Beyond Extraction

Material investigations for a post-carbon future

ARCH 6209 Material Investigation
Dalhousie School of Architecture
Fall 2023 Thursday, 9:30–12:30, HB2
James Forren (james.forren@dal.ca)
Office hours: Tuesday, 1:00–2:00

"Land restoration scheme, Goshems Farm, Tilbury Essex". Imagery (c) 2022 Google, Imagery (c) 2022 Getmapping pic, Infoterra Ltd, image from Material Reform by Material Cultures (MACK, 2022).

Calendar Description

This course uses a controlled workshop environment to examine characteristics of a material (e.g., metal, ceramic, glass) and methods for forming and finishing. Using principles of material science, it considers the harvesting or processing of raw material, the testing of structural capacity and environmental behaviour, and applications in design.

Additional Course Description. Conventional building practices cause significant environmental harm. They are frequently extractive and one-directional. Concrete, virgin steel, glass, extruded

polystyrene and non-certified timber use raw materials, or **feedstocks** (such as limestone, sand, iron ore, petrochemicals, and non-sustainable wood), whose **extraction** (mining, harvesting, or otherwise removing from their natural reservoir) and **conversion** to building materials damages the environment, release tons of **embodied carbon** and harms surrounding communities. The walls, columns, floor slabs, and windows created leave behind significant waste streams at their end of use, overlooking opportunities for buildings to take part in renewable and regenerative cycles which can otherwise repair our environment.

HG Matthews Brickworks, Bellingdon, Buckinghamshire. Jess Gough, image from Material Reform by Material Cultures (MACK, 2022).

In this course students will learn to look at the built environment as

a regenerative loop, exploring novel material reservoirs to disrupt conventional supply chains and means and methods of construction; thereby reducing and potentially reversing environmental harms for social, economic, and architectural benefit. Students will learn how advancements in energy, agriculture, aquaculture, and other industries can couple with advances (and traditions) in building technology to achieve net-negative climate goals.

In the course, students will learn about the use of bio-based and industry byproduct material feedstocks as alternatives to traditional construction materials such as steel, concrete, expanded polystyrene, and engineered timber. Students will have the opportunity to investigate a novel feedstock of their choice (such as flax, forestry waste, sewage sludge, mycelium, bacterial cellulose, or phytoplankton) in order to uncover new and emerging feedstock-conversion-utilization

Living Building Material (LBM) specimen (top); Additive manufactured biopolymer binder-aggregate composite specimens. Esther Fu, Gabriel Malo, Rodrigo Guerreiro, image from " Strategies for reducing your project's embodied carbon" (Build Green Atlantic, 2023).

toolkits for building materials. Students will demonstrate design potentials for their feedstock as part of a landscape, structural, enclosure, or finish assembly through models, physical specimens, drawings, and/or diagrams at a scale, scope and modality (model, drawings, prototypes) of their choice. This is intended to prepare students for graduate-level materials research in Thesis. The outcomes of the research will be formatted for publication and / or exhibit.

This is a new construction paradigm for architects to consider, where we can tune material

attributes in relation to desired environmental and performance outcomes. Guests from architecture and other industries will supplement lectures and readings.

Learning Objectives

1. Prepare a research framework for material inquiry in masters-level coursework and thesis.

2. Enact research methodologies for materials in masters-level coursework and thesis, including:

    - mastery of taxonomy of construction means and methods
    - ability to conduct literature review from relevant sources and databases
    - understanding and ability in the principles of composite construction materials
    - understanding tactics and strategies for conventional and novel means and methods of construction
    - ability to work with engineers, manufacturers,

and other professionals

- ability to work with researchers in other disciplines
- understand requirements of regulating bodies and authorities having jurisdiction

3. Deploy disruptive strategies and tactics for material practice, including:

- prioritizing local economies and feedstocks
- calculating embodied carbon
- addressing bio-based and byproduct material issues and strategies

4. Engage with experts, industry professionals, and general public through architectural dissemination strategies.

Rationale for the Course. This course is intended to prepare students for material-based research in masters-level coursework and thesis.

Class Format. lectures, workshops, seminars,

"Cleveland Steel & Tubes Ltd reclamation yard, Thirsk, Yorkshire". Imagery (c) 2022 Google, Imagery (c) 2022 Infoterra Ltd & Bluesky, Maxar Technologies, Map Data (c) 2022, image from Material Reform by Material Cultures (MACK, 2022).

Schedule

Stage	Wk	Date	In-Class	Course Lecture	Assignment Lect.	Due
A. Introduction	**1**	**Sept 14**	Course Outline Review and Course Q&A	1 Introduction (Material Research: Methods and Taxonomies, Feedstocks and Carbon)	A Assignment 1 and Assignment 2 Introduction	
B. Research	**2**	**Sept 21**	Reading discussion & Individual project discussion (time permitting)	2 Material Families and Feedstocks	B Research Methods and Lit Review	**A1.1**
	3	**Sept 28**	Individual project discussion	3 Embodied Carbon / Composite materials	C Handling materials? Easy and Hard	
	4	**Oct 5**	Individual project discussion	Guest 1	D Drawing, modeling, simulation	
	5	**Oct 12**	**Presentation**	None	None	**A2**
C. Application	**6**	**Oct 19**	Reading discussion & Individual project discussion (time permitting)	4 Conventional and Non-conventional Construction	E Assignment 2 Introduction & Conducting Tests	**A1.2**
	7	**Oct 26**	Individual project discussion	Guest 2	F Preparing Drawings, Models, and/or Specimens	
	8	**Nov 2**	Individual project discussion	None	None	
	9	**Nov 9**	**Presentation**	None	None	**A3**
	10	**Nov 16**		*Reading Week (No Class)*		
D. Dissemination	**11**	**Nov 23**	Reading discussion & Individual project discussion (time permitting)	5 Dissemination Strategies	G Exhibit Preparation	**A1.3**
	12	**Nov 30**	SLEQ & Individual project discussion	Guest 3	None	**A4**
	13	**Dec 7**	**Presentation**	None	None	**A5**

Lecture dates and topics subject to change.
Week 8, last week to withdraw. Check university calendar dates.
Student Learning Experience Questionnaires (SLEQ) will be scheduled during class time in the last two weeks.

