Learning from Our Past and Building for the Future

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Herodotus was among the earliest of a long roster of historians, geographers, pilgrims, travellers and conquerors to write about the pyramids. A more systematic approach to documenting and deciphering these monumental structures was launched with the Napoleonic Expedition in 1798–1801 and the resulting 23-volume publication of *Description de l'Égypte*. Ever since, Egyptologists and archaeologists have progressively revealed a rich body of knowledge about their dating, material forms and compositions.

Of the 118 pyramids in Egypt, and the even larger number in Sudan, those soaring high above the Giza Plateau outside Cairo are unquestionably of greatest renown. The three main pyramids at Giza – that of Khufu (or Cheops, Gk.), Khafre (or Chephren, Gk.) and Menkaure – were constructed between 2600 and 2500 BCE, during the fourth dynasty of the Old Kingdom. The fact that they remain structurally uncompromised and largely unaltered after four and a half millennia imbues them with an aura of permanence and eternity and they continue to rouse wonderment in all who visit and study them.

The Pyramid of Khufu, also popularly referred to as the Great Pyramid, is the tallest, originally reaching 146.6 metres high and remaining the loftiest humanmade structure until the completion of Lincoln's Cathedral in 1311. Composed of more than 2.3 million well-fitted blocks of stone, each weighing several tons and of non-uniform dimensions, it is estimated to have taken between just 20 and 30 years to build. Precise measurements of Khufu were recorded for the first time in the 1880s by British Egyptologist Sir Flinders Petrie. Its base is aligned almost perfectly with the cardinal directions and would have originally measured 230.3 metres square. The incline of its four faces is 51.5 degrees and its exterior was once clad in a smooth facing of brilliant white limestone, rendering a crisp, uniform geometric object. The Pyramid of Khufu was the oldest of the seven ancient wonders of the world and is the only survivor of that beguiling list of magnificent monuments.

Regarding the building of the pyramids more generally, there is broad consensus among scholars on the location of the quarries, the extraction processes, the tools used, the methods for dressing the stone, and even the ways that the gargantuan blocks were transported to the construction sites. Calculations have also been made for the rate at which the stones needed to be quarried and the velocity at which they needed to be moved and positioned in order to complete individual pyramid structures within the estimated timeframes of their construction. We have also learned from archaeological examination of the workers' camps in the vicinity of Giza about the size and compositions of the workforces, and even a little about their living conditions. A vital issue that remains unresolved, however, is the question of how the pyramids were physically assembled, from ground level to apex. It is this that architect Tom Leiermann ambitiously attends to in this book.

In doing so, Leiermann joins a long genealogy of eminent scholars, originating with Herodotus and Diodorus Siculus and extending to present-day archaeologists, engineers, mathematicians and physicists. Leiermann's adoption of an ethno-archaeological method delivers originality to his approach and fresh perspectives to our understanding about the ways that these enduring monuments were mechanically realised and the organisation of their resources and work teams. In his theoretical and engagingly illustrative reconstructions of the building programmes of Djoser's step pyramid at Saqqra, Snefru's so-named Bent, Red and Meidum pyramids, and the three great pyramids at Giza, Leiermann's principal focus is on the processual and progressive developments of the ramp systems erected to transport stone blocks efficiently and effectively from ground level to the ever-rising height of the monuments. In particular, the Meidum pyramid, with its three stages of construction and traces of the ramp used for its assembly, supplies the author with important clues for reimaging the building of Khufu, Khafre and Menkaure. His manuscript also addresses important longstanding questions about how the pointed peak, or "pyramidion", of the pyramids were placed into position and how the smooth outer casing was achieved.

Leiermann's thinking creatively combines architectural reasoning, an engineer's sagacity, and ethnographic methods that draw upon his expertise in vernacular earthen architecture and practical working experience with traditional builders in Yemen's Wadi Hadhramaut. Informed know-how about vernacular technologies has enabled him to move beyond the quest for a single model to explain the design and construction of ramps for pyramid building to a richer variety of project-specific solutions that take into account a host of contextual factors, including environmental, historical, cultural and technological. The rationalisations for the individual ramp solutions he supplies are grounded in deep considerations of the real possibilities and physical limitations that would have confronted master masons and work teams during the third and fourth dynasties of ancient Egypt, as well as the incremental learning that would have been amassed through the successes and failures of daring experimentation.

