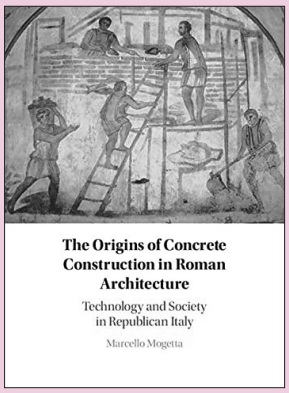

Book Review: The Origins of Concrete Construction in Roman Architecture: Technology and Society in Republican Italy

Marcello Mogetta
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Abstract

This book presents an analysis of early concrete architecture in Rome and Pompeii. Roman concrete, which includes volcanic ash, is an outstandingly durable material that in some cases has endured for thousands of years.

It far outlasts Portland cement, the most common modern building material, and is much less vulnerable to the effects of seawater. In addition, its production methods are less damaging to the environment than more modern substances. Among iconic buildings constructed with Roman concrete is the celebrated Pantheon in Rome.

The author argues that Roman concrete was first utilized around the middle of the second century BCE. Its technical implementation in public constructions appear to have occurred after use in private projects, including reconstruction of costly, high-level homes. Public building in Rome and Pompeii was organized by a small circle of nobility who hired private builders. While public monuments were first seen in Rome and Pompeii from around 150 to 125 BCE, the widespread popularity of Roman concrete had to wait until the end of the second century BCE.

The use of concrete in Roman architecture began to be omnipresent as adopted in Rome, but also in distant Pompeii and Campania. These innovative techniques were brought about by local élite groups, many of whom were not of Roman origin. In these localized centers of creativity, Roman concrete flourished.

How the localized spread of these building techniques was achieved is of ongoing interest, insofar as some advocates today point to the ecological virtues of Roman concrete, its durability and other advantages compared to more recently developed building materials. Enduring principles of concrete production may guarantee that lessons learnt from Roman concrete can be applied to modern building practice.

Keywords: Roman concrete, Volcanic ash, Portland cement, Rome, Architecture, Pantheon.

Modern builders must always feel modesty when confronted with notably superior techniques of previous eras.

Today's Portland cement, the most common type of cement in general use around the world, tends to disintegrate over time in seawater, lasting about fifty years. A significant after-product of Portland cement is carbon dioxide, which is harmful to the environment.

By contrast, the ancient Romans, as modern chemical analysis has revealed, mixed lime and volcanic ash to produce cement, which was then combined with volcanic rocks. Exposure to seawater actually strengthened the cement on a molecular level, and Roman concrete has proven remarkably durable.

One example is the Pantheon, a former Roman temple probably dedicated around 126 A.D., featuring the largest unreinforced concrete dome in the world. Now, despite being exposed in carbon monoxide fumes from traffic at its central Rome location as well as acid rain, the concrete dome of the Pantheon is still intact, without any steel reinforcing rods. The dome does contain some cracks, but is holding up remarkably well.

As structural engineers have noted, without steel reinforcement, the Pantheon could not be built today nor would builders be allowed to try, since it would be considered too unstable. Yet it has lasted almost 2000 years.

Perhaps somewhat less celebrated internationally, but in even better condition is another outstanding Roman concrete work, the Pons Fabricius or Fabrician Bridge in Rome, a vaulted arch bridge 62 meters long, spanning half of the Tiber River, from the Campus Martius on the east side to Tiber Island in the middle.

The oldest Roman bridge in Rome still existing in its original state, the Pons Fabricius was built in 62 BC. This construction which originated in the time of Julius Caesar and the slave rebellion led by Spartacus is still used today as a pedestrian bridge or footbridge.

It is named in honor of Lucius Fabricius, a Roman official responsible for building roads and supervisor of the bridge. On one of the bridge's arches, an inscription informs us: "Lucius Fabricius, Responsible of the Roads, supervised the execution of this job."

