CHAPTER 7

From Ashlar to Brick: Anchoring and Innovation in Roman Building Practice

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1 Introduction

In the early fourth century BCE, after the city had been sacked by the Gauls, the Romans decided to build a new city wall around their city. The project was spectacular in its scale, but conventional in building practice: the so-called Servian Wall was made by stacking carefully cut blocks of yellow tuff quarried in the Tiber Valley a few kilometres upstream of the city (fig. 7.1).[1] A similar technique, with comparable materials, had already been used in the podium of the temple of Iuppiter on the Capitol, in the late sixth century BCE, and the two early fourth century BCE temples in the sacred area of Sant'Omobono between the forum and the Tiber were built in the same way.[2] Indeed, throughout most of the Republican period, ashlar of locally quarried stone continued to dominate monumental public architecture in Rome, and the Italian peninsula.[3] Yet when about 660 years later, in the late third century CE, a second, much longer, wall circuit was built, it looked completely different: the walls constructed during the short reign of emperor Aurelian consisted of a concrete core faced with bricks—a technique allowing for a much quicker and more cost-effective construction process (fig. 7.2). Nevertheless, as had been the case with the Servian wall, the materials and techniques used in the project were part and parcel of local construction practice at the time: in and around the Roman Metropolis fully brick-faced concrete had been the default technique for public construction since the early second century CE, and it would remain so after the construction of the Aurelian Walls, throughout the late third and fourth centuries CE.

1 On the construction of the walls see now Bernard 2018, 75–117.
2 On the temple of Iuppiter Capitolinus (made of locally sourced tuff), cf. Jackson and Marra 2006, 426. On the temples in the sacred area of Sant'Omobono see Bernard 2018, 31; Arnhold 2020, 162–164.
3 Though not without technological change. Cf. Bernard 2018, 193–227.

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FIGURE 7.1 Remains of Rome's Mid-republican wall circuit on the Esquiline
PHOTO: LALUPA / WIKIMEDIA COMMONS

FIGURE 7.2 Rome, section of the Aurelian wall near Porta Metronia
PHOTO: LPLT / WIKIMEDIA COMMONS

The conservatism that connects these two projects is as significant as the gap in technical practice that separates them. The former illustrates how, in general, the circumstances under which larger-scale pre-modern construction took place were not conducive to innovation. In the Greco-Roman Mediterranean, larger-scale construction projects primarily served the social and political ambitions of individuals and communities, creating an extra incentive to make projects risk-averse: buildings needed to be finished, preferably more-or-less as they had been planned, and they would need to remain stable and safe afterwards.[4] The best way to keep such projects manageable is to start from practices firmly established in the local community. Failure was not without consequences: Pliny's letter to Trajan about the problems surrounding the construction of the theatre and baths at Nicaea in Bithynia highlights the realities of the structural and financial risks involved in case of errors.[5] It is not surprising that both wall circuits of Rome were built with well-established techniques, and with familiar building materials of which there was an ample supply in the direct hinterland of the city. Indeed, it is rather more remarkable that in a context in which there were strong logistical and economic incentives for conservatism, there was, in the long run, so much innovation that both wall circuits in terms of building materials and techniques have almost nothing in common.

This chapter starts from the idea that Roman innovations in building practice are a good starting point for exploring the potential of 'anchoring' in the context of ancient technological history: if building practice was, as a rule, conservative and risk-averse, innovations in materials and techniques probably could succeed much more easily if they could be connected to existing skills and routines: the 'anchoring' of innovations in established practice could be of critical importance for their adoption. Exploring the contexts and ways in which successful innovations in Roman construction technique were or became 'anchored' can thus add to our understanding of the evolution of practices in Roman building industry, and, thus, to the study of innovation and change in Greco-Roman technical practice. At the same time, it can also enrich our understanding of 'anchoring' as a heuristic tool. 'Anchoring' has, thus far, been used primarily in isolated contexts, and mostly on the basis of examples derived from the literary sources: the *guttae* in Doric temple architecture were explicitly anchored by Vitruvius in earlier wood-based construction practice; the *corvus* with which the Romans were able to beat the Carthaginians at sea

4 See also VandenBroeck-Parant, this volume.
5 Plin. *Ep*. 48.

was discussed by Polybius as a solution to one specific military problem.[6] Similarly, the anchoring strategies of Roman emperors are discussed by Roman authors in rather explicit terms, or are explicitly represented on visual culture.[7] Yet what happens to 'anchoring' if it is transposed to an area of practice for which the leading body of evidence is material and non-iconographic? Can anchoring flourish as an analytical tool beyond the textual record, and if so, what changes? And what happens to anchoring when it is applied not to sweeping, stand-alone innovations but to the smaller, often inter-connected changes in everyday practice? To explore these issues, the following pages will analyse three inter-related developments that have often been seen as critical steps in the history of Roman building practice: the emergence of concrete in the second century BCE, the development of *opus reticulatum* in the early first century BCE, and the appearance of brick in the Augustan and Early Imperial period.