Most significantly for me, as an architect and social anthropologist of traditional building-craft knowledge, Leiermann's book underscores the importance of learning from the past, not merely for the intellectual satisfaction of solving riddles of ancient engineering marvels but in order to incite practical thinking and action concerning the future of design and building. This is especially salient in our era of growing urbanisation, over-exploitation of diminishing natural resources, environmental collapse due in large measure to excessive carbon emissions, and the production of unmanageable quantities of (toxic) waste. Notably, the latter includes that generated by the hastening cycle of demolition and construction of buildings and infrastructure of all description. This accounts for 30 per cent of waste produced globally, of which more than 35 per cent finds its way to landfill sites.[1]

While humankind has made considerable advances over the centuries in structural design, building technologies and construction methods, contemporary urban planners, architects, engineers and manufacturers of materials and building systems have a great deal to learn about durability and long-term sustainability. Careful studies of extant ancient structures, such as the pyramids, the mud-brick vaulted granaries of the Ramesseum (circa 1300 BCE), the tower houses of Sanaa, or countless other examples, can teach us about design solutions and construction methods, but also about choosing stable and appropriate sites, using locally-available building materials that require minimal transportation and little to no industrial transformation, and making structures and infrastructure that survive long beyond their creators.

Many contemporary building materials, in fact, last for just a few decades or a century at most. Many also involve damaging extraction activities, transport over long distances, and processes of industrial transformation and production that consume high amounts of energy and are detrimental to the environment. The production of cement and concrete, for example, accounts for an estimated 6 to 8 per cent of global CO2 emissions and is depleting the sand on beaches and in riverbeds and reducing mountainsides to open pits and craters. Modern concrete often begins to deteriorate after only a few decades, but if properly maintained it might have a lifespan of about one hundred years.

Why, then, have ancient Roman concrete structures, such as the dome of the Pantheon or still-functioning aqueducts, lasted for millennia? This question has driven recent scientific inquiry into the chemistry and composition of Roman concrete and, in parallel, the search for new, more resilient and environmentally friendly mixes for today's construction industry. With the use of Raman microspectroscopy imaging techniques, scientists now know that the lime clasts found ubiquitously in Roman concrete were not the result of careless mixing but rather were formed during the exothermic reaction caused by a direct addition of quicklime to the mix (i.e. 'hot mixing'). These lime clasts possess a self-healing capacity in that they react with water that penetrates into the fissures of ageing concrete to 'recrystallise as calcium carbonate and quickly fill the crack, or react with the pozzolanic materials to further strengthen the composite material'.[2] Such re-discoveries of ancient

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[1] Purchase CK, Al Zulayq DM, O'Brien BT, Kowalewski MJ, Berenjian A, Tarighaleslami AH, Seifan M. 2021. 'Circular Economy of Construction and Demolition Waste: A Literature Review on Lessons, Challenges, and Benefits', in *Materials* (Basel). 2021 Dec 23;15(1):76.
[2] See L. Seymour, J. Maragh, P. Sabatini, M. di Tommaso, J. Weaver and A. Masic, 2023. 'Hot Mixing: Mechanistic Insights into the Durability of Ancient Roman Concrete', in *Science Advances*, volume 9, number 1, 6 January 2023.

know-how can fruitfully inform contemporary manufacturing and building practices by rendering what we make more durable and thereby reduce the construction industry's complicity in environmental degradation.

My final example briefly highlights key learnings from the study of ancient and traditional earthen construction technologies. The archaeological record reveals that unbaked earth has been continually used as a building material from the neolithic period to modern times, whether in the form of modular mud bricks, rammed earth, cob or wattle-and-daub.[3] In Ancient Egypt, earth was the chief material for constructing all manner of buildings from dwellings and citadels to monumental structures,[4] and this was also the case throughout ancient Mesopotamia, Anatolia, Persia and Arabia, and, indeed, across all inhabited continents. The advent of nineteenth-century industrialisation and urbanisation accelerated the abandonment of earthen buildings and twentieth-century modernism promoted a near-universal appetite for steel, reinforced concrete and glass curtain walls, and, subsequently, complex, multi-material exterior sheathing systems. Again, the life expectancy of these materials and components is a century and often far less.

