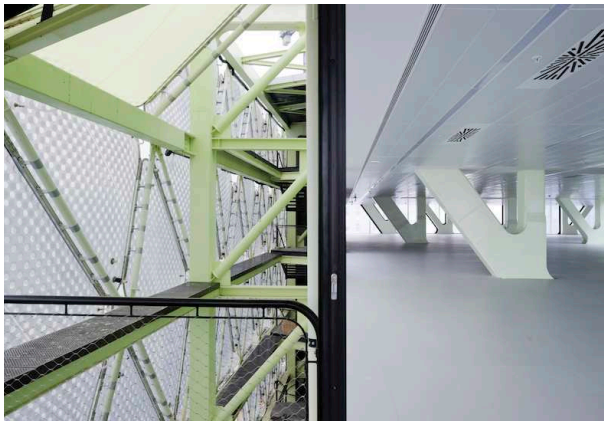

MATERIAL PERFORMANCE IN SUSTAINABLE BUILDING

ARCH 8565: GRADUATE SEMINAR, SPRING 2013
UNIVERSITY OF MINNESOTA SCHOOL OF ARCHITECTURE

TIME AND LOCATION
Tuesdays, 2:30-5:15 PM
109 Rapson Hall

FORMAT
3-credit graduate seminar

COURSE WEBSITE
arch8565.wordpress.com

INSTRUCTOR
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COURSE CONTRIBUTORS
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COURSE DESCRIPTION

The opportunity to design high performance "green" buildings challenges architects to create or find environmentally friendly materials and construction processes that suggest future value. Concepts such as designing for adaptability, disassembly, reuse, reduced waste or energy self-sufficiency promise important innovations. The selection of materials in architecture design and construction is inextricably linked to assessment methods for determining environmental and resource impacts over the life (and afterlife) of buildings.

This course investigates the complex issues associated with green building material selection, fabrication, construction and deconstruction processes in the production of high performance sustainable building designs. Using case studies and class exercises, students will apply LCA assessment tools (BEES, Athena, and others) as measures of green building performance, and creatively strategize the redesign of major building components.

We will address these questions: What are sustainable materials? What are the tools to evaluate sustainable materials? How do we make competent assessments? How do we observe and evaluate the flow of materials and energy and their environmental effects?

INTRODUCTION

Selection and use of materials and resources for more sustainable building has been an evolving process since the first recycled content products hit the market in the early 1970s. Costs related to increased waste from construction, depletion of non-renewable resources, and air and water pollution from production and distribution as well as habitat fragmentation are becoming increasing drains on our economy and disruptive to our environment. Because the building industry consumes over three billion tons of raw materials annually—around 40 percent of the total material flow in the global economy—the need to reduce the effects of building material extraction, processing, delivery, use, and disposal has become imperative to improving the health of our economy and our communities. To this end, guidelines and rating systems have sought to guide practitioners toward choices that reduce waste and the negative environmental impacts associated with materials through prescriptive requirements for such characteristics as amount of recycled content, locally produced or assembled products, and sustainably harvested wood. The State of Minnesota Sustainable Building Guidelines (MSBG) are moving away from prescriptive requirements toward material selection based on Life Cycle Assessment (LCA) and Life Cycle Cost (LCC), which will provide a better connection to real effects and costs based on outcome-based performance criteria. - *Minnesota Sustainable Building Guidelines* (MSBG), CSBR

LEARNING OBJECTIVES

- Develop knowledge about how materials selection fits within the context of a whole building design process
- Develop knowledge about material resource and energy flows, as well as ways to evaluate sustainable product certification methods—the interaction between manufacturing conservation, recycling/reuse and waste—as fundamental to the design process
- Develop evaluation and assessment (decision making) processes for material life-cycles; construction use and maintenance; manufacturing and fabrication; material acquisition/preparation/reuse; and recycling and disposal
- Develop knowledge about ecolabeling and LCA assessment tools and their function with other strategies (Athena, LEED, and B3) that improve energy efficiency, conserve materials resources and reduce waste during construction, building operations and deconstruction
- Develop methodologies for assimilating sustainable materials knowledge within the design process and utilizing design judgment as well as analytical judgment to evaluate green materials and systems

OUTCOMES

- Students will be able to evaluate material alternatives to optimize total life-cycle performance according to material properties such as: high recycled content, local production, rapidly renewable content, reusability, recyclability, biodegradability, and maximum durability based on anticipated life of interior construction, equipment, finishes, and furnishings.
- Students will be able to research and design material conservation strategies in the construction process and occupancy/operation of buildings to determine actual environmental, economic, human and community outcomes.
- Students will be able to understand the ecolabeling process and the market forces behind sustainable branding.
- Students will be able to apply assessment tools that measure the environmental impact of materials selection on building designs.
- Students will model an integrated design approach to building structure, envelope systems, interiors and energy systems that will perform as a resource and cost-efficient system that enhances building performance as well as occupants' productivity and health.
- Students will learn decision processes and criteria for selecting environmentally sound materials and incorporating the components into construction specifications for assembly and disassembly.
- Students will be able to acknowledge the scales of material and energy flows required to support the building industry and their subsequent impact on the environment.