2 Anchoring and Innovation in Ancient Technological History

The history of innovation in everyday technical practice in the Greco-Roman world has been debated throughout the nineteenth and twentieth centuries, but emphasis was long more on the resulting technological proficiency than on the actual processes of innovation.[8] In recent years, Greek and Roman archaeologists have increasingly begun to explore the anatomy of innovation to greater detail, starting from anthropological approaches to processes of 'making' and the embodied nature of craft skills.[9] Many have studied technological developments in ceramics production, particularly in the production of refined, decorated table wares, such as the Hellenistic, mould-made 'Megarian' bowls, Late Hellenistic and early Roman lead-glazed pottery, and Roman Terra Sigillata.[10] The invention and spread of transparent, blown glass, which had a profound impact on Roman material culture in the early imperial period, has also been debated intensively.[11] There is an emerging consensus among Greek and Roman archaeologists that these processes of innovation were uneven, slow and unpredictable: even a 'revolutionary' development like the

6 For these examples see Sluiter 2017, 26–29.
7 Hekster 2020.
8 See esp. Finley 1965; Greene 2000; Flohr 2016.
9 E.g. Sennett 2008; Marchand 2009; Ingold 2013.
10 Relevant studies include Rotroff 2006; Greene 2007; Van Oyen 2016.
11 See esp. Stern 1999; Larson 2019.

emergence of glass-blowing in practice can be divided into several smaller steps, and involved substantial trial and error. Thus, while the first experiments with blown glass can be dated to the first century BCE, the technology only was stabilized and standardised over the course of the first century CE.[12] Processes of innovation also were often local in nature—the spread of glass-blowing over the Roman empire in the first century CE was exceptional in its speed and its geographical reach, but quickly led to the establishment of a range of local and regional traditions. High-quality *terra sigillata* pottery was consumed in many places shortly after it had emerged, but its production long remained restricted to a limited number of production centres, which were not only clusters of production capacity, but also centres of skills and knowledge.[13]

The emerging consensus on these micro-histories of innovation in Greco-Roman antiquity connects well to the theoretically more refined work of pre-historical archaeologists. For instance, analyzing the uneven diffusion of the potter's wheel in the Bronze Age Mediterranean, Carl Knappett has argued that we should abandon sweeping, macroevolutionary interpretations of innovation and diffusion and 'turn to microevolutionary processes for explanation', advocating an emphasis on craft learning and technological traditions in local contexts.[14] Catherine Frieman's recent monograph on the archaeology of innovation, which covers all of human history, elaborates this point: as creativity is 'socially structured' and 'framed by human relations', innovation is

> a social process in which individual acts of creation emerge from histories of practice, collaboration, iteration, and experimentation that implicate a web of relations among people, things, ideas and practices.[15]

The step from this focus on the social construction of innovation on the micro-scale to the idea of 'anchoring' as defined by Sluiter is not big. In both cases, thinking about innovation is firmly anchored at the micro-level of actual decision-making processes by individuals and groups, and closely associated with the Social Construction of Technology-framework (SCOT) developed by Pinch and Bijker.[16]

12 Larson 2019.
13 Including particularly Arezzo, La Graufesenque, and Lezoux. See Van Oyen 2016.
14 Knappett 2016, 106. See also Knappett and Van der Leeuw 2014.
15 Frieman 2021, 187.
16 Sluiter 2017, 27; Frieman 2021, 50–53. See esp. Pinch and Bijker 1984; Bijker 1997. See also Bijker, this volume.

In the study of Roman building practice, the micro-scale, localized perspective on innovation has been less well-developed. Scholarship has traditionally focused on a limited number of places, particularly Rome and Pompeii, and has taken these to be normative. For Rome, discourse has long been dominated by the work of Marion Blake and Giuseppe Lugli.[17] At Pompeii, the leading framework for the development of local building techniques long rested upon the work of August Mau and, later, Roger Carrington.[18] These frameworks have been modified and refined over the course of the last decades: Filippo Coarelli studied the origins of *opus reticulatum* in the city of Rome in the late Republican period; Mario Torelli analyzed the subsequent spread of the technique through Late Republican Italy; Kees Peterse modelled the history of the limestone-framework technique in Samnite Pompeii.[19] The work of Lynne Lancaster and Janet DeLaine has further developed our understanding of imperial period building technology at Rome and Ostia.[20] Many of these contributions discuss the contexts and meaning of innovations, but most have a limited focus on the processes of change themselves. In recent years, scholars have become a bit more sensitive to these issues: Marcello Mogetta connected the emergence of concrete in Rome and Pompeii to a boom in the construction of large-scale elite houses: through these building projects, concrete was established as a building technique in these cities; Mogetta's approach, while mostly interested in reconstructing the chronologies of changing practice, recognized the localized nature of change, and its socially constructed nature, and emphasized the differences in practice within the Italian peninsula.[21] Starting from a mostly theoretical agenda, Astrid van Oyen has explored how concrete, as a material, did not emerge as a ready-made category, but 'developed along a trajectory of redefinition, categorisation, and differentiation', though, unfortunately, the actual historical details of this development remain underdefined, and the social contexts in which redefinitions, categorisations and differentiations took place stay mostly out of the picture.[22] In a recent article, the present author has explored the geographical relation between innovation in construction technology and the social heterogeneity that emerged, particularly in Italy, as a result of Roman imperial hegemony, in the last two centuries BCE, arguing that this created unprecedented conditions, particularly in and around Rome

