Graduate Program in Historic Preservation
Stuart Weitzman School of Design, University of Pennsylvania
HSPV 551 *Building Pathology*

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Course Syllabus

On-Line Class Meetings
Fridays, 2:00 PM to 5:00 PM (Eastern Daylight Time/Eastern Standard Time)
All class meetings will be synchronous via Zoom.

Communications

Office hours:	By appointment, Fridays, 11:00 AM to 1:30 PM (EDT/EST) *via Zoom*
Telephone:	By appointment, weekdays, 9:00 AM to 5:00 PM (EDT/EST)
E-mail:	*Note: Subject heading of emails should state "HSPV 551".*
	Note: I send emails from mhenry@watsonhenry.com *, please add this address to your "Safe Senders".*

Course Description
Buildings, their sites , systems and supporting infrastructure embody substantial investments in capital, labor and energy. Historic buildings embody the added value of their architectural, cultural or social significance.

The post-construction performance and function of buildings inevitably decline due to various pathologies. These pathologies are enabled by factors present in the environment, by use and occupancy of the building and by time. Eventually, the aggregate effect of these pathologies necessitates appropriate interventions to slow the loss of, or reinstate, utility and functional performance of the building. Appropriate interventions address the causal factors of the pathologies, slowing damage and inappropriate or symptomatic interventions exacerbate pathologies, increasing damage.

Building Pathology is the study of the deterioration processes that can ultimately determine a building's survival or loss. The course presents building pathologies as dynamic systems with causal factors such as energy and moisture acting over time, thus informing prevention as well as remediation. The course prepares the historic preservation professional to analyze existing conditions and identify the causal mechanisms and enabling factors of deterioration and loss. The course prepares the architect to identify potential building longevity problems during design of new buildings.

Building Pathology will:
- Consider the problem inherent to the longevity and sustainability of any building – deterioration, loss of utility and loss of functional performance as a *function of time*;
- Review the investment of capital, labor and energy embodied in new and existing buildings and the added value of buildings considered to be historically significant;
- Emphasize a *systemic approach* to understanding building deterioration, considering the building, its physical, economic and climatic contexts, its occupancy and use, and the implications of changes in these over time;
- Review the properties of building materials, their comparative values in terms of performance assets and potential vulnerabilities to deteriorative mechanisms;
- Review the mechanisms and causal factors of building deterioration - mechanical, hygrothermal, biological and electrochemical - as dynamic systems;
- Identify the factors necessary for the deterioration mechanisms to occur and the contextual sources for these factors;
- Study examples of how these mechanisms occur singly or synergistically in a building's structure, enclosure or systems;
- Consider the implications of preventive conservation, sustainability, and adaptability for building survival;
- Consider how to set objectives for remedy, mitigation and prevention of deteriorative mechanisms once the causal mechanisms are known and how to Identify and evaluate intervention strategies for achieving the objectives; and,
- Consider the implications of designing and implementing the intervention strategies.

HSPV 551 *Building Pathology* is complemented by HSPV 552 *Building Diagnostics and Monitoring*, which addresses diagnosis and monitoring of building pathologies.

Building Pathology will be taught by:
- Preparatory readings;
- Lectures;
- Class exercises and discussions;
- Tests of knowledge;
- Assignments.

Learning Objectives
Upon successful completion of the course, you should be able to:
- Think of buildings systemically in spatial and temporal dimensions;
- Understand the problem of achieving and maintaining adequate utility and functional performance in buildings;
- Recognize building materials for their vulnerabilities to deterioration and for their performance assets and durability;
- Know the primary mechanisms/processes of deterioration in buildings, the causative factors that are necessary and sufficient for these mechanisms to occur, and the potential for synergistic interaction between different mechanisms;
- Understand building deterioration as a dynamic system, rather than symptomatic results;
- Think critically and broadly about factors that differentiate between building survival and loss;
- Express building pathology issues in quantitative and qualitative terms, using professional terminology;
- Research technical information on building and building materials in professional journals;
- Define the objectives and evaluate potential intervention strategies to mitigate, remedy or prevent deterioration;
- Prepare a professional-quality reports that demonstrate application of the above to case studies of actual buildings.

