# A New Date for Concrete in Rome*

MARCELLO MOGETTA

ABSTRACT

*Concrete is regarded as a quintessentially Roman achievement. The spread of the technology is usually dated to the fourth or third centuries* B.C., *and interpreted as a symptom of Rome's early expansion in Italy. In this paper I offer a reappraisal of the available evidence for early concrete construction in Rome. On the basis of stratigraphic evidence, I conclude that a later date should be assigned to most of the remains. I situate the origins of the technological innovation within the radical change in architectural styles that unfolded in the middle of the second century* B.C., *affecting both domestic architecture and public building. The new chronology has an impact on current models of cultural diffusion in Roman Italy, linking the development of Late Republican architecture with the broader debate on the cultural implications of the Roman conquest.*

**Keywords:** Late Republican architecture; Late Republican building techniques; Roman concrete; technological innovation; topography of Rome; Roman Italy; urbanization; cultural diffusion

## I TESTING THE FOUNDATIONS OF ROMAN REPUBLICAN ARCHITECTURE

The phase of Rome's early military expansion during the Middle Republic, between the middle of the fourth and the early second centuries B.C., has often been highlighted as a crucial juncture for the formation of a recognizable Roman material culture.[1] The architecture of Roman urbanism has been singled out as the most emblematic case, for its emergence coincides with both Rome's growth as a metropolis and its intensive colonization programme in Italy in that period.[2] Yet, the last few decades of archaeological research in central Italy — Rome, Cosa and Pompeii being the most-thoroughly explored and published sites — have proved that the material record for the Middle Republic is elusive. Most urban entities have very little civic architecture

* This article is part of a broader, ongoing research project in which I investigate a crucial aspect of Roman Republican archaeology, the origins of concrete architecture. The content is based on the results of my PhD dissertation, as revised during post-doctoral work carried out at the University of Michigan, Kelsey Museum of Archaeology (*MCubed Project: Architectural Revolutions from the Roman Empire to the Digital Age*). The Institut für Klassische Archäologie at the Freie Universität Berlin provided useful resources to complete the final editing. I would like to thank particularly Nic Terrenato, Chris Ratté, Lynne Lancaster, Mario Torelli and Monika Trümper for their continued interest in this project. The comments of two anonymous readers were much appreciated, and helped me improve the final version. Any inconsistencies or mistakes are mine.

[1] The cultural phenomenon has come to be referred to as the 'Romanization of Rome': Keay and Terrenato 2001: vol. I; Stek 2014: 34–5. A classic account of this view is in Coarelli 1996: 15–84, who describes the process as an adaptation of Hellenistic models. On the adoption of Greek cultural forms to articulate 'national' values see also Gruen 1992.

[2] See especially Zanker 2000; Sewell 2010 emphasizes the influence of contemporary Greek practice. A summary of the question is in Laurence *et al.* 2011: 17–22.

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beyond fortifications and temples predating the late second century B.C.[3] Similarly, the sample of domestic architecture is surprisingly poor when compared to that of previous or later periods.[4]

This pattern, which is unlikely to be the result of later architecture masking earlier contexts,[5] prompts a thorough reassessment of the chronology of salient features of Roman Republican architecture. I wish to contribute to this important debate by making the case for a starker distinction between the cultural developments of the Middle and Late Republican periods. To this end, I investigate the relationship between architecture, technology and society through the lens of building techniques, analysing the spread of one of the most cited examples of Roman ingenuity, Roman concrete (*opus caementicium*).[6]

My main argument is that architectural change in Rome happened at a later stage, and more quickly than normally assumed. Thus, the Late Republican period can be characterized as a crucial developmental phase for what came in the Imperial period, as it provided the basis for what is commonly referred to as the 'Roman architectural revolution' (i.e. the development of structural concrete). Recasting previous reconstructions, in the following discussion I concentrate on the political and social context of the technological innovation, highlighting the impetus of private investments in domestic architecture, and its important relationship to public building, which ultimately determined a radical change in the texture of Rome's urban landscape.

The down-dating of most concrete architecture in Rome allows us to draw a sharp demarcation with the archaeological picture of the late third and early second centuries B.C., and to frame the emergence of the medium in the latter part of the second century. This period, which coincided in time with the incorporation of the cities of Classical Greece into the Roman Empire, influenced Rome's view of the nature of urban life to a much greater extent than did the conquest of Italy in the previous century. Not by chance, this phase witnessed other important contributions to the on-going public discourse about being Roman (from the birth of satire to the unprecedented spike in epigraphic habit).[7] The model I propose, therefore, has important implications for how we conceptualize cultural change in Roman Italy.

## II ROME, THE MIDDLE REPUBLIC AND THE HISTORIOGRAPHY OF ROMAN CONCRETE

The diffusion of concrete building techniques is commonly dated to the third century B.C. or even earlier (as summarized in Table 1). This view is based largely on corpora collected before 1950, which reflect old methodologies and theoretical frameworks. A deconstruction of the argument is, therefore, in order.

[3] Survey in Lackner 2008. The issue is explored further by Becker 2007. For Pompeii see most recently Ball and Dobbins 2013.

[4] The evidence is collected by Jolivet 2011. Recent contributions to this debate are collected in Bentz and Reusser 2010.

[5] In spite of its very fragmented state, the growing body of Archaic architectural remains uncovered in the monumental core of Rome undermines this view. Survey of the evidence in Cifani 2008.

[6] Important documents of the reception of Roman concrete in non-specialist literature are Lamprecht 1984; Lechtmann and Hobbs 1987. Lancaster 2008 surveys the main innovations that set Roman practice apart from previous Greek traditions. On the fascination with the 'lost secret' of the Roman recipe and process in modern scholarship see Gazda 2001: 147–55.

[7] The social context in which Lucilius operated and the genesis of the literary genre unfolded are discussed in Gruen 1992: 272–317. On epigraphic habit in Republican Rome: Panciera 1995: 321–2, with a quantification of second-century B.C. inscriptions from the city; Panciera 1997.

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TABLE 1 Current Models of the Diffusion of Concrete in Rome and Italy

| AUTHOR | WHEN | WHERE | CONTEXT OF INNOVATION | NOTES |
|---|---|---|---|---|
| Lugli 1957 | 3rd c. B.C. | Latium | Concerns for economic resources; Fast and cheap building method; Farms. | Properties 'discovered' in Campania; Developed by Roman colonists; Massive adoption in Rome after 211 B.C. |
| Brown 1951; 1980 | 4th–3rd c. B.C. | Rome/ Latium | Middle Republican colonization programme. | Technique 'imported' by Roman colonists at Cosa. |
| Coarelli 1977 | Before 204 B.C. | Rome | Standardization of *opus incertum*; Population pressure and slave influx. | Origins of mortar technology in Pompeii; Steady development of facing styles in Rome. |
| Rakob 1983 | 200 B.C. | Rome/ Campania | Interaction with Punic sites. | Link with *opus Africanum*. |
| Carandini and Papi 1999 | 3rd c. B.C. | Rome | Urbanization (after 211 B.C.). | Diffusion of mortar technologies from Rome to Middle Republican colonies. |
| Giuliani 2006 | 4th–3rd c. B.C. | Rome | Middle Republican colonization programme. | Long period of trial-and-error prior to Testaccio building. |

Two important developments in the period just before World War II contributed to the definition of the conventional chronology. The first was a new identification proposed by Gatti for a monument represented on the Forma Urbis Romae, for which only the last three letters of the name, i.e. *-lia*, were known.[8] This monument seemed to correspond in both plan and dimensions with a large concrete vaulted building preserved on the left bank of the Tiber, near the modern Testaccio. Based on the location of the archaeological remains, Gatti restored the inscription to read [*Porticus Aemi*]*lia*, a monument claimed by Livy to have been first erected in the early second century B.C. in the area of the Emporium.[9] This theory had important repercussions for the dating of concrete architecture because it provided a fixed point. Architectural historians assumed that the advanced features of the Testaccio building, especially its size (487 by 60 m) and complex vaulting (with record spans of *c.* 8.30 m), were the result of a long period of trial-and-error. They concluded that the introduction of Roman concrete long predated the construction date known for the Porticus Aemilia.

An important element in support of this idea seemed to come from the results of stratigraphic investigations below the floor levels of various buildings of Roman Pompeii, which Maiuri had launched in 1926.[10] These excavations revealed extensive remains of simple rubble architecture — some of it using lime — in the area of the

[8] Gatti 1934.
[9] Livy records two construction dates for this monument: 193 B.C. (35.10.12) and 174 B.C. (41.27.8).
[10] Reports on the various projects were published separately as work progressed, but are now collected in Maiuri 1973.

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forum, as well as in the early levels of some atrium houses. These structures were assigned to the third century B.C. or earlier, though on the basis of very limited soundings.

Lugli was the first to combine this evidence in a systematic fashion. In an attempt to classify the material from Rome and Latium, he produced a typology of concrete wall-facing styles, taking the so-called Porticus Aemilia as a reference.[11] He then linked his typology with the recent finds from Pompeii, which, together with a small sample from the deeper levels of Ostia, seemed to provide an example of the early stage of concrete architecture that would have existed in Middle Republican Rome.[12] While conceding that local builders at Pompeii could have discovered the properties of pozzolanic mortars independently, Lugli firmly believed that Latium was a likely candidate for the initial development of the technique. This idea was based on the results of extensive surveys he conducted in the 1920s in the countryside of early Roman colonies such as Tarracina and Circeii, where he documented mortar-and-rubble architecture of a type similar to that at Pompeii.[13]

Furthermore, because these remains were predominantly associated with rural buildings, he described concrete as a cheap architectural expedient, as opposed to ashlar or polygonal masonry, contributing to the view that it was invented at the lower level of society. From his perspective, the new technology would have eventually made its way from the *suburbium* of Rome into the city, where decisive improvements would be achieved over a period of experimentation in the third century B.C., leading to the large-scale adoption of the building medium by the end of the century. Following the lead of Lugli, Brown assigned all the standing remains of mortared masonry he excavated around the same time at Cosa to the first building phase of the colony of 273 B.C. (Fig. 1).[14] His expectation was in fact that Cosa's colonists learned the technique at their place of origin, i.e. Latium.[15]

The chronology proposed by Lugli had a profound impact on subsequent scholarship. The most notable example is the influential work of Coarelli, who set out to update the typology of concrete monuments from Rome (Fig. 2).[16] Taking the wall-facing style of the so-called Porticus Aemilia as a fixed point, he tried to identify concrete public monuments that could predate the Testaccio building. In his methodology, concrete walls featuring irregularly-shaped facing-blocks and mortar joints would normally be earlier in date than walls characterized by a more regular aspect. According to this system, there would be a progressive regularization of the class of concrete walls conventionally referred to as *opus incertum*, culminating in the standardized *opus reticulatum* through an intermediate phase described as *opus quasi reticulatum*.[17] In Coarelli's view, this process of standardization accelerated dramatically in the third

[11] Lugli 1957. Gatti believed that in its earliest phase the monument was built with perishable material. In order to confirm that the visible remains belonged to the 174 B.C. building and not to a later reconstruction, Gatti and Lugli excavated a test-trench across the door of one of the vaulted rooms. Upon reaching the bottom of the foundations, the trench revealed no traces of earlier structures or archaeological stratigraphy: Lugli 1957: vol. 1, 451 n. 1. Accepting Lugli's conclusions, Giuliani 1998: 60 n. 11 suggests that the two dates recorded in Livy do not refer to the original building and subsequent reconstruction, but rather to the beginning of the construction project and to the final inspection, respectively.

[12] Lugli 1957: vol. 1, 374–5.

[13] Lugli 1926; Lugli 1928.

[14] Brown 1951: 59–63, 102–13, based on comparanda from Ostia and Tarracina that Lugli dated to the fourth century B.C. These remains have been re-dated archaeologically to the second century B.C.: Fentress 2003: 14.

[15] For a critique of Brown's desire to find Roman prototypes for Cosan archaeological realities see Fentress 2000. Recent research on Middle Republican colonization suggests that colonial contingents were often of mixed ethnic composition, and could include as much as 50 per cent of settlers of non-Roman origins: e.g. Bradley 2006.

[16] Coarelli 1977.

[17] For a critique of this terminology see Lancaster 2008: 262, pointing out that *opus quasi reticulatum* is a subjective term that should be used with caution, thus I occasionally adopt the term 'rough *opus reticulatum*', stripped of any chronological implications.

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FIG. 1. Cosa, Basilica, Atrium Publicum. View of the north-east side and Basilica alley from the north-west, showing a sample of the mortar-and-rubble architecture uncovered by Brown at the site. (*Fototeca Unione, American Academy in Rome, negative AAR.Cosa I.BA.65; © American Academy in Rome, Photographic Archive; used by permission*)

quarter of the second century B.C., and was influenced by a combination of factors: first, the economic need to provide housing for the urban plebs (Livy 21.62, mentions high-rise compounds as early as 218 B.C.); second, changes in the organization of construction linked with the availability of unskilled labour.[18] From this perspective, the gradual development of concrete techniques would still have a relationship with important implications of Roman military expansion: population growth and the influx of slavery.[19]

Lugli's influence can also be seen in the scholarship of German architectural historians.[20] Rakob, for example, stressed the importance of the atrium houses of Pompeii, emphasizing the possible derivation of mortared rubble technologies from Carthage. He based this intriguing but controversial idea on similarities with walling

[18] This view was further developed by Torelli 1980. A more accurate quantification of the labour costs of concrete construction by facing style is offered in DeLaine 2001.

[19] While the first overseas conquests certainly accelerated the phenomenon, the growth of slavery is now viewed in more gradualist terms, with increments spreading over a longer period of time. Based on the tallies reported in ancient sources, Scheidel 2011: table 14.2 gives a total of between 672,000 and 731,000 captives in the 297–167 B.C. period, reconstructing a clear progression in the annual mean of slave supply to Rome (from *c.* 3,300 for 297–241 B.C., to *c.* 5,300 for 241–202 B.C., to *c.* 8,701 for the 202–167 B.C. period). Scheidel recognizes the deficiencies of the underlying tallies, but suggests that unreasonably large adjustments would have to be made to alter the ratios.

[20] A notable exception is von Gerkan 1958, who criticized many of Lugli's ideas.