17 Lugli 1957. See also Blake 1947; 1959; 1973.

18 Mau 1908; Carrington 1933.

19 Coarelli 1977; Torelli 1980; Peterse 1999.

20 DeLaine 2001; 2002; Lancaster 2005; DeLaine 2006; Lancaster 2008. See also, more in general Wilson 2006.

21 Mogetta 2015; 2016; 2021.

22 Van Oyen 2017, 146.

and the Bay of Naples, for technological innovation—including the innovations discussed in the following pages.[23] The present chapter builds upon this work, but it will dive a bit deeper into the local and socially contextualized micro-history of innovations.

3 From Blocks to Rubble: the Making of *opus incertum*

Concrete emerged when people began to build walls of which the loose parts—*caementa*—were held together not by their careful placement, but by a mortar that was sufficiently strong to keep them in place permanently. Mogetta has argued that in Rome, the earliest securely datable walls in concrete were built around the middle of the second century BCE, and not before, as was long believed; a wide distribution of the technique can be observed for the last quarter of the same century.[24] For Pompeii, he has dated the earliest buildings constructed with walls in *opus incertum* to around 150 BCE.[25] In both cases, Mogetta's work associates the earliest larger-scale application of concrete with the episodes of urban transformation and intense public and private building activity that characterized the latter half of the second century. These episodes followed, and can be linked to, Rome's spectacular expansion from a regional Italian power to a Mediterranean empire that culminated in the destruction of Corinth and Carthage in 146 BCE: on first sight, it would seem that it was the influx and redistribution of imperial wealth—and its translation into built property—that cemented the position of concrete in construction practice in Roman Italy.[26] However, reality was more complicated: concrete initially appeared as a local, or, at best, regional phenomenon. At Pompeii, the earliest applications of the technique can be found in the large elite houses of the mid-second century BCE, such as the House of the Faun (VI 12) and the *Insula Arriana Polliana* (VI 6). This led Mogetta to suggest that the emergence of concrete was somehow *related* to these new forms of architecture: the technique came with the design.[27] Yet at Paestum, Late Hellenistic elite houses were built with more traditional building techniques, even though they closely resembled the peristyle houses of Pompeii.[28] Paestum was constructed

23 Flohr 2023.
24 Mogetta 2015, 28–30.
25 Mogetta 2016, 66.
26 On the transformation of the Pompeian economy in the late second century BCE see Flohr 2019.
27 Mogetta 2016, 66–69.
28 On this point see, more elaborately, Flohr 2022, 163–164.

on a limestone plateau, and had no direct local access to volcanic sand, but the Bay of Naples is not far away: pozzolana could be shipped in without substantial transport costs. Moreover, the close resemblance in design between late Hellenistic houses in both cities suggests that Pompeii and Paestum participated in knowledge networks through which ideas about construction practice could easily have circulated between both places. Still, concrete was not adopted at Paestum in this period, and builders continued to work their materials with traditional techniques to construct the new peristyle houses.[29] Indeed, concrete became first successful in regions that not only saw significant building activity in the later second century BCE but also had direct, local access to substantial quantities of volcanic sand.[30] As the example of Paestum highlights, the technique did not immediately spread to regions where such sediments were not naturally available.

At Pompeii, some developments in building practice that followed the introduction of concrete suggest why the technique could become successful in the city. At least initially, mortar was not used in all sections of the wall. In the second century BCE, it was only used in the main body of the walls, while corners and door-posts continued to be made of large blocks of stone stacked directly on top of each other without mortar. Only in the early first century BCE, local builders begin to construct mortared posts and quoins.[31] Moreover, it is clear that concrete at Pompeii first appeared in a context in which so-called 'Sarno Stone' was the traditional building material.[32] This porous travertine was won at some distance from the city, and it had been the leading building material in the city from the fourth century BCE onwards. However, the introduction of concrete went hand in hand with the partial replacement of Sarno Stone with a locally available volcanic stone known among Pompeian scholars as 'Grey Lava' (fig. 7.3).[33] This material was less easy to cut to a regular shape than Sarno Stone, but with good-quality mortar that did not matter so much, and it was much cheaper, as it could be brought to the construction site without any meaningful transport costs. While Grey Lava had not been used at Pompeii before the mid-second century BCE, it had become the most important building material by the early first century BCE. Thus, one reason that concrete, once adopted, could become a success at Pompeii lied in the possibilities it

29 It is worth pointing out that this way of adopting 'new' peristyle architecture with 'traditional' local techniques is a form of anchoring *par excellence*.

30 See also Mogetta 2019 for the situation in early second century BCE Cosa.

31 See e.g. Flohr 2005, 40.

32 Mau 1908 and Carrington 1933 named the oldest phase of Pompeii after this material.

33 Mogetta 2016.

FIGURE 7.3 Pompeii, VII 4, 31. Wall in *opus incertum* of grey lava with door posts in Sarno stone
PHOTO: MIKO FLOHR

offered for the construction of longer wall-sections with cheaper building materials—alongside Grey Lava, early concrete walls also used substantial amounts of recycled Sarno Stone.[34] This incentive was lacking at Paestum, where building materials could already be won more or less on site, and the adoption of concrete would not have made any financial difference to builders.

