DOCUMENTATION/ RECORDING IN ENGINEERING EDUCATION

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Why Document?

"Architectural, engineering and landscape documentation broadens our experience of U.S. history. The historic built environment is frequently the only tangible evidence of history, and historic structures that can open new doors to understanding the past. They can be significant for their characteristics and features as well as for their association with people and events. As artifacts, they can provide insights into past cultures and activities, events and people (Burns 2004:6)". John Burns' explanation of why we document tangible heritage sees it as a record of human creations that might, inevitably, be lost. As Charles E. Peterson, the initiator of the Historic American Buildings Survey (HABS) put it in his 1933 memorandum to his superiors at the National Park Service, "*The plan I propose is to enlist a qualified group of architects and draftsmen to study, measure and draw up plans, elevations and details of the important antique buildings of the United States. It is the responsibility of the American people that if the great number of buildings must disappear through the economic causes, they should not pass into*

unrecorded oblivion . . . " The concept of recording as an archival memory of the past is not without merit, and with the subsequent addition of the Historic American Engineering Record (HAER) in 1969, and the Historic American Landscapes Survey (HALS) in 2000, the Heritage Documentation Programs within the National Park Service have deposited an extraordinary collection of drawings and photographs in the Prints and Photographs Collection at the Library of Congress. The collection, now largely accessible digitally, serves as a unique memory-bank of American aesthetic tastes, cultural heritage, and technical ingenuity (Woodcock 1998:21).

While the changing scale and scope of conservation are confronting us with new challenges of how to preserve the intangible heritage and to conserve cultural landscapes, it is now recognized that sustainability, and the associated conservation and adaptation of our built heritage, is integral to the business of historic preservation. Successful sustainable practice must be inter-disciplinary, and it is therefore critical that all members of the design team, whether they are architects, art historians, archaeologists; structural engineers, civil engineers, mechanical engineers, conservators, or constructors, must be equally attuned to the philosophy, language, and best practices of preservation.

"The preservation engineer is a practicing engineer who through knowledge, training, experience and skill provides technical services in conformance with established conservation principles" (Kelley and Lynch 1991:4). In this context, any engineer (structural, civil, mechanical, electrical etc.) who fulfills this definition can be considered as a preservation engineer. The main goal of the preservation engineer is to maintain the structural stability, and safety of the structure with minimum intervention. Their participation in the project supplies amassed knowledge to the issues that have been addressed by architects and material specialists (Friedman 2005:3).

Preservation Practice as an Inter-disciplinary Field

As Fischetti states *"Many times, it is the conservator and structural engineer working together who strike a balance between structural adequacy and the maximum retention of historic fabric* (1998:56)*."* The Association for Preservation Technology International (APT) is one of the pioneer interdisciplinary communication channels "*raising awareness and providing a forum for a wide spectrum of preservation-engineering issues"* (Fischetti 1998:55). It is therefore critical that interdisciplinary education programs expose students and professionals to work on historic existing structures. The Structural Engineering component of the Civil Engineering graduate program at Texas A&M University offers their students access to the Certificate in Historic Preservation administered through the Center for Heritage Conservation in the College of Architecture, allowing them to develop a body of knowledge in historic preservation alongside students in disciplines such as architecture, archaeology, anthropology, history, tourism and recreational parks, and construction science.

Learning from the Past

Vernacular design and engineering is a product of the accumulated knowledge and empirical practice developed over hundreds of years. As the transition between the empirical and modern engineering, 19th century practitioners made great leaps in structural theory such as" *the enclosure of great areas in the Crystal Palace; the spanning of great voids in the Brooklyn Bridge, and the reaching of great heights in the Eiffel Tower"* (Fitch 2006:89). As Fitch suggests, these three structures not only indicate the flowering of new structural concepts, but also demonstrate how the inter-relationship between theoretical analysis and computation, an understanding of materials, and new construction techniques result in dramatic structural advances. If one of the components lags, it will prevent the other two components to flourish. These three structures are the first examples of the engagement of modern scientific theory and practice (Fitch 2006:89-90).

Fitch’s examples remind us that an understanding of mathematics, materials and methods are essential for engineering practice. However, American engineering curricula have focused on their application to new construction, and American historic preservation practice has developed with little influence from the majority of engineers, since most engineers worked on new structures and engineering designs, neglecting historic structures (Friedman 2005:3).

