

Session Track: Heritage Conservation Technology and Philosophy
Session Code: CS14a

Paper: Case Studies in the Use of Ground-Penetrating Radar (GPR) for the Investigation of Historic Masonry Buildings

Presented by

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Speaker(s) Biography

Shelley E. Smith holds a BArch from Cornell and a PhD in architectural history from Columbia University. She has been active in architectural practice for more than 20 years, with an emphasis on historic structures. Smith now teaches architecture full time at New York City College of Technology, CUNY. Prior positions include Associate with the preservation and sustainable design firm of Walter Sedovic Architects, Irvington NY (1998-2007); Project Architect with the former Buttrick White & Burtis, New York NY; and adjunct at Marymount College of Fordham University in art history and historic preservation. In addition to her membership in the APT, Smith belongs to the American Institute of Architects (AIA), and is a member and presenter at annual meetings of the Society of Architectural Historians and the Vernacular Architecture Forum.

James S. Mellett received a BS in Biology from Iona College and a PhD in Geology from Columbia University in 1966. He is a certified professional geologist and is HAZWOPER certified. He has served as professor and department chair at New York University, and has taught biology and geology at Iona and NYU. Mellett founded Subsurface Consulting Ltd. in 1987 and has provided geophysical services such as ground-penetrating radar (GPR) and terrain conductivity (EM) surveys for Fortune 500 corporations and local businesses. He has worked with Federal and state law enforcement agencies in the location of clandestine graves, and mapping at archeological sites. He has provided non-invasive information to clients on the condition of bridge abutments, highway subgrades, floor slabs, the extent of footings, hydroelectric canal walls, and a variety of other applications in engineering and geology. Mellett has been an active participant and presenter at geophysical meetings and symposia, and was an organizer of the 4th International Conference on Ground-Penetrating Radar held in Finland in 1992.

Abstract

This paper will present findings from ground penetrating radar (GPR) surveys of two historically significant masonry churches in Westchester County, NY the Church of St. Barnabas in Irvington (by Sands & Renwick) and Christ Church in Bronxville (by Bertram Goodhue). Conventional investigations and GPR surveys were conducted to gather information on moisture infiltration, and to provide guidance for restoration and remediation. In both cases, multiple attempts had been undertaken, prior to the investigation and GPR surveys, to resolve chronic water infiltration issues including repointing, and repair or replacement of roofing, flashing and roof drainage systems with little or only partial success. Although wall construction differed significantly in the two examples, one common type of wall configuration was noted to be particularly vulnerable, that is, a continuous wall in which the upper portion is exposed to the exterior on one or both sides (for example, a tower, parapet, or clerestory wall) and the lower portion is interior with arched openings (for example, crossing tower arches, or arches that separate nave from side aisle). Water is apparently absorbed into the wall from the exterior and makes its way down through channels or voids in the mortar, causing staining or plaster damage at the head of the interior arches. Long periods of exposure to moisture cause the gradual deterioration of historic lime mortar, leaving sand and voids in place of solid mortar between the masonry units. At the Church of St. Barnabas, a thorough restoration of the tower parapets (including flashing, lead weathercaps, removal of impervious parging on the inboard face of the parapet, repointing and injection grout) eliminated visible water damage at the interior arches, but did not completely eliminate high moisture readings in the interior masonry behind the plaster. At Christ

Church, a suspect eave and gutter detail is believed to be chronically saturating the upper clerestory walls during rain and ice-melt conditions, and parapets with limestone copings have sustained long-term internal damage not addressed by surface repointing. The GPR surveys revealed a surprising finding in both of these case studies, that is, a similar pattern of voids that appear to increase in number and size in the lower sections of the walls. The paper will explore several possible mechanisms by which moisture can move through a wall, patterns and causes of mortar deterioration, and a theory that entrained water may develop a hydraulic head that aids its downward movement through a masonry wall.⁷

Session Track: Heritage Conservation Technology and Philosophy
Session Code: CS14b

Paper: Innovative Investigations: Determining the Condition and Durability of Steel Frame Buildings through Non-Destructive Evaluations

Presented by

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Jonathan Leavitt, AIA, P.E.
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Speaker(s) Biography

Gina Crevello is an architectural conservator with Electro Tech CP. She has been working in electrochemical evaluations and treatments of buildings for the last 3 years. Gina was formally trained at Columbia University's Graduate School of Architecture, Planning and Preservation. She worked in the field of architectural conservation for 9 years.

Jonathan Leavitt is an architect and engineer, formally trained at Princeton and Harvard's Graduate School of Architecture. Prior to opening his own practice, Jonathan worked as a Senior Engineer with Simpson Gumpertz and Heger for 6 years. He is often called in to trouble shoot on buildings with complex details requiring in-depth analysis and assessments.

Abstract

A number of techniques exist for evaluating the condition of steel frame masonry clad buildings. These techniques provide information on various issues with the building but do not address corrosion, one of the main factors in the durability of the building.

When evaluating buildings using typical techniques such as visual inspection, infra red, ground penetrating radar, sounding and moisture content information is gathered and assessed accordingly. These techniques do not enable the Engineer to scientifically determine the condition and are generally based on experience and the skill of the site technician. This kind of survey data does not allow the Engineer to determine the condition of the underlying steel frame but only the condition surrounding the steel. In the majority of cases high moisture content will be evident and only variants of this moisture content will be detectable. In addition to this some of the survey data may identify voids in the infill material where water could accumulate.