Teaching and Learning On-Line
Building Pathology will be taught on-line using the following platforms:
- *Canvas* will be used for quizzes and tests.
- *Canvas* will be used for distribution of materials, readings and lecture notes.
- *Zoom* will be used live on-line class meetings and individual student meetings.
- *Zoom* and *telephone* will be used for meetings with individuals and teams.

Class meeting time will be structured to maximize active learning and interaction among students and between students and the Instructor. As a consequence, lecture time will be minimized in favor of class discussion, exercises and case studies and application of the course material to real-world building pathology problems. This approach will require thorough preparation before class, including review of the readings and lecture slides. Class meetings will not be recorded unless a student cannot attend due to exceptional circumstances, such as an acute health issue.

The final assignment, consisting of one critical review of a published research article and two Building Consultations, will be introduced at the beginning of the semester. Drafts of the major sections of the final assignment will be submitted incrementally during the semester, so that feedback can be provided in time for more research and refinement of the final work product by the student teams.

On-line meetings with individual students are mandatory; anticipate two meetings throughout the semester in addition to meetings with induvial student teams.

Initiated with HSPV 551 in Spring 2020, on-line teaching and learning remains a novel and evolving undertaking for each of us. Real-time feedback on the effectiveness of the methods used in this course will be welcome, so that we can make mutually agreeable adjustments and introduce improvements during the semester. Your candid feedback on course content, readings, class exercises and teaching methods are encouraged so that the course may be continuously developed and improved. Course feedback may be delivered directly, or through the Teaching Assistant.

Information Sources

- **Texts**

The following texts for the basis for the course and will be on reserve at the Fisher Fine Arts Library:

Blockley, David. *Structural Engineering – A Very Short Introduction.* Oxford: Oxford University Press, 2014.

Brand, Stewart. *How Buildings Learn – What Happens after They're Built*. New York, NY: Viking, Penguin Books, USA, 1994.

Ching, Francis D. K. *Building Construction Illustrated*, 5th Edition. New York, NY: Wiley, 2014

Harris, Samuel Y. *Building Pathology – Deterioration, Diagnostics and Intervention*. New York, NY: John Wiley & Sons, Inc, USA, 2001.

Meadows, Donella H. *Thinking in Systems, a primer.* White River Junction, VT: Chelsea Green Publishing, 2008.

Watt, David S. *Building Pathology – Principles and Practice.* London: Wiley-Blackwell, 2008.

- **Print and other media**

In addition to the texts, the Course, Reading and Submission Schedule lists other materials required for class preparation.

- **Other Resources**

The following professional references will be useful in the course and in the final assignment:

American Concrete Institute. Home page. http://www.concrete.org/General/Home.asp?HP=h_home

American Society of Civil Engineers. Home page. http://www.asce.org/

ASCE 11-99 Guideline for Structural Condition Assessment of Existing Buildings. New York, NY, USA: ASCE, 1999.
ASCE 30-00 Guideline for Condition Assessment of the Building Envelope. New York, NY, USA: ASCE, 2000.

American Society for Testing and Materials. Home page. http://www.astm.org/

Architectural Engineering and Design Management. This publication analyses and discusses the integration of the main stages within the process of design and construction and multidisciplinary collaborative working between the different professionals involved. Taylor & Francis.
http://www.tandfonline.com/action/journalInformation?journalCode=taem20#.Vpv4JfkrIfI

Architectural Science Review. This publication presents papers on environmental issues, covering topics such as thermal comfort, lighting, and sustainable architecture. Taylor & Francis.
http://www.tandfonline.com/action/journalInformation?journalCode=tasr20

Association for Preservation Technology. Home page. http://www.apti.org/

Brick Industry Association. *Technical Notes*. http://www.gobrick.com/TechnicalNotes/tabid/7658/Default.aspx

Building and Environment. The International Journal of Building Science and its Applications. Elsevier.
http://www.journals.elsevier.com/building-and-environment/

Building Research and Information. This publication focuses on buildings, building stocks and their supporting systems, reflecting the complexity and linkages between culture, environment, economy, society, organizations, quality of life, health, well-being, design and engineering of the built environment. Taylor & Francis.
http://www.tandfonline.com/action/journalInformation?show=aimsScope&journalCode=rbri20#.Vpv5xPkrIfI