SUSTAINABLE DESIGN COURSE PHILOSOPHY

The four foundation courses in the M.S. in the Sustainable Design Track embody and promote a pedagogy based on ecological literacy and ecological principles. Ecological literacy is the knowledge and understanding of the basic patterns, processes and structures of natural systems. This natural system is the model of sustainability existing and thriving on current energy and nutrient flows. Nature is the first teacher, and the primary guide. The program and courses employ an ecological model as pedagogy; curriculum and course structure; and as a template for student, faculty, and community relationships.

ASSIGNMENTS (SEE SCHEDULE FOR DETAILS)

MATERIAL COMPARISON (20%)

An assessment of the environmental features of two materials

MATERIAL ASSEMBLY (20%)

An evaluation of a precedent building envelope and a proposed alternative

MATERIAL RESOURCE EVALUATION FOR UMORE PARK: PRESENTATION (20%)

A research and design presentation for the optimization of material life cycles on the UMore Park property

MATERIAL RESOURCE EVALUATION FOR UMORE PARK: DOCUMENT (30%)

A research and design report for the optimization of material life cycles on the UMore Park property

READINGS + CLASS PARTICIPATION (10%)

REQUIRED TEXT (OTHER READINGS ON COURSE WEBSITE)

- Michael F. Ashby, *Materials and the Environment: Eco-Informed Material Choice* (Oxford: Butterworth-Heinemann, 2009)

TOOLS (TO BE DISTRIBUTED TO STUDENTS)

- BEES: Life Cycle Assessment protocols for product comparison
- Athena EcoCalculator: Life Cycle Assessment protocols for building assemblies
- Athena Impact Estimator: Life Cycle Assessment protocols for buildings

REQUIREMENTS AND POLICY

GRADING

The grading criteria are listed with each assignment. In general, clarity, organization, detailed analysis of material criteria, and references to broader temporal and physical scales are desired. All work will be graded on a 100 point system, then weighted according to the percentages listed in the assignments section above.

Final grades will be based on the following:

Grade Points

A	90-100
B	80-89
C	70-79
D	60-69
F	59 or below

ABSENCES

More than two absences (excused or unexcused) will result in a full letter grade reduction.

LATE WORK

No late work will be accepted.

INCOMPLETE WORK

Incomplete work will not be accepted without instructor's prior approval and written agreement as to revised due dates and grading policy.

SUBJECT TO CHANGE

Except for the grade and attendance policies, parts of this syllabus are subject to change with advanced notice, as deemed appropriate by the instructor.

HANDICAPPED ACCESSIBILITY

Every effort will be made to accommodate students with diagnosed disabilities. Please contact the instructor to initiate a discussion about how to best help you succeed in this class.

RETENTION OF WORK

Student work will become part of a permanent archive. All work must be clearly labeled with: student name, class name, semester, year, and instructor's name. The School of Architecture has the right to retain any student project whether it be for display, accreditation, documentation or any other educational or legal purpose.

SCHEDULE

Material Performance in Sustainable Building follows two parallel organizational structures. The first is a scale structure relating to the scope of focus, also divided into three stages: 1) materials, 2) assemblies, and 3) systems. The second is a repeating temporal structure based on material cycles in three stages: 1) pre-use, 2) use, and 3) post-use. Together, these structures are utilized to enhance students' knowledge of the different phases and scales of material use.

WEEK 01 [01.22]

COURSE INTRODUCTION

Course overview: purpose of course, course structure, classroom discussions, explanation of individual and group projects, student involvement, and student expectations

WHAT MAKES A MATERIAL GREEN?

Assessing the environmental sustainability of materials; preview of topics in resources, energy, material properties, legislation, and tools

DISCUSSION: MATERIAL COMPARISON

Which material is greener?

WEEK 02 [01.29]

MATERIAL DEPENDENCE

The historical context of materials production and consumption; examining environmental impacts of mining, manufacturing, transporting, constructing and disposing of building materials

RESOURCE CONSUMPTION

Broad introduction to energy and material flows, growth factors, reserves and the resource base, resource criticality

DISCUSSION: TRAGEDY OF THE COMMONS

Does Hardin's solution for "mutual coercion mutually agreed upon" work? Is it plausible for sustainable design? What are some of the other options?