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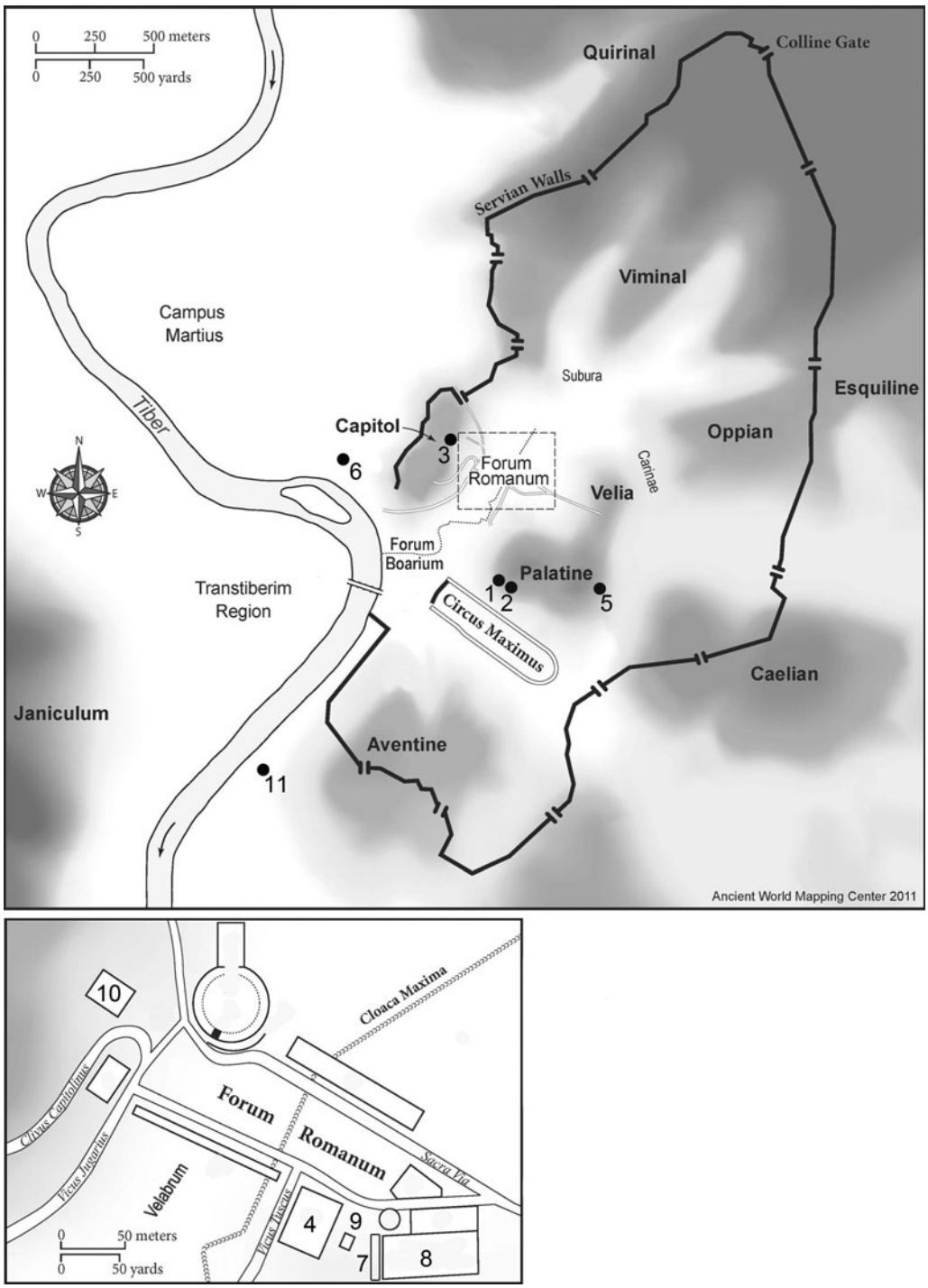


FIG. 2. Schematic map of Rome showing the location of the public buildings discussed in Section III (1. Temple of Magna Mater; 2. Temple of Victoria; 3. Temple of Veiovis; 4. Temple of Castor and Pollux; 5. East slopes of the Palatine site; 6. Porticus Metelli; 7. Concrete ramp on the east side of the Roman Forum; 8. Aedes and Atrium Vestae; 9. Lacus Iuturnae; 10. Temple of Concord; 11. Testaccio building). (*Base map: Ancient World Mapping Center © 2014 (awmc.unc.edu); used by permission*)

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techniques common at Punic sites in Sicily and North Africa.[21] The technological transfer was interpreted as the result of two overlapping phenomena: on the one hand, the increased interaction between Carthage and Rome in the period of the Punic wars; on the other, the intensification of contact between Rome and Campania throughout the third century B.C., from the Samnite wars onwards. Thus, the development was once again related to the political history of the Middle Republican period.

The Lugli-Coarelli scheme eventually crystallized in influential manuals on Roman construction. Giuliani supports the high date of mortar-and-rubble architecture at Cosa and other Middle Republican colonial sites, such as Alba Fucens.[22] Adam accepts the idea that in Rome concrete was routinely used for public construction projects by 200 B.C. at the latest.[23] These reconstructions identify the Middle Republican period as a decisive phase in the shaping of Roman architecture, and in various ways suggest that elements of this trickled down to the rest of the peninsula as different areas were incorporated into the Roman sphere, especially through the agency of Roman colonists.

## III REDATING ROME'S CONCRETE ARCHITECTURE: THE PUBLIC BUILDINGS

Coarelli's synopsis of purported early concrete wall-facing styles in Rome is a good place to start our discussion. That canon includes what Coarelli believed to be well-dated known monuments that would demonstrate the sequence of development of *opus incertum*. His conclusion was that there was a gradual progression in technique, so that walls with irregular facings would normally be earlier than structures with more regular ones, regardless of the type of building material (rubble architecture made of a harder or more intractable stone does not normally feature standardized facing blocks), its provenance (whether quarried on purpose or recycled), and the structural context of the wall (e.g. the small walling of a niche as opposed to a massive terracing wall). In the following discussion I offer a re-analysis of the canonical buildings on which the high chronology rests. The current dating of these monuments is inadequate because it is based on false ideas of the evolution of wall-facing styles. It relies mostly on conventional classifications of wall-paintings and decorated floors found within the structures, and on historical events or persons whose association with the monuments in question is often problematic. On the other hand, stratified pottery assemblages recovered from excavations carried out at some of these sites can provide a more precise guide to date the remains (see Table 2; Fig. 2).

The temple of Magna Mater, a multi-phased building located on the south-west corner of the Palatine, is usually cited as the earliest monument of the *opus incertum* sequence (Fig. 3, a). For this reason, it deserves a lengthier discussion. Coarelli's interpretation was based on evidence collected in the early 1960s by Romanelli with limited soundings in the cella.[24] These revealed that the podium consists of a concrete box made of alternating courses of varying height, which are clearly distinguishable on the basis of the prevailing types of rubble, or *caementa* (Tufo Giallo della Via Tiberina, Peperino and Cappellaccio; Travertine and Tufo Lionato of the varieties from Monteverde and Anio, and Tufo Rosso a Scorie Nere from Fidene).[25] Coarelli classified these walls as a

[21] e.g. Rakob 1983: 361 connects the use of formworks with the precedent of the local clay-based technique commonly referred to as *terre pisé*. Similarly, Wallace-Hadrill 2013: 40–1 highlights the 'Punic' character of Pompeian architecture.
[22] Giuliani 2006: 217–18.
[23] Adam 1994: 79–80.
[24] Romanelli 1963: 227–39; 260–90.
[25] To describe the different types of building materials, I follow the geological classification proposed by Jackson and Marra 2006.

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TABLE 2 Early Concrete Public Monuments in Rome
(UC = unfaced concrete; OI = *opus incertum*; OR: *opus reticulatum*; TL = Tufo Lionato; TGPP = Tufo Giallo di Prima Porta; TGVT = Tufo Giallo della Via Tiberina; Tr = Travertine; P = Peperino; C = Cappellaccio)

| MONUMENT | BUILDING TECHNIQUE | TYPE OF RUBBLE | VAULTING SYSTEM | STRATIGRAPHIC DATING | OTHER DATING EVIDENCE |
|---|---|---|---|---|---|
| *Castor (IA)* | UC | C; TL, P | n/a | n/a | Before 117 B.C. (Phase II) |
| *Porticus Metelli* | OI | TGVT | n/a | n/a | 141–131 B.C. (*locatio*) |
| *Concord* | UC | TGVT | n/a | n/a | 121 B.C. |
| *Palatine east slope* | OI | TL; TGVT (vaults) | Voussoirs (2.90–3.15 m) | n/a | n/a |
| *Navalia* | OI | TGVT or TGPP; C (lower parts) | Concrete (8.30 m) | n/a | 110–100 B.C.? |
| *Magna Mater* | UC; OI; OR | TL; TGVT; Tr; P | Concrete (4.00–4.50 m) | 150–100 B.C. | After 111 B.C. fire |
| *Victoria* | UC | n/a | n/a | 150–100 B.C. | After 111 B.C. fire |
| *Veiovis* | UC | TGVT | n/a | n/a | Before 78 B.C. (construction of *Tabularium*) |
| *Scalae Graecae* | OI | TL | Concrete (3.00–5.00 m) | n/a | 100 B.C.? (cf. *Atrium Vestae*) |
| *Atrium Vestae* | UC | TGVT; TL; C | n/a | 100–50 B.C. | Before 47 B.C. fire |
| *Lacus Iuturnae* | OI (Phase I) | ? | n/a | n/a | After 117 B.C.; before 78–74 B.C. |

rough *opus incertum*, and assigned them to the original construction of the temple, an event recorded by Livy (29.37.2, 36.36) for 204–191 B.C. This date would, in Coarelli's view, correspond well with the particularly unrefined aspect of the concrete masonry.[26] The large-scale excavation and mapping of the sanctuary resumed in 1978 under the direction of Pensabene, and is still ongoing.[27] A different reconstruction can be proposed on the basis of the new finds.

A complex series of concrete structures has been exposed to date both within the temple and in the adjacent area (Fig. 4). Pensabene's excavations on the west side of the temple revealed that the concrete podium was originally clad with ashlars, and that these were robbed in modern times.[28] Removal of the fill of the spoliation trench exposed traces of

[26] Coarelli 1977: 10–13, followed by Adam 1994: 80.
[27] Pensabene 1978; Pensabene 1980; Pensabene 1985; Pensabene *et al.* 1993. A synthesis of subsequent fieldwork at this site is presented in Pensabene and D'Alessio 2006; D'Alessio 2006; D'Alessio 2009. Cf. Coarelli 2012: 249–82, who rejects the stratigraphic sequence as reconstructed by Pensabene.
[28] Pensabene *et al.* 1993: 28–34.

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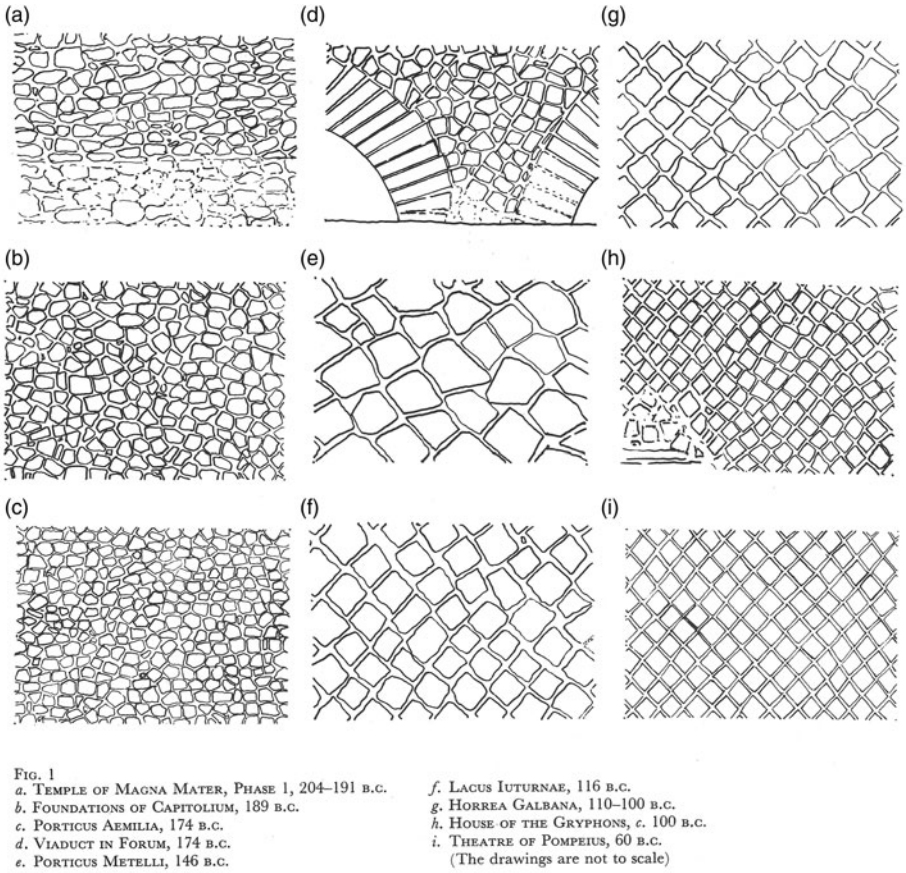


Fig. 1
*a*. Temple of Magna Mater, Phase 1, 204–191 b.c.
*b*. Foundations of Capitolium, 189 b.c.
*c*. Porticus Aemilia, 174 b.c.
*d*. Viaduct in Forum, 174 b.c.
*e*. Porticus Metelli, 146 b.c.
*f*. Lacus Iuturnae, 116 b.c.
*g*. Horrea Galbana, 110–100 b.c.
*h*. House of the Gryphons, *c*. 100 b.c.
*i*. Theatre of Pompeius, 60 b.c.
(The drawings are not to scale)

FIG. 3. The sequence of development of *opus incertum* wall-facing styles in Rome as suggested by Coarelli. Note the alleged high dating of the temple of Magna Mater and of the so-called Porticus Aemilia, and the steady evolutionary trajectory, eventually culminating in the class of *opus reticulatum*. (*After Coarelli 1977: 11, fig. 1; © The British School at Rome; used by permission*)

timber shuttering. The concrete structures, therefore, can be best described as unfaced because the *caementa* were placed by hand within the formworks without a clear distinction between core and faces.[29] In the south-west corner of the podium, however, the concrete mass appears to have been retained by a pre-existing stretch of ashlars whose imprint is clearly visible on the surface of the concrete core, consisting of five courses whose orientation is the same as that of the concrete structures.[30] At the northern end of the podium, where the robbing trench turns sharply to the west, two courses of blocks of Tufo Giallo della Via Tiberina sit perfectly on axis with the other traces. These remains should be assigned to the first phase of the temple.[31] Their alignment differs markedly from that of other ashlar structures detected in the adjacent area, which are securely dated to the Middle Republican period.[32] The raising of the concrete structure, which almost

[29] Pensabene 1980: 71; D'Alessio 2009: 237–8.
[30] A similar building process is attested in the neighbouring site of the temple of Victoria. The ashlar facing of the Middle Republican podium was maintained and reused with the function of permanent shuttering to retain a concrete fill: Pensabene 1991: 14–15, 26–7, figs 13–14.
[31] For a reconstruction of this stage, see Pensabene and D'Alessio 2006: 37–8, figs 4–5.
[32] Pensabene 1980: 67; Pensabene 1981: 104; D'Alessio 2006: 433–4; Pensabene and D'Alessio 2006: 32, fig. 2.

