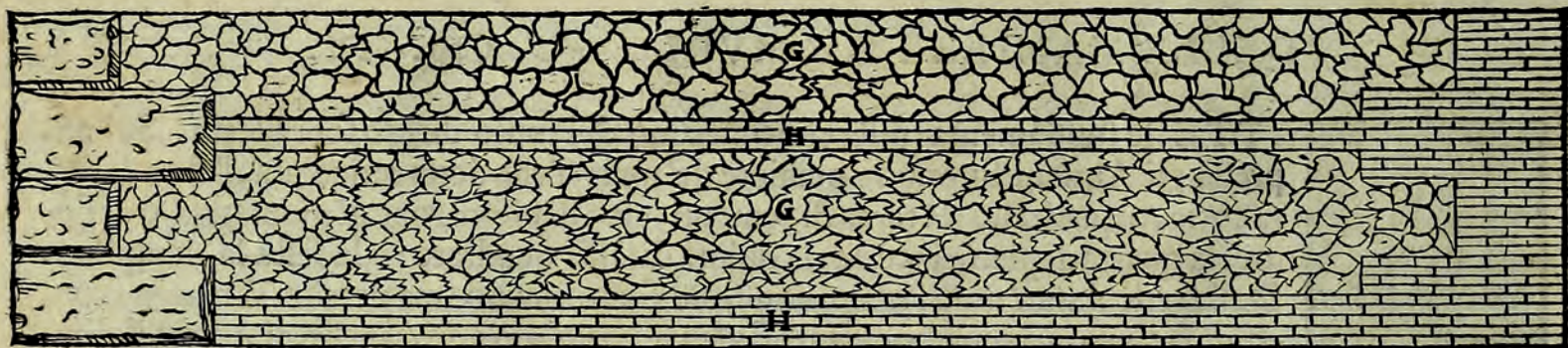


M, Tauole poste in coltello.  
N, Parte di dentro del muro.  
O, Faccia del muro tolte via le tauole.

# Palladio and Concrete

## Archaeology Innovation Legacy

Louis Cellauro and Gilbert Richaud



G, Cementi, ò cuocoli di fiume.  
H, Corfi di quadrelli che legano tutto il muro.

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*monografie*

26



LOUIS CELLAURO and GILBERT RICHAUD

Palladio and Concrete  
Archaeology, Innovation, Legacy

With a foreword by

HOWARD BURNS

«L'ERMA» di BRETSCHNEIDER  
Roma-Bristol

Louis Cellauro and Gilbert Richaud  
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Archaeology, Innovation, Legacy

*With a foreword by*  
Howard Burns

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*Front cover*

*Figure above:* Andrea Palladio, 'La maniera riempita che si dice ancho à cassa' ('The infill method also called coffering'), from Andrea Palladio, *I Quattro libri dell'architettura* (Venice: Domenico de' Franceschi, 1570), p. 13, detail, The Getty Research Institute, Los Angeles (86-B23467) (Photo: The Getty Research Institute, Los Angeles).

*Figure below:* Andrea Palladio, 'I muri di cementi' ('concrete masonry made of small stones'), from Andrea Palladio, *I Quattro libri dell'architettura* (Venice: Domenico de' Franceschi, 1570), p. 12, detail, The Getty Research Institute, Los Angeles (86-B23467) (Photo: The Getty Research Institute, Los Angeles).

**Louis Cellauro and Gilbert Richaud**

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*To my parents Prima Giulia Maglio (1914-1986)  
and Diego Cellauo (1924-2020),  
Knight of the Order of Merit of the Italian Republic*





## FOREWORD

Louis Cellauro and Gilbert Richaud present here an illuminating and unfamiliar history of the interest from the Renaissance onwards in ancient Roman techniques of concrete construction using shuttering to form foundations and other structures, such as walls and vaults.