READINGS

- Michael F. Ashby, *Materials and the Environment*, Chapter 1: "Introduction: material dependence," 1-14 and Chapter 2: "Resource consumption and its drivers," 15-38
- Blaine Brownell, "Material Ecologies in Architecture," *Design Ecologies*, Lisa Tilder and Beth Blostein, ed., (New York: Princeton Architectural Press, 2009)
- Garrett Hardin, "The Tragedy of the Commons," *Science* 1968, Vol. 162, 1243-1248
- Charles J. Kibert, "Background," *Sustainable Construction: Green Building Design and Delivery* (Hoboken, NJ: Wiley, 2005), 31-64
- "Building Materials: What Makes a Product Green?" *Environmental Building News* (January 2000)
- USGBC Final TSAC Report on PVC

FILM

- Judith Helfand and Daniel B. Gold, *Blue Vinyl* (2002) The hazards of bio-accumulation, pollution, and the makeup of what we commonly hope are benign plastics

WEEK 03 [02.05]

PRESENTATION: MATERIAL COMPARISON

Each student will present a comparison of two materials, one considered to be a standard construction material and one that represents a more environmentally-friendly substitute. (See assignment for details.)

READINGS

- "Green Building Materials" list of selection criteria

WEEK 04 [02.12]

MATERIALS LIFE CYCLE

Examination of components of Life Cycle Assessment (LCA), LCA processes and their benefits and drawbacks, comparison of LCA with LCC and LCI, overview of primary LCA tools

DISCUSSION: PROS AND CONS OF LCA

What values, markets and conditions are inherent in creating and modeling a materials using LCA? How effective is LCA in determining sustainable products? Should we be looking for other methods to replace or supplement LCA?

READINGS

- Michael F. Ashby, *Materials and the Environment*, Chapter 3: "The materials life cycle," 39-64
- John Carmody and Wayne Trusty, "Life Cycle Assessment Tools," *Implications*, Vol. 5 Issue 3
- Barbara C. Lippiat and Amy S. Boyles, "Building for Environmental and Economic Sustainability (BEES): Software for Selecting Cost-Effective Green Building Products," CIB World Building Congress, April 2001
- Wayne B. Trusty, "Life Cycle Assessment, Databases and Sustainable Building," Athena Sustainable Materials Institute

- Wayne B. Trusty, "Understanding the Green Building Toolkit: Picking the Right Tool for the Job—Comparison of BEES and Impact Estimator"

WEEK 05 [02.19]

GREEN LEGISLATION

Landmark publications, international treaties, protocols, and voluntary agreements

ECOLABELS, GREEN RATING SYSTEMS + MARKETING

First, second, and third-party ecolabels; green marketing, greenwashing, overview of green rating systems and industry scorecards

DISCUSSION: STICK OR CARROT?

Is legislation the best way to control material use? Are ecolabels effective? Are they clear or confusing? Which systems of material evaluation and representation will best inform and influence the market?

READINGS

- Michael F. Ashby, *Materials and the Environment*, Chapter 5: "The long reach of legislation," 85-100
- "Introduction to Ecolabelling," *Global Ecolabelling Network Information Paper*, July 2004
- Russell Fortmeyer, "(Mis)Understanding Green Products," November 2007
- "Understanding Eco-labels" by the Federal Electronics Challenge (June 5, 2006)
- Optional: *Green Marketing: Opportunity for Innovation*, Chapters 4, 5, and 9 (McGraw-Hill, 1998)

WEEK 06 [02.26]

SECOND LIFE

Material repurposing, recycling, and recombination; technical and biological nutrient systems; second life applications and implications

DESIGN FOR DISASSEMBLY

Design and specification of buildings that may be decommissioned and disassembled, technical evaluation of building construction for material reuse, field studies and documentation, assembly protocols

DISCUSSION: LIFE AND AFTERLIFE

How do we design adaptable structures? How do we address durability and temporal programming in architecture? What are the best approaches to disassembly and adaptive reuse?

READINGS

- Michael F. Ashby, *Materials and the Environment*, Chapter 4: "End of first life: a problem or a resource?," 65-84 and Chapter 6: "Ecodata: values, sources, precision," 101-128, and Chapter 7: "Eco-audits and eco-audit tools," 129-160
- "Assessing Buildings for Adaptability," Annex 31: Energy-Related Environmental Impact of Buildings, November 2001
- Vince Catalli and Maria Williams, "Designing for Disassembly: Designing for disassembly provides an innovative strategy for attaining environmental goals and building adaptability," *Canadian Architect*, January 2001
- "Design for Detailing and Deconstruction," *SEDA Design Guides for Scotland* (2005), No. 1
- Bradley Guy, "Design for Deconstruction and Materials Reuse," Center for Construction and Environment

WEEK 07 [03.05]

PRESENTATION: MATERIAL ASSEMBLY

Each student team will present an analysis of a building envelope assembly precedent compared with a modified version. (See assignment for details.)