Before concrete, the dominant building technique at Pompeii was the so-called 'Limestone Framework' technique (fig. 7.4). Walls constructed in this technique typically were held together by pillars consisting of large blocks of Sarno Stone stacked alternatingly upright and horizontally; the space between these pillars was filled by carefully stacked smaller blocks of Sarno Stone, held together by mortar, initially clay-based, later increasingly lime-based.[35] The most thorough study of the technique, by Kees Peterse, sketched a roughly linear evolution of the technique, culminating in *opus incertum*: initially, the pillars were close together, and the blocks of stone between the pillars were regular in shape; as the mortar became stronger, stones became less regular, and the pillars became fewer in number: the distance between them

34 Cf. Flohr in press.
35 Mogetta 2019, 242.

FIGURE 7.4 Pompeii, VII 3, 13. Wall in limestone-framework technique
PHOTO: MIKO FLOHR

increased.[36] Eventually, the pillars lost their function—and disappeared. This model was rejected by Mogetta, who argued that in many cases, differences in the execution of the technique could easily be ascribed to a variety of factors, such as the function of a wall within a building—carrying walls required a different execution than non-carrying walls—and differences in economic power—wealthier people building a home could afford better techniques than poorer people.[37] Yet while the evolution of Pompeian Limestone Framework as a building technique may have been somewhat less linear than Peterse believed, his model should not be cast away too easily. Peterse distinguished three varieties of the technique (A, B, and C). While buildings with the A and B variant were clustered close to the city center, the buildings with the (later) C variant can be found over the entire urban area, suggesting that the city in which they were built was larger than the city in which the earlier variants were used.[38] Furthermore, a chemical analysis of the mortars made clear that the mortar used in Type C walls contained more volcanic material than that in

36 Peterse 1999, 49–55.

37 Mogetta 2016, 48–55. See also Peterse 1999, 49–50 acknowledging the overlap between his type B and C.

38 Peterse 1999, 64–69.

walls of the other two types—even if there is still a significant difference with the levels of volcanic material found in the earliest Pompeian *opus incertum*.[39] It is possible that the development in reality was gradual, but that we simply lack the data due to the lower intensity of building activity in the first half of the second century BCE. It is also possible that there was a real innovative leap from 'late' Limestone Framework to 'early' *opus incertum*. Yet in both cases, the crucial point is that Pompeian builders had already begun to use locally available volcanic material in their mortar—and this had brought the innovation within the reach of everyday experimentation: it simply was a matter of finding the right mixture.

4 From *caementa* to *cubilia*: the Appearance of Standardized Building Materials

The appearance of concrete in Pompeii was thus well-anchored in preceding developments in local construction practice: it built upon an existing use of volcanic materials in mortars, facilitated by the easy availability of this material in the region. Rather than a revolution, the early history of concrete was a sequence of pretty small conceptual steps. The development towards *opus reticulatum* followed the introduction of *opus incertum* from the end of the second century BCE onwards. Unlike concrete, which could also be traced at Pompeii at an early moment, *opus reticulatum* seems to have been a local development of Roman metropolis. *Opus reticulatum* consists of small diamond-shaped blocks of natural stone with a flat surface that were placed in a regular, 'net-like' pattern (fig. 7.5). The development from *incertum* to *reticulatum* has generally been seen as gradual: over time, *caementa* became gradually more similar in size and shape, and they would increasingly be placed in a regular pattern, until, finally, a fully standardized and completely regular *opus reticulatum* emerged. Traditionally, archaeologists have referred to the intermediate stage between *opus incertum* and *opus reticulatum* as *opus quasi-reticulatum*, though the term is a modern invention.[40] The first more-or-less regular facings in this tradition can be found in the Horrea Galbana, constructed around 110 BCE; a fully developed form of *opus reticulatum* can first be found in the Theatre of Pompeius (55 BCE).[41]

39 Peterse 1999, 88–90.

40 On *opus quasi-reticulatum* see Blake 1947, 251–253; Lugli 1957, 501–505; Coarelli 1977, 10; Torelli 1980, 141.

41 Cf. Coarelli 1977, 15.

FIGURE 7.5 Ostia, *tabernae* I X 1 ('*Taberne Repubblicane*'). Late Republican *opus reticulatum* in tuff
PHOTO: MIKO FLOHR

According to Vitruvius, *opus reticulatum* had completely eclipsed *opus incertum* by the time he was writing, in the Augustan period:

> There are two kinds of walling; one like network, *opus reticulatum*, which all use now, and the old manner which is called *opus incertum*. Of these the *reticulatum* is more graceful, but it is likely to cause cracks because it has the beds and joints in every direction. … *opus incertum*, lying course above course and breaking joints, furnishes walling which is not pleasing but is stronger than the reticulatum.[42]