Few if any architects or builders today can imagine that their creations will last thousands of years, and while we cannot be sure what Roman workers thought about their work, even they might have been surprised to find how long some of them survived.

In addition to its startling durability, the manufacturing process for Roman concrete involves less fuel and lower temperatures than Portland cement, representing further ecological advantages.

Despite its almost magical-seeming properties, ancient concrete was not a mystery material. Pliny the Elder, a Roman naturalist and navy commander, specified that superior maritime concrete was produced from volcanic ash collected near the Gulf of Naples.

Vitruvius, a military engineer and architect for the Emperor Augustus who died around 2100 years ago, wrote extensively about the use of volcanic ash in Roman concrete:

"There is a kind of powder which from natural causes produces astonishing results. It is found in the neighborhood of Baiae and in the country belonging to the towns round about Mount Vesuvius. This substance, when mixed with lime and rubble, not only lends strength to buildings of other kinds, but even when piers of it are constructed in the sea, they set hard under water. The reason for this seems to be that the soil on the slopes of the mountains in these neighborhoods is hot and full of hot springs. This would not be so unless the mountains had beneath them huge fires of burning sulphur or alum or asphalt. So the fire and the heat of the flames, coming up hot from far within through the fissures, make the soil there light, and the tufa found there is spongy and free from moisture. Hence, when the three sub- stances, all formed on a similar principle by the force of fire, are mixed together, the water suddenly taken in makes them cohere, and the moisture quickly hardens them so that they set into a mass which neither the waves nor the force of the water can dissolve."[1]

Romans had a particular advantage in using volcanic ash in their construction techniques, because volcanoes erupted periodically around Rome and Naples. The best remembered of these eruptions was of Mt. Vesuvius in southern Italy in A.D. 79, destroying the resort city of Pompeii, on the Bay of Naples. And because the Romans built extensive road projects, volcanic ash could be transported efficiently around the nation for building projects.

Whereas modern day Portland cement applies extreme heat to bond lime to clay, volcanic ash had already been through this process naturally and had gone through the chemical reactions needed to strengthen it. The result was of such lasting interest for construction that some current advocates argue for a building material that adapts Roman concrete to present-day architectural needs as a replacement for Portland cement. So the subject remains especially timely.

Assistant Professor Marcello Mogetta teaches Roman Art and Archaeology at the University of Missouri in Columbia, Missouri. USA. Educated at the University of Rome and the University of Basilicata at Matera, he

specializes in Italian field archaeology, earning a Ph.D. in classical art and archaeology from the University of Michigan.

His thesis, The Origins of Concrete in Rome and Pompeii (2013) analyzed early concrete architecture in Rome and Pompeii. The present book further develops some of these investigations in a somewhat more elaborate literary style. Paradoxically, Assistant Professor Mogetta's thesis is more clearly written than this new book, possibly due to different editorial assistance. Assistant Professor Mogetta's excavation and survey work at Rome (Palatine Hill) and Pompeii (Temple of Venus), among other sites, helps him understand how concrete technology began and spread in Roman Republican architecture.

Although most studies of the Roman Empire focus on the centralized political power of its rulers, Roman concrete was apparently developed through "innovative techniques" that "emerged independently in the provinces, in response to local environmental circumstances and sociopolitical conditions."

Concrete construction was referred to in Latin as opus caementicium, and became identified over the years as a characteristic part of Roman practical ability in matters like construction.

However, archeological evidence from the Greek Islands reveals that volcanic ash was added to create high-quality building materials hundreds of years before Roman builders used them locally. This suggests that the Romans did not entirely discover the technology that is the basis for opus caementicium, but Roman architects surely implemented the discovery with skill for structural reinforcement.

As Rome developed its colonization program, colonial sites were redeveloped through ambitious building programs.

While it is now impossible to say which individual builder developed these novel approaches to cement manufacture, Assistant Professor Mogetta observes, "Technological change is often brought about as a result of everyday use and experience of something that already existed rather than abstract thought. Thus, innovation happens with relation to an existing tradition, to which it contributes something 'new.'"