Building Science Corporation. *Building Science Digests* and *Building Science Insights* series.
http://www.buildingscience.com/index_html

Canadian Architect. Architectural Science Forum series. Ted Kesik.
https://www.canadianarchitect.com/?s=Architectural+Science+Forum

Construction and Building Materials: An international journal dedicated to the investigation and innovative use of materials in construction and repair. Elsevier. http://www.journals.elsevier.com/construction-and-building-materials/

Energy and Buildings. An international journal devoted to investigations of energy use and efficiency in buildings. Elsevier.
http://www.journals.elsevier.com/energy-and-buildings

Engineering Weather Data: a compilation of National Climate Data Center Charts and Tables for worldwide locations as used in the course. Can be accessed for free at University of Indiana University, Bloomington website.

http://webapp1.dlib.indiana.edu/cgi-bin/virtcdlib/index.cgi/4910250
at bottom of page select either "Download" for the entire file or "Browse" then open "EngineeringWeather.html" to find a location.

Forest Products Laboratory. Home page. http://www.fpl.fs.fed.us/

International Journal of Architectural Heritage. This publication provides a multidisciplinary scientific overview of existing resources and modern technologies useful for the study and repair of historical buildings and other structures, including information on history, methodology, materials, survey, inspection, non-destructive testing, analysis, diagnosis, remedial measures, and strengthening techniques. Taylor & Francis. http://www.tandfonline.com/action/journalInformation?show=aimsScope&journalCode=uarc20#.Vpv61PkrIfI

Journal of Building Engineering. An interdisciplinary journal that covers all aspects of science and technology concerned with the whole life cycle of the built environment, from the design phase through to construction, operation, performance, maintenance and its deterioration. Elsevier. http://www.journals.elsevier.com/journal-of-building-engineering

Journal of Building Physics. Covers on-structural performance of a building and particularly in heat, air, moisture transfer and includes: insulation and building envelope materials and systems including polymeric, mineral, cellulose-based, and composites, building interactions with the environment, occupants, and allied building materials, components, and sub-systems, green roofing, double skinned envelopes and interaction of building enclosure with mechanical systems. Sage. http://intl-jen.sagepub.com/

Journal of Cultural Heritage. A multidisciplinary journal of science and technology for conservation and awareness; presents innovative methods concerning all aspects of science and technology of cultural heritage as well as interpretation and theoretical issues related to preservation. Elsevier. http://www.journals.elsevier.com/journal-of-cultural-heritage

Masonry Institute of America. Technical Publications. http://www.masonryinstitute.org/products.php?catID=5

National Geologic Map Database. https://ngmdb.usgs.gov/ngmdb/ngmdb_home.html

National Research Council of Canada:
Canadian Building Digests series https://researchguides.georgebrown.ca/CBD
Construction Innovations series http://www.nrc-cnrc.gc.ca/ci-ic/
Construction Technology Updates series http://www.nrc-cnrc.gc.ca/ctu-sc/

Torraca, Giorgio. *Lectures on Materials Science for Building Conservation*. Los Angeles, CA: The Getty Conservation Institute, 2009. http://www.getty.edu/conservation/publications/pdf_publications/

US Department of Agriculture, Natural Resources Conservation Service, *Web Soil Survey*. http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Learning - Your Responsibilities as a Student

- **Attendance**

You are expected to attend all classes and attendance will be taken. Notify me by email before class if you will not be able to attend a class meeting. The Course Absence Report system will not be used for this course.

- **On-line Class Meetings**

You should treat on-line class meetings as if you are in a live classroom or a live business meeting with other professionals. Eliminate distractions to you and your fellow students. Turn-off mobile your phones, email and texting apps/programs. Eat your lunch/dinner before or after, but not during, class.

- **Highlights of the Previous Class**

Beginning with the third class meeting, each class will begin with a ten-minute student summation of the key points of the previous class meeting. Prior to the second class meeting, you will contact the Teaching Assistant to secure your presentation date.