While aesthetics cannot credibly explain the gradual evolution from *opus incertum* to fully regular *opus reticulatum*, Vitruvius is probably right about the aesthetic value ascribed to *opus reticulatum* in his time, and in his assessment that the technique was vulnerable: the long, straight joints running up and down the wall facing were prone to cracking.[43] His text, however, is of

42 Vitr. 2.8.1. Translation Granger 1931, 111.

43 For this reason, the use of *opus reticulatum* in the early imperial period has increasingly become restricted to panels surrounded by bands of *opus latericium*.

little help in reconstructing why *opus reticulatum* became successful. Scholars have argued that the key advantage of the technique was that it allowed for a higher speed of construction on site: the *cubilia* of *opus reticulatum* were identical in size and thus could be much more easily put into place, whereas the traditional facings of irregular *caementa*—*opus incertum*—took more time as workers needed to find the right piece for each place, place, and *caementa* may have needed ad hoc reworking.[44] However, as DeLaine has argued, arguments in favour of efficiency should not be overblown. Time won *on site* was lost in the preparation of the *cubilia*, which took considerable time, meaning that the overall costs for *reticulatum* could even be higher than for *opus incertum*.[45] Still, *reticulatum* offered some practical advantages. Laying standard-sized *cubilia* in a regular pattern required less skill and effort than selecting and shaping *opus incertum* rubble, making it possible to separate more complicated parts of the work flow—making the *cubilia*—from easier parts of the work flow. Similarly, the use of standardized building materials made it possible to separate the preparation of building materials from the construction of the walls in time and space. This helped: the building industry was characterized by significant seasonal differentiation, as concrete walls could not be constructed between November and March, and during the hottest part of the summer.[46] The production of *caementa*, however, could continue all year around. Using pre-fabricated *caementa* of standard size and shape made it possible to use the building season more effectively and to do more with the same number of people: workers could spend part of the year making *caementa*, and part of the year using them to construct walls.

In the context of second century BCE Rome, improving the division of labour made a lot of sense. At a macro-economic level, this has been recognized before, but scholars have not generally thought-through how this was supposed to work at the micro-level of strategic decision-making by individual entrepreneurs—and it is here that the innovations in practice that led to *opus reticulatum* would have been anchored.[47] The spectacular expansion of

44 See esp. Rakob 1976; Coarelli 1977.

45 See esp. DeLaine 2001, 240–245.

46 Based on Front. *Aq.* 2.123: *Idoneum structurae tempus est a Kalendis Aprilibus in Kalendas Novembres ita ut optimum sit intermittere eam partem aestatis quae nimiis caloribus incandescit*. Cf. Blake 1947, 352; Van Oyen 2017, 139. Blake and Van Oyen also refer to the *Lex Puteolana parieti faciendo* (CIL 10, 1781), but the date of November 1st mentioned in this building contract specifies the planned completion date of the project, not some general rule about the building season. It does, however support the idea that there was a season for building in concrete that ended around the start of November.

47 See for macro-economic perspectives Coarelli 1977, 18; Torelli 1980, 156–158.

the city, and the continuous construction of public infrastructure and civic monuments made sure that there was an endless sequence of building projects, and this led to the emergence of a more or less permanent building industry providing work to an increasingly large workforce. Seasonality, however, offered a challenge to entrepreneurs, as they needed many people to do the work during part of the year, and much fewer people in other parts of the year. Letting go and re-hiring wage labourers on a seasonal basis created an insecurity and unpredictability, particularly when workers would need to be skilled—if projects are many in number, and substantial in size, it would be attractive to retain at least part of the (skilled) work force throughout the year, to reduce excessive friction costs while re-hiring in spring. Moreover, in the context of Late-Republican Rome, building entrepreneurs could not only draw upon paid laborers, but also may have been able to use people they held as slaves. Particularly in the second half of the second century BCE, the Romans brought large numbers of enslaved people to Italy, and these disproportionally ended up in the possession of Rome's senatorial elite—which, indeed, was disproportionally involved in construction activity in and around the quickly expanding Roman metropolis.[48] Construction workers held as slaves, of course, would be available throughout the year, but there would be limited work for them in the winter. Separating the construction of the walls from the preparation of the building materials could solve this people problem both for entrepreneurs relying on hired labour, and for those relying on people held as slaves. If the costs of building were for a large part determined by labour, this created a meaningful competitive advantage. Thus, once some builders in Rome came up with this idea, others would have had a strong incentive to follow suit—otherwise, they would be unable to perform at the same level as their competitors.[49]

Changing the logistics of the construction process, and improving the division of labour set in motion a development towards *caementa* that were more alike in size and shape, but this did not automatically lead to the strictly regular *opus reticulatum* of the late Republic and the Early Imperial period. In that sense, it is misleading to refer to walls with regularized *caementa* as *opus quasi reticulatum*: the term suggests builders were mimicking a technique that did not yet exist, nor was on their mental horizon.[50] 'True' *opus*

48 The role of slavery was suggested by Coarelli 1977, 18; Torelli 1980, 156. See also Mogetta 2015, 5. On the increase of slavery in Rome over the second and first centuries BCE see Scheidel 2005, 75–79.