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completely replaced the old ashlar podium, must, therefore, be dated to the second phase of the sanctuary, which historical texts place after 111 B.C.[33]

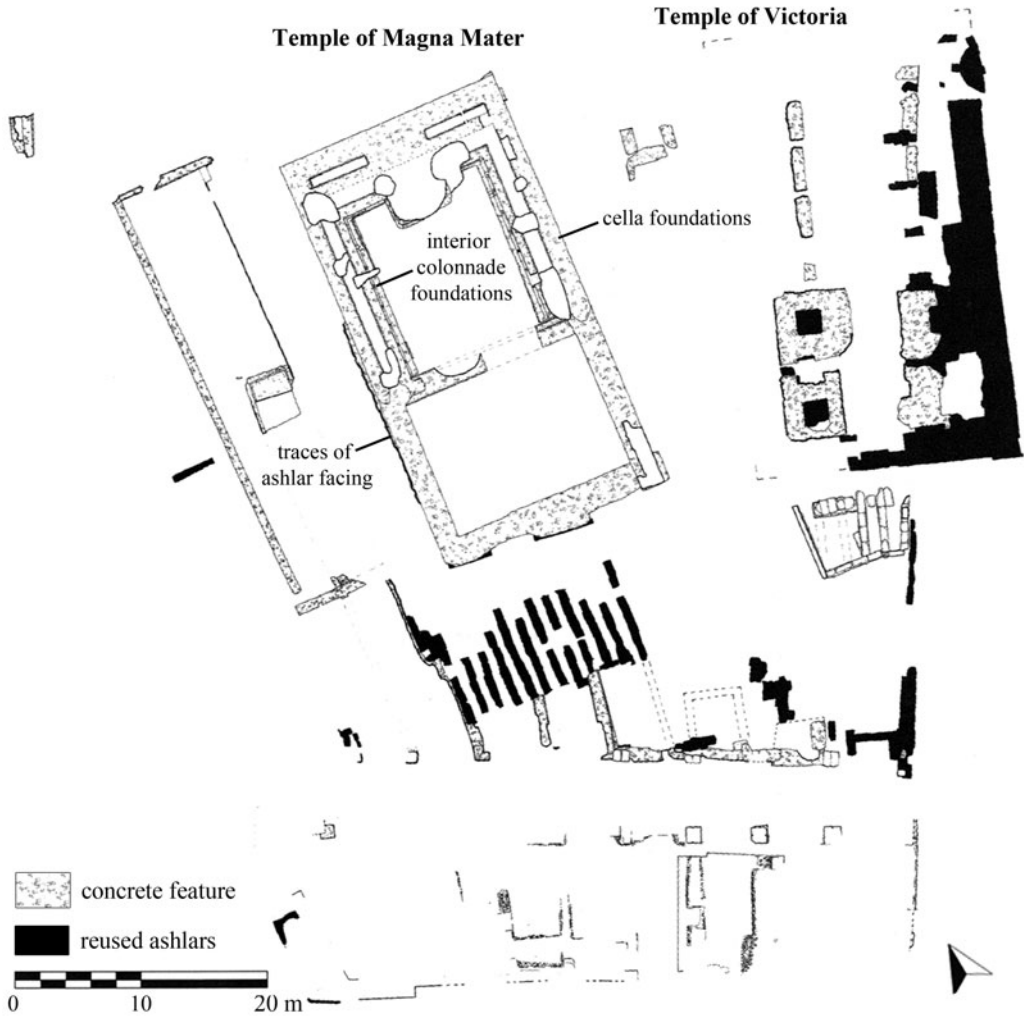


FIG. 4. Composite plan of the sanctuary of Magna Mater showing the architectural remains dating to the late second-century B.C. phase. (*Adapted from D'Alessio 2006: table N; © Quasar; used by permission*)

The substructures of the cella include a concrete wall dividing cella and pronaos, joined to the concrete box, and the foundations of the cella side-walls, abutting both the podium and the dividing wall. The foundations of the side-walls feature a rough *opus reticulatum* on the inner face. Parallel to the latter is another foundation built using timber shuttering on the exterior and a rough *opus reticulatum* facing on the interior. Its function was to support an inner colonnade. The direct stratigraphic relationship with the podium clearly indicates that all the substructures belong to the same phase, and that unfaced concrete was used side-by-side with *opus reticulatum*. The free-standing parts of the

[33] Sources in Pensabene 1996. For the dating of the dedication see also D'Alessio 2009: 234–6.

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cella are also in rough *opus reticulatum*, made with *caementa* of Tufo Rosso a Scorie Nere, and thus are likely to be contemporary with the second phase of the podium.[34] These remains are generally connected with a redecoration of the cella documented by the surviving mosaic floor and architectural ornaments, which can be dated stylistically to the Augustan period.[35] Below the mosaic floor was a uniform construction fill extending down to the bottom of the podium foundations. This layer contained numerous inclusions of building debris, such as fragments of an earlier *cocciopesto* floor and Peperino architectural elements (which are also used as *caementa* in the concrete structures of the podium), as well as a group of Hellenistic terracotta figurines clearly in secondary deposition. This assemblage attests that temple decorations and votives associated with the first occupation of the sanctuary were disposed of in a systematic way, as part of the late second-century B.C. construction activities.

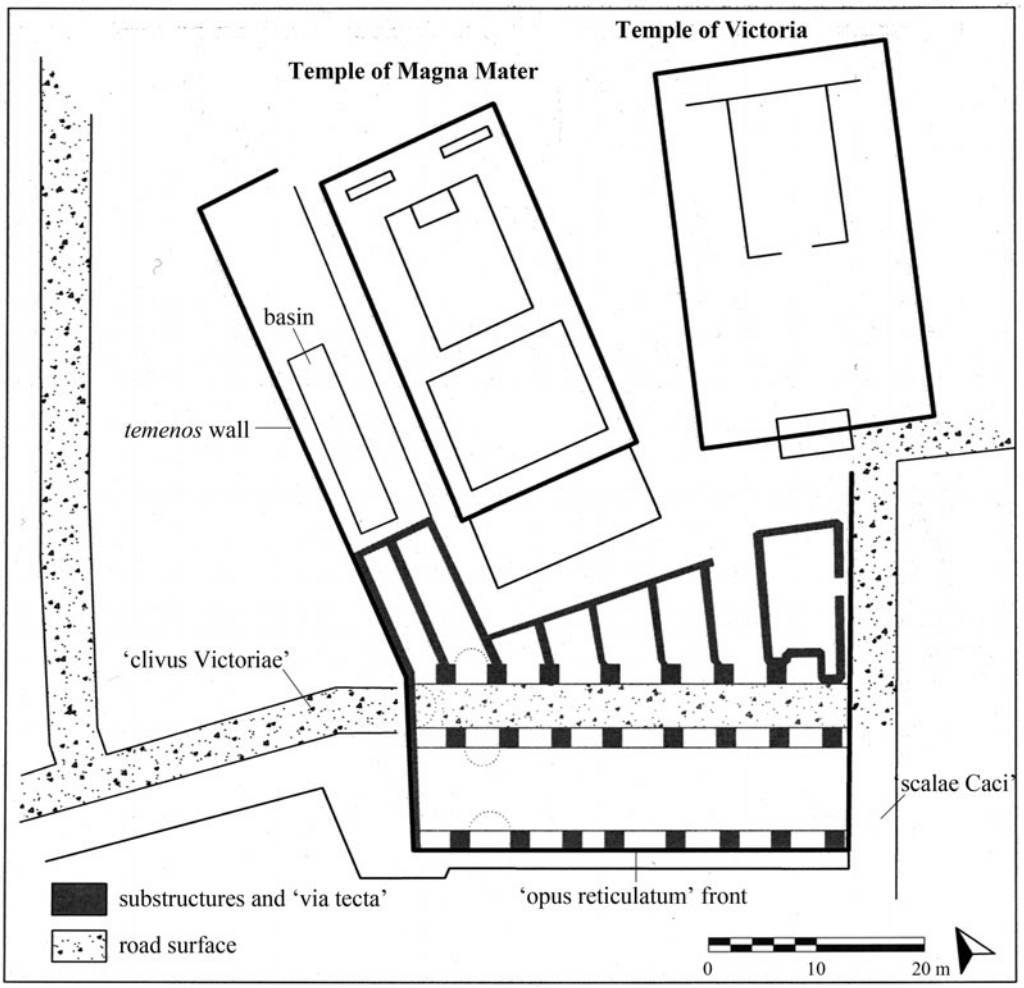


FIG. 5. Restored plan of the sanctuary of Magna Mater in the late second-century B.C. phase. (*Adapted from Pensabene and D'Alessio 2006: 41, fig. 6; © Journal of Roman Archaeology; used by permission of the author*)

[34] As suggested by D'Alessio 2009: 229 n. 7, with bibliography.
[35] Romanelli 1963: 321–30. Pensabene 1978: 69; Pensabene 1980: 71; Pensabene 1985: 182–3.

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A paved terrace extending to the south slope of the Palatine was built in front of the temple at this stage (Fig. 5). This terrace is supported by a series of concrete vaulted rooms and corridors flanking a *via tecta* (the so-called 'clivus Victoriae'). These structures feature ashlar piers connected by arches made of voussoirs of Tufo Lionato (Anio), and spandrels faced with *opus reticulatum*. Farther to the south, the platform rested on a pillared structure supported by a system of vaulted substructures in *opus reticulatum* of Tufo Lionato (Anio), which formed the monumental front of this side of the hill (Fig. 6).[36] Furthermore, a lower terrace delimited by a concrete *temenos* that includes parts in *opus incertum* was created west of the temple podium. An oblong basin lined with hydraulic mortar was added here.[37] The construction fills of the lower terrace contained hundreds of fragments of the same type as those found in the podium fills, providing a link between the building process of the podium and that of the platform in the reconstruction of the sanctuary post-111 B.C.[38] Thus, both *opus incertum* and *opus reticulatum* were used in this phase of the sanctuary, but for different purposes within the structure. A different crew may have worked on the *opus incertum* retaining wall, whose structural function was not as complex in comparison with the terrace front. The important implication, of which most modern building archaeologists are well aware, is that different wall-facing styles do not always represent successive building events, so any periodization based solely on building techniques must be taken with caution.

Next in the canonical sequence of early concrete architecture are two minor monuments that have been singled out on account of morphological similarities with the facing of the Testaccio building (i.e. dimension of the blocks, thickness of the mortar joints, use of small tuff ashlars to face the intrados of concrete vaults). For this reason, the low arches visible behind the Rostra in the Forum Romanum (Fig. 3, d) were linked by both Lugli and Coarelli with the first paving of the Clivus Capitolinus (Livy 41.27.7: 174 B.C.).[39] The viaduct, however, can also be compared with the substructures of the sanctuary of Magna Mater, and could just as well date to the late second century B.C. The other monument is a terracing wall on the east slopes of the Capitoline (via della Consolazione). This incorporates a stretch faced with a slightly less regular *opus incertum* (Fig. 3, b). Lugli's assumption was that the creation of the paved road involved a major reorganization of the Capitoline hill.[40] Coarelli argued for a higher date, identifying the remains with another feature located on the Capitoline, the *substructio super Aequimelium*, the construction of which was recorded by Livy for 188 B.C. (38.28.3).[41] The fact that the *opus incertum* structures appear juxtaposed to stretches in ashlars of Tufo Lionato (Monteverde; Anio seems absent) and Tufo Giallo della Via Tiberina (Grotta Oscura) was seen as a confirmation of the early character of the concrete facing. An alternative interpretation is possible for this stratified architectural sequence, with the *opus incertum* walls post-dating the *opus quadratum*.

[36] D'Alessio 2009: 231–3.
[37] Pensabene *et al.* 1993: 29–30.
[38] For a detailed description of the assemblage see Rossi 2009.
[39] Lugli 1957: vol. 1, 452. Filippi 1997–98: 161–6 emphasizes other Late Republican modifications to the stratigraphy of the road (particularly in the context of the works carried out under L. Opimius in the late 120s B.C.). Van Deman 1922: 14–16 described the same structure as *opus reticulatum*, and connected it with the building of new streets in the western end of the Forum in the Sullan period.
[40] Lugli 1957: vol. 1, 452 n. 2; 467 (174 B.C.).
[41] Coarelli 1977: 13–14.

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FIG. 6. Construction detail of the *opus reticulatum* front of the sanctuary of Magna Mater. (*Adapted from Pensabene and D'Alessio* 2006*: 43, fig. 10; © Journal of Roman Archaeology; used by permission of the author*)

The dating of the *opus incertum* building of Testaccio (Fig. 3, c) is even more problematic. Cozza and Tucci have recently made the case for a different identification of this monument on both epigraphic and typological grounds.[42] This is based on an alternative restoration of the inscription associated with the building represented on the Forma Urbis: [*Nava*]*lia* instead of [*Aemi*]*lia* (which, by the way, would account for the otherwise puzzling absence of the word *porticus* on the slab).[43] Cozza and Tucci's survey of archaeologically attested shipsheds seems to provide close comparanda for the internal organization of the Testaccio building. [44] In fact, the complex bears little in

[42] Cozza and Tucci 2006: 175–202.

[43] This reading was first suggested by von Gerkan 1958: 189, but found little consensus thereafter. Cozza and Tucci 2000 identified a preparatory incision visible on old photographs of the fragments in question with traces of an *a* visible before the *l*. The letter would be visible in a low oblique-light photograph taken before 1960. A recent inspection of the fragments by Arata and Felici 2011 demonstrated that only the letters *ia* are preserved, though this does not necessarily undermine Cozza and Tucci's argument. A response is in Tucci 2012, who incorporates preliminary evidence from recent excavations conducted at the site by the Soprintendenza Speciale per i Beni Archeologici di Roma in collaboration with the Royal Dutch Institute in Rome. These confirmed that in the first phase the Testaccio structure was oriented toward the Emporium and the Tiber to the west: Tucci 2012: figs 2–4. They revealed that in the Imperial period at least parts of the building were altered to install new structures for the storage of foodstuffs, but did not provide evidence of a commercial function for the Republican complex: Contino and D'Alessandro 2014. For a recent review of the problem see D'Alessio 2014.