Required References [Draft]

Required readings will be uploaded to Brightspace. The following references are available through the library.

Block, Philippe, Cristián Calvo Barentin, Francesco Ranaudo, and Noelle Paulson. “Imposing challenges, disruptive changes: rethinking the floor slab.” *The materials book: inspired by the 6th lafargeholcim foundation* 67 (2019).

Brand, Stewart. *How buildings learn: What happens after they’re built*. Penguin, 1995.

Dahmen, Joseph. “Soft futures: mushrooms and regenerative design.” *Journal of Architectural Education* 71, no. 1 (2017): 57-64.

De Wolf, Catherine Catherine Elvire Lieve. “Material quantities in building structures and their environmental impact.” PhD diss., Massachusetts Institute of Technology, 2014.

De Wolf, Catherine Catherine Elvire Lieve. “Low carbon pathways for structural design: embodied life cycle impacts of building structures.” PhD diss., Massachusetts Institute of Technology, 2017.

Fernandez, John. *Material architecture*. Routledge, 2012.

Forren, James. “Soft Rock Studio: Exploring a “Soft Systems” Approach to “Artificial Rock”.” *Building Technology Educator’s Society 2021*, no. 1 (2021): 14.

Forren, James. “Material as Common Good: Feedstock Valorization in Building Materials Using Biochar as a Case Study.” *The Plan Journal: The Good Material*, no. 2 (2021).

Ingold, Tim. *Making: Anthropology, archaeology, art and architecture*. Routledge, 2013.

King, Bruce. *The new carbon architecture: building to cool the climate*. New Society Publishers, 2017.

King, Bruce, and Chris Magwood. *Build Beyond Zero: New Ideas for Carbon-smart Architecture*. Island Press, 2022.

Lewis, Paul, Marc Tsurumaki, David J. Lewis. *Manual of Biogenic House Sections: Materials and Carbon*. ORO Editions, 2022.

Magwood, Chris. *Making better buildings: a comparative guide to sustainable construction for homeowners and contractors*. New society publishers, 2014.

Magwood, Chris. “Opportunities for Carbon Dioxide Capture and Storage in Building Materials.” Trent University, 2019.

Material Culture and Amica Dall. *Material Reform: Building for a Post-Carbon Future*. Mack, 2023.

Mockford, Kevin, Laure Nolte, Preston Stronach, and James Forren. “Sky Pillar: Characterization and prototyping of biochar-cement composites”. In Post-Carbon: CAADRIA 2022. *International Conference for The Association for Computer-Aided Architectural Design Research in Asia (CAADRIA)*, 2022. https://caadria2022.org/projects/sky-pillar-characterization-and-prototyping-of-biochar-cement-composites/

Oxman, Neri. *Neri Oxman: Material Ecology*. The Museum of Modern Art, 2020.

Simonen, Kathrina, Barbara X. Rodriguez, and Catherine De Wolf. “Benchmarking the embodied carbon of buildings.” *Technology| Architecture+ Design* 1, no. 2 (2017): 208-218.

Tsing, Anna Lowenhaupt. *Friction: An ethnography of global connection*. Princeton University Press, 2011.

Optional References [Draft]

Barentin, Cristián Calvo, Ioannis-Athanasios Zornatzis, Gnanli Landrou, Thibault Demoulin, Guillaume Habert, and Philippe Block. "When low strength materials meet funicular structures: a sustainable clay floor structure solution for emerging contexts." In *IOP Conference Series: Earth and Environmental Science*, vol. 588, no. 4, p. 042024. IOP Publishing, 2020.

Bennett, Jane. V*ibrant matter: A political ecology of things.* Duke University Press, 2010.

Ching, Francis DK. *Building construction illustrated*. John Wiley & Sons, 2020

Dahmen, Joseph, Juchan Kim, and Claudiane M. Ouellet-Plamondon. “Life cycle assessment of emergent masonry blocks.” *Journal of cleaner production* 171 (2018): 1622-1637.

Kayaçetin, Nuri Cihan, and Ali Murat Tanyer. *Embodied carbon in buildings: Measurement, management, and mitigation*. 2018.

Myers, Lynn, “Robotically wound flax fiber builds a ‘bioinspired’ pavilion in freiburg, germany”. Designboom. https://www.designboom.com/architecture/robotically-wound-flax-fiber-livmats-pavilion-freiburg-07-19-2021/. Accessed June 30, 2023.

Fu, Esther. “Building with Biomaterials.” Dalhousie University, 2023.

Gonchar, Joanne. “Neri Oxman’s ‘Material Ecology’ Exhibition at MoMA Illuminates and Inspires”. Architectural Record. April 6, 2020. https://www.architecturalrecord.com/articles/14545-neri-oxmans-material-ecology-exhibition-at-moma-illuminates-and-inspires

Kimmerer, Robin. *Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Milkweed editions, 2013.

Korol, Larissa. “Biofiberous Potentialities: Cultivating, Experimenting and Scaling Biological Fibre Materials in Architecture.” Dalhousie University, 2023.