READINGS

- Mike Davies, "A Wall for All Seasons," *RIBA Journal* (February 1981)

WEEK 08 [03.12]

CATALYST WEEK

No class (optional field trip for non-catalyst students, details forthcoming)

WEEK 09 [03.19]

SPRING BREAK

No class

WEEK 10 [03.26]

TOUR: UMORE PARK

A guided tour of the 5,000 acre University of Minnesota Outreach, Research and Education property in Dakota County. Be prepared to take photographs, video footage, and/or sketches.

READINGS

- "UMore Park Fact Sheet"
- "UMore Park Concept Master Plan Summary"

- CSBR, "UMore Park Sustainable Materials Report"
- CSBR, "UMore Park Zero Waste Report"
- John Lauber, "A Historical Interpretation and Preservation Plan for UMore Park" (April 2006)
- Sasaki Associates Inc., "UMore Park Strategic Plan" (October 2006)
- "Creating the Vision: The Future of UMore Park" (October 2006)
- "Distinctiveness through Academic Mission" (March 2008)
- "Integrating Academic Mission into Planning and Development of the UMore Park Property" (November 2006)

WEEK 11 [04.02]

FOREST STEWARDSHIP

Certification processes and their influences in the market, Forest Stewardship Council Certification development and use

FOREST PRODUCTS

State of world forests, established markets for forest materials, relationship between tree farms and building industry

DISCUSSION: FOREST PRODUCT MANAGEMENT

Sustainable wood products and labeling systems, industry clashes over forest stewardship certification, influence of the *Yale Program on Forestry Policy and Governance Report*

READINGS

- Wendy Baer, "An Overview on Certification," International Wood Products Association (IWPA), BIFMA Members Meeting, Washington, D.C. (October 21, 2002)
- ForestEthics, Greenpeace, Natural Resources Defense Council, and Rainforest Action Network, "Ecological Components of Endangered Forests" (July 2005)
- Daniel Hall, "Forest Certification: Sustainable Forestry or Misleading Marketing? Forest Certification Systems Still Not Created Equal" American Lands Alliance (March 2005)
- E. Hansen, R. Fletcher, B. Cashore, and C. McDermott, "Forest Certification in North America," Oregon State University (February 2006)
- "Seeing the Wood: A Special Report on Forests," *The Economist* (September 25, 2010)
- The Yale Program on Forest Policy and Governance, "Assessing USGBC's Forest Certification Policy Options" (September 16, 2007), 1-3
- Weyerhaeuser, "Forest Ecosystems"
- Brief descriptions of American Tree Farm, Canadian Standard Association, Forest Stewardship Council, and Sustainable Forest Initiative systems

WEEK 12 [04.09]

SELECTION STRATEGIES

Principles of material selection, criteria and properties, resolving conflicting objectives, case studies

MATERIAL CHEMISTRY AND IEQ

Indoor Environmental Quality, macro and micro context, Sick Building Syndrome (SBS), moisture and envelope

DISCUSSION: MATERIAL TRADEOFFS

What makes one material more sustainable than another? How do we balance environmental, social, and economic needs within building environments? What are unresolved conflicts concerning LCA?

PRESENTATION REVIEW

Student teams will discuss preparations and logistics for class presentation

READINGS

- Michael F. Ashby, *Materials and the Environment*, Chapter 8: "Selection strategies," 161-198, and Chapter 9: "Eco-informed material selection," 199-230
- *Handbook of Sustainable Building: An Environmental Preference Method for Materials for Use Construction and Refurbishment*, Part 4: "Environmental Effects of Building Materials in Common Use," 165-175
- Tom Lent, "Toxic Data Bias and the Challenges of Using LCA in the Design Community," presented at GreenBuild 2003
- William McDonough and Michael Braungart, *Cradle to Cradle* (New York: North Point Press, 2001), Chapter Six: "Putting Eco-Effectiveness into Practice," 157-186
- Mark Rossi, "Reaching the Limits of Quantitative Life Cycle Assessment," Clean Production Action, June 2004

WEEK 13 [04.16]

RENEWABLE RESOURCES

Bioproducts and biosystems, making chemicals and industrial materials from plant matter, the carbohydrate economy, balancing different market demands

BIOMIMICRY

Taking inspiration from nature, retooling manufacturing processes, the next industrial revolution, biomimetic forms, processes, and systems

DISCUSSION: LEARNING FROM NATURE

How can we harvest renewable materials in a more environmentally responsible way? What can we authentically learn from nature? What are the broader implications of biomimicry? How will the "made" and the "born" converge?

