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Engineering History and Heritage

Editorial

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When I was a student, recording a historic building or landscape was a slow, physical and intensely manual process. We measured by tape, climbed scaffolding, sketched by hand, annotated drawings on site, and then returned to the laboratory or studio to translate those records into CAD. The process was imperfect, but it forced a particular form of attention. One had to look carefully, measure selectively, and make decisions about what mattered. More than three decades later, the tools available to heritage professionals have changed beyond anything I could then have imagined.

Today, point clouds, multi-source data fusion, artificial intelligence, sensor networks, digital twins, laboratory characterisation and numerical modelling are transforming the evidential basis of heritage conservation. Historic buildings, structures and landscapes can now be recorded, modelled and monitored with remarkable precision. These methods do more than produce better drawings or more detailed records. They alter what can be seen, what can be measured, what can be compared over time, and what can be claimed as evidence.

Yet this technological progress also sharpens an old question rather than removing it. Accuracy, by itself, is not conservation. A highly detailed digital model may capture geometry without capturing meaning. A monitoring system may generate continuous data without creating accountability. A structural assessment may identify capacity without resolving the question of compatible intervention. Heritage is not only a physical object or a dataset, it is also a material system, a cultural record, a social setting and, often, a contested field of values. The central challenge for heritage engineering is therefore not only how to record heritage more precisely, but how to use that precision to support better judgement: what should be retained, what may be adapted, what must be repaired, who should be involved in those decisions, and how intervention can take place without erasing the very qualities that make the heritage significant.

This is not an argument against accuracy. On the contrary, accuracy matters profoundly. Poor records lead to poor diagnosis, and consequently poor intervention. The ability to capture complex geometries, monitor environmental change, model structural behaviour and reconstruct lost or damaged fabric has become indispensable to heritage practice. However, accuracy should be understood as the beginning of conservation judgement, not its end point.

A precise record does not automatically tell us what is significant. A detailed model does not determine what should be retained, repaired, adapted, or allowed to change. A digital reconstruction may create an apparently complete representation while concealing uncertainty, interpretation and absence. Similarly, a monitoring system may generate large volumes of data without answering the more difficult questions of responsibility, access, consent and action. In heritage engineering, the key question is not simply whether the evidence is accurate, but whether it is meaningful, accountable and usable.

The three papers in this issue can be read through this lens. Each addresses, in a different way, the movement from recording heritage towards deciding how heritage should be conserved: through the precision of digital reconstruction, the governance of digital preservation under development pressure, and the material and structural understanding required for compatible rehabilitation. Read together, they suggest that the future of heritage engineering will depend not only on better tools, but on better judgement.

Lin's paper begins at the point where many contemporary heritage workflows now begin: the production of a reliable digital record. The paper addresses a practical problem familiar to those working with complex historic architecture. Single-source methods, whether based on laser scanning or photogrammetry, may struggle to capture both geometric complexity and texture detail (Lin, 2026). The paper responds by proposing a workflow that combines multi-source data fusion, voxel quotient filtering, curvature-based feature extraction, Poisson surface reconstruction and point-cloud registration. The aim is not simply to produce a visually convincing model, but to improve the completeness, accuracy and technical reliability of the reconstructed architectural record.

This contribution is important because recording is never merely descriptive. The quality of the record shapes what can later be diagnosed, compared and acted upon. An incomplete point cloud, a poor alignment or a simplified surface model may all affect how damage, deformation, loss or change is understood. In this sense, this paper reinforces the value of accuracy as a foundation for heritage engineering. However, it also brings us back to the larger question. Once a building has been reconstructed with greater precision, what kinds of conservation judgement should that reconstruction support?

That question becomes more explicit in Su, Osman and Islam's paper. Here, the focus shifts from the technical reconstruction of

individual buildings to heritage under wider development pressure. The paper examines how Belt and Road Initiative-related infrastructure and tourism can both endanger and revitalise built heritage, using examples from Pakistan, Kenya, Uzbekistan and Malaysia (Su *et al*., 2026). Digital preservation is therefore presented not simply as a matter of recording vulnerable sites, but as part of a broader system of infrastructure, economic ambition, tourism management, cultural representation and governance.

The significance of this paper lies in its refusal to treat digital technology as neutral. Generative AI, IoT systems, digital twins and predictive monitoring may expand the capacity to document, simulate and communicate heritage. Yet they also raise difficult questions about bias, cultural agency, data ownership, consent and representational authority. A digital system may be technically advanced and still be weak as a conservation system if it lacks accountability, maintenance capacity, community participation or clarity over who controls the data. In this sense, the paper extends the argument from accuracy to responsibility. Heritage may be recorded more completely, but it must also be governed more carefully.

Cardoso, Paiva and Lanzinha's paper brings the discussion back to the material and structural realities of conservation practice (Cardoso *et al*., 2026). After the digital and governance questions raised by the first two papers, this study is a useful reminder that heritage is ultimately embodied in fabric, construction logic and accumulated material behaviour. The paper synthesises long-term fieldwork, laboratory characterisation, numerical modelling and statistical surveys to develop an engineering-oriented understanding of Tabique buildings: a vernacular timber-framed system incorporating earth-based infill, stone masonry and metallic connectors.

The importance of this paper lies in its insistence on system-level understanding. Tabique buildings cannot be assessed only by isolating their individual materials. Their behaviour depends on the interaction between timber framing, earth-based infill, masonry support and metal connectors. This has direct implications for rehabilitation. The authors argue that, although many Tabique buildings show deterioration, their constituent materials and structural systems may retain satisfactory performance. The problem is that common interventions often remove original timber systems and replace them with reinforced concrete or steel. Such approaches may appear efficient or compliant, but they risk erasing the very construction logic that gives these buildings their heritage value.

Taken together – although they arrive there by different routes – these papers suggest that heritage engineering must move beyond the production of better records towards the making of better decisions. Lin shows why precision matters. Su, Osman and Islam show why digital preservation must be accountable. Cardoso, Paiva and Lanzinha show why intervention must remain materially and structurally compatible. Accuracy is therefore necessary, but it is not enough. The real challenge is to convert records, models, data and tests into conservation decisions that are technically sound, culturally responsible and materially compatible with the systems they seek to preserve.

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