Kwinter, Sanford. "Soft systems." *Culture Lab* 1 (1993): 208-227.

Nolte, Laure. “On Light and Matter: Structural Optics of Biomaterials.” Dalhousie University, 2023.

"Vault construction process photos". Esther Fu, image from Building with Biomaterials (Dalhousie 2023)

ASSESSMENT

Components and Evaluation

	Assignment	Weight	Type	Authorship	Evaluated by
1	Reading discussion	10%	Letter	individual	instructor
2	Feedstock Dossier	35%	Letter	individual	instructor
3	Exploration and Testing	35%	Letter	individual	instructor
4	Final Dossier	15%	Letter	individual	instructor
5	Exhibition	5%		group or individual	instructor

Components that are Required but not Assessed
Students must have updated WHMIS certification. Depending on nature of individual material investigation, respirator fit-testing may be required.
Field trips to local farms, manufacturers, or other related sites are required.

Guidelines for Citing Sources
Chicago Manual of Style: Author-Date Style. For details, see:
Chicago quick guide: http://tinyurl.com/chicago-quick-guide
Chicago Manual full guide: http://tinyurl.com/chicago-full

Format for Assignments
See assignment description.

Submission of Assignments
See assignment description.

Criteria and Standards for Assessment
See assignment description.

University Standards for Individual Assignments

Letter	Percent	Definition	Description
A+	90–100%	Excellent	Considerable evidence of original thinking; outstanding capacity to analyze and synthesize; outstanding grasp of subject matter; evidence of extensive knowledge base.
A	85–89%		
A–	80–84%		
B+	77–79%	Good	Evidence of grasp of subject matter, some evidence of critical capacity and analytical ability; reasonable understanding of relevant issues; evidence of familiarity with the literature.
B	73–76%		
B–	70–72%		

Letter	Percent	Definition	Description
C+	65–69%	Satisfactory	Evidence of some understanding of the subject matter; ability to develop solutions to simple problems.
C	60–64%		
C–	55–59%		
D	50–54%	Marginal pass	Evidence of minimal familiarity with the subject matter; minimal analytical and critical skill.
F	0–49%	Fail	Little evidence of understanding of the subject matter; weakness in analytical and critical skills; limited or irrelevant use of the literature.
INC		Incomplete	(counts as zero in GPA calculation)
W		Withdrew after deadline	(neutral in GPA calculation)
ILL		Compassionate reasons, illness	(neutral in GPA calculation)

In a graduate course, a final grade below B– will be recorded as an F.

Calculation of Final Grades
Percentage grades will be multiplied by their weight, added, then converted to a final letter grade.

Grading Format
Assignment evaluations will be issued to students as grades, written comments, and/or oral comments.

ICD/ITKE/intCDC university of stuttgart, image from “Robotically wound flax fiber builds a ‘bioinspired’ pavilion in freiburg, germany” (Designboom 2023)

COURSE-SPECIFIC POLICIES

Due Dates and Late Submissions

	Due date	Is a late assignment accepted?	If so, what is the deduction per weekday?*	Is there a final deadline for a late submission?	What happens after that?
1	Sept 21, Oct 19, Nov 23	No	n/a	n/a	n/a
2	Oct 12	Yes	3%	no	n/a
3	Nov 9	Yes	3%	no	n/a
4	Nov 30	Yes	3%	no	n/a
5	Dec 7	No	n/a	n/a	n/a

* For example, if an assignment is evaluated at 75% before applying a 3%-per-weekday deduction, it would receive 72% for being 1–24 hours late; 69% for 25–48 hours late; etc.

Note: The following University or School policies take precedence over course-specific policies:

- No late assignments are accepted after the last day of weekly classes (the Friday before review week).
- With a Student Declaration of Absence (maximum two per course), an assignment may be submitted up to three weekdays late without penalty. An SDA cannot be used for the final assignment.
- With a medical note submitted to the School office, a course assignment (including a final assignment) may be submitted more than three weekdays late without penalty. The number of weekdays depends on how long you were unable to work, as indicated in the medical note. If more than one course is affected, you should consult with the Undergraduate/ Graduate Coordinator to set a new schedule of due dates.
- A student with an accessibility plan that allows for deadline extensions does not need to submit an SDA.

Academic Integrity
Instructor may use plagiarism software to check written assignments.

Lecture Notes or Recordings
Students may record lectures.

Field trip sites
Possible field trip sites include:

Tap root (https://taprootfarms.ca/)

Deanery (https://thedeaneryproject.com/)

Elmsdale lumber (https://www.elmsdalelumber.ca/)

RDA Atlantic (https://www.rdaatlantic.com/)

Strescon limited (https://oscoconstructiongroup.com/strescon/)

Halifax Water

Sky Pillar installation at the Deanery Project. James Forren, image from "Sky Pillar" (CAADRIA, 2022)

Facilities

Facilities at Dalhousie which may be accessed for course:

Light Prototyping Lab (https://virtualtour.dal.ca/dal/engineering-/chorus-aviator-light-prototyping-lab)

Design Lab (https://virtualtour.dal.ca/dal/engineering-/2005-design-lab)

Heavy Prototyping Lab & Central Shops (https://virtualtour.dal.ca/dal/engineering-/central-shops)

Light structures testing lab

Heavy structures testing lab

SEM (https://www.dal.ca/dept/ctri/research-areas/fmc/technique.html)

Researcher labs

Affiliated research labs and centres who may speak with us about their work.