READINGS

- Michael F. Ashby, *Materials and the Environment*, Chapter 10: "Sustainability: living on renewables," 231-246 and Chapter 11: "The bigger picture: future options," 247-264
- Janine Benyus, *Biomimicry*, Chapter 1: "Echoing Nature" (New York: Harper Perennial, 2002)
- "Bio-Architecture" summary
- "The Biobased Economy of the Twenty-First Century: Agriculture Expanding into Health, Energy, Chemicals, and Materials," *Natural Agricultural Biotechnology Council Report* (2000)
- Chapter 12: "Biobased Materials"
- Ralph W. F. Hardy, "The Bio-based Economy"
- David Morris, "The Carbohydrate Economy, Net Fuels, and the Energy Debate," Institute for Local Self Reliance (August 2005)
- Kohmei Halada, "Progress of Ecomaterials Research towards Sustainable Society," National Research Institute for Metals
- Schmidt-Bleek, "How to Reach a Sustainable Economy," Wuppertal Institute

WEEK 14 [04.23]

WORK IN PROGRESS PRESENTATION: MATERIAL RESOURCE EVALUATION FOR UMORE PARK (SET 1)

Each team will present work to date on research and design proposals for the optimization of material life cycles on the UMore Park property.

WEEK 15 [04.30]

WORK IN PROGRESS PRESENTATION: MATERIAL RESOURCE EVALUATION FOR UMORE PARK (SET 2)

Each team will present work to date on research and design proposals for the optimization of material life cycles on the UMore Park property.

WEEK 16 [05.07]

PRESENTATION: MATERIAL RESOURCE EVALUATION FOR UMORE PARK

Each team will present final research and design proposals for the optimization of material life cycles on the UMore Park property. (See assignment for details.)

WEEK 17 [05.14]

DUE DATE FOR REPORT: MATERIAL RESOURCE EVALUATION FOR UMORE PARK

No class. (See assignment for details.)

ASSIGNMENTS

MATERIAL COMPARISON

According to the AIA *Ecological Literacy in Architecture Education Report* (2006), "The careful selection of materials and products can conserve resources, reduce impacts of harvesting, production, and transportation, improve building performance, and enhance occupant health and comfort." Such careful selection requires a thorough comprehension of the environmental effects of materials, in addition to their functional and economic attributes. The evaluation process also relies upon the comparison of reliable data using well-structured, defensible criteria.

SCENARIO

Imagine that you are currently designing a building, and one of your first tasks is to determine if a new "sustainable building material" should be recommended for the project. Considering the client's program and budget, it is imperative that the sustainable material be *functionally equivalent* to the one presently selected for the project. (Functional equivalency is a term used in the sustainable design community to compare like products. Each of the products is the same in all functional aspects but not necessarily the same in price, availability, environmental impacts, etc.) To ensure this equivalency, you must compare the following characteristics for each of the materials in your research:

FUNCTIONAL CHARACTERISTICS

Durability, reusability, recyclability, adaptability, availability, applicability to its intended use

Owens Corning fiberglass insulation versus Bonded Logic cotton insulation

ECONOMIC CHARACTERISTICS

Cost per square foot (labor and materials), product warranties, waste during manufacturing, waste during construction, labor availability to install product, compliance with building codes, compliance with life safety and fire codes

ENVIRONMENTAL CHARACTERISTICS

Natural resource depletion: non-renewable energy, wood resources, water, scarce metals, terrestrial habitats, wetland habitats, lake habitats, river habitats, keystone species

Emissions: cumulative greenhouse gases, oceanic acidification, regional acidification, smog, soot, neurotoxicity due to mercury, human systemic toxicity, eco-toxicity

Risks from Indoor Exposure: radon/radioactive exposure; inhalation toxicity (VOCs and PM); dermal toxicity; contains endocrine disruptors (diethylstilbestrol (the drug DES), dioxin, PCBs, DDT, and some other pesticides) or eco-cedes (the destruction of large areas of the natural environment by such activity as nuclear waste, overexploitation of resources, or dumping of harmful chemicals); contains chemical on the US EPA's List of Persistent, Bio-accumulative and Toxic Chemicals and Pollution Prevention (http://www.wrppn.org/PBT/table1.htm); or contains heavy metals such as mercury, lead, cadmium, chromium, and nickel.

MATERIALS

The following examples are pairings that your client might consider. Feel free to use one of these, or develop your own pairing for your comparative evaluation.