The advantages of Roman concrete took shape on the local level, as builders who often traveled between building sites derived technological solutions. Rather than a centralized process responding from orders from the capital, these advances were the result of imaginative solutions created at provincial locations.

Surviving contracts for architectural projects from about 2200 years ago show that landowners and builders of the day made agreements, supervised by local magistrates and town councils in colonies for public projects.

One of the aims of Assistant Professor Mogetta's research was to disprove previously held notions that building techniques were developed and transmitted through architectural models originating in Rome.

Instead, he points to recent archaeological discoveries dating to about 2200 years ago, revealing that most monumental construction apart from fortifications and temples coincided with the development of concrete construction.

This flurry of building activity is described by Assistant Professor Mogetta as an "euergetic urge that was driven by the colonial elites."

Euergetism, from a Greek term meaning to do good deeds, was the ancient practice of high-status and wealthy individuals in society who distributed part of their wealth to the community, rather than to individuals. This practice was also part of the patron-client relation system of Roman society.

This neologism, or newly coined term, was invented by the 20th century French historian André Boulanger. The euergetic urge that motivated colonial elites was directed toward projects built for the benefit of local sociopolitical institutions.

With these participants eager to help society, the question became how new technology could be diffused to help projects be realized in as strong and permanent a way possible.

Assistant Professor Mogetta suggests that elite networks of skilled craftspeople may have moved from project to project, resulting in the transfer of technology. Insofar as local contexts and needs spread the technology to remote corners of Roman Italy, the problem became who to hire to make sure the processes were done reliably.

As a practical matter, Assistant Professor Mogetta notes, "groups of builders with similar backgrounds were involved in these projects… magistrates tasked with the completion of public works would have preferred to hire experts whose skills had been already put to the test."

This meant that building trade workers who traveled from project to project 2200 years ago became a feature of colonial urbanism. Ambitious building projects often required the importation of considerable numbers of skilled craftspeople, but only temporarily.

After the projects were concluded, workers moved on to the next location where they would be offered employment. Then as now, construction project schedules could be uncertain, and buildings that were intended to be finished by a certain date might be delayed, with schedules that advanced with some unpredictability. While it is uncertain how craftspeople learned about job opportunities, it is presumed that as always, independent workers heard about potential employers and followed up by making their availability known.

In monumental projects, it was considerably more economical and practical to move the building trade workers, rather than to have them work in a central location and then transport the finished products to the sites where they would be used.

Some building components in ancient Rome were signed, for example stone blocks, wall paintings, and mosaics. This makes it possible to be certain that most skilled building workers were not of local origin, but moved to a region expressly to work on a given project.

On occasion, the craftspeople were slaves, or former slaves who had been freed. For these workers, traveling was associated with social and economic imperatives issued by their present or former owners.

As projects followed other projects, further technological understanding spread. While today's builders using Portland cement are dealing with a material developed less than 200 years ago, the use of Roman concrete incorporating volcanic ash was refined over several centuries.

Processes that evolved included carefully using as little water as possible to mix the concrete, using wooden casting forms and special implements to force the concrete into place.

After the fall of the Roman Empire around 1600 years ago, when Roman territory was divided up into several entities, the Roman infrastructure decayed. The recipe for Roman concrete would be forgotten, until a version of it, minus the essential ingredient of volcanic ash, was rediscovered in the early 1800s in the United Kingdom. By helping readers to better understand how the use of Roman concrete spread through the Empire, The Origins of Concrete Construction in Roman Architecture offers hope that the enduring technological achievement it represents can offer hope for the future of the world's construction industry.

The book's structure is clear, distinguishing between general ideas of how Rome influenced its colonies, and how Roman material culture formed in distant corners of the Empire, sometimes not based on orders issued from Rome.