Palladio has a central place in this story. In his *Quattro Libri dell' Architettura* (1570) he illustrated and described the various ancient Roman methods of wall construction including what Vitruvius calls *em-plekton* and Palladio the *maniera riempita*, the filled-in method. Palladio was familiar with the mention of this walling technique in Vitruvius and with Alberti's pioneering discussion of Roman construction. However, in his *Quattro Libri* he illustrated the *maniera riempita* on the basis of personal observation: he correctly identified an example of this constructional method in the ruins of the large villa complex known as the Grotte di Catullo, at Sirmione on the Lago di Garda. This was a decisive, indisputable and influential insight, whose echoes are traced in this book. The Grotte had been visited by Isabella d' Este in 1514 and 1535, as the authors recall, and it is interesting to remember that Palladio knew two persons – Giulio Romano and Giangiorgio Trissino – who were acquainted with Isabella: she lent Trissino her gardener to lay out the garden at his newly modernized villa at Cricoli.

Palladio built on the pioneering achievement of Alberti in documenting and uncovering the whole world of ancient Roman architecture, using Vitruvius and other ancient texts and at the same time examining surviving Roman structures from an architectural and structural point of view.

This double approach - study of texts and study of buildings - was an important extension of the methods which humanists had applied to the study of ancient texts. Alberti's contemporary Flavio Biondo, one can recall, also based his account of ancient Roman houses in his *De Roma Triumphante* (1459) in part on an examination of the remains of ancient structures.

Cellauro and Richaud contribute here to a reassessment of Palladio as scholar and researcher. His studies of ancient bridges, baths, and other building types constitute a significant contribution to an understanding of the ancient past, while his *Quarto Libro*, dedicated to Roman temples, offers an extraordinary recovery of knowledge concerning the temples published, based on surveys and a judgement in reconstruction which few of his contemporaries could rival. His comments on the buildings show familiarity with the sources, attention to inscriptions and the ability to date details on the basis of style and workmanship. He also reveals a historian's capacity to raise questions and speculate, as when he suggests that the irregular layout of the Forum of Augustus was the result of the Emperor's unwillingness to expropriate the properties of local residents.

The story recounted here, however, does not stop with the publication of Palladio's book in 1570. The *Quattro Libri* was much read, reprinted and translated. Cellauro and Richaud write: 'One of the central claims of the present study is that Palladio was the first to illustrate the process, which has subsequently

been used to construct concrete walls in modern and contemporary architecture.’ This is a large and intriguing claim, amply supported in this book – a work of scholarship which is an important contribution to a knowledge of Palladio’s interests, and which reveals a hitherto unrecognised aspect of his impact on architecture and construction long after his death.

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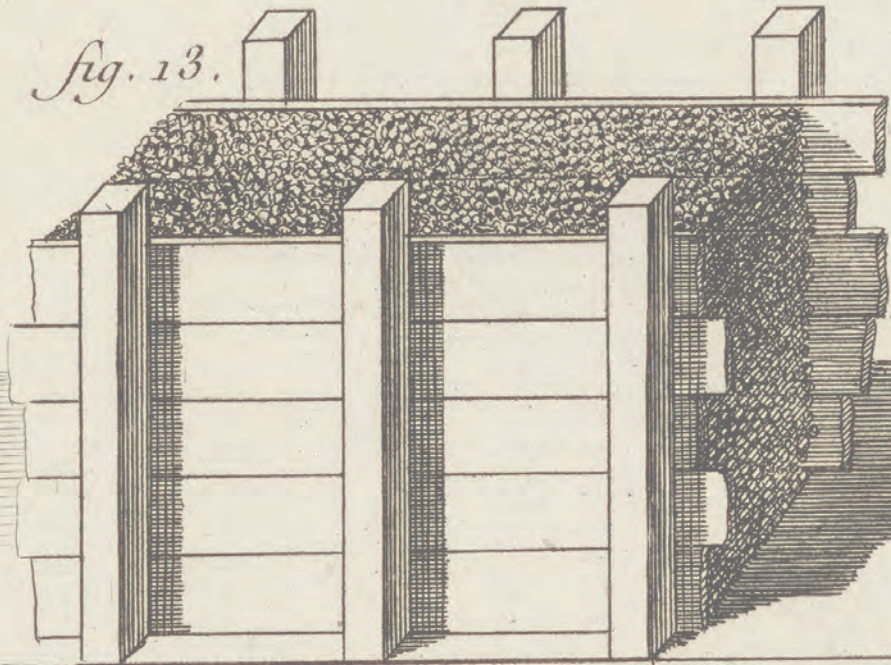