In all these instances we have not addressed the actual condition of the steel frame nor have we identified how it is behaving in its environment. To enable us with some accuracy to determine the effects the steel frame corrosion will have on the building, we have to evaluate the rate at which it is currently corroding. Linear Polarization Resistance, an electrochemical method which determines corrosion rates, provides the potential of the steel, the corrosion rate, and from the potential testing, saturated conditions and voids. The rate of corrosion is directly related to Faraday's Law of metal loss, and the amount of steel loss can be directly converted to the amount of iron oxide that will form on the surface of the steel.

From the calculations of metal loss and the formation of oxide, time to cracking or failure can be predicted. The resistivity of the masonry also plays an account in the calculations as does the masonry infill. Other conditions effecting corrosion in historic masonry clad buildings, such as increased moisture, oxygen, chlorides, and carbonation can be included in these calculations. Testing and calculations will be discussed in detail.

Both authors have been involved on various projects where traditional, visual and hands-on investigations provide only a small amount of data necessary to determine the underlying causes of building failures. Personal

experience on projects will be used for case studies with examples of test data, and project specific challenges and finding.⁷

Session Track: Heritage Conservation Technology and Philosophy
Session Code: CS14c

Paper: Active Interrogation Techniques for Non-Destructive Investigation of Historic Structures

Presented by

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Speaker(s) Biography

Education

University of Florida	Civil Engineering	B.Sc.Eng. 1983
University of Florida	Civil Engineering	M.Eng. 1984
Penn State University	Civil Engineering	Ph.D. 1999

Academic Appointments

Aug. 2007 - Present: Associate Professor, University of Florida, Rinker School of Building Construction, Gainesville

Aug. 2001 - Aug. 2007: Assistant Professor, University of Florida, Department of Civil and Coastal Engineering, Gainesville

Aug. 1999 - May 2001: Assistant Professor, Iowa State University, Department of Civil and Construction Engineering, Ames, IA

Aug. 1996 - Oct. 2000: Faculty Associate, Pennsylvania Transportation Institute, University Park, PA

Aug. 1996 - Jul. 1998: Instructor, Penn State University, Department of Civil and Environmental Engineering, University Park, PA

Research Areas

Sensor-based Non-destructive Construction Quality Control and Evaluation of Construction Materials, Financial Analysis of Construction Contractors, Construction Claims Avoidance and Dispute Resolution, Construction Project Control, Economic Evaluation of Construction Materials and Processes, Health Monitoring of Infrastructure Systems

Synergistic Activities

American Society of Civil Engineers (ASCE)-----
Committee on Construction Inspection and Quality Control (Chair)
Construction Research Council
Transportation Research Board (TRB) -----
Committee A2F05: Construction Management
Committee A2F06: Construction Equipment
Committee A2F09: Application of Emerging Technologies

Counseil International du Batiment (CIB)

Recent & Significant Publications

1. Minchin, R.E.; Swanson, D.C.; Gruss, A. F.*; Thomas, H.R.; Computer Applications in Intelligent Compaction, Accepted for publication by ASCE Journal of Computing in Civil Engineering, American Society of Civil Engineers, Reston, VA, December, 2007
2. Minchin, R.E.; Baciak, J.; Haghghat, A.; A Non-destructive Active Interrogation Technique for Material Identification in Civil Structures, Conditionally Accepted for publication by ASCE Journal of Construction Engineering and Management, American Society of Civil Engineers, Reston, VA, December, 2007
3. Minchin, R.E.; Baciak, J.; Haghghat, A.; Identification and Demonstration of a Technology Adaptable to Locating Water in Post-tensioned Bridge Tendons, Proceedings of the 87th Transportation Research Board, Washington, DC, 2008, pp. 1-18 (CD)

Abstract

Active Interrogation Techniques
For Non-Destructive Investigation of Historic Structures

By: R. Edward Minchin Jr. , James Baciak , Alireeza Haghighat

ABSTRACT

Every year, millions of dollars are spent nationwide in the rebuilding, repairing, re-engineering, and maintaining of historic buildings, buildings in the midst of their service life, and all manner of civil structures, both historic and those still in full use. For instance, the presence of water is very destructive to buildings and civil structures. The ability to identify pockets of water, or even high moisture content within a structure would be very beneficial.

Another need for those who would preserve historic buildings or monitor the health of civil structures is the ability to ascertain the exact contents and the condition of the contents of the structure. For instance, the City of St. Augustine has identified several historic buildings, many from the 17th century, in dire need of maintenance. Obviously no as-built plans exist for these buildings, so those who would come to the aid of the structures only know that reinforcement metal is within the structure if a fragment of the structure has fallen away, revealing a bar. However, there is no proof of the existence of reinforcement, nor of the condition of the reinforcement in any part of the building which is still intact.

A very useful tool for the preservationist would be one that allowed one to see inside the structure to verify the existence of the reinforcement metal, identify the metal, gauge the depth / location of the metal, and measure the condition of the metal.

Through active interrogation techniques, a research team from the University of Florida is involved in the development of a system to both locate harmful elements such as water or salt inside a structure, and to verify, identify, gauge, and measure all facets of the contents of the structure. The ultimate goal of this research is to develop the technology through which a system may be developed that will make it possible to peep inside buildings, bridges and other civil structures.

This research will examine innovative nondestructive methodologies based on neutron activation followed by gamma ray spectroscopy, neutron back-scattering, and/or transmission. It is envisioned these methodologies will ultimately provide the means of developing portable sensors, which can identify target isotopes in orders of minutes.

The proposed technique uses a combination of neutron sources of various spectra (through the use of different source types and different neutron moderation thicknesses) and detection systems. Neutrons, because they are not charged, can penetrate materials, and therefore provide valuable information about material compositions through by-products of their interactions with nuclei of different elements and isotopes. For instance, if the search is for water, the technique relies on the detection of hydrogen, the main constituent of H₂O.

The proposed paper and publication will discuss the progress made in the research up to the time of the conference.⁷