However, the increasing need to rehabilitate and reuse existing structures, to bring existing structures up to code, to address issue of seismic and energy retrofit is creating a need for preservation engineers. This need is not only reflected in the ‘traditional historic building’ but in modern architectural heritage such as industrial structures, transportation buildings, iron bridges, high rise buildings and increasingly for buildings of the Modern Movement and buildings that were built in the 1950s and 1960s.

Learning How to See and Seeing How to Learn

Working with existing structures has been fundamental to architectural training since the 18th century, and was intrinsically based on the practice of on-site observation, drawing and measuring. In the educational programs of the recent past, careful examination of historic structures helped the student to understand the design, craftsmanship, materials, construction techniques and practices. They also learn to identify changes that are made through time, interpret the nature of the structure, providing a sound basis for the future repair and preservation of the historic structure. This experience equips students with the tools to analyze and interpret evidence presented by the subject buildings (Woodcock 2006:38-39).

Much design education in both architecture and engineering encompasses the latest in research and engineering techniques. However, this academic preparation often suffers from a lack of connection between classroom teaching and a direct contact with real case studies. Since engineering students are rarely involved in field work they cannot examine existing structures, analyze construction techniques and investigate materials. According to Friedman, *"The engineers need to improve their methods for investigating and analyzing existing buildings and for designing interventions; for given levels of cost and disruption of existing materials, engineering methods are influenced by only engineering concerns* (2005:3)*"*. Fischetti acknowledges historic structures as laboratories for basic research in materials. He suggests that investigating historic structures provides invaluable information about the service life of a material or system. These investigations supply us with the cycles of thermal and moisture changes, long periods of sunlight and gravitational force (Fischetti 1998:56).   In this context, S. Patrick Sparks, P.E., a preservation engineer who is now principal of his own preservation engineering firm near Austin, Texas, shared his field experience regarding the documentation of the roof system at Grimes County Courthouse. As a practicing preservation engineer, his quote is significant to demonstrate the importance of examining existing buildings. *"I remember coming to grips with the naturally confusing structural geometry of the roof at Grimes County Courthouse. It was not at all intuitive, until I had measured it. Only then did I begin to understand it."* (Fig. 1)

Such an experience is not the only outcome from the physical examination of a historic structure. This hands-on experience helps the students to develop skills of observation, and the ability to create measured hand drawings to record their observations (Warden and Woodcock 2005:111). Since the process of recording and documentation involves team activity and the ability to establish a drawing and note-taking process, and to select what to record, the students develop invaluable professional responsibilities and skills in an academic setting. In many cases this field experience is undertaken in a multidisciplinary setting where the participants also learn how to communicate with other disciplines and develop a mutual understanding with other professionals. Further, the students develop a genuine appreciation for history; acknowledge craftsmanship and inherent values embedded within the project (Woodcock 2006:42).

Methods and Tools

The process of documenting, that is, the meticulous measuring and drawing of existing structures of the Greeks and Romans, led to the development of Renaissance architecture. However, while the architects of the Modern Movement are often accused of having no interest in the past, some of the finest annotated drawings of Tuscan architecture can be found in Le Corbusier's sketch books from his travels in that region in 1907. Similarly, his careful records of design details and proportions in The Modulor (1950) are applied in his later work. (Woodcock 2006:38)

The guidance for field work can be found in National Park Service publications going back to McKee's first edition of Recording Historic Buildings (1970) that was based on practice standards used by architects and draftsmen in the 1930s when HABS first began. Field drawings were based on careful hand measurement with cloth and steel tapes, folding rules, and with pencil on paper as the media of recording the data. The data was organized in the manner of construction documents of the day, with plans, sections, details, and even schedules densely-composed on each sheet, with the final documents drawn in ink on linen or high quality vellum.

The techniques called for a clear understanding of what was being drawn, and utilized horizontal and vertical datum lines created by surveying equipment and simple plumb bobs applied to the structure. The recording process required the drawing to be made first, at a scale chosen to match the level of detail to be gathered and the size of the structure being studied. Dimension lines were then applied to the drawing, based on the author's recognition of what would be needed to transfer the field note into a finished drawing, and dimensions added last, using running dimensions wherever possible for maximum accuracy. Diagonal dimensions on plans, elevations and sections allowed the HABS drawing to reflect the "as found" nature of the subject building.