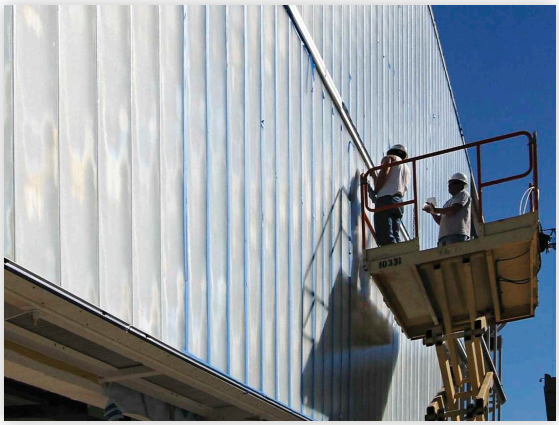
- Drywall, United States Gypsum versus Demountable Wall System, Smartwalls LLC
- Granite counter top, Cold Spring versus Vetrazzo, Wheat Board Counter Production; Syndecrete, Syndesis; or Richlite, Richlite Inc.
- Quartz composite surface, Cambria versus Reclaimed wood countertops, TerraMai
- Standard CMU, Anchor Block versus Enerblock
- Red oak flooring, Carlisle versus Bamboo flooring, K & M Bamboo Products
- Glulam, Boise Cascade versus Underwater salvage timber, Triton Logging
- Wood veneer, Donear versus Paperstone, KlipTech Composites, Inc.
- FSC Wood Trim versus Recycled-content interior molding, Timbron International
- Low e-glass, Viracon versus SageGlass tintable glazing, Sage Electrochromics
- Plywood, Weyerhaeuser versus Microstrand Wheat Board, Environ Biocomposites
- Ceramic tile, American Olean versus Tile with 60% minimum recycled glass content, Terra Green
- Plastic signage, Thomas Net versus Biofiber signage, Phenix Biocomposite
- Fiberglass insulation, Owens Corning versus Cotton insulation, Bonded Logic, Inc.
- Cedar siding, Western Wood Products Association (WWPA) versus Parklex Facade, Composites Gurea

TOOLS

You should utilize two primary tools for your evaluation—ecolabeling standards and green resource guides. Select either two ecolabels or one ecolabel and one resource guide from the provided lists (see references) that pertain to your selected materials. In addition to evaluating the materials, you should be able to assess the usefulness of the ecolabel and resource guide that you apply.

PRESENTATION

You will be required to give a 6-minute presentation in pdf, keynote, or ppt format to about your research and



Steven Holl Architects, Nelson-Atkins Museum of Art, Kansas City, 2007

recommendation to the client. Be prepared to give a brief explanation of the tools you used, your side-by-side comparisons of the two materials, and the reasons for your recommendation of one material over the other. Your final slide must be a synopsis of your recommendation, summarizing your study with a clear comparison of the most important data (this slide should be able to stand on its own without the need for verbal explanation).

You will be evaluated based on your ability to give a clear and concise presentation with sufficient depth of research, and a well-articulated set of values and criteria used to make an authoritative recommendation. Points will also be awarded for creative representation and communication of the data.

MATERIAL ASSEMBLY

The assembly assessment is a collaborative project that builds on the experience gained from the material comparison assignment, expanding the scale to consider a primary building envelope. Like the material comparison, you will analyze the environmental benefits and drawbacks of particular materials. However, in this case you will study a collection of materials used in an exterior building assembly, and your study will include a life cycle assessment (LCA) performed using selected software tools. Based on your findings, you will also generate an alternate design proposal that improves upon the LCA of your assembly.

METHODS

Since this is a two-person effort, each student is requested to select a partner for this exercise. Your team will then select an exterior building assembly that is part of an existing "sustainable building" for study. This assembly must be either an exterior wall or roof system (or both), and should be well documented in annotated drawings and photographs sufficient for an adequate life cycle assessment. (See the recommended sources below for suggestions.)

For your assessment, you will examine a typical structural bay of this assembly using the software tools listed below (limit your assessment to one story if the building is more than one level). You are requested to generate clear, informative diagrams of the assembly in order to document and present your analysis graphically.

Based on your life cycle assessment findings, you are then requested to propose changes in order to improve upon the assembly. These changes should focus on the material content of the assembly as opposed to thermal, daylighting, or other implications; however, you are free to address other aspects in your alternative proposal as you wish. Illustrate your alternative proposal in a similar fashion as the original assembly for the purpose of easy visual comparison.

RECOMMENDED SOURCES

The U.S. Department of Energy Solar Decathlon competition is a good source of information for creative, environmentally sensitive architectural proposals. The solar decathlon website provides robust documentation on past projects: http://www.solardecathlon.gov/

The following journals are also good sources for analytical drawings and photo documentation of architectural assemblies. Architectural monographs can also be good references for this kind of information.