- **Class Exercises**

Class exercises are an important part of the student-centered learning process and will apply information or methods addressed by the readings and lectures. Class exercises require reasoning, analysis, basic mathematical calculations and sketching. Some exercises will be done individually; others will be collaborative.

You must have knowledge and comprehension of the assigned reading materials and will need a simple calculator, graph paper and writing instruments to complete the class exercises.

- **Quizzes**

Periodic quizzes demonstrate your progress with assimilation of the course material in the lectures and the readings. All quizzes will be "closed-book." You will need a simple calculator, graph paper and writing instruments for the quizzes.

- **Tests of Knowledge**

The tests of knowledge demonstrate that you have command of essential course content. The tests of knowledge require your comprehension and retention of information contained in the readings and lectures. The tests will be "closed-book." You will need a simple calculator, graph paper and writing instruments to complete the test.

- **Final Assignment Deadline**

The deadline for the final assignment is firm and there will be ample time for you to plan and execute the assignment. Short of hospitalization, no extensions will be granted. Late delivery of your assignment will be reflected in your grade.

- **Academic Integrity**

Honesty is fundamental to your future practice as a professional and academic honesty is fundamental to our community at the University of Pennsylvania. Honesty includes attributing and citing the sources used in your assignments.

The UPenn Code of Academic Integrity can be found at https://catalog.upenn.edu/pennbook/code-of-academic-integrity/
A confirmed violation of that Code in this course will result in failure for the course.

Metrics for Student Performance

Letter grades and their numerical equivalents will be based awarded upon successful completion of the course. The final grade will be based on the following allocation:

• Preparation for and participation in class	25 %
• Test of Knowledge 1	15 %
• Test of Knowledge 2	20 %
• *Building Pathology Consultations*	40 % (1/3 for each consultation)
• Total (maximum)	100 %

At the Instructor's discretion, the final course grade will be adjusted to reflect unexcused absences and late assignments.

Participation in class will be based on your individual:
- Preparation, including demonstration of retention and comprehension of the readings;
- Exercises - participation and outcomes;
- Engagement in discussions.

Tests of Knowledge will be scored based on based on points and letter grades will be assigned based on distribution of the numeric scores.

The *Building Pathology Consultations* will be graded on:
- Focused, substantive and concise content, founded on clear and logical analysis, substantiated by facts, research beyond the course materials and citations, including professional citations from outside the course readings;
- Clear and logical narrative exposition of the information, substantially free of grammatical, punctuation and spelling errors;
- Graphical presentation of key concepts illustrating the important or complex points of the narrative;
- Conformance with format requirements.

The grading rubric for *Building Pathology Consultations* will be:

- A Exceptional work, equivalent to professional quality, thorough grasp and synthesis of all course content.
  Thorough preparation for class, demonstrated by engagement and participation.
  Writing: Logically organized, clear and concise with correct use of technical terminology.
  Research: citations from professional journals and publications other than class readings.
  Graphics: multi-variant, demonstrating causality & connections, clear and compelling.
- B Very good work, near-professional quality, thorough grasp and synthesis of nearly all course content.
  Rare lapses in preparation for class, occasional lack of engagement and participation in class.
  Writing: rare lapses in clarity or application of technical terminology.
  Research: citations from class texts and readings.
  Graphics: dual variant, showing causality or correlation, clear and convincing.
- C Average work, sub-professional quality, understanding of basic information.
  Marginal class preparation, moderately engaged, occasional participation.
  Writing: Weak organization or structure, poor application of technical terminology.
  Research: citations on technical matters from popular web sources, such as Wikipedia.
  Graphics: single variant, clear.
- F Unacceptable work.

Student Work Product - *Building Pathology Consultations*: Overview, Format Submission & Disposition

In partial fulfillment of the course, students will work in teams of two, and each team will submit three (3) distinct *Building Pathology Consultations*. Two of the consultations consist of a professional-level letter addressing a specific building pathology problem. The third Building Consultation will be a critical review and interpretation of a published technical article. The letters (up to 6 pages of text for each letter) will be supplemented by appendices and graphics.

