A PHILOSOPHY FOR PRESERVATION ENGINEERS

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This article summarizes some key aspects resulting from collaboration within the ICOMOS International Scientific Committee of the Analysis and Restoration of Structures on Architectural Heritage (ISCARSAH).[1] One product of this collaboration, the *ICOMOS Charter: Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage* (ISCARSAH *Principles*) was ratified by the ICOMOS 14th General Assembly in Zimbabwe in October 2003 and can be downloaded from the ICOMOS website.[2] Much of what is discussed below is based upon the philosophy advocated by the ISCARSAH *Principles*.

The philosophical framework and approaches discussed will be familiar. The principles of research and documentation, authenticity and integrity, compatibility (both visual and physical), minimal intervention, and reversibility are in harmony with those that are the foundation of the *Venice Charter* (1964) and *The Secretary of the Interior's Standards for Historic Preservation Projects* (1979). Although the concepts presented are not new, their comprehensive development within the ISCARSAH *Principles* is about as poetic as one can become in a highly technical arena. What is more, some of the principles set forth not only are valid for the preservation engineer but also would be appropriate for others involved in technical preservation.

Heritage Buildings and the Engineering Profession

The history, materials, and assemblies of heritage buildings (the term *building* is meant to include structures and monuments) present a number of unique challenges in their evaluation and restoration. For the preservation engineer the value of this heritage is not only in its outward appearance but also in the integrity of the hidden components, since they represent increasingly rare products of the building technology of their time. We find great satisfaction in crawling through dirty attics, basements, and crawlspaces — to see the old bones of the building, those aspects that may be of secondary interest to other experts.

For the engineer the protection of "public health, safety, and welfare" is paramount, and safety must play a key role in the evaluation and determination of the optimal recommendations for strengthening.[3] However, the application of modern building codes and standards to heritage buildings is extremely difficult. The application of current safety levels to match those used in the design of new buildings may require excessive, if not impossible, measures that ignore the incalculable robustness of these historic buildings and are also incompatible with preservation goals. As Giorgio Croci, former president of ISCARSAH, has said, each heritage building "should set its own standard rather than be expected to comply with current standards, which have been established for contemporary structures."

Framework of Thought

Philosophy is defined in a dozen ways, but for our purposes it is a "study of the principles underlying conduct, thought, and the nature of the universe" of preservation engineering.[4] What is your preservation-engineering philosophy? This question has come up countless times among our colleagues, and the answer is usually a short sentence or concise motto. These answers will not be repeated here, but typically they are similar to each other in that they refer to our interventions: how we avoid them if possible, how we limit them when they are necessary, and how we respect and use what remains of the original structure if we must intervene.

Can we consider the highly precise profession of structural engineering, relate it to the specific area of preservation, and then define a philosophy in just a few words? Most would agree that a framework for decision making would have to be further defined because of the peculiarities of heritage structures: they vary in size, shape, age, usage, material composition, structural system, geographical terrain,

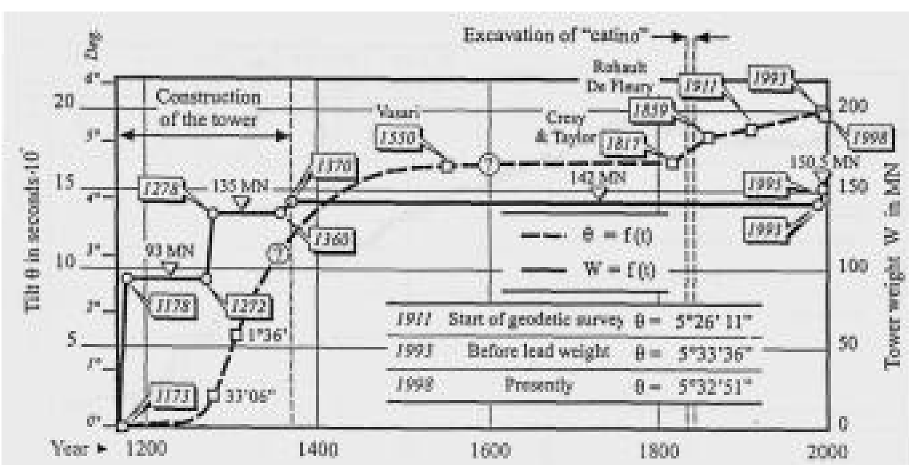

Fig. 1 The data in this graph shows the evolution of the lean of the Tower of Pisa over an 800-year period. This data could never be collected nor its significance understood in the course of a lifetime. Begun in 1173 and completed almost two centuries later, the tower was leaning noticeably during the 1272 construction campaign. The lean was first measured with a plumb bob in 1278, but after 1350 there were no known measurements taken for 500 years. The lean was measured with a plumb bob in 1817 and again in 1859. During the twentieth century the ever-increasing lean was almost continuously monitored using a variety of techniques. Graph courtesy of the Workshop on the Tower of Pisa, July 1999, Pisa, Italy, the International Committee for the Safeguard of the Tower of Pisa.

climatic location, the cultures that created them, and the cultures into which their care has fallen, just to name a few categories. Let's step back and look at the "big picture" and some concepts that may prove useful as a framework of thought.