The first and second chapters deal with definitions and explanations of how concrete construction came to be viewed as a sign of Roman identity and self-image in specialized literature and popular writings. Chapter Two also analyzes ancient literary descriptions of the technology involved to weigh how building techniques became implicated in political debates about how the Roman elite wished to present themselves in public.

Through this self-expression, patrons and builders became the essential components for the communication and development of technology, rather than governmental orders from a centralized state. The author focuses on how identity was built in the domain of domestic architecture, and how this related to designs for public buildings.

The remaining chapters explore early development of concrete architecture in categories of settlements, including primary urban centers, select rural sites, and colonial foundations. There are detailed case histories of different sites and groups of sites in varied environmental and cultural zones. In this way, the social and cultural contexts of innovations at the local level are captured.

While the sites are organized geographically from the center of Rome outward to exterior regions, the traditional way of looking at cultural communication about building techniques in the Roman Empire as owing everything to messages issued from Rome is discounted here.

Chapter Three discusses the origins of concrete construction in Rome, underlining the importance of elite domestic architecture as a proving ground for early experimental phases of achievements, given that the latest archeological findings suggest that the earliest concrete public buildings were created slightly later than previously thought.

Chapter Four offers a more profound look at archaeological urban and rural patterns, comparing villas outside Rome with limestone architecture from the same era found in the territory of nearby Tibur. The question is asked whether easy access to volcanic ash and lime, essential ingredients for Roman concrete, were enough to inspire technological change.

Chapter Five recounts how different forms of construction were distributed as part of the urban development of Pompeii, another site rich in volcanic and limestone geological resources. The well-studied archaeological legacy of Pompeii establishes that highly placed societal leaders were able to boost innovations through commissions in domestic architecture.

As compared to other major urban sites in Rome, Pompeii's public buildings as a regional phenomenon revealed a lack of imposition of direct Roman political influence on fashions in building.

The final chapter, Chapter Six, attempts to add historical context through an account of Rome's colonization program in Cosa, a Latin colony founded in southwestern Tuscany in 273 BC, on land confiscated from the Etruscans to solidify the control of the Romans and offer the Republic a protected port; Puteoli or modern day Pozzuoli, a city and commune of the Metropolitan City of Naples, in the Italian region of Campania; Luna, known today as Luni, a municipality in the province of La Spezia, in the easternmost end of the Liguria region of northern Italy; and Aquileia, an ancient Roman city in Italy, at the head of the Adriatic at the edge of the lagoons, about 10 kilometers from the sea, on the river Natiso.

These investigations express doubt that technology was directly imported from Rome, rather than developed on site according to the requirements of individual projects. Overall, The Origins of Concrete Construction in Roman Architecture displays the development of concrete construction as originating through intricate communications between "Roman Republican political and economic power structures, local cultural traditions, and global waves of fashion. By highlighting the ways in which elite networks and personal agendas may have influenced the mobility of skilled craftsmen, it ultimately shows how technological transfer in Roman Italy could occur from the bottom up," as Assistant Professor Mogetta concludes.

Other authors have also been captivated by the uncannily effective properties of Roman concrete. David Moore, the author of The Roman Pantheon: The Triumph of Concrete (Mangilao, Guam: University of Guam Micronesian Area Research Center, 1995) designed imaginative experiments to reproduce Roman concrete using volcanic ash from Vesuvius, but also from the 1980 volcanic explosions at Mount St. Helens in Skamania County, Washington, the United States of America.

Such efforts indicate that a growing number of researchers are aware that enduring principles of modern and ancient concrete production may coincide. For this reason, careful study of Roman concrete manufacture can help modern builders produce a more efficient and durable material, even if it will not last as long as its predecessor.

Remark:

[1] Vitruvius Pollio, The Ten Books on Architecture, translated and edited by Morris Hicky Morgan (Cambridge, Mass.: Harvard University Press, 1914), Book II, Chapter Six, pp. 46-7.