[44] Hurst 2010: 32–3 believes that the vaulted corridors are too wide for both triremes or quinqueremes, too far from the river bank (90 m) and too high up from the projected river level. The Tiber levels, however, rise and fall

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common with other known late Republican porticus.[45] With regard to the local topography, if the Testaccio building is to be identified with shipsheds attached to the Emporium, the Porticus Aemilia is more likely to be found in a location closer to the Porta Trigemina and the Forum Boarium area — the term *porticus* referring to a covered passageway rather than to a utilitarian building.[46]

The main implication of the new identification is that the Testaccio building does not date the *opus incertum*; at best, the opposite is true. Cozza and Tucci, therefore, emphasized the advanced typological features of the facing, which in their view would correspond with a date in the second half or the late decades of the second century B.C.[47] Textual evidence for a secure dating of the Navalia is scanty. Cicero (*De or.* 1.14.62) connects an *opus navale* with the work of a Greek architect named Hermodorus of Salamis, presumably the same Hermodorus known to have built the first marble temple in Rome, the temple of Iuppiter Stator (Vitruvius 3.2.5).[48] The attribution remains uncertain because other Navalia are attested by ancient sources in the Campus Martius,[49] but if it were correct, a significantly lower date would have to be assigned to the monument, perhaps not earlier than 110 B.C.[50]

With the so-called Porticus Aemilia out of the picture, the earliest surviving archaeological example of concrete architecture in Coarelli's canon is the Porticus Metelli. This monument was famous in antiquity because it included a number of architectural innovations (Velleius 1.11.3–4; 2.1.2; Pliny the Elder 34.31; 34.64; Vitruvius 3.2.5). It was the first porticus of the peristyle type (or quadriporticus), and its main function was to provide a formal columnar framework for the display of statues. The Imperial version of the monument was known as Porticus Octaviae.[51] This is represented on the Forma Urbis as a *temenos* featuring a single colonnade on the short sides to the north and south (the latter incorporates a hexastyle propylon), and a double colonnade on the long sides to the east and west. The plan of the Republican building did not differ much from that of the Augustan phase (Online Fig. 1). The earlier porticus was associated with the marble temple of Iuppiter Stator, which stood at its centre, adjacent to the pre-existing temple of Iuno Regina. This association provides a date of 143–131 B.C. for the letting of the contract.[52] The exact relationship between the foundations of the temple and the floor level of the courtyard is not known in any detail, but the erection of the temple probably started before that of the precinct surrounding the sacred area, since moving heavy building material in and out of a raised enclosure would not have been logistically feasible. Thus, a construction date in the 130s B.C. is the most likely.

considerably during the seasons: Aldrete 2007: table A1. Blackman 2008: 30 identifies a category of wider shipsheds with a clear width of 7–8 m. The Testaccio building has been taken as a parallel for an oblong structure recently investigated at Portus, which is divided by lines of piers into bays, for which Keay *et al.* 2012 suggest a possible function as military or commercial shipsheds rather than warehouses.

[45] cf. Nünnerich-Asmus 1994: 25–54. The new identification has been accepted by, among others, Coarelli 2007, Steinby 2012a: 50–1, and Jackson and Kosso 2013: 280.

[46] Cozza and Tucci 2006: 176–80. On the interpretation of the Porticus Aemilia as a colonnaded connector see also Richardson 1976; Tuck 2000.

[47] Cozza and Tucci 2006: 194. Cf. Coarelli 2007: 42–3, still arguing for a date in the middle of the second century B.C.

[48] On the career of Hermodorus of Salamis see in particular: Gros 1973; Gros 1976 (with a high date of 175–150 B.C. for his formative years).

[49] e.g. Livy 45.42.12 (167 B.C.); 3.26.8. Servius, *ad Aen.* 11.326.

[50] Reference to the low dating of the *opus navale* is in Morgan 1971: 499–504.

[51] Fragments 31bb, 31cc, 31dd, 31u and 31vaa. Literary sources on the monument are collected in Viscogliosi 1999a.

[52] Morgan 1971: 500.

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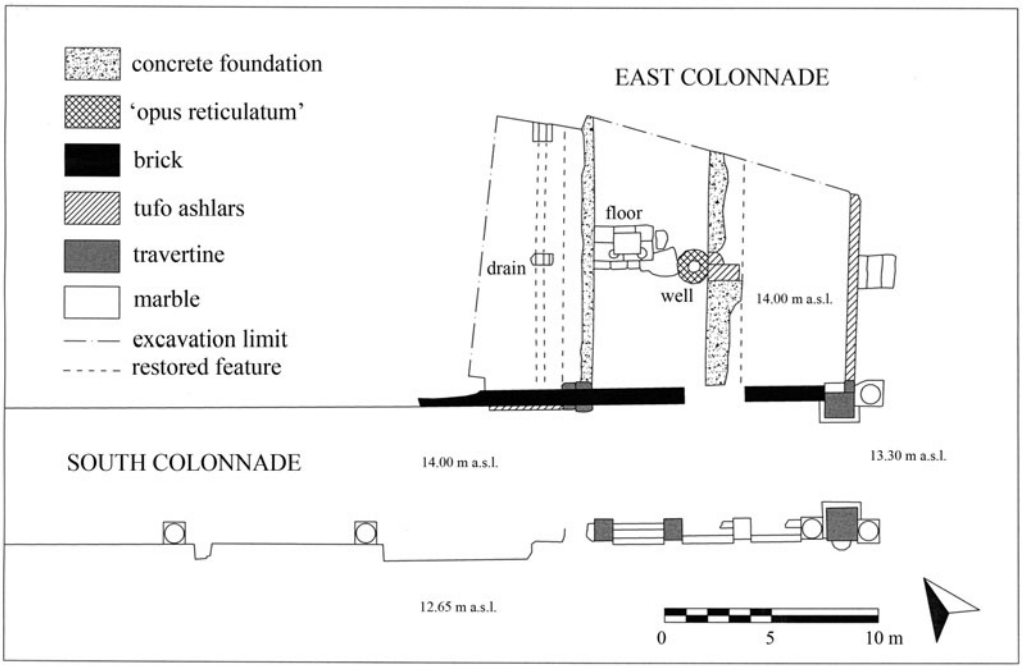


FIG. 7. Plan of the south-east corner of the Porticus Metelli. (*Lauter 1980–81: 40, fig. 1; © L'Erma di Bretschneider; used by permission*)

Parts of the south side were investigated first by Colini in 1950.[53] Excavations by the Soprintendenza Speciale per i Beni Archeologici di Roma were then carried out in the 1980s and 1990s in the north side, the north-west corner, and in the monumental entrance to the south.[54] The south colonnade of the quadriporticus rests on a stylobate formed by two parallel structures retaining a construction fill (Fig. 7). The external retaining wall is a thick concrete foundation with *caementa* of Tufo Giallo della Via Tiberina faced with stretchers of Tufo Lionato (Monteverde) ashlars (the top course of Peperino headers belongs to the Augustan reconstruction).[55] The internal retaining wall is of *opus incertum* made with facing blocks of Tufo Lionato (Monteverde).[56] The projecting propylon at the centre of the south side seems to have been added only in the Imperial period: the external retaining wall continues behind it, and is flanked to the south by a drain.[57] The original entrance was probably marked by columns of bigger module incorporated in the exterior colonnade.[58] Interruptions in the ashlar facing indicate the presence of other staircases.[59] Both the south-east and the north-west corners of the porticus feature two parallel concrete foundations built with the same technique (Figs 7–8). These structures confirm the presence of a double colonnade on the long sides.[60]

[53] Cressedi 1954; Lugli 1957: vol. 1, 409, 412. A reappraisal of the old documentation is in Lauter 1980–81.
[54] Giustini 1990; Ciancio Rossetto 1995; Ciancio Rossetto 1996; Ciancio Rossetto 2009.
[55] Ciancio Rossetto 1995: 96–8; Lauter 1980–81: 39–40.
[56] Lugli 1957: vol. 1, 409.
[57] Ciancio Rossetto 1996: 270, fig. 4.
[58] Ciancio Rossetto 2009: 65.
[59] Lauter 1980–81: 42 (cross–section C–C'; the features are interpreted as exedrae).
[60] Giustini 1990: 71; 72, fig. 15.

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FIG. 8. North-west corner of the Porticus Metelli. The white arrows indicate the *opus incertum* foundation of the stylobate. (*Giustini 1990: 73, fig. 17; © Istituto Poligrafico e Zecca dello Stato; used by permission*)

In sum, the system employed to raise up the quadriporticus is clearly that of the concrete box lined with *opus quadratum*, which has been described for the temple of Magna Mater. The continued development of this building type is attested throughout the last third of the second century B.C., particularly for temple podia. Well-known examples are the temple of Veiovis (third quarter of the second century B.C.),[61] the temple at S. Salvatore in Campo (post-132 B.C.),[62] the temple of Concord (121 B.C.),[63] and the temple of Castor and Pollux (post-117 B.C.).[64]

The last few decades of archaeological research have failed to produce conclusive evidence of earlier concrete-based public architecture in the monumental core of Rome. A series of concrete vaulted structures are located on the east slopes of the Palatine (between the sites of Vigna Barberini and the Domus Flavia; Fig. 9). The barrel vaults feature an intrados faced with medium-sized oblong rectangular blocks of Tufo Giallo della Via Tiberina laid radially. The walls are made with *opus incertum* of quite regularized facing blocks of Tufo Lionato (Anio) of various sizes, recalling the technique

[61] Colini 1942: 26. The first phase of the temple dates to the early second century B.C., but does not feature concrete.
[62] Tortorici 1988.
[63] Hafner 1984.
[64] Nielsen 1992.

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of the Testaccio building and of other contexts in Latium that can be generically dated to the second half of the second century (Praeneste, Via degli Arcioni; lower terrace of the Forum of Cora) or early first century B.C. (the extra-urban sanctuary at Tusculum).[65] The monument has been interpreted as a temple platform, though no traces of the supposed temple building are associated with it. Anselmino has proposed a date as early as 150 B.C. for the complex, assuming that a group of terracotta sculptures found in secondary deposition farther downslope during old excavations formed part of its original decoration.[66]

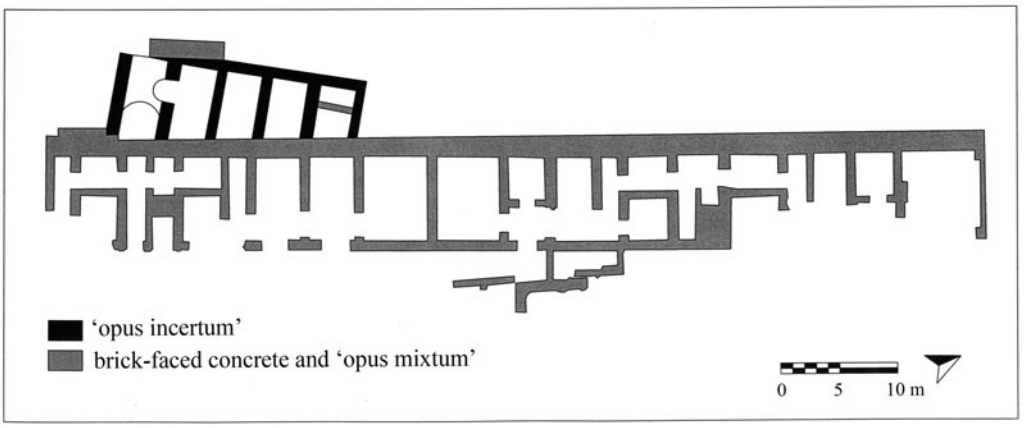


FIG. 9. Schematic plan of the *opus incertum* substructures located on the north-east slopes of the Palatine. (*Adapted from Anselmino 2006: 231, fig. 8; © Quasar; used by permission*)

A possibly safer case can be made for some small-scale concrete features in the temple of Castor and Pollux. Concrete fills were poured for minor repairs of the ashlar foundations of the front part of the podium (Fig. 10). This had been radically modified in the middle of the second century B.C., dismantling several courses in order to accommodate a lower step in the platform (perhaps a tribunal),[67] most likely causing structural damage over time. More of the old Cappellaccio blocks were thus removed at a later stage, only to be recycled as rubble in the concrete cores. Steinby has proposed to contextualize these modifications within a broader building programme affecting the east side of the Forum Romanum (Online Fig. 2). This programme would have included, in rough chronological order, the creation of a ramp along the western boundary of the sanctuary of Vesta, the monumentalization of the Lacus Iuturnae, the recasting of the temple of Castor and Pollux, and the erection of a stoa, portico or basilica incorporating the Lacus, a series of works which in her view should be attributed to the censorship of L. Aemilius Paullus (164 B.C.).[68]

[65] Anselmino 2006: 233–4. On the vaulting technique see D'Alessio 2014, 18–22.
[66] Alternative hypotheses have been advanced to reconstruct the relative position of surviving elements in the pedimental group, iconography, meaning of the scene and identity of the main deity. The pediment has been connected with various temples known to have been located either on the Palatine or on the Caelian (Mars, Venus, Victoria, Fortuna Respiciens), influencing to a great degree the dating of the sculptural piece (ranging from as early as the third century to as late as the first half of the first century B.C.): Anselmino *et al.* 1990–91, with further reference.
[67] Phase IA: Nielsen and Poulsen 1992b.
[68] The argument is in Steinby 1985; Steinby 1987; Steinby 1988; Steinby 1993. More recently: Steinby 2011; Steinby 2012a: 61; Steinby 2012b: 34–70.