The requirements for each consultation will be provided in the first three weeks of the course and the students will submit a draft of one consultation on three separate dates as indicated in the *Course, Reading and Submission Schedule.*

In preparing the *Building Pathology Consultations*, students will apply and extend critical concepts, fundamental principles, methods and information from the lectures and readings, supplemented by their own research in professional and technical publications. This effort will provide active, student-centered learning in the context of authentic, real-world building problems.

The narratives must be clear and logical exposition of the facts.[1] Writing must be substantially free of grammatical and spelling errors. Graphics should illustrate the important or complex points of the narrative.[2] Conclusions and recommendations must be substantiated by facts and reflect a rational thought process.

The format of the *Building Pathology Consultations* must conform to the following:

- White paper, 8.5 by 11.0-inch, portrait orientation, single-sided printing for text and small graphics;
- White paper, 11.0 by 17.0-inch, landscape orientation, single-sided printing, z-folded for large graphics;
- Calibri font, 10-point, black print, single spaced lines;
- Margins set at 1.25 inches (binding edge), 1.00 inches (other edges);
- Single-line footer with Project Name (left) and page number (right);
- Pages numbered sequentially:
  1, 2, …for report body; A1, A2, … for appendix A, similar for B, et cetera;
- Endnotes;

[1] *Elements of Style Illustrated* by William Strunk, Jr. and E. B. White is a classic guide to writing. The current edition is delightfully illustrated by Maira Kalman.

[2] *The Visual Display of Quantitative Information, Second Edition* by Edward R. Tufte provides an excellent review of graphical presentation of information.

- Photographs, images and charts/graphics:
  Landscape format (top edge to rings) or portrait format.
  Black and white or color, laser/bubble jet printed from digital images or scans.
  4 inches in the least dimension.
  Captioned with self-evident descriptive text, source name and date;
- Cover (Title) page with:
  Course number, title and program and date of report
  Each student's printed name and signature with statement "I have contributed equally with my team partner(s) in this assignment"

Submission of Final Assignment:

- Prepare a **digital copy** of the entire assignment as a single .pdf file and title the file: "2021 HSPV551 Final Assignment xxxxx and xxxxx" where xxxxx are the names of the student team members. Upload the digital copy of the *Building Pathology Consultations* to the address provided to you of the *Building Pathology Consultations* **before the time and date** specified in the *Course, Reading and Submission Schedule*.
- Self-Evaluation: Each team member must complete a self-evaluation of the final assignment using the grading rubric.
- Upload the digital copy of the *Building Pathology Consultations* and the self-evaluations **before the time and date** specified in the *Course, Reading and Submission Schedule*.

Date	Topics	Readings and Preparation	Reading Orientation Questions	Submittals (due prior to class)
22 January 2021 Class 1 *Getting underway*	Introductions, course orientation, content Learning methodologies, tests of knowledge Student work product Building pathology, survival & loss, Utility & use, Functional performance, Obsolescence & adaptability, Assets & liabilities, Value, Sustainability, Contexts	**Required Readings (* denotes provided on-line):** Henry. HSPV 551 Course Syllabus* Henry, *GCI Technical Note: Context and Use** Levin, *Preventive Conservation,* in *Conservation Perspectives* 7.1 Spring 1992* **Required Readings (From Texts)** Brand, *How Buildings Learn*, Chapters 1-4, Chapter 10, Appendix. **Optional Resources:** Ching, *Building Construction Illustrated*, 1.07-1.22: The Building Site	• How does Brand's diagram of shearing layers of change inform our understanding of buildings? • What are examples of new forces that are changing buildings today? • What does "preventive conservation" mean when applied to immoveable cultural heritage?	Self-assessment Current resume
29 January 2021 Class 2 *Entropy: It's a law & the results are inevitable*	Basic concepts in material longevity: Entropy & the 2nd Law of Thermodynamics Durability & service life Deterioration & loss of performance Damage & failure Intervention & prevention Sustaining building longevity thru reinvestment Exercise: Building Reinvestment	**Required Readings (* denotes provided on-line):** For fun: http://www.youtube.com/watch?v=KTHiIwxcexI Watt, *Building Pathology*, Chapters 1-2* Lstiburek, BSD 144, *Increasing Durability of Building Construction** Henry, *Technical Note: Building Reinvestment Model** CSA S478-95 *Guideline on Durability in Buildings, Appendix D pp65-72** **Optional Resources:** Ching, *Building Construction Illustrated*, A.19-A.25: CSI Masterformat and ASTM Uniformat II	• What costs does the Heritage Building Reinvestment Model not include? Why does it not include these costs? • Consider the different requirements of buildings as outlined by Watt. How are these requirements related? How can they be prioritized? • What are the terms used to define durability in buildings?	
05 February 2021 Class 3 *Materials:* *A brick is* *A brick is* *A brick…* *Or is it?*	Materials properties Quantitative & qualitative comparisons Archaic materials vs. modern materials Variability Properties of interest Design – Indicators of strengths Durability – Indicators of vulnerabilities Composite materials & assemblies Exercise: Identifying materials by properties, not names	**Required Readings (* denotes provided on-line):** Harris, *Material Profile Charts – Brick, Steel, Wood & Blank** Watt, *Building Pathology*, Chapter 3* Henry, *NCPTT Technical Note: Materials and Older Buildings** Porous Building Materials Handout* **Optional Resources:** Ching, *Building Construction Illustrated*, Chapter 12: Notes on Materials	• For which properties were units of measurement difficult to find? • How do the units of measure inform our understanding of the property? • Do some material properties have more than one unit of measure? Why? • How do we know that actual measurements for material properties are comparable and consistent? • How do you define material compatibility if selecting a replacement material in historic fabric?	Complete the blank Materials Property Chart by entering the *units of measure* for each of the properties