- *Abitare*
- *Detail*
- *Mark*
- *Materia*
- *The Plan*

TOOLS

Each team must use the following two tools for the analysis, which may be downloaded for free from the listed websites (Athena Impact Estimator requires a temporary license code):

- BEES: Life Cycle Assessment protocols for product comparison (http://www.bfrl.nist.gov/oae/software/bees/bees.html)
- Athena EcoCalculator: Life Cycle Assessment protocols for building assemblies (http://www.athenasmi.org/tools/ecoCalculator/index.html)

- Optional: Athena Impact Estimator: Life Cycle Assessment protocols for buildings (http://www.athenasmi.org/tools/impactEstimator/)

For your life cycle analysis, you must select at least three possible environmental performance measures, with an argument for your prioritization of these criteria:

- Embodied primary energy use (Energy Consumption)
- Acidification Potential
- Global Warming Potential
- Human Health Respiratory Effects Potential
- Ozone Depletion Potential
- Smog Potential
- Aquatic Eutrophication Potential

Document and present the environmental performance score of your case study assembly as well as the alternative assembly you design. Remember to address functional equivalency in your proposed alternative. You may also wish to include qualitative evaluation for critical materials as in your material comparison project.

You may not be able to determine exact data for all materials in the assembly; however, you are asked to make your best guess. If your building's geographic region and project type is not included in the Athena software, please select the region and project type that most closely approximates your building of study and its context.

PRESENTATION

Your team will be required to give a 12-minute presentation in pdf, keynote, or ppt format about your research and recommendation. Be prepared to give a brief explanation of the tools you used, your side by side comparisons of the two assemblies, and the justification for your changes in the alternative scheme. Your final slide must be a synopsis of your assessment, summarizing your study with a clear comparison of the most important data (this slide should be able to stand on its own without the need for verbal explanation).

You team will be evaluated based on your ability to give a clear and concise presentation with sufficient depth of research, and a well-articulated set of values and criteria used to make an authoritative recommendation. Points will also be awarded for creative design proposals and visual display of information.

Gopher Ordnance facility ruins, UMore Park, Minnesota

MATERIAL RESOURCE EVALUATION FOR UMORE PARK

In a lecture that followed the publication of his book *Hot, Flat, and Crowded: Why We Need a Green Revolution—and How It Can Renew America*, journalist Thomas Friedman claimed that there will be nothing easy about counteracting global warming. "If we have any chance of preventing disruptive climate change," stated Friedman, "it will require the biggest industrial project mankind has undertaken since the Tower of Babel." Scientists point to buildings as major contributors to climate change—comprising some 30% of world energy consumption for conditioning and lighting alone. Considering buildings' intensive use of resources, it is obvious that materials will play a fundamental role in Friedman's call-to-arms.

The University of Minnesota's Outreach, Research and Education (UMore) Park is a 5,000 acre site located 15 miles south of downtown Saint Paul. Envisioned for the development of a "unique sustainable community" of 20,000 to 30,000 residents over a period of 25 to 30 years, the site provides an unusual opportunity to design and deploy progressive, experimental approaches in sustainable building. In this class, we will have the uncommon opportunity to evaluate optimal material resources and make design proposals of effective material-focused design strategies for UMore Park.

Although the objective is simple, its attainment will be difficult. Despite the burgeoning number of regulations and guidelines available to ensure the environmentally responsible manufacture and application of materials,

there is a lack of clarity, consistency, and prioritization of proper implementation strategies for sustainable materials. As a result, architects, designers, engineers, and contractors remain confused about responsible material choices. This uncertainty is exacerbated by a recent explosion of available materials, many of which make dubious claims about environmental sustainability.

Within the continually shifting territory of material selection and application, several important trends have emerged that indicate dramatic changes in our future built environment. These trends highlight the imminent transition from an industrialized, hydrocarbon-based global economy to a regenerative, carbohydrate-based system. Climate change, peak oil, food shortages, water conflicts, and pervasive pollutants are all global concerns that require fundamental changes in the way we select, harvest, process, and manipulate materials—yet questions remain about how to implement these changes.