49 On the importance of labour costs see DeLaine 2001.

50 For a critique of the label '*quasi-reticulatum*' see Coarelli 1977, 10.

reticulatum differs from what preceded it in one very fundamental way: its *cubilia* were mass-produced to have exactly the same dimensions. This was done not through cutting, but through sawing them to shape.[51] The arrival of mass-produced *cubilia* and of truly regularized *opus reticulatum*, thus, must be seen as a separate innovation: it was preceded by and dependent upon the development towards regularized *caementa*, but did not directly follow from it. The separation of materials preparation and wall construction did offer an anchor that allowed for the quick integration of mass-produced *cubilia* once someone had come up with the idea, but this still leaves open the question of how this idea came about. While direct evidence is lacking, it would seem that standardized *cubilia* were produced with the aid of a long stone-saw, which made it possible to saw a larger number of them at the same time. This suggests that they may first have appeared in the context of quarrying, where larger stone-saws were already being used to cut larger blocks of ashlar. In this scenario, *cubilia* would be mass-produced in quarries before being transported to the building site. This would make perfect sense: from the Late Republic onwards, quarries increasingly became involved in further processing excavated blocks of stone.[52] Producing *cubilia* in quarries would have the advantage that places and installations to do this sawing in an efficient way could develop a (semi-)permanent form, further streamlining the process; additionally, transporting *cubilia* rather than large blocks of tuff limited the risk of damage during transport.

5 From Stone-Faced to Brick-Faced Concrete: the Emergence of *opus latericium*

The emergence of *opus latericium* is dependent on the appearance of, first, concrete and, then, standardized building materials, but it made use of a material that had been around for quite some time: fired brick had emerged as a building material in the early third century BCE on Sicily and in Magna Graecia.[53] In Roman construction practice, fired brick appeared much later, first in loose architectural elements, such as columns, and then in quoins, door posts, and relieving arches; later, brick began to be used in bands throughout the entire

51 DeLaine 2001, 241.

52 See on quarrying practices esp. Trimble 2011, 67–77. Trimble focuses on marble quarries, but her work, in highlighting the complexity of operations done at these quarries, suggests a model for other quarries as well.

53 Östborn and Gerding 2015, 317.

wall, often in combination with *opus reticulatum*; full *opus latericium* entirely made of brick, appeared yet later again. Its early use in corners, door-posts and relieving arches suggests that brick could offer additional strength compared to alternatives of natural stone; its use in combination with *opus reticulatum* seems to address the shortcomings of this technique noticed by Vitruvius.

The oldest known examples of brick-faced concrete can be found in Pompeii—in the Odeon and the Forum Baths, which were constructed by urban magistrates in the decade following the establishment of a Roman colony in the city in 80 BCE (fig. 7.6). These buildings had walls with a semi-regularized *opus incertum* facing of grey lava, but corners and door posts were faced with brick.[54] This combination of materials and techniques is specific to these early colonial construction projects at Pompeii: they had not been used earlier, and would rarely be used afterwards. The Pompeian amphitheatre, built in the same period, had walls in a similar *opus incertum*, but with *opus vittatum* of stone instead of brick on the edges. No contemporary parallels for this use of brick are known elsewhere in Italy.[55] Perhaps, the choices made in the construction of these buildings reflect the specific social and political circumstances in Early Colonial Pompeii: the magistrates leading the Roman colony were outsiders to the region, and seem to have relied on their own networks to recruit the architects and builders for these projects. They were well-equipped to do so: Quinctius Valgus, one of the *magistri quinquennales* involved in the construction of the Odeon and the Amphitheatre, belonged to the circle around Sulla, and was involved in building projects in at least two other cities elsewhere in Italy.[56] It seems that the people he and his colleague brought in simply started from their usual way of working, and adapted it to Pompeii. Thus, following contemporary practice, they built in *opus incertum* with prepared, regularized *caementa*, using the most easily available local building material—grey lava. However, unlike the tuffs and limestones that could be used elsewhere in Italy, Pompeian grey lava could not be easily shaped in any regular form. Thus, the wall-facing looked more irregular than it did in other places, and a solution was needed for corners and door-posts, for which grey lava was not suitable. It is in this context that, in the case of the Odeon and the Forum baths, a choice for fired brick was made. Yet the brick did not stick: after

54 The facing is sometimes described as *opus quasi-reticulatum* (e.g. Lugli 1957, 498).

55 Adam (1994, 131) notices similarities with the Augustan (?) amphitheatre in Cassino, and the catalogue of Welch (2007, 189–252) makes clear that there were many parallels for the use of semi-regularized *opus incertum* resembling *opus reticulatum* in late-Republican amphitheatres, but there are no parallels for the use of bricks. For theatres see Sear 2006, 119–195.