Photography is a vital element in heritage documentation. This important tool makes it possible to capture a vast amount of details within a single shot. Photography can record all the relational information of the building elements in situ including meticulous details, ornamental, structural and weathering information. By incorporating measuring rods of known dimension and marked along their length, it is possible to scale directly from the photograph so long as the rod is in the plane being measured. Further, photographic images can easily be rectified, manipulated and scaled making it possible to trace the details onto a measured drawing. Once the field work is complete photography is a fundamental tool in architectural documentation to check the accuracy of the hand drawn notes (Woodcock 2006:41).

In recent years heritage recording has benefited from advances in surveying technologies. Photogrammetric tools that capture unreachable details, total stations with GPS units, and 3D laser scanners that capture the digital image in real time are just a few examples of this proliferation of recording tools.

Total station theodolites capture three-dimensional data points. They can generate a highly accurate three-dimensional network that all these points can be accumulated and the relative data can be placed. Recent total stations have integrated Global Positioning System (GPS) units so that once they collect a data point; they can also engage this point to the geodetic network. (Fig. 2)

The 3D laser scanner is a surveying tool that has been increasingly utilized in the heritage sector since the1990’s. The scanner generates a three-dimensional digital image of the structure in near-real time. The scan data is a ‘point cloud’ of millions of three-dimensional coordinates which give information about the color and even the texture of the structure. The point cloud is available as soon as the laser scanner emits and collects the reflected laser beams to the structure. In heritage projects, as with the original use of the device in the petrochemical industry, the point cloud is not only used to derive drawings of the structures, but is also extensively utilized for monitoring purposes, generating structural analysis reports, and deformation analysis For heritage projects the data can therefore guide the conservation project as well as create a record.

Critical Thinking and Professional Judgment

While all these advanced technologies provide vast quantities of accurate data in a short time frame, observation and recording are still the basis of analysis. Paper, pen and pencil are still essentials in the documentation armory. Students create measured hand documents on the site to demonstrate their observations, connect the materials, forms and the structure. These observations are significant in the later stages of the drawing process. This level of thinking is independent of the technology that is utilized to capture data (Warden and Woodcock 2005:112).

Opportunities for Field Documentation in Engineering Curricula

The current focus on sustainability, the need to retain and reuse our existing resources, partly for economic reasons, but also for their value artifacts that link the past to the future, encourages a greater attention to saving buildings rather than demolishing them. The retention of historic buildings is only possible with the support of a well-trained professional team whose members approach the structure much in the way a good medical practitioner approaches a patient. An effective and thorough history, careful observation and examination, and reflective analysis of the findings, leads to selective testing and the preparation of a treatment plan, with continuous monitoring of the results. It has been said that in preservation practice the client is the building or the structure!

"Civil engineering curricula in most North American universities should adequately equip the graduate engineer with sufficient skills to address the varied challenges posed by evaluation and condition assessment through observation, measurement, analysis and testing. (Fischetti 2009: vii)*"*

As Stephen J. Kelley has noted, *"the goal of the preservation engineer is to stabilize the structure with a minimum of intervention."* (Kelley 1991:6) The field developed as a response to natural and other disasters, and in the United States as the nation prepared for the Bicentennial. Its leaders, like other professionals in preservation, learned by using their highly-developed professional judgment, and by examining the structure, its materials, and its condition from first principles, and using contemporaneous data. This respect for the structure is the basis for good preservation practice, and as with any other relationship, respect comes from open-minded personal interaction.

Face-to-face contact with existing structures encourages this open-minded approach. The engineer is forced to develop powers of critical observation, to identify the basic nature of the structure, and to record it as it is found. Once the dimensional data is gathered, the materials must be identified and, when necessary, researched using historical information on archaic materials and assemblies. While professional curricula struggle to provide sufficient knowledge and skills to enable the graduate to enter practice, the abilities of critical thinking, working from first principles, and communicating effectively have always been valued, for these are the factors that enable continuous self-learning. These are also the traits that are developed by field study.