In this project for the UMore Park development, you will address the "front lines" of this transition by investigating and presenting material developments that have the greatest promise to affect positive change. Student teams will investigate material research and suggest proposals within the following feedstock-related material topic areas:

- Forest Products (Onsite)
  Wood available for building construction, products, fuel, and other uses
- Agricultural Products (Onsite)
  Cellulosic materials available for building construction, products, fuel, and other uses
- Minerals (Onsite)
  Rock, clay, and other earthen materials available for various uses
- Technical Nutrients (Onsite/Offsite)
  Metals, polymers, glasses, and other technical materials
- Waste (Onsite/Offsite)
  Reusable or recyclable feedstocks with second life potential

METHODS

Students are requested to form teams of three or four students each around the topic areas listed above. Each student should select a particular research focus within the topic area that will compliment the other team members' work. For example, students could focus on material subcategories (e.g., softwood or hardwood) or cycle stage (e.g., harvesting or use). The individual topics should be selected to establish a balanced and well-rounded group effort. Each student is expected to conduct independent research while coordinating regularly with his or her group to address broader themes and collaborate on coordinated design proposals). To the extent possible, you should each use BEES, EcoCalculator, or other LCA software to assess the environmental impacts of these materials. Attention should be paid to embodied energy, water, CO2, and potential environmental impacts. The effective visualization of data and development of experimental yet competent design proposals will be crucial for success in this project.

PRESENTATION

The first component of this assignment is a group presentation to the UMore Park Management Team in pdf, keynote, or ppt format. This presentation should consist of both individual and team-based work. Your team should present introductory and conclusion slides that address the general topic and shared themes (3-5 minutes total). The remainder of the presentation will consist of each individual's focused investigation (5 minutes each). Manufacturer data, industry information, visualization tools, LAC assessments, and physical material samples are all recommended content for the presentation.

You will be evaluated based on your ability to give a clear and concise presentation with sufficient depth of research, visualization, and a well-articulated argument for the transformative potential of the material topic you are investigating. Provocative insights about innovative (not necessarily new) material technologies, processes, and applications are welcomed.

REPORT

The second component of this assignment is a documented report of your work, to be shared with the UMore Park Management Team. Like the presentation, the report should present both team-based and individual-based research, and must incorporate a written summary, data visualizations, relevant images, and design proposals. We will work as a class to determine the ideal format for the report. Moreover, the basic format should be designed to serve as a template for potential future class reports.

Student work will be evaluated according to the rubric listed under "Presentation" (above), with a special consideration for effective teamwork.

REFERENCES

ECOLABELS

- AENOR (Spain): www.aenor.es/desarrollo/inicio/home/home.asp
- American Tree Farm System (ATFS): www.treefarmsystem.org
- Blue Angel (Germany): www.blauer-engel.de/englisch/navigation/body_blauer_engel.htm
- Community Supported Agriculture (CSA): www.nal.usda.gov/afsic/pubs/csa/csa.shtml
- EcoLogo (Canada): www.environmentalchoice.com
- Energy Star: www.energystar.gov
- Environmental Choice (Australia): www.aela.org.au
- Environmental Choice (New Zealand): www.enviro-choice.org.nz
- Forest Stewardship Council (FSC): www.fsc.org
- Global Ecolabelling Network (GEN): www.gen.gr.jp
- Good Environmental Choice (Sweden): www.snf.se/bmv/english.cfm
- Green Dot (Germany): www.gruener-punkt.de
- Green Seal: www.greenseal.org
- NF Environment (France): www.marque-nf.com
- Sustainable Forestry Initiative (SFI): www.sfiprogram.org

GREEN RESOURCE GUIDES

- *AIA Environmental Resource Guide* (there is a copy at CSBR)
- Ecocycle (Canada): www.ec.gc.ca/ecocycle/en/index.cfm
- GreenSpec—Environmental Building News: www.buildinggreen.com
- Guide to Resource Efficient Building Elements: www.crbt.org
- MSDS—Material Safety Data Sheets (provided by material manufacturers)
- Oikos Green Building Source: www.oikos.com/green_products/
- Pharos: www.pharosproject.net
- The Sustainable Resource Guide: www.aiacolorado.org/SDRG/home.htm

TOOLS

- BEES, NIST: www.nist.gov/el/economics/BEESSoftware.cfm
- EcoCalculator, The Athena Institute: www.athenasmi.org/tools/ecoCalculator/
- Impact Estimator for Buildings, The Athena Institute: www.athenasmi.org/tools/impactEstimator/
- SimaPro, Pre Consultants: www.pre.nl
- Bousted model, Bousted Consultants: www.boustead-consulting.co.uk
- TEAM (EcoBilian), PriceWaterhouseCooper: www.ecobalance.com
- GaBi, PE International: www.gabi-software.com
- MEEUP method, VHK, Delft, Netherlands: www.pre.nl/EUP/
- GREET, US Department of Transportation: www.transportation.anl.gov/
- MIPS, Wuppertal Institute: www.wupperinst.org
- CES Eco '09, Granta Design, Cambridge UK: www.grantadesign.com
- Aggregain, WRAP: www.aggregain.org.uk
- KCL-ECO 3.0, KCL Finland: www.kcl.fi
- Eiloca, Carnegie Mellon Green Design Institute, USA: www.eiolca.net