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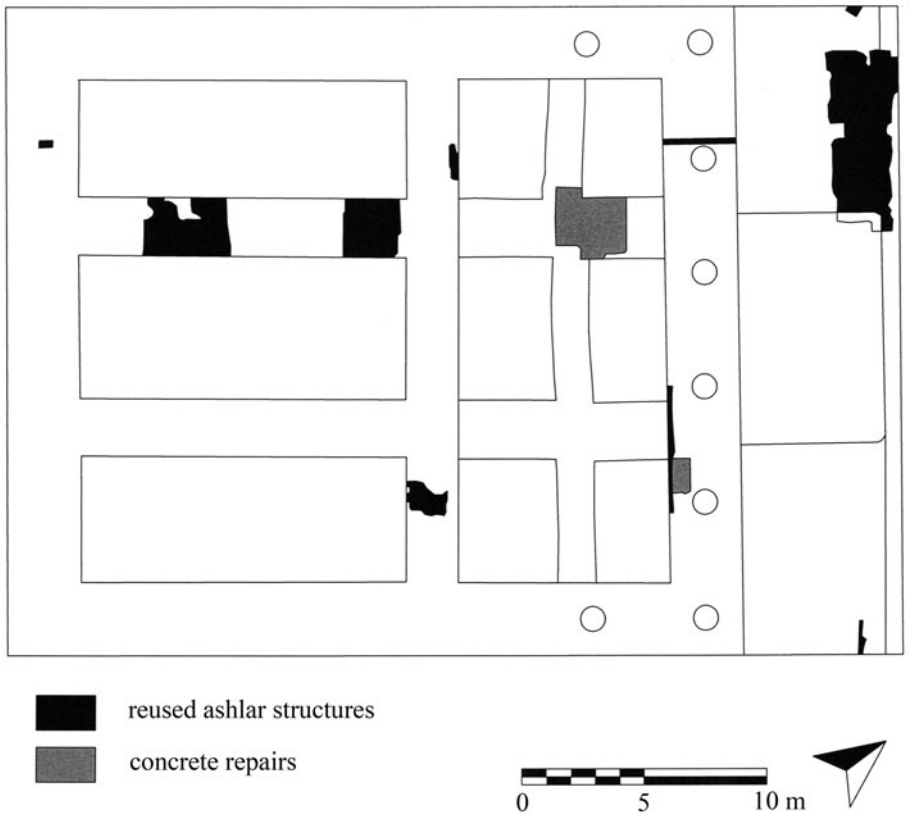


FIG. 10. Restored plan of Phase IA of the temple of Castor and Pollux, with indication of the actual remains. (*Adapted after Nielsen and Poulsen 1992b: 83, fig. 61; © De Luca; used by permission*)

Steinby's identification and dating of these monuments is mostly based on textual evidence.[69] Following Coarelli's chronology, she takes the occurrence of *opus incertum* in both the ramp and the basin as confirmation of a date in the early second century B.C.[70] The ramp, supported by a row of parallel rooms covered with barrel vaults, was built to span the drop in elevation from the Via Sacra to the Via Nova. The function of this ramp, commonly referred to as the *scalae Graecae* or *scalae Anulariae*, was to serve as a public route to reach the site of the Porta Romanula on the north-western corner of the Palatine without having to pass through the Forum.[71] The structure, which can be compared with the viaduct of the Clivus Capitolinus on the opposite side of the Forum, formed an integral part of the Atrium Vestae. Most likely, therefore, it was built in connection with the first phase of the latter complex in which there was a widespread

[69] The connection between Aemilius Paullus and the monumentalization of the Lacus Iuturnae is inferred from a passage of Minucius Felix (*Oct.* 7.3) claiming that the Dioscuri appeared to announce Paullus' victory at Pydna, in the same spot where statues of them were then consecrated. Fragments of these statues were found in old excavations in the area: Boni 1901: 88–92, figs 42–4. A different identification is proposed for the Basilica Aemilia, which Steinby distinguishes from the Fulvia, located on the northern side of the Forum: sources in Steinby 1987: 172–6.

[70] e.g. Steinby 1987: 168 and n. 122: 'La tecnica di costruzione, opera incerta ed opera quadrata, permette senza difficoltà una datazione subito dopo l'a. 168 a.C.' (referring to the first phase of the Lacus Iuturnae).

[71] Hurst 2006.

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use of concrete. Recent stratigraphic excavations in the sanctuary of Vesta date this phase to around 100 B.C.[72]

Three concrete phases have been identified in the Lacus Iuturnae on the basis of facing styles and stratigraphic relations (Fig. 11). The earliest structures consist of *opus incertum* and *opus quadratum* (Fig. 11, a; Fig. 12). The second phase features unfaced concrete and *opus quadratum* (Fig. 11, b; Fig. 12). The third phase is represented by *opus reticulatum* modifications (Fig. 11, c). The absolute dating is uncertain but the level of Phase 2 can be linked with a generalized reorganization of the Forum pavement, a building episode that has been dated to 78–74 B.C.[73] The new pavement required a raising of the basin rim, so a *terminus ante quem* for the *opus incertum* phase of the fountain can be established. The original construction of the Lacus Iuturnae could just as well be connected with other activities involving the temple of Castor and Pollux in the post-117 B.C. period.[74]

Two roughly parallel concrete foundations of considerable thickness run north of the basin, truncating part of the wall delimiting the concrete ramp to the north (Online Fig. 3, structures a and b). Remains of a floor preserved at approximately the same level as the Sullan pavement of the Forum are associated with these structures.[75] A third foundation with square buttresses (Online Fig. 3, structure c), not perfectly aligned and perhaps later than the other two, was found razed in test-trenches excavated along the eastern side of the temple of Castor and Pollux.[76] The identification of these structures, which overall seem to post-date the original Lacus, remains problematic.[77]

## IV REDATING ROME'S CONCRETE ARCHITECTURE: THE HOUSES

What is also emerging very clearly with the progress of stratigraphic investigations in the deeper levels of Rome is that the Middle Republican period witnessed limited developments in élite domestic architecture. An intensive phase of house construction has been documented for the sixth century B.C, when new types of aristocratic residences with expensive architecture surfaced both in the urban core and in the *suburbium*.[78] These buildings were carefully maintained for centuries with little structural modification other than the periodic reconstruction of floor levels in the fourth and third century B.C.[79]

[72] Arvanitis *et al.* 2010: 54–9. Second-century B.C. construction activities are exclusively represented by structures in *opus quadratum* of Tufo Giallo della Via Tiberina: ibid., 48–51. Cf. Scott 2009: 18–24; 28–9, tentatively dating some of the party-walls in the house of the Vestals and the concrete foundations of the round temple between the late third and the middle of the second century B.C.

[73] Giuliani and Verduchi 1987: 55–66. Nielsen 1992: 112 reconstructs a floor surface on the eastern side of the podium of the temple of Castor and Pollux at 13.10 m a.s.l. The elevation of the crepidoma of the Metellan temple is 13.40 m a.s.l. The raised rim of the basin sits between 13.37 (Steinby 1985: 77) and 13.44 m a.s.l., so Steinby 2012b: 54–6, connects Phase 2 of the Lacus Iuturnae with the post-117 B.C. reconstruction of the temple. From her perspective, Phase 3 would date to the first half of the first century B.C. or later.

[74] Coins of A. Albinus depicting statues of the Dioscuri on horses near a well-head, minted in 96 B.C., could refer to the dedication of the group (and perhaps even to the reconstruction of the Lacus) by the Postumii, a family that was indeed connected with the original dedication of the temple of Castor and Pollux: Palmer 1990.

[75] Steinby 1985: 81–2; Steinby 2012b: 60–70.

[76] Steinby 1988: 32–3, fig. 1. Carnabuci 1991: 280–7 considers it implausible that the three foundations formed part of a single building.

[77] Steinby's identification with the Basilica Aemilia has not found a consensus: Ertel and Freyberger 2007: 110–17; Freyberger *et al.* 2007. Cullhed *et al.* 2008 interpret the buttressed foundation as a retaining wall (perhaps connected with the raising of the levels in the area of the Lacus), rejecting the idea that this supported a colonnade. Carnabuci 1991, loc. cit., sees the structures as part of a ramp connecting the Forum with the Palatine.

[78] Carandini and Carafa 1995; Carandini *et al.* 2007.

[79] Torelli and Marcattili 2010: 44–6 show that the style of architectural decorations and mouldings remained anchored to Archaic conventions for most of the third century B.C.

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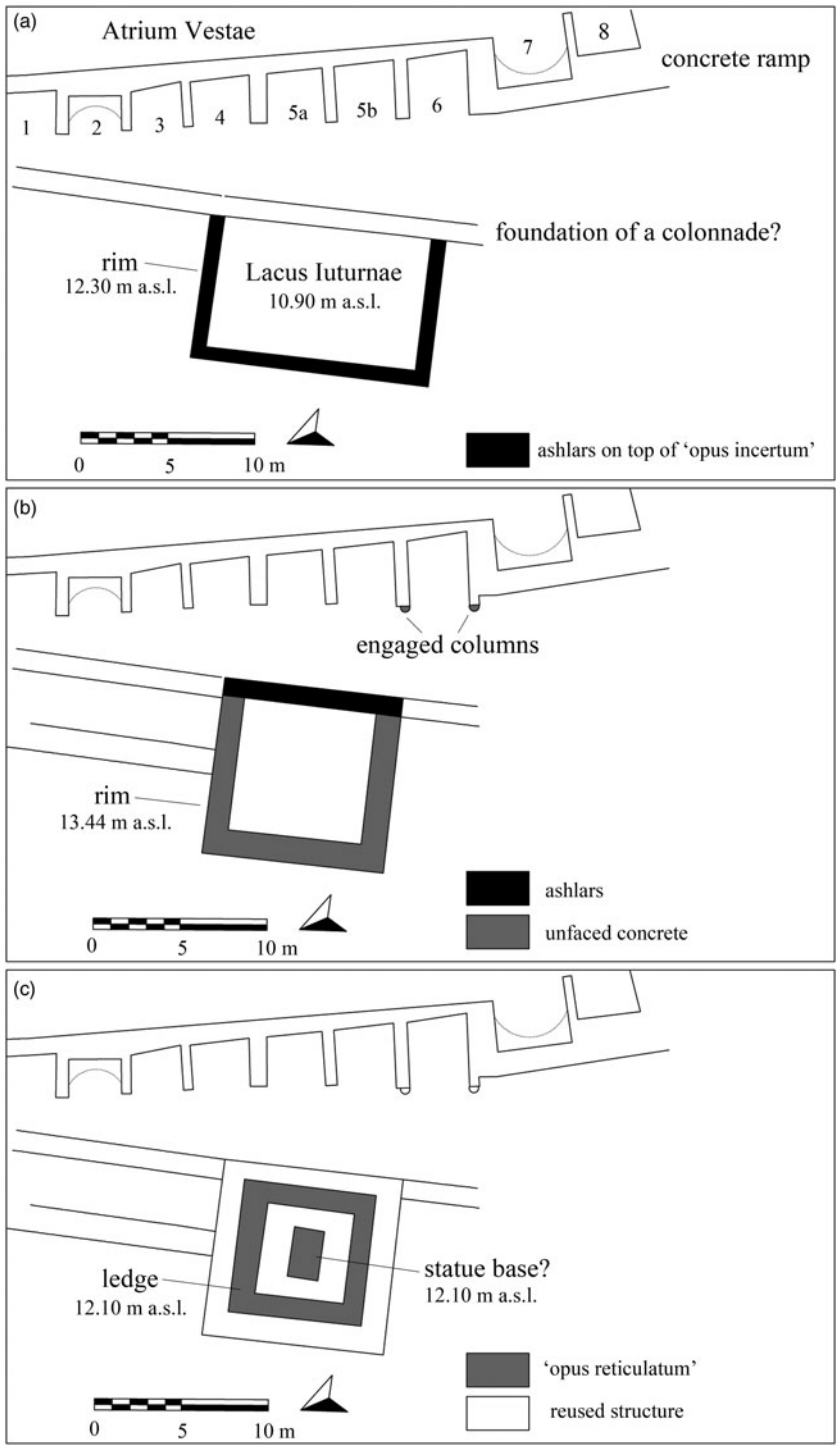


FIG. 11. Simplified map showing the relationship between the concrete ramp and the three main phases of the Lacus Iuturnae (a: end of second century B.C.; b: mid-first century B.C.; c: Augustan period). Plan and room numbers based on Steinby *1985*: 79, fig. 2.

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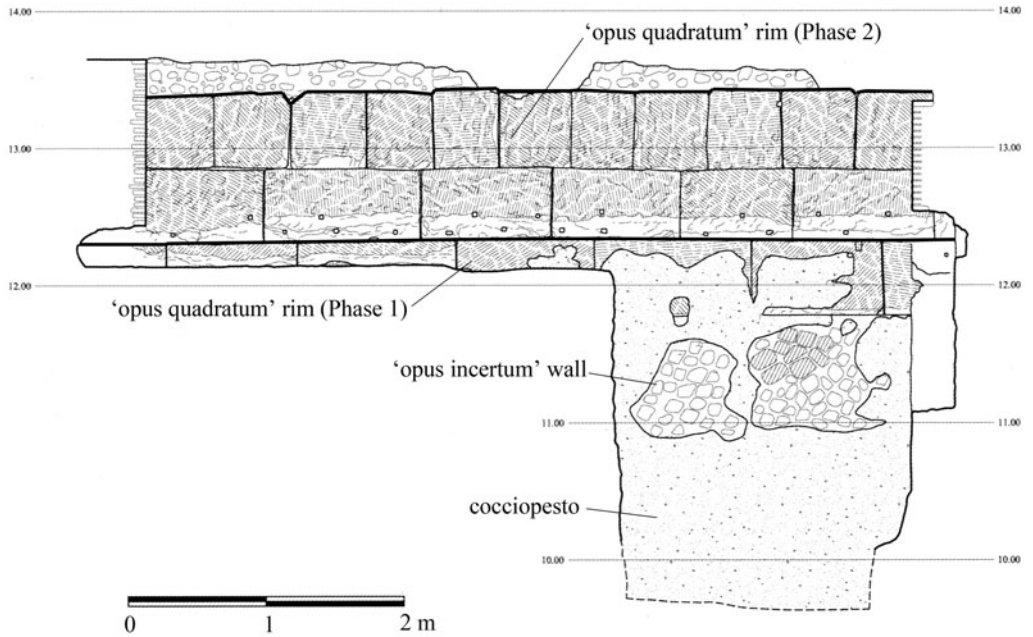


FIG. 12. Elevation drawing of the east side of the Lacus Iuturnae basin showing the superimposed remains of Phases 1 and 2. (*Steinby 2012b: 52, fig. 16; © Quasar; used by permission*)

Another peak of activity is attested in the first century B.C. There is a great deal of information about the urban development of the Palatine hill. A series of literary accounts vividly portrays the phenomenon of élite competition for real estate property in this area of the city throughout the Late Republican period.[80] At least twenty-three domestic contexts are known archaeologically, all featuring a phase in *opus reticulatum* dating to the early or middle part of that century.[81] Both here and in other areas of Rome, however, the record for the second century B.C. is much less consistent.[82]

*Opus incertum* architecture has been securely identified only at a handful of sites (Fig. 13; Table 3), whose dating is difficult due to the lack of contextual finds.[83] As already mentioned, a deeply rooted opinion is that the implementation of Roman concrete originated from a slow process of trial-and-error, of which only the later phases of development would be archaeologically visible.[84] This common view is based on the assumption that no trace of early mortars could possibly be preserved in the

[80] An early survey is in Patterson 1992: 200–4. Royo 1999: 72–5 lists twenty-eight house plots known to have been the object of successive transactions (including inheritance, confiscation, sale or rental) between 200/150 and 36 B.C. See also Guilhembet and Royo 2008: 196–209.

[81] For the quantification see Papi 1998: 50–2; Carandini *et al.* 2010: 78–225; Coarelli 2012: 112–26, 287–346.

[82] e.g. Andrews 2014.

[83] The evidence is collected in Morricone Matini 1967; Morricone Matini 1971; Morricone 1980. A few other contexts known from early excavations do not appear in these corpora, either because no mosaics or decorated floors were found or because, in spite of the association with possible *opus incertum* walls, the pavements were considered to be much later in date. For a complete survey of the evidence see Mogetta 2013: 59–83.