CWRS (https://centreforwaterresourcesstudies.dal.ca/)

Mapel (Oceanography) (https://www.dal.ca/faculty/science/oceanography/people/faculty/hugh-macintyre.html)

Structural Assessment and Retrofit (SAR) Research Group (https://www.dal.ca/sites/sar/about.html)

Canada Research Chair in Sustainable Infrastructure (https://www.dal.ca/faculty/engineering/research/research-chairs/crc-sustainable-infrastructure/about.html)

UNB Off site construction Centre (https://www.unb.ca/ocrc/)

Verschuren Centre (https://www.verschurencentre.ca/)

Flaxmobile (https://nscad.ca/nscad-professor-jennifer-greens-flaxmobile-project-receives-support-from-research-nova-scotia/)

Software Applications

As student investigations will be self-directed, there is not a specific software methodology proposed for the course. While students are expected to have working knowledge of Rhino and Grasshopper in alignment with their previous BEDS coursework, no assignment requires the use of a specific or any application. Software utilization will be engaged critically; the use of a particular platform will be

considered in relationship to its appropriateness for the task at-hand. For instance, if a student has the ambition to model complex form, do material quantity take-offs, or prepare files for fabrication they will be engaged with and guided through appropriate tools to accomplish these goals. The course instructor is a researchers in computation and design and will offer guidance on platforms below, as well as fabrication technologies. Independent explorations of software potentialities are encouraged.

Below are a list of some Grasshopper for Rhino plug-ins that may be of use. Fologram

Rhinovault

LCA in Rhino

- https://nomadarchitects.lv/lca-in-rhino
- https://www.oneclicklca.com/parametric-and-generative-carbon-optimisation/
- https://res.cloudinary.com/patternbuildings/image/upload/v1615456641/tutorials/paper_on_GH_tools_c0m9ge.pdf

Karamba

Galapagos

Octopus

Four meter span prototype. Block Research Group, Image from “When low strength materials meet funicular structures” (IOP Publishing, 2020)

FACULTY POLICY

Equity, Diversity and Inclusion

The Faculty of Architecture and Planning is committed to recognizing and addressing racism, sexism, xenophobia and other forms of oppression within academia and the professions of architecture and planning. We, the faculty, are working to address issues of historic normalization of oppressive politics, segregation, and community disempowerment, which continues within our disciplines today.

UNIVERSITY POLICIES AND RESOURCES

This course is governed by the academic rules and regulations set forth in the University Calendar and the Senate. For university regulations, go to https://academiccalendar.dal.ca/Catalog/ViewCatalog.aspx?pageid=viewcatalog&catalogid=82&chapterid=4741&loaduseredits=False.

A. University Statements

Academic Integrity

http://www.dal.ca/dept/university_secretariat/academic-integrity.html

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. Read more: https://www.dal.ca/content/dam/dalhousie/pdf/dept/university_secretariat/Syllabus_Statement_(Aug%202015).pdf

Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of: a disability, religious obligation, or any barrier related to any other characteristic protected under Human

Rights legislation (NS, NB, PEI, NFLD). Read more: https://www.dal.ca/campus_life/academic-support/accessibility.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. Read more:

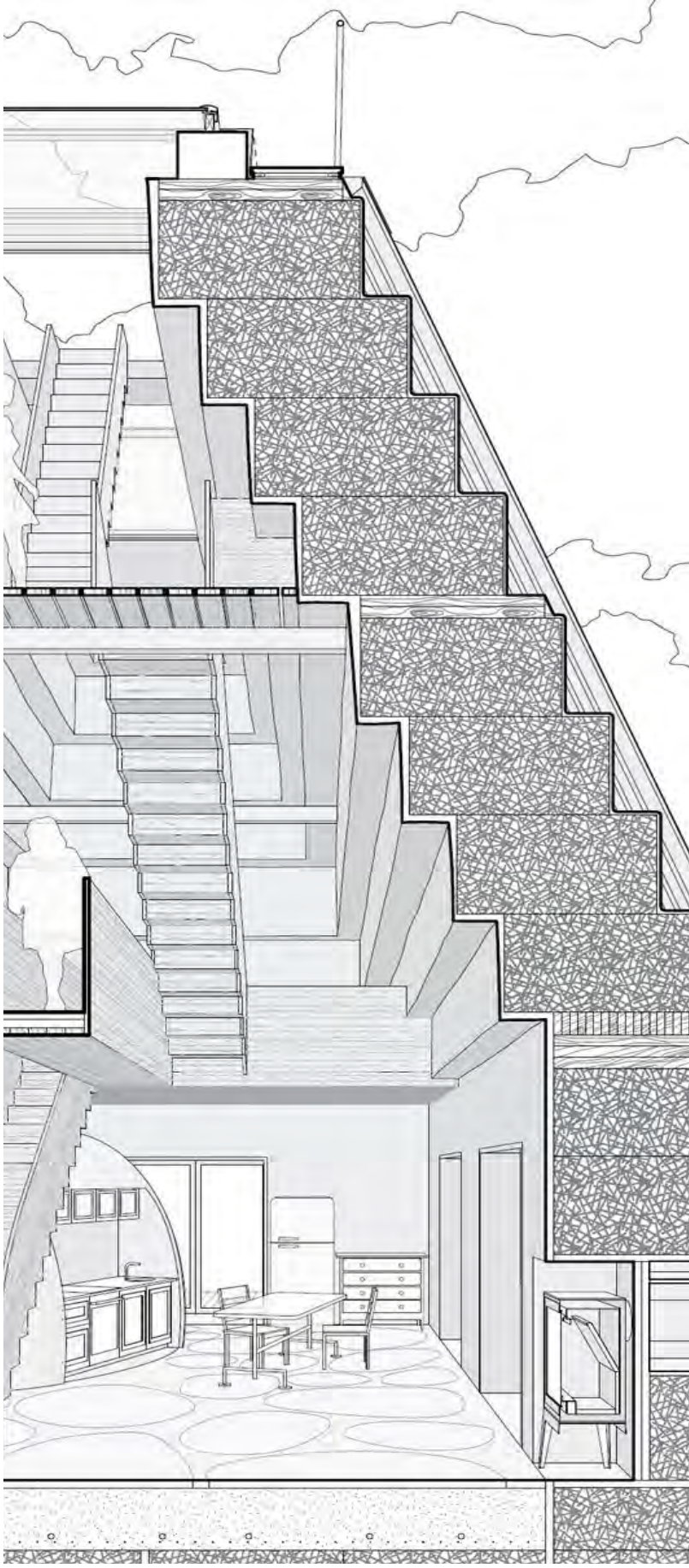
https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/student-life-policies/code-of-student-conduct.html