56 Santangelo 2007, 72–73.

FIGURE 7.6 Pompeii, Odeon: early colonial *opus incertum* with grey lava and brick
PHOTO: MIKO FLOHR

these early colonial construction projects, Pompeii's new Roman elite seems to have adopted the traditional regional building materials.[57] First century BCE second style wall-decorations in Pompeii are generally associated with corners and door posts of *opus vittatum* in tuff or Sarno Stone.[58]

In Rome, the situation was similar: despite the famous Suetonian saying that Augustus left 'in marble what he had found in brick', there was hardly any brick in Rome in 27 BCE.[59] Late Republican architecture in the city almost

57 This is exemplified by the tomb of M. Porcius outside Porta Ercolano, who had been involved in the construction of the odeon and the amphitheatre, but was buried in a tomb of Nocera tuff and travertine. See for this tomb Kockel 1984, 53–57. There may have been some continuity: some tombs in the Via Nocera necropolis use a construction technique similar to the Odeon and the Forum Baths (cf. D'Ambrosio and De Caro 1983, 4EN, 6EN, 10EN); D'Ambrosio and De Caro date these tombs to the Augustan period, but they may well have been constructed in the preceding decades.

58 As e.g. in the Villa dei Misteri (Maiuri 1937), in the House of the Labyrinth (VI 11, 8–10, Strocka 1992) and in rooms 11–13 off the east side of the peristyle of VI 8, 20–21.2 (personal Observation). On the second style see Heinrich 2002.

59 Suet. *Aug.* 28.3: *marmoream se relinquere, quam latericiam accepisset*. Suetonius clearly misinterpreted the story, and re-anchored it in the building practice of his own age; Dio used slightly more neutral terms: 'τὴν Ῥώμην γηΐνην παραλαβὼν λιθίνην ὑμῖν καταλείπω' (56.30: 'I found Rome made of earth, and left it to you made of stone'), adding that

FIGURE 7.7 Pompeii, Temple of Fortuna Augusta
PHOTO: MIKO FLOHR

completely depended on tuff, and used either ashlar or concrete with a facing in *opus reticulatum* combined with corners and door posts of *opus vittatum* in the same material.[60] Public architecture of the Augustan period continued in this vein, with a clear preference for ashlar. It is in the private architecture of the metropolitan elite—in houses and tombs—that brick first began to appear. Indeed, one of the earliest uses of brick in Rome is—perhaps somewhat ironically—in the House of Augustus on the Palatine; the first public building in Rome to use brick-faced concrete is the theatre of Marcellus, where it can be found in the inner concrete vaults.[61] In Pompeii, brick was used in the door posts of the Temple of Fortuna Augusta, which was constructed around 3 BCE or a little later (fig. 7.7), and in the Augustan reconstruction of the theatre by Holconius Rufus, where it was used for the facing of the *scenae frons*.[62] After the Augustan period, brick became a more common building material in

Augustus was not literally referring to the architecture of the city, but rather to the robustness of the state.

60 See esp. Lugli 1957, 505–506.

61 For an overview see Lugli 1957, 588. On the house of Augustus on the Palatine see Gallocchio 2019. On the theatre of Marcellus see Buonfiglio 2016.

62 On the Temple of Fortuna Augusta see Van Andringa 2009, 56–59. On the theatre of Pompeii see Johannowsky 2000, 20.

Rome and Pompeii, but not overwhelmingly so. In Pompeii, most brick-faced walls are associated with the 60s and 70s CE, when large parts of the city were reconstructed after earthquake damage.[63] In Rome and Ostia, brick only became dominant in the (very) late first century CE.[64] In many places in the peninsula, and indeed elsewhere in the Roman world, brick-faced concrete would always remain, at best, a secondary building technique, even if it was occasionally used.[65]

It is not hard to see why the application of brick in actual building projects in many places remained limited: brick required a dedicated industry that needed investment in specialized equipment and access to raw clay. This was not uncomplicated: raw clay could be won in many places, but it would often be found in locations that could also be used for agriculture—meaning that land owners would have to weigh their priorities. In many places, agriculture may often have been more rewarding than clay extraction. Thus, if good-quality building stone was locally available, this might often have been the more straightforward option for urban builders. Economically, brick particularly would come into the picture when elite land owners developed a direct interest in urban construction—because they were personally involved in big public construction projects, or in urban property investment, and because such initiatives were financially or socially rewarding. The Roman metropolis, and its booming property economy of the later first and second centuries CE was one obvious context where brick production became feasible; Pompeii in the period following the seismic upheavals of the early 60s CE was another; large-scale public building projects—such as the Baths of Caracalla and the Aurelian walls—also offered circumstances that could justify dedicated investment in brick production. In most places in the Roman world, these conditions were never met on a structural basis. By consequence, in many places, quarried stone remained the preferred building material throughout the imperial

63 See e.g. Fröhlich 1993, 157; Wallat 1993, 356.

64 For Rome, the Neronian fire of 64 CE has sometimes been seen as a watershed (Cf. MacDonald 1982, 30; Van Oyen 2017, 145), but besides imperial building projects, including the *Domus Aurea*, the Neronian Nymphaeum and the aqueduct branch to the Caelian hill, there are relatively few buildings in plain *opus latericium* that can be dated to the years immediately following the disaster, while there is considerable evidence for *opus latericium* in earlier Julio-Claudian projects, such as the *Castra Praetoria* (Lugli 1957, 590), and the Neronian Baths of 62 CE (Lugli 1957, 595). See also Blake 1959, 11.