Date	Topics	Readings and Preparation	Reading Orientation Questions	Submittals (due prior to class)
12 February 2021 Class 4 *Psychrometrics* *Air, moisture & earth:* *The stuff around the building*	Basics of psychrometrics Climate characterization Soils Composition Classification Behavior Groundwater	**Required Preparation:** Psychrometric Chart tutorial – basic https://www.youtube.com/watch?v=OsWm8dfhP_U Psychrometric Chart tutorial – in depth with quiz http://www.uwsp.edu/papersci/Pages/charttut/story_html5.html Download climate data near your hometown from: http://www1.ncdc.noaa.gov/pub/data/EngineeringWeatherData_CDROM/engwx/ Browse the Web Soil Survey and learn about soil near your hometown: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm **Required Readings (* denotes provided on-line):** Soils and Water Handout* USGS, *Basic Groundwater Hydrology Water Supply Paper 2220*, p. 1-15* Watch: Water Movement in the Soil https://www.youtube.com/watch?v=ego2FkuQwxc Watch: Capillary rise in soil https://www.youtube.com/watch?v=5waNTa2b-yg **Optional Resources:** NCDC Climate Data Handbook* ASHRAE, *Climatic Data for Building Design Standards**	• Do you have a proficient understanding of psychrometrics? • Do you understand the relationship of the properties of moisture vapor? • Do you understand what the climate data presents? (Hint: Read the NCDC Handbook) • How does your hometown climate compare with a climate for a city in different part of the United States? • Do you know the properties and behaviors of the different soil types? • What is the fundamental difference between water moving in a pipe and water moving through very fine sand?	
19 February 2021 Class 5 *Building physics:* *"follow the water"*	Building Physics Material structure Moisture and thermal energy transport in materials Thermal response Moisture transport and soluble salts Exercise: Africa House	**Required Readings (* denotes provided on-line):** Straube, *Moisture, Materials and Buildings** Straube, BSD 138, *Moisture & Materials** CBD 130, *Wetting and Drying of Porous Materials** Building Science Insight 011, "Capillary: Small Sacrifices"* Melloy, *Heat Transfer Handout** *Porous Building Materials Handout** Watt, Chap. 4, p. 114-119*	• Consider water and its molecular structure. Why do material surfaces have the tendency to hold water? How is this tendency manifested in the three regimes of moisture storage outlined by Straube? • Define hysteresis. What causes hysteresis in the movement of moisture in and out of a material? • Briefly look up the definitions of the Law of Conservation of Mass and the Law of Conservation of Energy. How do they affect the storage of moisture and thermal in materials? How do they relate to time? • What are the different transport mechanisms for thermal energy transport?	**Draft Consultation 1 due**

