought several properties which were remodelled in a unique and modern palace in 1658 CE. A new façade was made and plastered with earthen mortar, unifying the external appearance of the buildings. The interior was completely restored, adding a loggia and a superposed large gallery connected to the ground floor by a monumental staircase. The ancient walls of the unified houses were therefore partly preserved, raised or demolished and rebuilt (reusing bricks). The inside wing of the building, overlooking the courtyard and garden, was built from the ground between 1768 CE and 1780 CE; the construction lasted more or less a decade.

Pallavicino Soldi Palace was one of the most important residences at Cremona until the XV century. It was built by the unification of different edifices, which lasted till at least 1776 CE. The building was subjected to substantial restorations, even in the interiors, altering the structural setting of the building.

The restoration of the San Francesco Basilica and its transformation into a hospital was projected by the architect Faustino Rodi and started in 1777 CE.

Ala-Ponzone Palace as it appears nowadays is the result of consistent restorations commissioned by the marquis Ala-Ponzone to Faustino Rodi. Even Ala-Ponzone Palace represents the assembly of previous ancient buildings which started in the fourth decade of XIX century.

## 2. Materials and methods

### 2.1. Sampling

Fourteen mortar joint samples were collected from the five buildings of the town of Cremona (Fig. 1B) which are described in Section 1.2. Samples were collected in order to cover a time range from the late XV century to the XIX century (Table 1). Moreover, samples were collected in different structural positions to verify if some correlation exist between mortars compositions and their locations in the buildings.

Samples are named according to their provenance and the capital letters indicate the building. PM indicates Magio Grasselli Palace, PS stands for Pallavicino Soldi Palace, PR indicates Raimondi

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