## SUMMARY

The history of modern concrete is generally believed to have its roots in the late eighteenth century, although the material – widely used in ancient Imperial Rome – was rediscovered and studied by Renaissance architects and humanists. It was even employed to a certain extent in fifteenth- and sixteenth-century buildings, most significantly at St Peter's, the most important building site in Renaissance Europe. Aside from closely observing surviving ruins, architects were able to refer to Vitruvius's treatise, *De architectura*, to garner information on Roman concrete. The ancient author proved to be a key source of technical knowledge concerning the employment of a mix of rubble and mortar for the purposes of infill walling construction (*De arch.* 2.8.7 on *emplekton*). This study outlines how the subject was treated by Renaissance writers on architecture, commencing with Alberti and continuing with early commentators on Vitruvius. Of key importance, however, were the editions of Vitruvius by Daniele Barbaro, which were accompanied by illustrations by Palladio, and the latter's own *Quattro libri*. These texts offered a consideration of the textual evidence in combination with features derived from surviving ancient buildings. One of the central claims of the present study is that Palladio was the first to illustrate the process, which has subsequently been used to construct concrete walls in modern and contemporary architecture, and to foster its employment in his own time. Palladio's reconstructions of ancient masonry techniques, and in particular his ideas on the use of removable wooden formwork for the infill walling technique, which he termed *la maniera riempita*, were taken up by later writers, who contributed in varying degrees to their dissemination. Palladio's treatise would become almost the sole source of reference for authors discussing ancient masonry in eighteenth-century France. During this period, the vernacular practice of using formwork to construct walls of compressed earth was drawn into the debate; in the mid-twentieth century, Canadian scholar, Peter Collins, would come to view it as the sole source of the structural processes used in modern concrete construction. This widely accepted thesis needs to be revisited today, because, although Palladio was a major source for the emergence of this system of construction, his contribution has been overlooked until now by scholars researching the history of concrete.



*fig. 13.*



## INTRODUCTION

The history of modern concrete usually begins with the eighteenth century, as it does in the recent study by Roberto Gargiani, *Concrete, from Archaeology to Invention, 1700-1769: The Renaissance of Pozzolana and Roman Construction Techniques* (Lausanne/Oxford, 2013) (Gargiani, 2013), which was the first in a series of five projected books on the history of concrete. Modern concrete, however, has a humanist legacy derived from the impact of Vitruvius and the first-hand study of surviving Classical ruins, as they appeared in the fifteenth and sixteenth centuries. Nonetheless, little has been published on the subject, in particular on its rediscovery by Renaissance commentators on Vitruvius and Palladio's *I Quattro libri dell'architettura* (Venice, 1570) (Palladio, 1570), which is the main focus of this study. Pier Nicola Pagliara wrote three notable articles on the subject of the revival of ancient Roman techniques in the Quattrocento and Cinquecento, in which, referencing sources, such as Giorgio Vasari's *Vite de' più eccellenti pittori, scultori e architettori* (1550 and 1568) (Bettarini and Barocchi, 1976), he discussed the use of concrete by Renaissance architects, in particular its employment in the construction of the vaults of several fifteenth- and sixteenth-century Roman buildings (Pagliara, 1998-99; 2002; 2007).