Date	Topics	Readings and Preparation	Reading Orientation Questions	Submittals (due prior to class)
25 February 2021 Class 6 *Deterioration: understanding causality*	**Test of Knowledge 1** Deterioration as a system Overview of deterioration pathologies Necessary & sufficient factors Types of deterioration Combined or sequential mechanisms & synergies	**Correct Test of Knowledge 1 in class.** **Required Readings (* denotes provided on-line):** Henry, *Technical Note: Systems Thinking** Watt, *Building Pathology*, Chapter 4, p. 96-114 Harris, *Building Pathology*, Chapter 2, p. 15-28 **Meadows, *Thinking in Systems, a Primer* (complete reading the entire book before this class)***	• Define necessary and sufficient factors for deterioration? • Can we represent a deterioration mechanism, or a necessary and sufficient factor for a deterioration mechanism, with a system diagram?	
05 March 2021 Class 7 *Goo & crud: How & why*	Biological Deterioration Microorganisms, vermin & critters Electrochemical Deterioration Corrosion Galvanic corrosion Alkali-silica reaction in concrete Alkali deterioration of wood Ozone & ultraviolet light	**Required Readings (* denotes provided on-line):** Watt, *Building Pathology*, Chapter 4, p. 120-125* Watt, *Building Pathology*, Chapter 4, p. 130-137* Meloy, Technical Note: "Biological Mechanism of Deterioration"* Andrady, et. al., "Effects of Increased Solar Ultraviolet Radiation on Materials"* Davis, *Corrosion: Understanding the Basics*, Chapter 2* Harris, *Building Pathology*, Chapter 3, p.95-130	• What are the necessary and sufficient factors for fungal growth to occur? • What are the different types of wood-attacking insects and how do they interact with wood differently? Consider characteristics such as the insect's diet, modes of transportation, etc. • How does the electromotive series influence how galvanic corrosion occurs? • How are ozone degradation and UV degradation related? In what ways are they different?	
12 March 2021	Spring Break NO CLASS		•	
19 March 2021 Class 8 *Cracks & fractures How & why*	Mechanical deterioration Principal stresses Elastic versus plastic deformation Strain hardening, fatigue, creep & cracks Hygrothermal deterioration Linear & volumetric expansion/contraction Freeze-thaw Exercise: Estimating expansion & contraction	**Required Readings (* denotes provided on-line):** Harris, *Building Pathology*, Chapter 3, p. 58-95* CBD 047, *Extreme Temperatures at the Outer Surfaces of Buildings** CBD 056, *Thermal and Moisture Deformation in Building Materials** Stresses and Constraints Handout*	• Why is constraint/restraint such an important consideration for the performance of building materials? • What kinds of materials are anisotropic? How will this characteristic affect their performance with respect to their hygrothermal response? • There are different types of gradients: thermal, moisture, and stress gradients. Why are gradients important to understand and identify?	**Draft Consultation 2 due**