65 At Paestum, for instance, brick was used in a reconstruction phase of the amphitheatre, in the 'basilica', in some *tabernae* and in imperial-period bathing installations, but never consistently: brick was clearly 'anchored' in the local building repertoire, but it was only used under certain circumstances, in particular construction projects.

period, even though, in many places, it seems clear that brick was well-known as a possible building material.

6 Discussion

The introduction of concrete, the development of *opus reticulatum* and the appearance of brick were three of the defining changes in Roman (metropolitan) building practice that paved the way from the ashlar of the Servian walls to the *opus latericium* of the Aurelian walls. In line with recent discourse on innovation in archaeology, analysing the coming about of these changes at a micro-level highlights first and foremost their gradual character: each of these changes gradually 'conquered' building practice, starting either from the corners of the walls, or from the centre, or being achieved through a number of subsequent steps. Moreover, it also makes clear that local circumstances played a key role in the uptake of innovations: for concrete, this was not only the availability, in certain locations, of volcanic ash, but also the increased range of materials that could be used in wall facings held together by strong mortar, which could—locally—lower construction costs. The regularization of *caementa* and the emergence of *opus reticulatum* were facilitated by the benefits of separating materials preparation from construction. This was caused by the seasonal limits imposed to the erection of walls of concrete in the context of large-scale urban construction in the Roman metropolis. For the use of brick, there is the growth of a large-scale brick industry in a limited number of places with sustained high levels of larger scale construction activity—again, the city of Rome played a key role. More importantly, however, in all three cases, the social and economic limits to the diffusion of the innovation appeared as pronounced as the eventual impact these new techniques would have in some places.

The role of using 'anchoring' in this analysis has been to direct the enquiry towards the actual introduction of practices into the technical vocabulary of builders, to extend it beyond the empirical questions of where and when into the hermeneutics of why and how. The result is a history of innovation and change that, compared to earlier discourse, is more sensitive to everyday practices, and to decision-making processes 'on the ground'. It has also resulted in a narrative that evokes a more fragmented picture of innovation than regular discourse on the history of Roman concrete has done: instead of a progressive sequence from the first experiments with pozzolana to the *opus latericium* of imperial and Late antique Rome, what emerges is rather a gradual diversification of the amount of options available to the people involved in construction. This change of perspective is extremely meaningful: earlier approaches have primarily looked at the evolution of building technology in hindsight—starting from the materials and techniques used in the Baths of Caracalla or the Pantheon in Rome. From such a perspective, inevitably a simplified genealogy emerges that suggests a gradual, but ultimately linear development towards a pre-defined end point.[66] Conversely, analyzing the individual contexts in which innovations became anchored, and the decisions taken (and not taken) at those moments, generates a much more diverse, much more complex picture—and one that is much more intimately connected to local urban histories of practice. Ultimately, this allows for a much more complete understanding of the chronological and geographical diversity of Roman construction practice than the genealogies of Roman concrete that have dominated discourse on Roman building technology, and it makes it possible to de-center and contextualize the spectacular, but outrageous developments of building practice in and around the Roman metropolis.

Finally, it could be argued that the argument made in this chapter differs from most earlier approaches to anchoring in two meaningful ways. The first is that the actual processes of anchoring have mostly remained implicit: rather than anchoring strategies, this chapter has essentially discussed processes and circumstances of 'becoming anchored'. The second difference is that the episodes of anchoring in the evolution of building techniques were not simply isolated instances of adopted innovation, but rather specific moments in much longer trajectories of change. As such, they were not only responsive to what preceded, but also shaped the possibilities in what was to come. I would suggest that both points enrich the conceptual anatomy of 'anchoring'. The first highlights the distinction between the discursive practices that made that an innovation could 'stick', and the event of sticking itself: both can be referred to through 'anchoring', but they are different things that may need to be distinguished more sharply in anchoring literature: 'anchoring narratives' do not need to lead to 'anchoring events', while anchoring events can occur without explicit narratives.[67] The second point highlights the need to close-read anchoring narratives and anchoring events in their evolving historical context: anchoring a 'new' idea to something that already was there was not so much a matter of making a connection between two stably existing things, but rather of durably connecting an emerging phenomenon—e.g. brick—to an evolving

66 As most explicitly in Van Oyen 2017, 140–146.

67 On discursive practices connected to anchoring see Sluiter 2021. Hekster 2020, 104 touches upon, but ultimately evades this distinction in discussing the use of *spolia* in the Christian *basilicae* in Later Antiquity. These spolia may be seen as discursive—a strategy to make seem familiar what in fact was new—but they also may reflect that basilicae *had become anchored* in normal practice and *thus* could share in the visual language that had long been reserved for *fora*.

target—concrete—in one specific place at one specific moment. Anchoring happens between ideas and practices that are in flux, and an established connection affects both: after brick became anchored in concrete, not only the history of concrete changed, but also that of brick, which subsequently could be mass-produced for large-scale construction in *opus latericium*. Anchoring, thus, does not refer to a (desired) *end point*, but to a moment of transition; it creates new possibilities as much as that it realizes existing potential. The examples discussed in this chapter have also suggested that anchoring events not only (or even 'not so much') transform practice, but rather diversify: the result of an anchoring event often was an increase in the number of options available, and a multiplication of subsequent development trajectories.

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