Holistic View

There is a humorous aphorism: "Engineers are professionals who know a lot about a little and, as time goes by, know more and more about less and less until finally they know everything about nothing." The truth in this passage is that engineers are typically retained on projects to focus on specific issues and are not normally required to provide a more holistic view, which is usually the purview of others. Consequently, engineers become adept at speaking about details and other minutiae.

Preservation, restoration, and reinforcement of heritage buildings require a collaborative effort of many disciplines, structural engineering being only one. Preservation engineers, however, cannot afford to turn a blind eye to all else but the detail at hand. Our recommendations, if implemented, can impact other parts of the building that are seemingly unrelated to our work. There is, therefore, a responsibility to consider the whole, as well as the parts.

Medical Analogy

A medical analogy is one good place to start to further define a philosophy. If we are "building doctors" and the buildings are patients, then how is our relationship to these patients the same as that of the medical doctor and patient? How is it different? How should these similarities and differences affect our approach?

Buildings are alive. Though buildings, structures, and monuments do not live, they are living documents of our built heritage. We live in and around buildings, and they are a part of our consciousness. A building's lifespan is obviously finite, and its demise is always a sad loss. In this way they are alive for us.

Buildings can speak. Buildings speak but not verbally. Experts are trained to listen to them. One could argue that much of what is written in the *APT Bulletin* and similar publications provides a translation of this language.

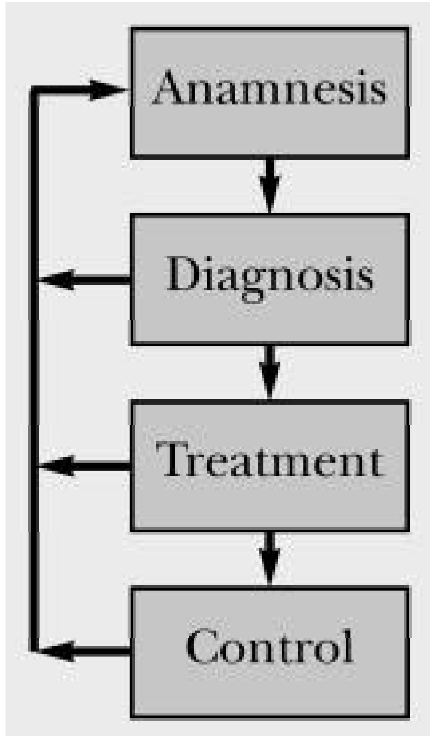

Fig. 2. This flow chart describes the medical analogy. It should be noted that a diagnosis amends and changes the anamnesis (or case history). Likewise any therapies or controls enacted will affect the anamnesis and future diagnosis. In this way the analogy framework is interdependent and cyclical, but not linear.

Buildings last much longer than we do. Here is an important distinction between our approach and that of the medical doctor. Almost without exception the buildings that we care for have a far greater lifespan than any single individual (Fig. 1). If we look at the span of time in those terms rather than our own, our intervention occurs in a short time frame.

With the medical analogy one can structure a way of reasoning similar to that used in medicine: anamnesis, diagnosis, therapy, and control. *Anamnesis* is the case history of a building, including past traumas, interventions, modifications, etc., and the research done to acquire this information prior to examination. *Diagnosis* is the process of identifying or determining the nature and cause of damage and decay through observation, investigation, analyses, and the conclusions derived from these activities. The evaluation of building safety is the underlying and last step in the diagnosis. *Therapy* is the choice of intervention in response to the diagnosis — be it preservation, restoration, or strengthening — and it addresses the safety issues. *Control* is the standard of comparison that is established for checking the results and long-term impact of the therapy.

These four steps follow sequentially (Fig. 2). We are introduced to a building and its complaints and are shown its past "medical records." Then an examination is commenced with review of historical documents, proceeding to a visual exam, sounding, and probing with nonintrusive devices. If found to be absolutely necessary, exploratory surgery is performed to reveal what lies beneath. Samples are also removed for laboratory testing. The collected data may be used for a more intensive analysis. Once the diagnosis is reached, one or several treatments are recommended. If we are stumped or concerned with an issue, we may suggest further evaluation and long term monitoring. Although the terminology may be new, the processes described are certainly familiar.

