MATERIAL MATTERS

Towards a Preservation Engineering Curriculum Based on Understanding of Materials

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Abstract

The paper suggests that a broad understanding of the behavior of historic building materials is an essential component of any Preservation Engineering curriculum. Knowledge of material properties is vital to understanding heritage construction (components and systems) and for any assessment of its condition or structural stability. Understanding traditional or contemporary regimes for the consolidation, repair, restoration or maintenance of historic buildings and structures also requires knowledge, skills, judgment and experience concerned with material characteristics and performance - be they ancient or modern. The conservation and future welfare of the historic environment is intimately and inextricably associated with material culture and involves debates about authenticity based on physical material. It can truly be said that "material matters".

Keywords

Materials, preservation, engineering, knowledge and understanding.

Introduction

Two large and inter-connected problems confront the international preservation community in the context of this colloquium: firstly, the shortage of structural engineers who are expert in preservation engineering, and secondly the over-supply of civil and structural engineers working on historic buildings and structures with absolutely no understanding of the subject[1].

Both situations are evidently harmful to the built heritage and threaten its future welfare both here in America and further afield.

In the author's experience – with due respect to those experts attending this colloquium - many structural and civil engineers have little or no understanding of the historical development (in terms of design, production, manufacture and construction) of vernacular or traditional buildings based on materials such as timber, stone, brick, adobe, and lime mortars, plasters and renders. Mass masonry or heavy structural carpentry construction bewilders them as the structural behavior of such buildings is not precisely delineated in modern software programs based around steel and reinforced concrete.

Materials such as terracotta, cast and wrought iron are condemned out of ignorance of their capabilities and historic performance. So-called remedial solutions designed by the unaware, the ignorant and the obdurate often fail to recognize the huge factors of safety inherent in these materials or the composite structural support engendered by, and integral to, their construction systems. Thus, many unfortunate historic buildings and structures are inappropriately condemned as being redundant, weak or failing when their continued existence (often over several centuries) patently bears testimony to inner strengths unknown to their assessors.

Curriculum needs

Materials curricula for unit-based Preservation Engineering options within vocational courses in civil engineering would, of course, differ considerably from specialist fulltime postgraduate studies for those continuing their university education or for returnee mid-career professionals. Similarly, the scope of study for a specialist Preservation Engineering option within a more generic multidisciplinary Historic Preservation program would again vary according to the time allotted to teaching and personal inquiry, the technical capabilities and experience of the students, and the competencies of the faculty.

Among the basic topics needing to be covered are those concerned with structural materials but a wider understanding of the implications for structure and the welfare of historic buildings would also include for historic cladding materials (i.e., dead loads and those subjected to uplift from wind forces, traffic vibration and seismic motions etc) in fired clay tile, faience slabs, wood, stone and plaster etc

Topics could be:

Natural production

Of traditional building materials

- Geomorphology and geology of
  - building stones
  - lime-based materials (mortars, plasters, stucco, cement and concrete)
  - pozzolans
  - clay soils (for adobe and brick manufacture)
- Biology of trees
- Mineralogy of porous building materials
  - water sensitive minerals e.g. pyrites, clays
- Material science to understand
  - internal physio-chemical or biological structure

- coefficient of thermal expansion
- hygro-thermal behavior
- porosimetry
- permeability and porosity
- surface tension
- pulse velocity, etc
- thermal resistance, etc

Human production/manufacture

Consequent impacts on performance of materials/systems

- Mining and quarrying of stone, lime, gypsum
- Masonry techniques for sawing, processing and carving stone
- Processing of clay and sand for adobe, pise, cob and other forms earth building
- Blending and firing of clays and sands for bricks and terracotta
- Cropping, quarter sawing and processing of structural carpentry
- Molding and mixing stone and cement to form cast stone
- Foundry and rolling mill processes for making cast and wrought iron
- Foundry and craft processes in casting and making glass

Having established basic materials found in historic buildings and most often used in their maintenance, repair and restoration, significant time needs to be spent learning about their soiling, weathering and decay processes. This section would include:

Vectors for deterioration and decay:

- Climatology

- Surface wet/dry pollution
- Biological growths (e.g., molds, fungi, algae, lichens and higher plant species
- Other biological impacts (e.g., masonry bees, carpenter ants, termites etc)
- Human interventions (e.g. graffiti attacks)
- Surface behavior of porous building materials

<u>Deterioration processes in</u>

- earthen materials
- brick, tile and terracotta
- stone: for example, marble, limestone (e.g. calcareous and dolomitic types), sandstone (e.g. calcareous, siliceous, argillaceous and ferruginous types), slate, granites etc)
- timber (fungal, insect and UV light attack)

<u>Analytical and Testing procedures</u>

To include in situ, mechanical and electronic laboratory methods of individual materials (e.g. stone block, and systems e.g. masonry wall including mortar)

- Need to understand research design, statistical relevance of sampling procedures etc
- ASTM, RILEM and other test methods and standards and the limitations
- Benign and minimal sampling methods
- Nondestructive evaluation and monitoring systems (refer to other breakout session at this Colloquium)
- Petrographic, chemical and FTIR analysis of concrete, mortars, plasters and stuccos
- Compressive strength
- Shear strength
- Flexural Strength

- Bond Strength
- Pull-out resistance
- Glaze fit
- Porosity and permeability
- Surface water absorption (e.g. RILEM tube) and total absorption

Current state of knowledge

The body of knowledge for many of the traditional building materials is well understood and widely published in preservation circles but is much less known in engineering circles. The European Commission's DGXII Environment *Framework* Research program (1986 onwards, see www.cordis.eu) and research programs of English Heritage, Historic Scotland, the CNR in Italy and other national initiatives provide a vast research platform for studies in historic materials and systems that can be used as both a teaching reference and prompt for future studies.

Research funding

Apart from the NCPTT program, no significant regular sources of funding exist in the USA, though the NSF and other federal sources are occasionally tapped. Collaborative research with European partners is possible under the afore-mentioned Framework Program but no EC funds can be given to American establishments.

Materials manufacturers (e.g. cement and lime producers) are investing heavily at present in "green" end-use technologies (e.g. employing pozzolans with the binders) and these sources may be used when the appropriate expertise is offered.

Learning opportunities

- Tours of quarries, factories are encouraged by industry
- Technical representatives visit schools to provide free information and lectures
- Web-based resources abound but sifting appropriate technical and scientific outputs from the amateur dross can be challenging
- Engineering co-ops and internships are well established in the industry, less so for non-scientists in analytical and mechanical testing laboratories

Bibliography

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[1] Fidler, 2009 p1