Renaissance architects revived ancient architectural forms and showed great interest in ancient Roman construction methods, but the use of concrete did not become ubiquitous at this time as a building material. It seems to have been limited almost exclusively to Rome and Lazio, although Giuliano da Sangallo (1445-1516) is said by Vasari (1511-74) to have introduced it for vaults in Tuscany (Pagliara, 1998-99: 260 n. 207; Belli, 2017; and Bettarini and Barocchi, 1976: 152).<sup>1</sup> In fact, rather than suddenly re-emerging in the Renaissance, the ancient Roman tradition of building walls and vaults in concrete continued uninterrupted in the Eternal City during the Middle Ages, as attested to by features in several important Late Medieval churches: the thirteenth-century vaults of the monastery of San Martino ai Monti, the barrel vault of the prothyrum of St Praxedes (eleventh to twelfth centuries) and the groined and barrel vaults of the so-called Chapel of San Giuliano at San Paolo fuori le Mura (twelfth century) (Pagliara, 1998-99: 233; 250).

Apart from Vasari's *Vite* and several documents relating to St Peter's, the primary sources about the actual use of concrete in Renaissance architecture are scant. Most of our knowledge on the subject stems from on-site inspections and from restoration campaigns. A major early Renaissance example is the *all'antica* coffered barrel vault built by Francesco del Borgo (c. 1415-68) in the vestibule of the Palazzo

<sup>1</sup> 'Portò Giuliano da Roma il gettare le volte di materia [concrete] che venissero intagliate, come la casa sua ne fa fede una camera, e al Poggio a Caiano nella sala grande la volta che si vede ora'.



Venezia in Rome (c. 1466) (fig. 1) (Frommel, 1982: 24; Frommel, 1984: 97). Other significant examples include the flattened barrel vault of the Sistine Chapel, the vaults of the cellars of the Palazzo Farnese, the lunette vault of the vestibule of San Stefano Rotondo (c. 1450), the vault of the Loggia di Psyche at the Farnesina and the minor dome of Santa Maria di Monte Moro in northern Lazio (Pagliara, 1998-99: 250; Felici, 1993-94: 14-16). However, it was Donato Bramante (1444-1514), who experimented more consistently with Roman methods of concreting, using concrete for the core of the crossing piers and for the large arches of St Peter's (1511-13). These features formed part of his design for the church, which would have included a large dome (1506; unexecuted) (fig. 2) (Metternich and Thoenes, 1987: 164-74; Krauss and Thoenes, 1996), a perfect hemispherical structure clearly inspired by the ancient Roman Pantheon (constructed c. 118 to 124 CE) and still the world's largest unreinforced concrete dome with a clear span of 43.4 metres. It is likely that Bramante also intended the dome of St Peter's to be built in concrete (Frommel, 1991: 181). There is no evidence for this, but he would certainly at least have envisaged it as a serious option at some stage of his design process. His other experiments with concrete included the smaller hemispherical dome of San Pietro in Montorio (1502) (Giovannoni, 1922: 427-8; Di Geso and Pentrella, 1990: 824-5), the vaults of the *Ninfeo* at Genazzano (c. 1500) (Frommel, 1969), and the walls and the half-columns of the Palazzo Caprini (after 1501; destroyed) (Pagliara, 2007: 61; Frommel, 1973, II: 83, Pl. 32a). In the 1550 edition of the *Vite*, Vasari claimed that the Palazzo Caprini was '*lavorato di mattoni et di getto con casse e le bozze di opera Dorica et rustica, cosa molto bella et invenzion nuova, del fare le cose gettate*' (Bettarini and Barocchi, 1976: 252), that is to say, 'made of bricks and material cast with formwork [*di getto con casse*], the columns and rough-hewn stones Doric and rusticated, a most beautiful work incorporating a new way of making cast elements [*le cose gettate*]'. The Italian term *di getto* refers especially to the *opus caementicium* of ancient Roman vaults, and, beneath the quoted passage, Vasari described Bramante's activity at St Peter's, stating that 'he found a method of casting the vaults with wooden formwork' (Bettarini and Barocchi, 1976: 82).<sup>2</sup> The *magistri lignaminis*, Antonio da Sangallo the Younger (1484-1546) and Antonio del Pellegrino, were paid several times in 1510 and in 1511 for the centering and formwork boards of St Peter's coffered arches (Pagliara, 2007: 61, n. 218; Frommel, 1991: 181). A drawing dated 1532-36 in Maerten van Heemskerck's Roman album shows the large coffered concrete vaults connecting the crossing piers (fig. 3) (Difuria, 2019; Hülsen and Egger, 1913-16). By the time of Bramante's death, only the crossing piers, the great concrete arches spanning them and the lower sections of the pendentives had been completed. As Vasari noted, they had also been built in great haste (*prestezza*) (Bettarini and Barocchi, 1976: 82).