We (as a society and as professionals) sometimes err in our approach in the following ways:

We mistakenly envision a linear process that comes to an end. Once we have enacted a therapy, we may feel that the work is ended. But the process of preservation is cyclical rather than linear. Others have most likely intervened before us, and this work has an impact on the decisions that we make today. And our interventions will have an impact on the decisions of tomorrow. While our work represents only a brief moment in the history of the building, our actions may be evident for years to come.

We end at therapy and do not consider establishing control. Any intervention, no matter how slight, damages the historic fabric of the building in some way. The use of chemicals may remove material or otherwise change its behavioral characteristics. New materials or components having different physical properties can endanger original materials or components. Changing the load path of a structure from that intended by the original designer can also have serious and unwanted side effects. A cause-and-effect list could become quite long, and establishing controls for our interventions can provide valuable insight.

We do not recognize that preventative maintenance is the best therapy. Too often we will perform a therapy but then provide only the minimum of care for the building until major work is again required. Lee H. Nelson, a pioneer in the

Fig. 3. The atomic-absorption spectrophotometer is often used to perform quantitative elemental analysis. A solid is placed in solution and is then aspirated into a heat source, so that it can be measured. Elements can be identified by their signature wavelength, and the absorption of light by the aspirated atoms can be measured and quantified.

field of historic-preservation technology and career–NPS employee, frequently said that "historic buildings would seldom need to be preserved, restored, or rehabilitated [except to update systems] if they were properly maintained."

Preventative maintenance and repair is extremely important for the survival of any historic structure. Deferred maintenance often costs three to five times as much (or more) as preventative maintenance and results in more replacement of materials. If maintenance is deferred too long, parts of structures or whole resources can be lost. Preventive maintenance becomes particularly urgent in seismic areas. During such a disaster, nature has a way of finding the "weakest link" in the form of damage and decay in seconds.[5]

Approaches to Diagnosis

The medical analogy provides a framework for reasoning, but it does not provide an approach to begin the evaluation of heritage buildings. Each of the approaches presented has advantages and disadvantages. Thus preservation engineers should rely on more than one approach. The safety evaluation, which is the last step in the diagnosis, should reconcile these approaches.

The Historical Approach

Knowledge of what has occurred in the past can help to predict what might occur in the future and may provide an indication of future safety expectations. Consequently, satisfactory past performance becomes an important consideration when predicting the future service life of the building.

However, you have probably heard the common argument that "this building has stood for a hundred years already, so it should be ready for another hundred!" Susceptibility to such arguments is tempting because they are often presented by well-meaning preservation advocates. Such arguments should not be accepted without thorough scrutiny, and past safety is not always a reliable guide to future safety.

The following disaster aptly illustrates the pitfall of this argument. In 1989 in the town of Pavia, just south of Milan, the fourteenth-century *Torre Civica* (Civic Tower) collapsed suddenly, killing four people. The masonry tower walls had a core of masonry rubble laid in lime mortar that had decayed over the years due to water infiltration, but the decay was completely hidden, and the collapse came without warning.[6]

The Qualitative (Inductive) Approach

Analogous comparison can often be made between the present condition of a building and that of other structures that have related typologies and whose behaviors have already been studied and understood. A good example of similar typologies would be late-nineteenth-century basilica-type churches with wooden scissors trusses. Comparing the behavior of similar structures based on experience can offer a reliable basis for an evaluation of safety.

However, since this approach is based upon inductive reasoning, it can only provide an indication of the likely response and, therefore, is not entirely reliable. Such an approach relies more on personal judgment and less on scientific method. In essence it offers the same pitfalls as those described in the historical approach and the warning of the Pavia tower disaster still applies.

The Analytic (Deductive) Approach

The approach that is the foundation for most preservation engineers is the implementation of rigorous investigation (Fig. 3). A hypothesis is established before or during such an investigation, and the resultant conclusions are derived through deduction. This approach can employ modern methods of scientific laboratory analysis, mathematical modeling, and detailed monitoring of changing conditions.

However, even with logic that offers a degree of certainty, there are pitfalls — especially with unique structures. Material characteristics can change from age and use. Masonry decays from exposure; metals can fatigue; wood can become brittle, lose elasticity, and be attacked by insects and fungi; and so on. Inconsistencies between deduced and actual conditions are inevitable due to the simplified representation of the properties of materials and to the imperfect representation of actual structural behavior in mathematical modeling. Therefore, structural models are not completely reliable and can provide misleading results.

Conversely, an examination that shows that the structure does not seem to satisfy safety requirements does not necessarily mean that safety conditions are lacking. Such situations can occur when analysis is based on insufficiently accurate information (low reliability) or excessive caution (high prudence). Many robust structures could otherwise be condemned under such circumstances.[7]

The Experimental Approach

Specific tests can also provide evaluation of safety levels. Examples of such tests include the load testing of elements such as floor assemblies and individual components or the seismic testing of scaled models of buildings on a shake table (Fig. 4).