[84] e.g. Ward-Perkins 1981: 98: 'Such slow, empirical advances are in the nature of things hard to document. *It is the successes that survive, the failures that are swept away*.' See also Adam 1994: 73: 'In reality, the only buildings with concrete masonry […] that have survived above ground in a good condition are those that were constructed with great care, using a high quality lime […] *It is not possible to discuss the innumerable inferior buildings since those remaining in the open air have disappeared due to their vulnerability*.' (Emphasis mine).

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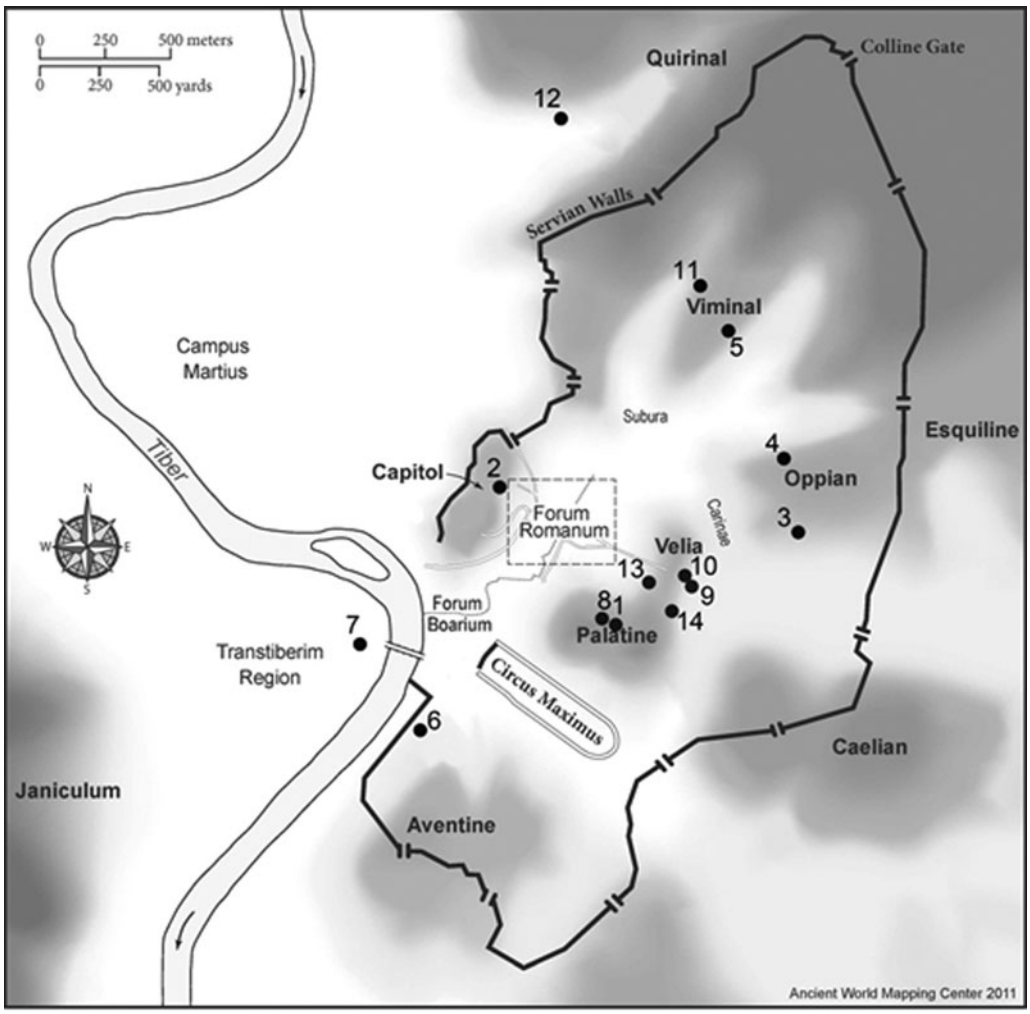


FIG. 13. Schematic map of Rome showing the location of Late Republican concrete houses (1. Casa dei Grifi; 2. Temple of Veiovis site; 3. Domus Aurea site; 4. S. Pietro in Vincoli; 5. S. Pudenziana; 6. S. Sabina; 7. S. Cecilia; 8. Aula Isiaca; 9. Temple of Venus and Rome site; 10. Via dell'Impero; 11. Via Palermo; 12. Via Sistina; 13. North slopes of the Palatine; 14. North-east slopes of the Palatine). (*Base map: Ancient World Mapping Center © 2014 (awmc.unc.edu); used by permission*)

archaeological record of Rome because of the weak properties possessed by the binding materials allegedly used during the experimentation phase (whether clay, simple lime or mixes of lime and sand). The body of Archaic architecture made of perishable materials that is emerging from the early layers of Rome is more than enough to undermine this idea. The scarcity of *opus incertum* structures has also led some to believe that there was a distaste for the unrefined aspect of this masonry style, whose origins were thought to lie in the rural context, and that the development of *opus reticulatum*, which is typically described as more aesthetically pleasing, determined radical reconstructions of earlier concrete buildings.[85] The problem, of course, is that the unrefined character of

[85] Blake 1947: 249–51. Lugli 1957: vol. 1, 487 links the transition from *opus incertum* to *opus reticulatum* with the growing demand by élites for more aesthetically pleasing structures in their urban mansions.

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TABLE 3 Late Second and Early First Century B.C. Domestic Concrete Architecture in Rome (OQ = *opus quadratum*; OI = *opus incertum*; OR = *opus reticulatum*)

| SITE | BUILDING TECHNIQUES | WALL-PAINTINGS | FLOOR TYPES | OTHER DATING EVIDENCE |
|---|---|---|---|---|
| *Casa dei Grifi* | OQ; OR | Second Style | Decorated *cocciopesto* on first level; mosaics in basement | After 111 B.C. |
| *Temple of Veiovis* | OQ; OI | n/a | Decorated *cocciopesto* mosaics | Before 83 B.C. |
| *Domus Aurea* | OI(?); OR | First Style | Decorated *cocciopesto* | n/a |
| *S. Pietro in Vincoli* | OQ; OI(?); OR | n/a | Undecorated *cocciopesto*; mosaics (second phase) | n/a |
| *S. Pudenziana* | OI | n/a | Decorated *cocciopesto* | n/a |
| *S. Sabina* | OI(?) | n/a | Decorated *cocciopesto* | n/a |
| *S. Cecilia* | OQ; OR | n/a | Decorated *cocciopesto* | n/a |
| *Aula Isiaca* | OI; OR; unfaced concrete | Second Style | n/a | After 111 B.C. |
| *Temple of Venus and Rome* | Unfaced concrete | Second Style | Mosaics (glass) | n/a |
| *Via dell'Impero* | OI | n/a | Undecorated *cocciopesto* | n/a |
| *Via Palermo* | OI | n/a | n/a | n/a |
| *Via Sistina* | OI | Second Style (?) | Mosaics | n/a |

the masonry would have been masked by the thick layer of plaster that usually covered the walls. If we look to the much larger sample of aristocratic residences from the *suburbium*, we see that *opus quadratum* remained the predominant building technique well into the second century B.C. (Online Fig. 4; Table 4).[86] Medium-sized farms of the Middle Republican period typically show substantial renovation phases only in the middle to late first century B.C., with extensive additions in *opus reticulatum* transforming their plans quite radically. Larger rural residences, which were often created in the Early Republican period, feature only minor additions, whether in *opus incertum* or *opus reticulatum*. Evidence of clay-based or simple lime-based mortared rubble is virtually absent, even in small farms. When continuity of occupation through the Late Republican period is attested, concrete structures make a significant appearance only in the first century B.C.[87]

[86] Sources in De Franceschini 2005; Jolivet *et al.* 2009. See also Volpe 2012.
[87] Mogetta 2013: 102–15.

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TABLE 4 Distribution of Building Techniques in Rural Sites of the *Suburbium* of Rome (Fifth to First Century B.C.)

| BUILDING TECHNIQUE | NUMBER OF FARMS AND/OR VILLAS |
|---|---|
| *Opus quadratum* only (fifth to third century B.C.) | 8 |
| *Opus quadratum* only (second century B.C. or later) | 4 |
| *Opus quadratum* and *opus incertum* in the same building phase | 3 |
| *Opus incertum* with previous phase in *opus quadratum* | 6 |
| *Opus incertum* only | 17 |
| *Opus reticulatum* with previous phase in *opus quadratum* | 24 |
| *Opus reticulatum* only | 29 |
| Concrete foundations only | 3 |
| TOTAL | 94 |

While in many ways confirming the extent and impact of similar architectural developments in élite urban housing of the first century B.C., the recently published results of a large-scale research project carried out between 1985 and 1990 by Carandini and his team on the north slopes of the Palatine provide a detailed picture of building practice in the preceding period.[88] Stratigraphic excavations were conducted in the block delimited by the Via Sacra to the north, the so-called Clivus Palatinus to the east, and an east–west road leading from the Clivus Palatinus to the so-called Scalae Graecae (by some identified with the Nova Via mentioned in historical texts).[89] This insula (Fig. 14) contains a series of concrete foundations associated with *opus incertum* and *opus quadratum* walls built on top of decapitated *opus quadratum* remains dating to the Archaic, Early and Middle Republican periods.[90] *Opus reticulatum* structures are also attested, documenting the redevelopment of the block in the first century B.C. Although late features hamper the overall legibility of its internal organization, the excavators identified four houses with access from the Via Sacra and the Clivus Palatinus (labelled Houses 5–8). The best preserved case for a plan can be made for House 7, a complex that can confidently be said to have had two atria separated by an axial *tablinum*. The internal organization centred on two atria, with the bigger one being without a cistern, finds a comparison in late second-century B.C. examples such as the Casa del Criptoportico at Vulci.[91]

The construction process started with the systematic demolition of the Archaic houses. These were razed to a uniform level across the new block; a sequence of construction fills was dumped to regularize the undulating topography. Trenches up to a few metres deep were then dug through these deposits for the concrete foundations, with no evidence of shuttering being used.[92] When new foundations for load-bearing structures had to be built on the same alignment as previous walls, the latter were usually demolished down

[88] Carandini and Papi 1999.
[89] cf. Carandini *et al.* 2010: 98 and 102, fig. 43 (the road in question is interpreted as a *vicus*, while the toponym *Nova Via* is connected with a minor alley between the Atrium Vestae and the Lucus Vestae). For other identifications see Hurst and Cirone 2003: 23, fig. 4.
[90] For the early remains see Carandini and Carafa 1995 (Phase 9 Att. 23, Houses 1–4).
[91] As suggested by Gualandi and Papi 1999a: 42 n. 118.
[92] Gualandi and Papi 1999a: 41.

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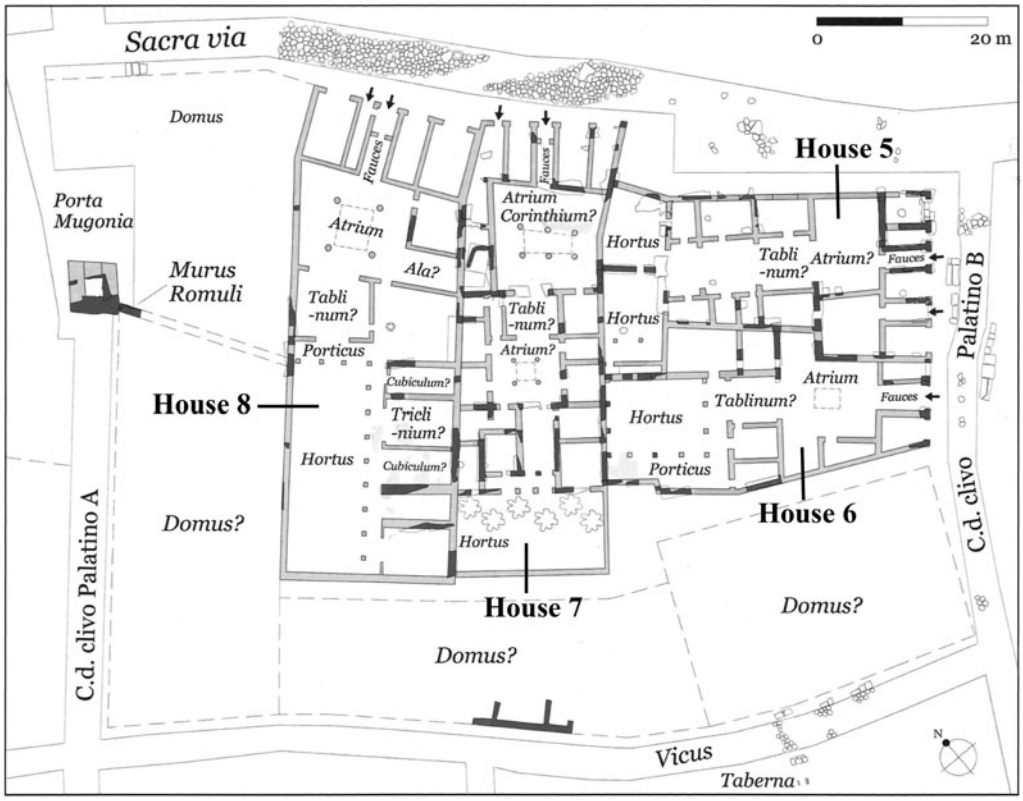


FIG. 14. Map of the city-block excavated by A. Carandini on the north slope of the Palatine, showing the hypothesized property divisions. The actual remains are indicated with solid line. (*Adapted from Carandini et al. 2010: 102, fig. 43; drawing by Daniela Bruno; used by permission of the author*)

to a deeper level, suggesting that the use of concrete was deemed structurally superior. Provenance of the *caementa* indicates that the rubble was most likely obtained from the destruction of the Archaic structures (these were in fact built with ashlars of Cappellaccio; Tufo Giallo della Via Tiberina had been employed in fourth century B.C. restorations).[93] When Cappellaccio aggregates are predominant, it is always in combination with a mortar of poorer quality, which, however, normally contains pozzolana. On the other hand, Tufo Giallo della Via Tiberina *caementa* occurs in greater quantity with mortars of improved composition. Likewise, aggregates of Tufo Lionato, a material which was extensively exploited for cut-stone construction of the Republican period, are far less frequent. They increase noticeably when used in combination with a type of mortar of better quality that occurs only in foundations located along the irregular boundary between Houses 5 and 6, as well as in structures that can be more securely assigned to the first century B.C. (these foundations, therefore, could represent later modifications). Similarly in House 8, the boundary walls have foundations built with the Cappellaccio-based concrete, but the series of small rooms adjacent to the eastern limit feature the better type of mortar, suggesting that there were changes in the internal organization of the house at a later stage.

[93] Scientific evidence in Misiani 1999.