Along with Bramante, Palladio occupies an important place in the history of Renaissance concrete: the former as practitioner and the latter as the theorist and archaeologist of concrete technology. In fact, in his own buildings, Palladio never used concrete, whether for foundations, walls or vaults, preferring brick covered with *intonaco* (a plaster, giving the impression of stone), concealed wooden beams for architraves, stucco, and sometimes terracotta for capitals, as in the interior church of the Redentore and the exterior of the Tempietto at Maser. He sometimes used plaster over reeds fixed to a wooden framework in his construction of vaults, as at the Convento della Carità, and was very sparing in his use of costly stone or marble (Burns *et al.*, 1975: 209; Zorzi, 1966: 89; Piana and Soragni, 2011).

In chapter IX of the first book of the *Quattro libri* (Palladio, I.9: 11-4), under the heading '*Delle maniere de' muri*' [On different kinds of walls], Palladio announced his intention to recreate seven ancient types of masonry, as found in ancient architectural remains, or as described by Vitruvius in Book 2.8.1-8. No fewer than four of these seven types employ concrete as an infill material. The third

<sup>2</sup> '*trovò il modo di buttar le volte con le casse di legno*'.



Fig. 1. Francesco del Borgo, *Coffered barrel vault of the vestibule of the Palazzo Venezia*, Rome, c.1466 (Photo: Sailko, Wikipedia Commons).