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2). Read more: http://www.dal.ca/cultureofrespect.html

Recognition of Mi'kmaq Territory

Dalhousie University would like to



Lewis, Paul, Marc Tsurumaki, David J. Lewis, image from Manual of Biogenic House Sections (ORO Editions, 2022)

acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit the office in the McCain Building (room 3037) or contact the programs at elders@dal.ca or 902-494-6803 (leave a message).

B. University Policies and Programs

- Important Dates in the Academic Year (including add/drop dates): http://www.dal.ca/academics/important_dates.html
- University Grading Practices: Statement of Principles and Procedures: https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html
- Scent-Free Program: http://www.dal.ca/dept/safety/programs-services/occupationalsafety/scent-free.html
- Student Declaration of Absence: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/academic-policies/student-absence.html

C. Learning and Support Resources

- General Academic Support – Advising: https://www.dal.ca/campus_life/academic-support/advising.html
- Fair Dealing Guidelines: https://libraries.dal.ca/services/copyright-office/guidelines/fair-dealingguidelines.html
- Dalhousie University Library: http://libraries.dal.ca
- Indigenous Students: https://www.dal.ca/campus_life/communities/indigenous.html
- Black Students: https://www.dal.ca/campus_life/communities/black-student-advising.html
- International Students: https://www.dal.ca/campus_life/international-centre.html
- Student Health Services: https://www.dal.ca/campus_life/health-and-wellness.html
- Counselling: https://www.dal.ca/campus_life/health-and-wellness/services-support/student-health-and-wellness.html
- Copyright Office: https://libraries.dal.ca/services/copyright-office.html

- E-Learning website: http://www.dal.ca/dept/elearning.html
- Dalhousie Student Advocacy Services: http://dsu.ca/dsas
- Dalhousie Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html
- Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html
- Faculty or Departmental Advising Support: Studying for Success Program: http://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

D. Safety

- Biosafety: http://www.dal.ca/dept/safety/programs-services/biosafety.html
- Research Laboratory Safety Policy Manual: http://www.dal.ca/dept/safety/documents-policiesprocedures.html
- Faculty of Architecture and Planning: Work Safety: https://www.dal.ca/faculty/architecture-planning/current-students/inside-building/work-safety.html

REUSE

MATERIALS - BIOTIC LOOP

Biotic materials are environmentally preferable based on their ability to sequester carbon during the lifespan of the building and their regenerative capacity. As natural products they are intrinsically biodegradable and can feed back into growth cycles as nutrients for soil. However, chemical additives, use of adhesives or metal fasteners, and binding to other materials impede humification.

REUSE

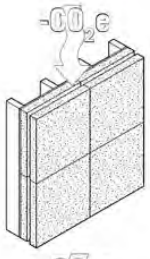
Biotic materials may not be strong enough to withstand damage during the disassembly process. Other barriers to reuse are a lack of standardization of the components and the time and cost necessary to dismantle the materials.

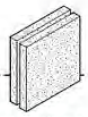
RECYCLING

Recycling involves th material in order to product of equal qua like hemp-lime and for use in new versio identical products d and adhesives.

CORK

Includes expanded cork insulation and cork façade panels. The process of expanding cork uses heat to bind cork granules together rather than using an adhesive, which makes it compostable and recyclable.



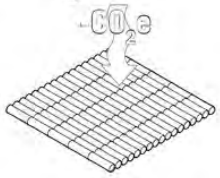


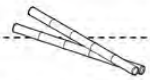
Modular cork panels and insulation can be disassembled for reuse or processed into granules. Mechanically detachable systems facilitate reuse while adhesive binding makes recovery more difficult.

Cork granules can be re in new cork-based build materials.

BAMBOO

Whole bamboo culms and bamboo wattle are minimally processed, making them more readily reuseable and biodegradable, while products such as bamboo plywood and flooring may contain adhesives.





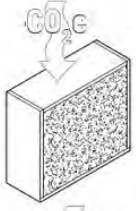
Whole bamboo members can be recovered for reuse, especially if assembled with non-damaging methods or the use of added materials.

STRAW

Straw is an agricultural waste product typically formed into bales or framed into prefabricated panels. Its direct reuse is limited by the natural degradation of the material, but bales can safely decompose at end of life if free of added chemicals or finishes and panels can be designed to be disassembled for composting.

HEMP

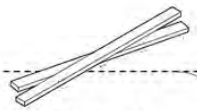
Hemp itself is compostable. However, hemp-lime uses lime as a binder and should be reused if possible. Hemp in this form may also be incinerated for energy.



Hemp-lime can be broke reused in new hemp-lim Insulation panels can b if they are disassemble damage.