The National Park Service Heritage Documentation Programs provide standards for field recording, and there is surely no shortage of built structures to examine. While financial support may be hard to find, owners are generally willing to provide access, and professional firms to offer guidance and even some limited funding. The summer-long documentation programs favored by the HABS, HAER and HALS programs are often regarded as the gold-standard for recording, but even a short, intense field study or assignment within an existing class is an opportunity to experience the excitement of direct contact with the products of earlier craftspersons and professionals. A course that examines materials and assemblies, historic and contemporary, can include a field component that tests the students' ability to "observe, measure, and analyze," perhaps with a design proposal to provide a stable and safe structure. The key goal is to encourage the student to go beyond book learning, and experience the thrill of recognizing that they have basic knowledge that can be used to develop professionally and personally. (Fig. 3)

“Educational models that involve learning by discovering seem to me the most productive, as well as the most exciting. Perhaps they are productive because they are exciting. The fact that discovery (of a built structure) can rarely be performed alone adds to the value of learning, since teamwork is an essential part of life.” (Woodcock 2005:44)

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Figures

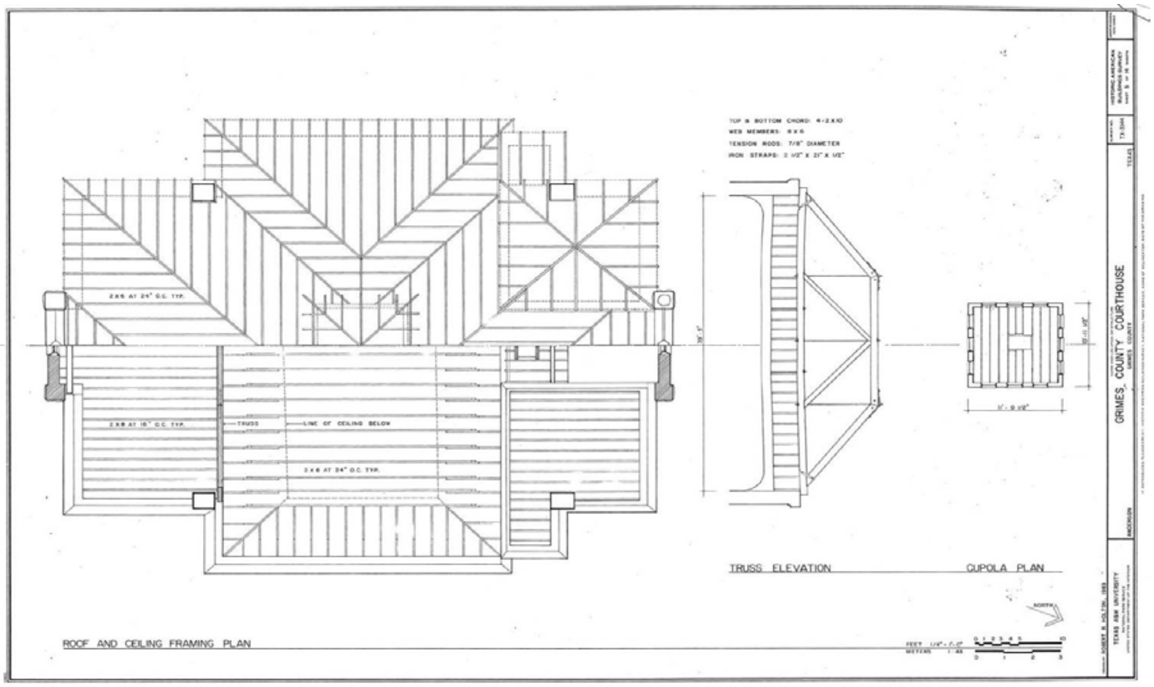

Fig. 1: Roof Plan of Grimes County Courthouse, Anderson, Texas. Built in 1894, the steeply pitched wood-framed roof included major hip rafters and a series of gables, as well as accommodating a raised coved ceiling in the second floor courtroom. Recording the roof structure was complicated by the later insertion of air-conditioning ductwork, but the accuracy of the Texas A&M University’s HABS team work identified significant sagging that required immediate stabilization. The documentation later provided base data for a major restoration of the building. HABS Collection, Library of Congress.

Fig. 2: An upper level terrace at Montezuma's Castle, a National Historic Landmark in Arizona, being recorded with a Total Station Theodolite to connect hand-drawn and photogrammetric data in this 14th century Sinaguan dwelling. The Texas A&M University team included graduate students in architecture and civil engineering. Photograph by the author, 2002.

Fig. 3: The author emerging triumphant from an examination of the ground floor framing of the Mrs Sam Houston House in Independence, Texas. Field study is not always a clean activity, but it has no equal in developing respect for the structure and its makers, and in challenging the practitioner to use judgment as well as knowledge. Photograph by Samer Al Ratrout, 2003.