Date	Topics	Readings and Preparation	Reading Orientation Questions	Submittals (due prior to class)
26 March 2021 Class 9 *Structures: Loads & bones*	Building Structures Strength & stiffness Forces & loads Soils & groundwater Foundations Types of structures Performance deterioration Failures	**Required Readings (* denotes provided on-line):** **Finish reading Blockley's *Structural Engineering: A Very Short Introduction* before this class** CBD 003, *Soil & Buildings** CBD 054, *Horizontal Deflections of Structural Members** CBD 148, *Foundation Movements** Expansive soils https://www.youtube.com/watch?v=SW-NoiM726U&t=23s **Optional Resources:** Ching, *Building Construction Illustrated*, 1.30-1.33; 2.08-3.26; 4.02-4.40; A.06-A.07 Active statics: http://ocw.mit.edu/ans7870/4/4.461/f04/module/Start.html	• What are the components of the three-phase system of soil? What are the important implications of this system with respect to building foundations? • Imagine you are in a historic wood-frame house. According to the L/360 rule for allowable deflection without cracking of finishes, how much is a 15-foot-long wood joist allowed to deflect? • Settlement is typically divided into two phases: immediate settlement and consolidation settlement. What are the differences between these two phases of settlement? How do these two phases, as well as other factors, affect/cause differential settlement of a structure? • The active statics site looks at trusses and hanging cables/arches in two-dimensions. Consider the visual presentation of these statics' scenarios. What components of the visual presentation were helpful to you for understanding the concepts? Were any of the force distributions surprising or counter-intuitive to you?	
02 April 2021 Class 10 *Enclosure: external organs*	Building enclosure systems Static elements: roofs & walls Types of wall systems Operable elements Sash, shutters/shades & doors Energy efficiency improvements	**Required Readings (* denotes provided on-line):** Straube, BSD 018, *Building Enclosures** Straube, BSD 011, *Thermal Control in Buildings** Straube, BSD 030, *Rain Control Theory** Straube, BSD 013, *Rain Control in Buildings** Lstiburek, BSD 106, *Understanding Vapor Barriers** Lstiburek, BSI 117 *Rain Control in Buildings** **Optional Resources:** Ching, *Building Construction Illustrated*, Chapters 5-7 Harris, *Building Pathology*, Chapter 3 Harris, *Building Pathology*, Chapter 4 Harris, *Building Pathology*, Chapter 5	• Review the vapor profiles for the different types of wall assemblies laid out in Lstiburek's article. What might complicate these assemblies? I.e. how is the cladding connected to the structure? Comfort is an extremely important consideration in how buildings function. What are the features of traditional enclosures that can be used to improve comfort?	**Draft Consultation 3 due**

Date	Topics	Readings and Preparation	Reading Orientation Questions	Submittals (due prior to class)
09 April 2021 Class 11 *Systems: internal organs*	Building systems Comfort, climate & environmental Health & sanitation Fire detection & protection Information: security, data & communications	**Required Readings (* denotes provided on-line):** Harris, *Building Pathology*, Chapter 6, p. 618-635 NPS, *Preservation Brief 24: Heating, Cooling & Ventilation in Historic Buildings** Straube, BSI-022 *Perfect HVAC** Straube, BSD 109 *Pressure in Buildings** Padfield, *How Air Conditioning Works** **Optional Resources:** Ching, *Building Construction Illustrated*, Chapter	• From last week's reading, the important of ventilation was made clear with respect to moisture transport in wall assemblies. What are the negatives of having good ventilation? • What features do all utility systems have? Consider how these different features could fail and the consequences of these failures? Human thermal comfort can be affected by both physiological and psychological factors. Consider what these could be.	
16 April 2021 Class 12 *We know what's wrong—what can we do about it?*	Interventions Setting objectives Identifying evaluating & selecting preferred strategies Design for intervention & prevention Longevity & maintainability, reversibility Material & craft availability, costs Implementation of interventions Setting & achieving construction quality Follow-through, measuring efficacy Course review	**Required Readings (* denotes provided on-line):** Harris, *Building Pathology*, Chapter 1, p. 36-56 Watt, *Building Pathology*, Chapter 5 Brand, *How Buildings Learn*, Chapter 8 and 11-12 NPS Preservation Brief 17: "Architectural Character—Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character"	• What are the benefits of Harris' intervention Matrix, as well as the way in which he sorts intervention options and the variations on this (Table 2.2-2.5)? What are the potential problems with this type of evaluation? • How are the questions and tables that Watt presents helpful? How could they potentially be problematic given that each building is unique? • Harris' general categorization of intervention approaches is helpful; however, the interventions he discusses are really more like individual treatments. Instead, interventions should be thought of as projects that more holistically consider the building—not only the different deterioration mechanisms and systems present but also the building's environmental and cultural context. Consider the differences between the four levels of intervention identified by the Secretary of the Interior. Additionally, how should treatments and the environmental and cultural context be integrated into these approaches? • How should character-defining features guide interventions?	
05 May 2021	**Upload digital copy of Final Assignment and the Self-Evaluations to the designated DropBox folder before 12 Noon EDT. No extensions.**			
24 April 12 Noon EDT **30 April 12 Noon EDT**	**Take Test of Knowledge 2 on-line using Canvas. No extensions.**			