LUMBER

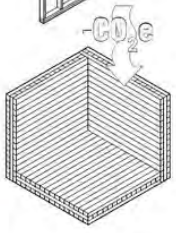
Dimensional lumber can be repurposed, downcycled into other wood-based products, or composted at the end of its lifespan if it has not been treated with chemicals and preservatives.

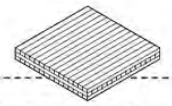


Dimensional lumber can be carefully disassembled and reused in other projects.

MASS TIMBER

Mass timber can be reused, downcycled, or composted. However, monolithic mass timber assemblies such as dowel-laminated timber are easier to recycle and compost than products that use adhesives or mechanical fasteners.

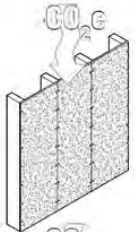




Mass timber panels can be reused, but one obstacle is the lack of standardization, as custom panels are cut for a particular project.

WOOD COMPOSITE

Wood composite materials such as MDF and particle board are made from downcycled wood fibers. However, they contain adhesives that make them unable to be composted or recycled.



Wood composite materials use wood fibers from recycled wood.

PLYWOOD

Plywood is formed by glue laminating thin wood veneers with perpendicular grain orientations into a sheet good

BIOTIC

Lewis, Paul, Marc Tsurumaki, David J. Lewis, image from Manual of Biogenic House Sections (ORO Editions, 2022)

ASSIGNMENTS

Assignment 1. Reading Discussion

Through the term there will be three reading seminars: four to five readings each, five pages or less.

Each seminar will have four to five seminar leaders who will be responsible for co-facilitating the discussion. As a discussion leader, come to the session with at least three Thoughts, Questions, or Epiphanies (TQEs) from your readings. The class will take 15 minutes at the start to discuss the reading in small groups. You'll then write two TQEs from each group (including your group) on the board and select a few for us to workshop into more developed questions for further discussion.

Seminar Readings

Seminar 1. Feedstock

Stewart Brand, *How Buildings Learn*, "Shearing Layers" (excerpt)

John Fernandez, *Material Architecture*, Introduction (excerpt)

Material Cultures, *Material Reform*, Introduction (excerpt)

Bruce King, *New Carbon Architecture*, Introduction (excerpt)

Catherine De Wolf, "Low carbon pathways for structural design" (excerpt)

Seminar 2. Conversion

Anna Tsing. *Friction* (excerpt)

Sanford Kwinter, "Soft Systems" (excerpt)

Joe Dahmen, "Soft Futures" (excerpt)

Tim Ingold, *Making*, "Materials" (excerpt)

James Forren, "Soft Rock Studio" (transition design?)

Seminar 3. Utilization

Lewis Tsurumaki Lewis, *Manual of Biogenic Sections* (excerpt)

Philipe Block, "Imposing challenges, disruptive changes" (excerpt)

Chris Magwood, *Making Better Buidlings* (excerpt)

Neri Oxman, *Neri Oxman: Material Ecology* (excerpt)

TBA

Rubric

This rubric is a general guide to help frame evaluation for discussion leaders. This is not a check-box evaluation, but rather a general guide capturing dimensions of an overall impression, and intended to help clarify for you what is expected in discussion.

A+. "A" level standards, plus exceptional discussion leadership. Contributions provide exceptional insights, or exceptional supports/advancement of others insights into readings to define discussion takeaways. Demonstrates exceptional familiarity with the material.

A. "A minus" level standards, plus provides advanced leadership, supporting classmates's comments, finding threads to connect discussion points, and advancing gaps in the conversation. Demonstrates excellent familiarity with the material.