By contrast, archaeological remains at Çatalhöyük, the Great Ziggurat at Ur and Los Morteros on Peru's north coast, among many others, demonstrate the ability of earthen building components to endure for millennia. Numerous extant earthen architectural masterpieces have persevered for centuries, such as the medieval fort of Bahla in Oman, the Ksour of Morocco, the Sahelian mosques in Djenné, Timbuktu and Agadez, the fortified Chinese Fujian *toulou* communal dwellings, and the Yemeni 'high-rise' city of Shibam, where Leiermann has worked. So too have countless vernacular settlements, farmsteads and individual dwellings around the world. Popular awareness of the diversity and expressive qualities of earthen architecture took root in the 1960s in tandem with the rising allure of so-called "primitive" architecture.[5] During the following decades, scholarly publications on earthen architectural heritage flourished and dedicated scientific research into the materials and myriad techniques for preparing, processing and building with earth became firmly established.[6] Close examination of earthen materials from

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[3] See A. Daneels and M. Torras Freixa (eds.), 2018. *Earthen Construction Technology, Proceedings of the XVIII UISPP World Congress, 4–9 June 2018, Paris*. Volume 11. Archaeopress Publications.

[4] Egyptian architect and author of *Architecture for the Poor* (1973), Hassan Fathy, examined the mud-brick vaulting of the Ramesseum and earthen construction of ancient structures around Aswan in developing his contemporary designs for affordable and thermally comfortable dwellings and public buildings in New Gourna – a settlement commissioned by the Antiquities Department in 1946 and located near Luxor.

[5] For example, see B. Rudofsky, 1964. *Architecture without Architects*. New York: MoMA.

[6] A notable leader in this broad field of research has been CRATerre, founded in 1979 and based at the École Nationale Supérieure d'Architecture de Grenoble. The Getty Conservation Institute, ICOMOS, ICCROM and UNESCO have also played seminal roles in promoting knowledge about and safeguarding earthen architectural heritage.

archaeological and living heritage contexts can recover ancient and vernacular strategies for stabilising mud bricks and renderings, including the addition of mineralogical and botanical substances that bolster compressive strength, allow for stable expansion and contraction in response to changing humidity levels, and fortify surfaces against erosion by wind, sun and rain.

In the same spirit as those current efforts to produce "greener", lasting concrete, a reembracing of earth as a present-day building material would also constitute a critical step in decelerating the pace of climate change. Suitable soils, including loam and laterite, are generally abundant and locally accessible, thereby minimising transportation costs and carbon footprint. They are easily prepared, worked, moulded and handled, involving no other energy but the heat of the sun for drying. Earthen building techniques entail a modest palette of uncomplicated tools and no machinery, thereby enabling wider, more inclusive participation in the construction processes, as well as in the cycles of repair and maintenance. Structures can be economically modified in response to changing household needs or building programme requirements. If walls are homogenous and sufficiently thick, they absorb daytime heat and radiate it at night when temperatures drop, thereby producing optimal thermal inertia as well as constant humidity levels within the interior spaces. This eliminates need for electric or generator-powered air conditioning and dehumidifier systems. And, significantly, earthen building materials can be recycled and reconstituted; or, when abandoned, they return from whence they came without harmful or toxic impact.

Ancient and vernacular architectural heritages, whether erected in stone, concrete or earth, need to be reconceptualised as repositories of knowledge rather than merely as mute representations of bygone eras to be preserved for posterity. Leiermann's book simultaneously rouses awe at the problem-solving skills of our ancestors and ambitions to build better and more sustainably in terms of duration and environmentally. I am not suggesting that we replicate past building methods, but that, in rediscovering the wisdom and the know-how, we adapt our learning to the current needs and changing conditions of our time, place and environmental context. This, of course, demands not only individual resolve but the collaborative force of communities, the commitment of trained professionals to think creatively and daringly beyond standard construction solutions, and the willingness of authorities to adapt building regulations accordingly. This is a tall order, but a necessary one for our future and the survival of our small blue planet.