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*Opus quadratum* was extensively used in combination with the concrete foundations for exterior façades and internal walls. In House 8, the walls of the *tabernae* on the Via Sacra, the west boundary wall, and at least one of the internal subdivisions have free-standing parts in Tufo Lionato ashlars. Both Tufo Lionato and Cappellaccio blocks were used for load-bearing walls in House 6 (on the west and south-west sides), while earlier Cappellaccio walls were maintained for internal subdivision in the front and back of the house. The party-wall separating House 5 from House 6 is made of Tufo Giallo della Via Tiberina ashlars, further suggesting that this part of the house was built in quite a different fashion, perhaps at a later stage. In House 7, ashlars were used for internal subdivision on the north-western side of the larger court, and negative impressions of blocks have been detected on the top surface of the foundation that separates the central part of the house from the *tabernae*. The evidence, therefore, suggests that there was a selective use of concrete. The new building medium seems to have been developed in order to provide a rapid and economical way of building solid foundations for the new houses, making extensive use of recycled building materials, as can also be observed in the case of the temple podia discussed in the previous section. Its use for free-standing walls is poorly documented, due to the levelling of the city-block in the subsequent phase, but some of the foundations may have supported concrete walls.

The dating of these concrete structures is difficult. Unfortunately, the construction of semi-subterranean quarters in the middle of the first century B.C. caused the almost complete destruction of the stratigraphy that was originally associated with the early concrete buildings.[94] Floor levels are preserved only in one of the houses, House 8 (Fig. 15), which seems to come later in the sequence of occupation of the block. This building features decorated *cocciopesto* floors of a type that is attested in the second phase of the houses of Fregellae (185–150 B.C.), as well as in other domestic contexts in Rome dated stylistically to the end of the second century B.C.[95] The floor of Room 130 is associated with what may have been a wall-painting in the First Style, the remains of which are very limited. The introduction of this decorative system in Latium has been dated to the second quarter of the second century B.C., though its diffusion peaks in the last quarter of that century.[96] A small assemblage of (early?) second-century B.C. pottery has been recovered from a construction fill in House 7,[97] but deposits of this kind normally contain frequent residues, and at best provide a *terminus post quem*. A *terminus ad quem* has been derived from the possible identification of one of the houses in this block with a known building, the domus of Cn. Octavius, which Cicero (*De off.* 1.138) places on the Palatine and connects with Octavius' election to the consulship in 165 B.C.[98] The link between the excavated remains and literary accounts, however, should be taken with caution. The archaeological evidence from this site seems to be consistent with a date between the second and last quarters of the second century B.C.

A more precise and reliable date can be assigned to another group of aristocratic houses, which C. Panella and her team have been investigating just one block away from Carandini's dig, on the north-east slopes of the Palatine and the south-east slopes of the

[94] Medri 1999: 70 (Att. 300); Gualandi and Papi 1999b: 112–17.
[95] As noted by Papi 1995. On the floors of Fregellae see Coarelli 1995.
[96] Caputo 1990–91; Torelli and Marcattili 2010.
[97] Gualandi and Papi 1999a: 39 (citing black-gloss pottery and tile fragments, though ceramic types are not specified).
[98] Carandini 1986: 263–8 links the *domus* of Cn. Octavius with the *Octavi domus* mentioned by Sallust (*Hist.* frg. 2.45). This belonged to L. Octavius (consul in 75 B.C. and grandson of Cn. Octavius), and was located near the Via Sacra, adjacent to the house of M. Aemilius Scaurus (into which it would be eventually incorporated). On the basis of the topology, Carandini identifies the monument with House 5. The identification is accepted by Coarelli 2012: 290–2. Cf. Tamm 1963: 32 who places the *domus* of Scaurus on the north side of the Domus Tiberiana.

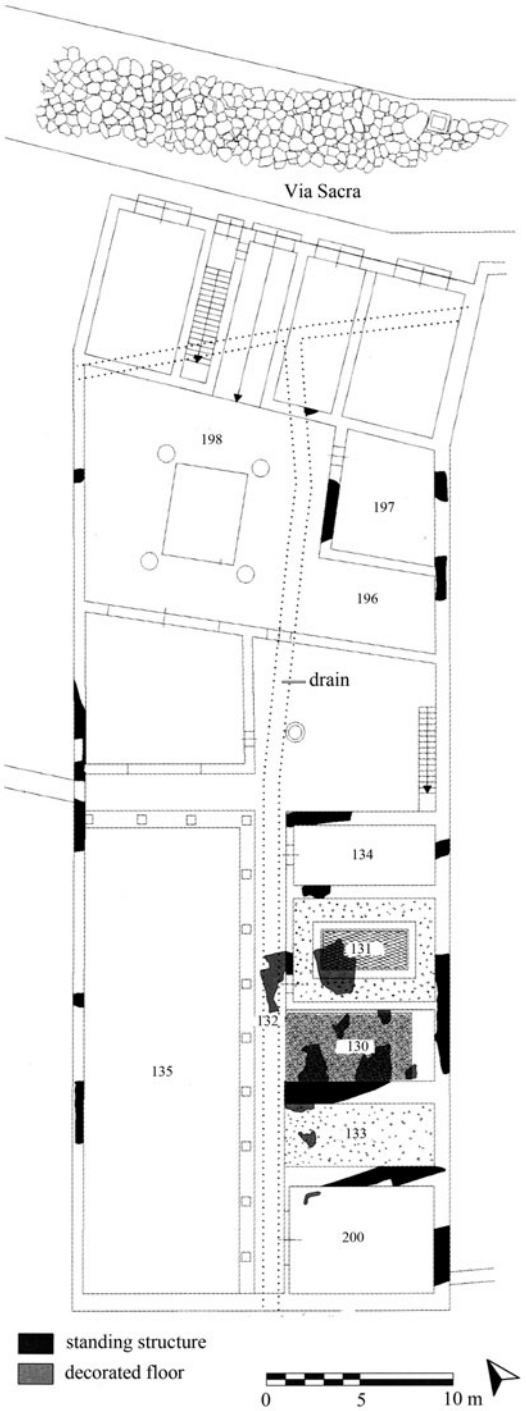


FIG. 15. Restored plan of House 8 with room numbers and indication of actual remains. (*Carandini and Papi 1999: 44, fig. 28; © Istituto Poligrafico e Zecca dello Stato; used by permission*)

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Velia, in the area of the Meta Sudans.[99] These buildings, of which only the front parts are known in any detail, feature deep concrete foundations, which support ashlar façades and *opus incertum* party-walls (e.g. in the house identified on the north-east slope of the Palatine: Fig. 16).[100] The pottery assemblage recovered from the levels associated with the houses and related infrastructure date the construction to the middle of the second century B.C.[101] As on the north slopes of the Palatine site, the concrete is composed of mortar made with lime and pozzolana (thus, the mortar is of the hydraulic type), and the aggregates are mostly of Cappellaccio. The *caementa* were obtained from the demolition of the Archaic structures that occupied the same area in the previous period, which only showed minor modifications in the Middle Republican period.

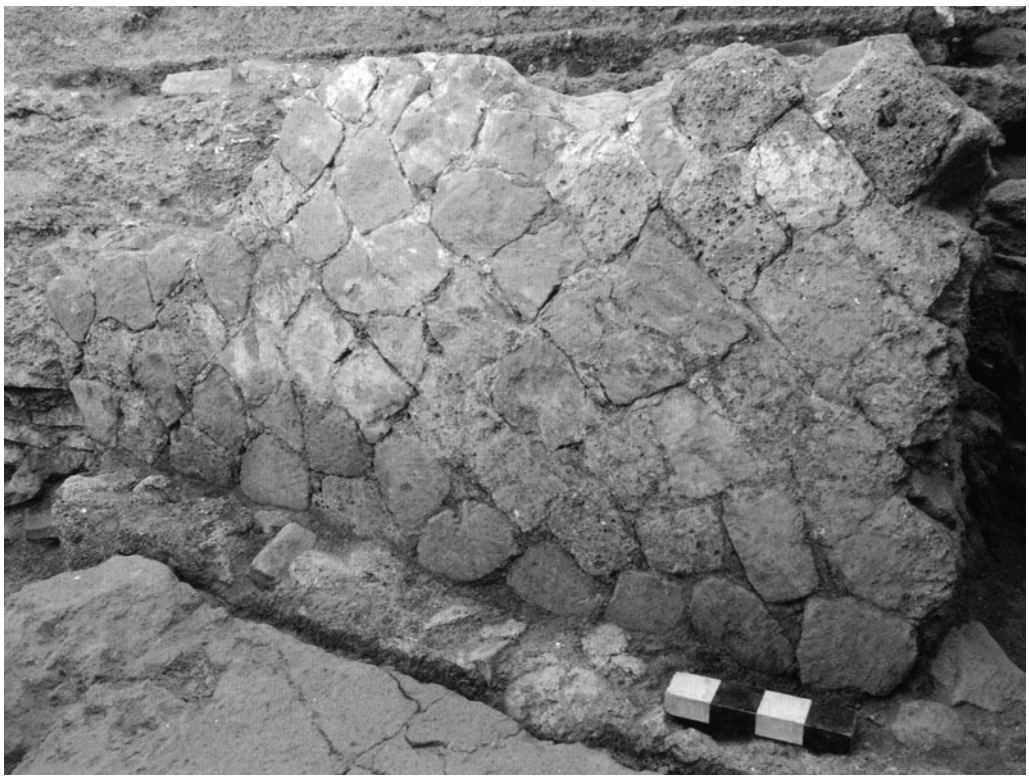

FIG. 16. Construction detail of the Late Republican house excavated by Panella on the north-east slopes of the Palatine, showing an *opus incertum* party-wall on top of a concrete foundation. (*Carbonara 2006: 18, fig. 3;* © *Quasar; used by permission*)

The many similarities in the architectural sequence attested at both sites strongly suggest that these early examples of concrete architecture belong to the same building phase. The reconstruction of the houses probably followed the overall reconfiguration of the urban infrastructure in the central sector of the city, which involved first the laying-out and

[99] A general interpretation of the remains in the broader topographical context is attempted by Zeggio 2006: 74–5, fig. 8, nos 11–13.
[100] Carbonara 2006 presents a phasing of the architecture.
[101] Panella 1990: 46–7.

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paving of new road surfaces and the redefinition of the city blocks (Livy 41.27.5 informs us that this undoubtedly lengthy project was started by the censors of 174 B.C.).

## V THE SOCIAL CONTEXT OF THE TECHNOLOGICAL INNOVATION

While many contradictions characterize the traditional chronology of public buildings, which depends on questionable associations between archaeological remains and historical characters or episodes mentioned in ancient texts, the survey of excavated urban sites for which stratigraphic data are available allows us to lay some firmer groundwork. Thanks to the new material, élite house construction can be brought into the picture, complementing previous reconstructions based mainly on public architecture. The private building industry emerges as a context in which important steps toward the development of concrete may have been achieved. Starting around the middle of the second century B.C., long-lived aristocratic compounds that had stood unaltered for centuries were torn down and rebuilt, particularly in the areas closer to the monumental and political core. The theme of private expenditure in the domestic architecture of that period in Rome is in fact well-known from literary accounts, which also seem to establish a link between the consumption of luxury building materials and self-aggrandizement, ultimately connecting architectural developments with the semi-public function of the Roman house and increasing political competition for public office.[102] Interestingly, Torelli and Marcattili suggest that the spread of First Style wall-decorations in élite houses of this period may have primarily had the function of visually recreating, within the domestic space, the ashlar masonry environment of political buildings such as the basilicas and quadriporticus. They also point out how the isodomic stuccoes alluded to the marble environment of Classical Greece, and that this would be another instance of the neoatticism that characterized contemporary arts.[103] They connect this trend with the cultural impact of the conquest of the Greek East — and in particular of the Greek mainland — which eventually determined the demise of old Middle Republican values and canons. The development of concrete architecture in the domestic sphere can be contextualized as part of this process, and the important conclusion seems to be that the display of new architectural styles (also in terms of house plan and design) suddenly became more important than emphasizing the continuity of occupation of centuries-old homes. Far from originating at the lower level of society in the Middle Republic, as previously assumed, the origins of the new building medium have a relationship with Late Republican élite fashions.

The earliest public monument for which a construction phase in concrete can be pinpointed with a certain precision is the Porticus Metelli, whose date is within a couple of decades of that of the earliest datable houses. However, precisely because we have so little information about Rome's public buildings, to conclude that the use of the technique was initially limited to the private context would risk being an argument *ex silentio*.[104] A stark contrast can in fact be observed in the city-block occupying the north slope of the Palatine, south of the Via Sacra, where the group of public buildings

[102] See especially Coarelli 1989. For a reappraisal of the problem: Sewell 2010: 137–65.
[103] Torelli and Marcattili 2010: 50–3.
[104] A development of this kind has been argued in the case of second-century B.C. Tibur by Tombrägel 2012: 19–105. Tombrägel suggests that the spread of concrete in rural élite residences here predates the use of *opus incertum* in public building, though he sees the influence of villa owners of Roman origins. This view, however, is in contrast with the pattern observed in the *suburbium* of Rome, where second-century B.C. villas are predominantly built with *opus quadratum*: supra, n. 86. The date for the introduction of concrete the author proposes for Tibur (i.e. the first half of the second century B.C.) is also problematic, because it is partly based on the identification of the Testaccio building with the Porticus Aemilia and on Coarelli's interpretation of the temple of Magna Mater.

adjoining the aristocratic houses (so-called Domus Publica; Atrium Vestae) received concrete additions only in the course of the first century B.C. The reason for this, however, may have to do with the need for preserving the ancestral character of these public monuments. On the other hand, attempts at using the new building medium for repairs of foundations are attested, although on a smaller scale, in the temple of Castor and Pollux (Phase IA), which may be contemporary with the houses. As we have seen, the widespread diffusion of the new building medium can be observed in the last quarter of the second century B.C., particularly in connection with the rebuilding of temple podia on existing sites (thus mirroring the construction process described for the houses), as documented by the temples of Veiovis, Concord, Castor and Pollux, Magna Mater and Victoria. The latter two monuments are associated with the earliest datable examples of free-standing concrete walls and concrete vaults (i.e., the *via tecta* and the monumental front of the south-west corner of the Palatine, *c.* 110–100 B.C.). However, free-standing *opus incertum* architecture is attested from the beginnings of concrete construction in both Latium, at sites such as Tibur (particularly in aristocratic residences in the countryside, for which a date within the first half of the second century B.C. has recently been suggested),[105] and Campania, at sites such as Pompeii (e.g. the Casa del Fauno, which dates to 175–150 B.C., and the slightly later Casa di Pansa)[106] and Puteoli (Rione Terra).[107] The apparent gap in Rome may be due to the state of the evidence, suffering from the radical transformation of the monumental core in the Imperial period, and to the poor dating of terracing structures (particularly those on the east slope of the Palatine, which may be as early as 150 B.C.).

