

Romans' hot recipe for self-healing concrete unravelled in Pompeii

BY  ANTHONY KING | 11 DECEMBER 2025



Source: Archaeological Park of Pompeii

The neatly aligned ceramic roof tiles and tuff blocks found at a new excavation site in Pompeii reveal the organised storage of building materials ready for reuse during renovation.

Construction material uncovered by archaeologists in Pompeii has revealed that the Romans used 'hot mixing' to make concrete, new chemical analyses suggest.¹ The building materials and tools were discovered abandoned in rooms that were under construction when Mount Vesuvius erupted in 79AD, destroying the city.

'I walked into an excavation in Pompeii a year-and-a-half ago and it was like travelling back in time to a construction site in the Roman empire,' says [Admir Masic](#), a chemist at Massachusetts Institute of Technology who led the research. 'There were untouched piles of construction material vividly preserved.'

This historical snapshot captured work to repair a house in Pompeii after earthquake damage and just before the catastrophic eruption buried the Roman city. Close to walls under construction were piles of quicklime (CaO), a white solid made by heating limestone, and volcanic ash that was rich in silica and alumina-containing minerals.

Accounts by Vitruvius, a 1st century BC Roman architect and engineer, wrote that Roman concrete began with the preparation of quicklime from heated limestone that was then mixed with water to make slaked lime (Ca(OH)₂). This acted as a binder when combined with volcanic ash.

But Masic's team is now reporting that concrete production at Pompeii involved transporting quicklime and volcanic ash separately to a construction site, mixing the two dry powders and then adding water last to trigger an exothermic reaction that heated the mortar.

The MIT group previously analysed clumps of lime in ancient Roman mortars and proposed that they were the result of such hot mixing, which created hot spots in the forming concrete that could exceed 200°C.² The researchers concluded that these clumps wouldn't form if slaked lime was used and that this pointed to hot mixing as the method used to make these mortars. They came to this conclusion after chemically mapping the lime clasts and surrounding matrix and observing the microstructure of Roman mortars.

Two advantages of this method of making concrete are that it continues to strengthen over time and the material can even set underwater, allowing harbour construction, says Masic.

The 'lime clasts' left behind by hot mixing gave ancient concrete better longevity than today's Portland cement mortars. These clumps serve as reservoirs of calcium that can later dissolve and recrystallise to form various calcium carbonates or react with volcanic ash to create aluminosilicates. This restarts the cement-making process and fills in small fissures, healing small defects or damage.

'This is not an archaeology paper. It's a badass chemistry paper,' says Masic. 'We even showed using isotope analyses that the dry pre-mixed material is indeed quicklime.'

'This is a wonderful snapshot of a construction site in motion,' says [Marie Jackson](#), a geoscientist at the University of Utah. However, the evidence for ancient quicklime, which readily reacts with carbon dioxide in air to form calcite, is not entirely clear from the site, she says.

The Roman empire covered an enormous expanse of territory with many different types of concrete construction, she adds. 'Recent archaeological discoveries describe many nuances in the fabrication and installation of mortars in concrete structures along shorelines and in the sea.'

Jackson's research has shown that within monuments, such as Trajan's Markets in Imperial Rome (97–115AD), different concrete mixes and installation methods were deliberately implemented to enhance the performance features of concrete pavements, structural walls and vaulted ceilings.



Source: Archaeological Park of Pompeii

Neatly aligned ceramic roof tiles found at the site. Piles of pre-mixed quicklime and volcanic ash were discovered at the site too

‘A suggestion that the Romans never slaked, or hydrated, lime in concrete construction, would not be correct,’ says Jackson. ‘Romans were incredibly sophisticated in how they hydrated lime and mixed mortars and fabricated concrete structures.’

References

1 E Vaserman *et al*, *Nat. Commun.*, 2025, DOI: [10.1038/s41467-025-66634-7](https://doi.org/10.1038/s41467-025-66634-7)

2 L M Seymour *et al*, *Sci. Adv.*, 2023, DOI: [10.1126/sciadv.add1602](https://doi.org/10.1126/sciadv.add1602)

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