Even such precise testing has pitfalls. Load testing must take into account different types of pattern loading. Scale modeling of actual structures by their dimension and mass, though a precise science, cannot replicate subtleties of that structure. Seismic accelerations and frequencies delivered on a shake table are designed to mimic recorded historic seismic events and deliver only horizontal, not vertical, movements. In summary this type of approach, though extremely useful, is limited due to inherent heterogeneity and is only as valid as the design of the experiment.

Multiple Solutions

"Give ten engineers a problem, and you will get ten opinions on how to solve it." We are all creatures of habit and have our favorite way of doing things, but even so there is frequently more than one way to solve a structural problem. Multiple solutions are a good thing, and alternatives should always be considered. A therapy that is sensitive to one structure may be insensitive or even destructive to another. A cost-benefit analysis of the alternatives considered should be carried out: costs are measured in the potential loss of fabric due to the invasiveness of the therapy, and benefits can be gained by the therapy and by knowledge that will prove useful in the future. By thoroughly considering all feasible alternatives that offer safety, we can be reasonably certain that we are in fact providing minimal intervention.

Reporting Results

All interventions should be documented and maintained as part of the history of the structure in a report. We do not always thoroughly document the sources (the analyses and reasoning processes used) for our diagnoses or the reasoning behind our decisions about why certain therapies were rejected and the final one selected. The safety judgment and the consequent decisions of intervention should be recorded in such a way that all the considerations brought to the final evaluation and decisions are clearly explained. Conclusions and recommendations must take into account both the reliability of the decisions and any cautions underlying them. Stable conditions that can quickly become unsafe if no action is taken or required emergency temporary-stabilization procedures should be included in the report.

Conclusion

The ISCARSAH *Principles* provide an excellent foundation for preservation engineers to approach their profession. The concepts are based on sound principles and provide a framework for us to continue our important work without changing familiar approaches but by enhancing the retention of the structural integrity.

There is still work to be done on the ISCARSAH *Principles* for use in North America. They are international in scope and need to be tailored to fit our types of resources, materials, and technology; to conform with North American English; and of course, to reflect our culture. In the United States tailoring the *Principles* to our culture would also include considering the litigious nature of our society. It goes without saying that only equally safe alternative solutions should be evaluated because it is not in the interest of preservation to leave or put the occupants (including the preservation engineer) and heritage structure at risk.

Fig. 4. Testing of a 1:2.75 scale model of the Church of Sveti Nikita near Skopje, Macedonia, at the Institute of Earthquake Engineering and Engineering Seismology in Skopje (IZIIS). For a detailed discussion of this testing refer to Kelley, Gavrilovič, and Šendova. "A Study of Seismic Protection Techniques for the Byzantine Churches of Macedonia," *APT Bulletin* 34, no. 2-3 (2003): 63-69.

Fortunately organizations that write and publish building codes are now recognizing that existing buildings cannot comply with the prescriptive requirements of new codes in many cases and are writing codes for existing buildings with special provisions for historic structures. These new codes are performance based and allow alternative ways of providing adequate safety. The approach described in the ISCARSAH *Principles* is compatible with the approach of performance-based codes for existing and historic buildings.

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Notes

1. The committee, formed at the ICOMOS General Assembly in Sofia, Bulgaria, in 1996, is composed of preservation engineers and architects from around the globe, with active participation from representatives from Europe, Asia, Oceania, and North and Central America.

2. http://www.international.icomos.org/charters/structures_e.htm.

3. Of course evaluations and recommendations will also be defined by other factors such as economy, politics, time frame, availability of skilled craftsmen, etc.

4. *Webster's New World Dictionary*, Second College Edition (New York: Simon and Schuster, 1979).

5. The meaning of words becomes important in the ISCARSAH *Principles*. *Damage* is system based. It is defined as the "change and worsening of the structural behavior produced by mechanical actions or/and by the reduction of the strength. Reduction of the mechanical bearing capacity related to the breakdown of a structural system." *Decay* is material based. It is defined as the "change and worsening of the materials characteristics produced by chemical or biological actions. Chemical deterioration related to the breakdown of the materials of which a structural system is composed. Loss of quality, wasting away, decayed tissue."

6. The establishment in 1990 of the International Committee to Safeguard the Tower of Pisa is directly related to public concern following the Pavia tower collapse. The work of this committee led to the stabilization of the Leaning Tower of Pisa by extracting soil from beneath the foundations, which slightly decreased the lean. The tower, closed in 1990, was reopened to the public in December 2001.

7. In our experience the loss of heritage properties is often brought about by political pressure, and technical studies are the excuse rather than the reason for such decisions.