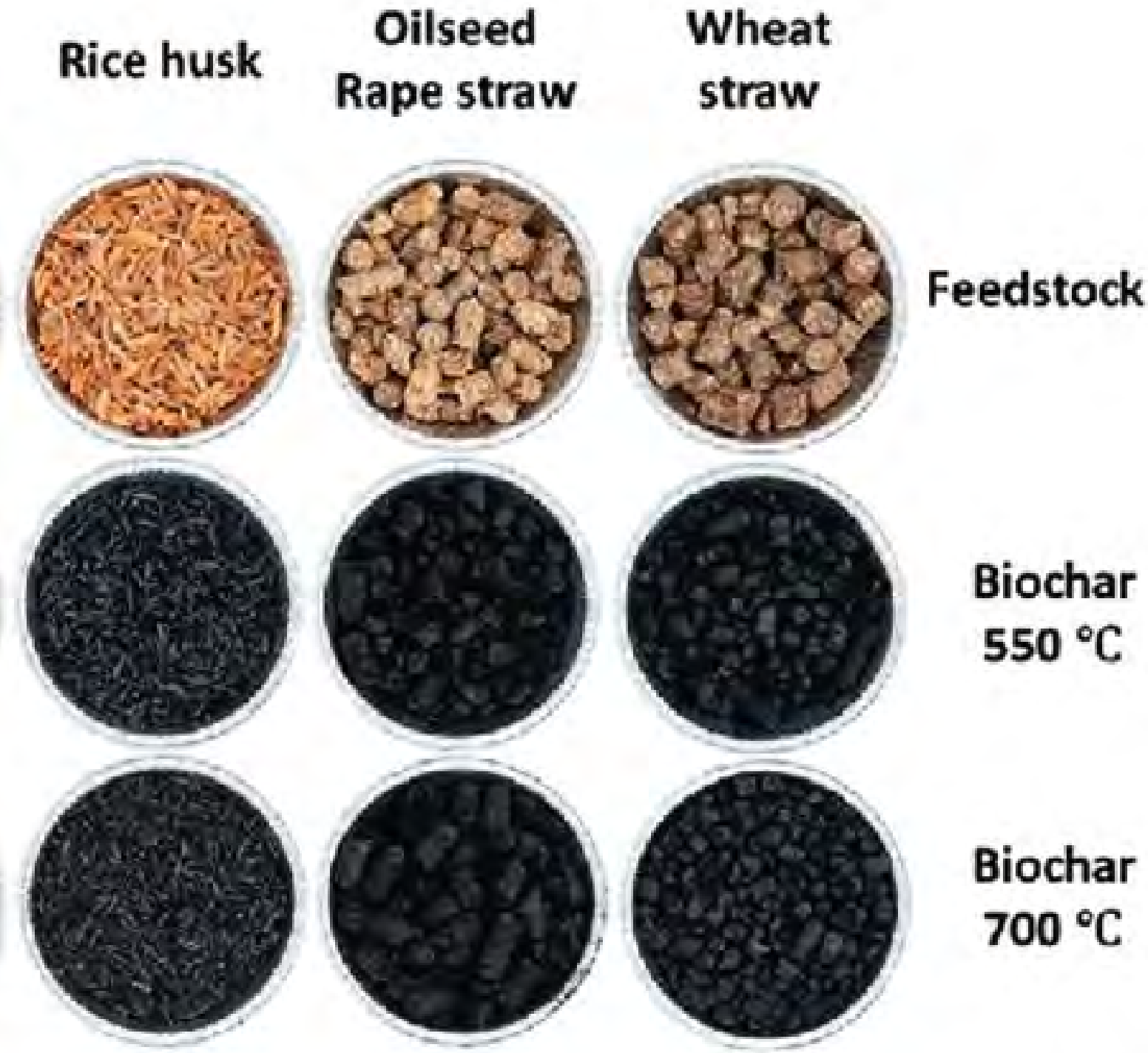
A-. Provides excellent leadership, and excellent effort to advance discussion. Additionally, provides space for classmate's reflection. Attentively listens to instructor and fellow students. Answers questions. Asks questions. Provides evidence from the text. Forms plausible, coherent explanations. Concedes to better points and arguments. Makes reasonable attempts to persuade other participants. Demonstrates excellent preparation with the material.

B+. Provides leadership, and good effort to advance discussion. Listens to instructor and fellow students. Answers questions. Asks questions. Forms plausible, coherent explanations. Concedes to better points and arguments. Makes reasonable attempts to persuade other participants. Demonstrates good familiarity with the material.

B. Good effort to lead. Listens to instructor and fellow students. Answers questions. Asks questions. Forms plausible, coherent explanations. Concedes to better points and arguments. Demonstrates some preparation with the material.

B-. Contributes to discussion. Listens. Answers questions. Asks questions. Demonstrates little preparation with the material.

F.



Biochar feedstock and byproducts from 550 deg C (1,022 deg F) and 700 dec C (1292 deg F). Image reprinted with permission from "Standard Biochar Materials" by Ondřej Mašek, Wolfram Buss, Saran Sohi in Environmental Science & Technology published by American Chemical Society, Sep 1, 2018.

Assignment 2. Feedstock Dossier

Select a feedstock such as wood, grass, aquaculture waste (lobster shells, oyster shells, etc.), mycelium, agriculture waste (flax byproducts, forestry byproduct), process waste (pulp), seagrasses, mine tailings, or other. From the lists of Required Content and Additional Content below, develop a profile of this feedstock and its potential for utilization in construction. This 'content' can include text, drawings, photos, as well as physical specimens. The dossier should identify relationships between content areas (ie. might utilization in other fields inform potential utilization in architecture).

Required Content

1. Literature references
2. One or more of its feedstock-converstion-utilization cycles.
3. Embodied carbon calculations
4. Possible utilizations (i.e. landscape element, wall assembly, structural span, structural point-load)

Additional Content (3 of the following)

1. Photos of Physical specimens
2. Examples of Physical testing potentials, such as
    - Means and methods of manufacture (Mix-design, production, moulding, etc)

- Mechanical, thermal, optical, or other testing
- Possible material corollaries (ie plaster for concrete)