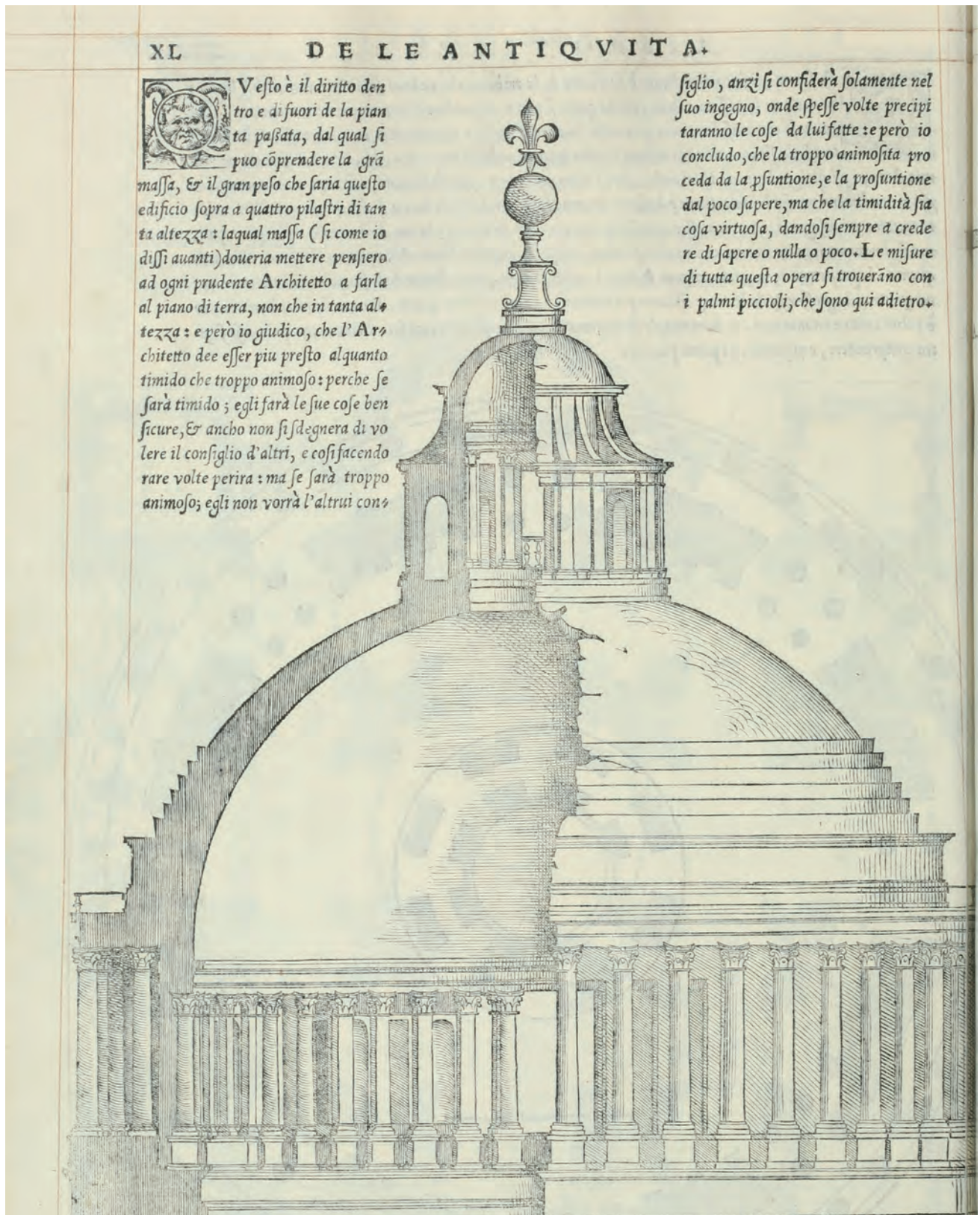


Fig. 2. Bramante's design for the dome of Saint Peter's in Rome, according to Serlio, from Sebastiano Serlio, *Il terzo libro nel quale si figurano e descrivono le antiqità di Roma* (Venice: Francesco Marcolini, 1540), p. 40, The Getty Research Institute, Los Angeles (85-B7159) (Photo: The Getty Research Institute, Los Angeles).





Fig. 3. Maerten van Heemskerck, *View of Saint Peter's in construction with Bramante's large concrete vaults connecting the crossing piers*, c. 1532-36, Kupferstichkabinett, Staatliche Museen zu Berlin, Berlin, Heemskerck-Album, vol. I, fol. 13r (Photo © Kupferstichkabinett, Staatliche Museen zu Berlin, Berlin).

type, said to be '*muri di cementi, ò cuocoli di fume*' [walls made of small stones, or river pebbles] (Palladio 1570: 12; Tavernor and Schofield, [1997] 2002: 14), and the sixth, which he referred to as '*La maniera riempita, che si dice ancho a cassà*' [the infill method, also called coffering] (Palladio, 1570: 13; Tavernor and Schofield, [1997] 2002: 15), were particularly influential, as they would play a major role as models for the design of a new type of coffered masonry, especially in France, until the early nineteenth century.

Palladio's interest in concrete and in other building technologies stemmed from his professional education. He was an expert in building techniques and materials, having served his apprenticeship in the workshop of Bartolomeo Cavazza da Sossano, a Paduan stonecutter. In 1523, Palladio enrolled at the Stonemasons' and Masons' Guild [*Fraglia dei lapicidi e dei muratori*] in Vicenza, working with Giovanni di Giacomo da Porlezza (1475-post 1550) and the sculptor Girolamo Pittoni (1490-1568) in the Pedemuro workshop. Unlike many of his contemporaries, who first completed apprenticeships as painters or sculptors, Palladio was trained in the working of stone, giving him a remarkably extensive understanding of the materials with which he worked and which he studied in ancient monuments.

His illustration in the *Quattro libri* of the *maniera riempita*, a creative reworking of one of three versions of Vitruvian *emplekton*, was particularly novel. This was a technique for constructing walls, which involved pouring concrete into removable wooden formwork made of planks and allowing