The pattern just described confirms that there was a close link in architectural practice between the public and private contexts. The fact that the few names of architects known for the Late Republican period are clearly connected with high ranking families, like the Mucii and the Cornelii, is in itself a strong indication that architectural developments in the public and private spheres had a common root at the élite level.[108] Furthermore, this idea fits well with what we know about the organization of public construction in Republican Rome.[109] Public building was sponsored by the same aristocratic patrons who commissioned the refashioning of the old élite residences in the urban core. An example may be Cn. Octavius, the possible owner of one of the concrete houses on the north slope of the Palatine, who also built a porticus, perhaps of the same general kind as that of Metellus (which we know incorporated concrete foundations).[110] In theory, he could have used the same professional builders for both projects. By the middle of the second century B.C., public works were normally contracted out to private builders, but

[105] Tombrägel 2012; Tombrägel 2013.

[106] On the dating of the first phase of the Casa del Fauno see Faber and Hoffmann 2009: 48–50 and 82–4. Scientific evidence for the use of pozzolanic mortar is available for the Casa di Pansa: Miriello *et al.* 2010: 2216–18. For a reappraisal of the data on early concrete architecture at Pompeii see Mogetta 2013: 168–283. At this site, the development of the building technique can be clearly linked with élite domestic architecture.

[107] Paternoster *et al.* 2007: 25–35. Free-standing concrete walls described as either *opus incertum* or pseudo-polygonal masonry are typically associated with ashlar vaults. Their chronology is uncertain because of the lack of stratigraphic data, though several cases are known in which *opus incertum* buildings destroy the rock-cut water-related features created with the original orthogonal layout. The foundation date of the colony (194 B.C.) provides a *terminus post quem*.

[108] As noted by Torelli 1980: 156.

[109] Martin 1989.

[110] Sources collected in Viscogliosi 1999b. Pliny the Elder (34.13) describes it as a *porticus duplex*, but it is unclear whether his terminology refers to a quadriporticus. The construction of the monument is dated between 167 and 163 B.C., making it contemporary with the *domus* on the Palatine. On the building activities of other leading families in Rome in the later second century B.C. see Morgan 1973 (on the Caecilii Metelli), and Wiseman 1993 (on the Aemilii, but the identification of individual monuments is problematic).

the system is certainly earlier.[111] The legal framework, therefore, originated in a period in which ashlar architectural traditions were dominant. Innovating in this field implied a great deal of social and political risk for the public official who let the contract.[112] This explains why the widespread adoption of concrete in public construction went in parallel with experiments in the private sector, i.e. contracting to builders whose skills would have already been tested by the same patrons. It may be that concrete was first introduced in domestic architecture, but in any case the time gap would not have been a long one.

On a related note, the evidence from Rome provides new insights into how the use and development of concrete came about.[113] The early contexts suggest that concrete was implemented as a building medium capable of transforming demolition or quarry waste into a versatile, durable and fast material, whether for house foundations or temple podia. The scale of the effort, with numerous projects progressing simultaneously at any one time in both public and private construction, certainly represented an impetus for the innovation.[114] In addition to economic needs, however, other important technological factors were at play. The introduction of new forms of wall decorations using high quality stucco and plaster (e.g. in the so-called First Style) most likely resulted in changes in the organization of industrial facilities in the lime-producing region, providing greater quantities of lime in order to meet the increasing demand.[115] This may have in turn triggered the transition to mortar-and-rubble building techniques.[116]

At the time concrete construction was first introduced, other mortar-based technologies of Hellenistic derivation were already common in the region, among which is the so-called *opus signinum* or *cocciopesto*.[117] Use of this medium, which consisted of a mix of lime, sand and ground terracotta, was limited to floor revetment and water-proofing.[118] Excavations at the Latin colony of Fregellae, located in the Sacco-Liri valley south of

[111] On the origins of this system, known as *locatio conductio operis*, and on the procedure of the *probatio* see Biscardi 1960. The earliest inscription mentioning a *probatio* (by the aediles) is *ILLRP* 45 (first half of the second century B.C.). It refers to the construction of a mosaic floor in the temple of Apollo in Circo, implying that the work was contracted out. Cato provides examples of the economic activities which were regulated by these contracts in the context of private construction: Martin 1989: 21–2. The so-called *lex Puteolana parieti faciundo* (*ILLRP* 518, of 105 B.C.) attests the practice of designating magistrates as final approvers of public projects.

[112] See Pobjoy 2000 for a reassessment of the first-century B.C. evidence, showing the concern of magistrates for documenting that public funds had been spent correctly. In several Republican inscriptions the task of inspection appears to be assigned to the same individuals who originally contracted the work even though they were no longer in (the same) office, so it has been suggested that there were early attempts to transfer at least part of the risks (*vitium operis*) from the *conductor* (i.e. the contractor) to the *locator* (i.e. the individual or group who let the contract): Biscardi 1960: 433–4.

[113] For an overview of the subject matter see Lancaster 2005: 51–67. The chemistry and materials science of Roman concrete is described in Lechtmann and Hobbs 1987: 94–102. For the scientific characterization of mortars from Rome see now Jackson *et al.* 2007; Jackson *et al.* 2010. The chronology suggested in the latter work (41, table II) is problematic. The purported fourth-century B.C. date for the podium of the temple of Saturn is unfounded, and so is the 192–174 B.C. date for the 'Porticus Aemilia'/Navalia. Cf. however Jackson and Kosso 2013: 279 ('Durable concrete constructions in Rome apparently date to the second century [B.C.]').

[114] cf. DeLaine 2006: 249–50 who regards the pace of construction activities in the Republican period as slow and gradual, and thinks that only in the Imperial period did the construction industry receive impetus.

[115] Lime for concrete construction in Rome was procured mainly on the urban market. The closest deposits suitable for lime production are the travertines of the Acque Albule near Tibur, though there is no explicit evidence that the Romans burned these rocks for lime. See the observations in DeLaine 1995: 560. Other sources were located farther away in the Monte Soratte and the Monti Cornicolani (on these Jackson *et al.* 2007: 42–3), and in the Monti Lepini.

[116] Just as in concrete, mortar containing pozzolana was typically used as a primer for plaster mouldings. Giuliani 2006: 185–6.

[117] On the diffusion of this medium from Hellenistic Sicily into the Italian peninsula see most recently Vassal 2006. Tang 2006 reviews the debate concerning the identification of ancient terms. A Punic origin is commonly assumed.

[118] On the specialized use of the mix see Trümper 2010. Giuliani 1992 considers *opus signinum* as a specific construction method for cisterns.

Rome, revealed a series of early examples, some dating to 200 B.C. or earlier.[119] Its introduction in Rome has been dated to the same period.[120] As is well-known, ground terracotta imparts *cocciopesto* with pozzolanic properties. The setting is much faster and can happen without requiring evaporation (hence its hydraulic properties). These properties would in fact make *cocciopesto* well-suited for use as a binder in air-tight structural environments such as foundation trenches and podium cores, where the hardening of simple lime mortars would not be possible, or would be extremely time-consuming. Thus, foundations and podium fills could have been built using *cocciopesto* just as well as using mortar including pozzolana, i.e. in a faster way, and avoiding the risk of damage due to compression of the core by its own weight (which is likely to happen if slow-setting mortars are used). Furthermore, ground terracotta gives superior strength to the mortar (not by chance, a layer of *cocciopesto* is often found in tessellated floors to fix the tesserae). Roman builders, who regularly employed it for water-proof lining, would have been familiar with its higher resistance to shrinkage and cracking during the hardening process, and would have easily realized that these properties could minimize problems of separation between facing and cores in free-standing mortar-and-rubble walls.[121]

Then, how did quarried pozzolana in mortar fills come to be substituted for ground terracotta? Why was *cocciopesto* never used for structural purposes on a large scale? The main reason is that the mass-production of ground terracotta as an additive for concrete construction would have had much higher costs than the quarrying of pozzolana, making it unfeasible.[122] Conversely, there is scientific evidence that pozzolana came to be added to the *cocciopesto* mix,[123] though it never really replaced ground terracotta (perhaps so that the building medium preserved the red hue that made it popular in the first place). The conclusion seems to be that Roman builders had an empirical knowledge of ground terracotta and natural pozzolana possessing very similar properties. Vitruvius (2.6.3–4) connected the superior quality of pozzolana with the effects of intense fire on certain natural deposits. The dry state (or 'want of moisture', *ieiunitas umoris*) and latent heat with which the material was left in the process would explain its reactivity (especially if it came in contact with water).[124] Terracotta was also obtained by firing natural deposits, and thus could be conceptualized as an artificial variety of pozzolana; it simply involved more processing. The switch from ground terracotta to natural pozzolana must have been easier to implement than one would assume knowing that the Romans did not understand the actual chemistry behind it. It happened, however, only when the social and economic needs presented themselves.

[119] Coarelli 1995.
[120] Morricone Matini 1971: 7. For a contextualization see Torelli and Marcattili 2010: 46.
[121] Giuliani 2006: 223 lists examples in which *cocciopesto* was used selectively as a conglomerate. Vitruvius (2.5.1) recommends adding ground terracotta when riverine or marine sands were used instead of volcanic ash to make mortar.
[122] Based on the figures by DeLaine 1997: 111–13, tables 6–7, and 116–18, tables 8–9, the man-power requirements per $m^3$ of finished product can be calculated as 0.468 man-days equivalents for pozzolana, versus 2.95 for bricks (*bessales* with average thickness of 0.04 m), not including fuel costs to fire the bricks and the man-power required for the subsequent grinding.
[123] This evidence dates mostly to the Imperial period: Bugini *et al.* 1993: 271. On the use of pozzolana in *cocciopesto* see also Giuliani 2006: 222.
[124] See especially Vitruvius 2.6.4: 'igitur dissimilibus et disparibus rebus correptis et in unam potestatem conlatis, calida umoris ieiunitas aquae repente satiata communibus corporibus latenti calore confervescit et vehementer efficit ea coire celeriterque unam soliditatis percipere virtutem.' 'Therefore, different and heterogeneous materials having been subjected to fire and reduced to the same condition, the hot dry state rapidly satiated by water boils together because of the heat latent in these types of ingredients, thus making them combine strongly, and quickly acquire a unique quality of solidity' (translation mine). Jackson and Kosso 2013: 273 read in this passage the influence of the Empedoclean theory of the four classical elements on Vitruvius.

## VI CONCLUSION

Although more focused excavations are needed, the new dating of the *opus incertum* monuments of Rome prompts a recasting of the development and cultural significance of concrete construction. Some important conclusions regarding the social context of innovation have been drawn from our analysis of early concrete architecture, posing a serious challenge to the orthodox view on the origins of this revolutionary building technique. The main result of this reassessment is that the spread of the technology can no longer be described as a symptom of Middle Republican Roman imperialism. The complete lack of concrete architecture for the period before the middle of the second century B.C. means that the diffusion of this building medium came at a time when Rome's uncontested control of Italy had long been achieved. Consequently, the idea that concrete became common as the programme of colonization and urbanization unfolded in central Italy during the Middle Republican period needs a thorough revision.

On the other hand, it emerges clearly how the impact of Rome's Mediterranean expansion on the cultural developments in the capital were much more profound. The development of concrete coincided in time with the codification of new architectural styles and building types that were adapted from the Greek world at precisely this juncture. Civic buildings like the basilica and the quadriporticus, not to mention the first marble temples, were indebted to Greek columnar architecture.[125] Similarly, the reconstruction of the aristocratic houses in some cases came with the introduction of more complex plans incorporating peristyle architecture of Hellenistic derivation.[126]

This rapid change resulted in the beautification of the new capital, both at the domestic and at the public level, in order to properly reflect its new political standing. In this sense the new architectural assemblage, of which concrete came to be an integral component, reflects profound changes in élite self-representation. The phenomenon of external influence, of course, was not without precedent, as Italian élites had often looked to that part of the world as a source for conspicuous consumption (most notable is the case of the Orientalizing phenomenon in the seventh century B.C.). Unlike before, however, a radically different Rome materialized in a matter of just one or two generations, which in all aspects of material culture seems to have little or no relationship at all with its recent past. The cultural distance between Middle Republican Rome and its Archaic incarnation is, in archaeological terms, far less pronounced. If archaeologists from another planet were to compare the city of around 100 B.C. with that of around 200 B.C., they would find very little in common, and perhaps even infer that a foreign culture had taken over. Concrete had by then integrated the centuries-old tradition of building exclusively with ashlars, replacing the use of wooden posts and mud-brick for superstructures, and thus revolutionizing the above-ground texture of Rome's urban fabric: the *opus reticulatum* remains of the cella of Temple B at Largo Argentina still stand as silent markers for the conclusion of the process.[127]

If accepted, the implications of the new model for the dating of other concrete monuments will be immediately obvious. Not only will they require a rethinking of

[125] For a recent overview of the phenomenon see Davies 2014. There is no evidence of concrete being used for the first phase of the Basilica Aemilia in Rome, but very little of the 179 B.C. building is preserved. Concrete is used for both foundations and free-standing walls in the basilica at Cosa, which Gros 2011: 240 considers the earliest canonical example of the Roman type. The marble temple of S. Salvatore in Campo had a concrete podium: Tortorici 1988.

[126] See the discussion in Gros 2006: 38–60.

[127] Coarelli 1977: pl. 1d. See also Coarelli *et al.* 1981: 19–21. These walls would have been plastered over with First Style decoration so that the concrete facing would not have been visible, but it is important to note that even temples whose walls were built with ashlars (e.g. the temple of Portunus in the Forum Boarium) received stucco decoration to imitate marble on the exterior: Moormann 2011: 47–9.

Rome's urbanization trajectory, but also of its relation to the contemporary, almost synchronous, architectural changes in central Italy, which due to the narrower scope of this paper have been mentioned only in passing.[128] The study of early concrete architecture from the broader region deserves to be developed further because it has the potential to contribute significantly to the broader intellectual debate about the formation of a distinctive Roman material culture, and the tempo and dynamics of its diffusion in Italy.[129]

## SUPPLEMENTARY MATERIAL

For supplementary material (Online Figs 1–5) please visit http://journals.cambridge.org/jrs

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[128] A useful and up-to-date survey of second-century B.C. concrete architecture in Latium and Campania is Cifarelli 2013.
[129] As outlined in Mogetta 2013: 296–311, reassessing the agency of non-Roman élites in the process; see also Terrenato 2008: 250–60; Stek 2014: 35–9. An evaluation of non-Roman sources for Romano-Hellenistic architecture is in Ward-Perkins 1979. Cf. Zanker 1976; Torelli 1999 and Wallace-Hadrill 2008 suggest in various ways that the flow of Hellenistic forms in Italy originated from Rome, and that the spread of prestige buildings in Italy closely followed Rome's example.

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