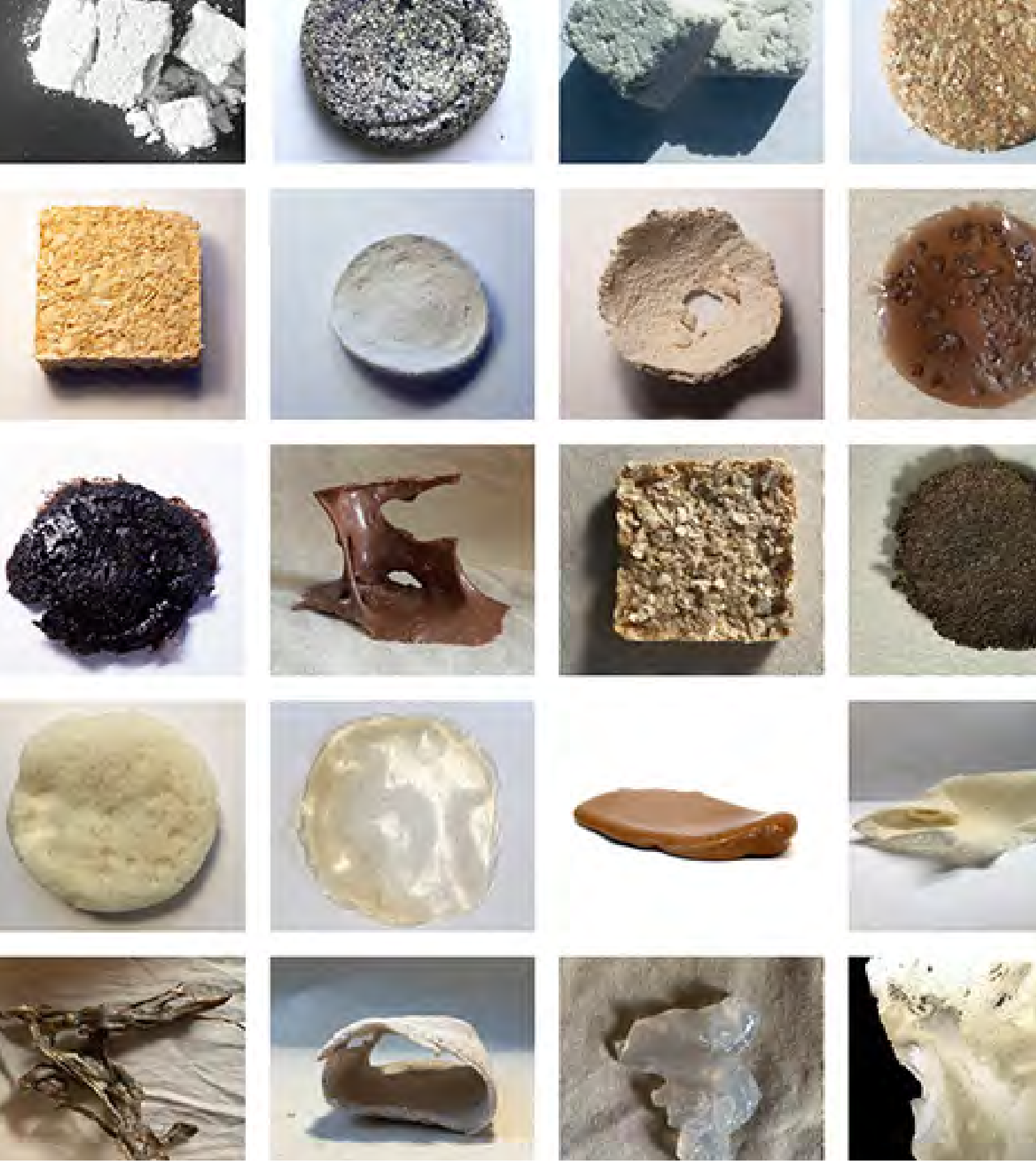
3. Significant Intrinsic material properties
   - Thermal, and/or
   - Mechanical, and/or
   - Optical, or other
4. Significant Extrinsic material properties
   - Economic, and/or
   - Socio-cultural, and/or
   - Governmental, and/or
   - Political, or other
5. Utilization in other fields (ie. manufacture, medicine, agriculture, energy, etc.)
6. Environmental harms
7. Environmental benefits
8. Corollary in contemporary construction

Organize your findings in the provided InDesign template.

Conclude your dossier with a Statement of Intent for Assignment 3, Material Exploration and Testing. What would you like to explore in your next assignment? For example, in your review of the 'state-of-the-art', what gaps have you discovered? For instance, can this be adapted to Atlantic Canadian context? Are there extensions to the studies you can offer, considering other domains or issues? Are there applications that remain to be explored? How do you wish to further investigate this feedstock for architectural application? What is a possible testing scenario for your anticipated application?

Outcomes

Submit dossier as PDF uploaded to Brightspace. Retain any physical specimens or samples for future exhibit.



James Forren, image from “Soft Rock Studio” (Building Technology Educator’s Society 2021, 2021)

Assignment 3. Material Exploration and Testing

Select an architectural application for your feedstock. This can be an existing or new application. Do you want to explore its potential as a component part of an envelope, structure, or landscape assembly? Develop a means and methods of developing, designing, and testing this application. What are the criteria you want to design for? What is the scale you want to test at? What is the test you want to run? What is the media you want to use? These decisions will form your ‘study design’. You can consider intrinsic characteristics (what does the material ‘want’ to be?). As well, you can consider extrinsic ones (what might an ‘enigmatic’ use of this material look like? Or, alternatively, a cost-

Compression tested cylinders of one hundred percent biochar content samples.These cylinders tested up to 14 MpA. James Forren, image from “Sky Pillar” (CAADRIA, 2022)

effective use?).

You will be evaluated on the rigor and precision of your investigation. If you elect to do drawings or virtual prototypes, you will need to determine a language and method of precision. If you elect to explore physical specimens, you will need to establish an iterative method of refinement. Through running repeated tests you will be able to either prove, refute, or evolve your hypothesis about its possible utilization.

Aguahoja, created with substances such as pectin and cellulose as alternatives to petro-based plastics. Photo courtesy The Mediated Matter Group (Architectural Record, 2020)

Assignment 4. Final Dossier

The outcomes of Assignment 2 make up the Background of a disseminated work. The outcomes of Assignment 3 make up the findings. The function of dissemination is to share your work with outside audiences who can benefit from what you have learned. This includes other architects and researchers, as well as the general public. As part of this you will also write a conclusion about your work. If you identified and responded to a gap in Assignment 2, how well has your investigation responded to or filled this gap? Was it successful? What would need to be done differently, or explored further? Is there a general framework you can distill from this that you can articulate and share with others?

Your work from the term will be compiled in a final Dossier. The spreads, along with any full size drawings, scale models, or physical specimens, will be displayed in the Exhibition Room reserved

for a day. We can invite guests from multiple places to come, see, and discuss the work.