



<b>Course Number</b>	ARCH 680.28 L05	<b>Classroom</b>	PF 2160
<b>Course Name</b>	From Waste to Artifact		
<b>Pre/Co-Requisites</b>	N/A		
<b>Instructor</b>	Alexander Crosby	<b>Office Hours/Location</b>	By appointment only
	<b>Email:</b> alexander.wayne.crosby@gmail.com	<b>Phone:</b> 1 (403) 818-4340	
<b>Class Dates</b>	Wednesday, 6:30 – 8:00pm, In-person, PF 2160 Thursday, 6:30 – 8:00pm, In-person, PF 2160		
<b>Instructor Email Policy</b>	Please note that all course communications must occur through either the classes MS Teams channel or through @ucalgary emails. Instructor will respond to student emails and discord posts within 48 hours		

## Course Description

### Calendar Description:

This course investigates the circular potential of waste through formulating, testing, and validating waste-based 3d printable material composites. Through practical projects, students will consider how additive manufacturing and generative design pipelines can be utilized in the translation of waste into meaningful architectural artifacts. Learning objectives will center around biomaterials, visual scripting, simulation, and analysis competencies.

Link to Calendar Description: <https://www.ucalgary.ca/pubs/calendar/current/architectural-studies.html#38564>

### Additional Description:

This course investigates the circular potential of waste through surveying, testing, and validating 3d-printable waste-based material composites. From single-use cups from our daily coffees to sawdust created from the production of furnishings for our homes, waste is produced in some shape or form. Often discarded, these materials could play new roles in our daily experiences and spatial structures. As such, recent research into waste-based

biomaterials has developed knowledge around processing and translating waste into new bio-composites, bioplastics, and bio-cementitious materials. Additionally, additive manufacturing (AM) methods like liquid deposition modeling (LDM) present new avenues for fabricating with new bio-composite materials. Waste-based materials and AM processes can also be paired with digital simulation, analysis, and desktop testing procedures to characterize and validate material performance. The overall goal of this elective is to evaluate the use of waste-based material composites, physically and digitally, in architectural building components. Focusing on practical assignments this course will provide foundations around slurry development, parametric tool-pathing, simulation, and analysis. In groups, students will design, formulate, and assess 3d-printable waste-based material composites via desktop mechanical testing and digital simulations. The elective will culminate in a suite of generative design and simulation-based scripts, 3d printed test specimens, and a final digital and/or physical artifact validated by the material testing and digital simulations.

**Key Words:**

Bio-composites, Waste, Feedback-loops, Material Testing, Material Driven Design, Additive Manufacturing

**Course Hours:** 3 units; (1.5 Lecture +1 .5 Workshop/Tutorial)

**Course Format**

This course emphasizes hands-on physical and digital experiences completed through assignments. The course will additionally provide supplementary lectures, demonstrations, workshops and learning resources to prepare students for hands-on experiences. In balancing time between your various courses and other commitments, you should allot approximately 9 hours per week outside of class time for this course, budgeted, roughly as follows:

<i>Course Component</i>	<i>Time Breakdown (hours)</i>	<i>Time Breakdown (%)</i>
Weekly Lectures, Workshops, Tutorials, and Review Session	3.0	25.0
Studies/ Experiments	7.5	62.5
Logbook Entries	1.5	12.5

You will be responsible for managing your own time. The weekly time allocations will vary depending on course deadlines.

## Course Learning Outcomes

Besides accumulation of factual knowledge, the primary learning objectives of this course are practical skills centered around additive manufacturing, computational design and materials and methods. You should develop the ability and competencies around the following:

1. *Develop literacy around technological ideas, skills, concepts, and terminology*
  - a. Take in and digest concepts and terminology through, readings, lectures, demonstrations, and review sessions,
  - b. Develop an understanding of LDM concepts, materials, and methods,
  - c. Synthesize and apply concepts and terminology through discussion, diagramming sketching, and project work,
  - d. Document and catalogue in term logbook.
  
2. *Explore material properties, attributes, and characteristics in relation to waste-based material composite formulation*
  - a. Develop and apply understanding of extrinsic and intrinsic material properties,
  - b. Consider the contextual impacts our physical environments have on our materials,
  - c. Hypothesize material-environment relationships in material development and design work,
  - d. Develop understanding in LDM slurry formulation and processing practices,
  - e. Consider a variety of binders, particulates, colourants, aggregates, and material wastes that can make up LDM slurries.
  
3. Create custom digital fabrication tools that aid in simulation, analysis and fabrication of material artifacts.
  - a. Generate iterative and performance-driven testing options that tie into physical and digital testing methods,
  - b. Translate geometry into toolpaths and GCode for fabrication via visual scripting or other market available slicing software,
  - c. Develop digital tools to assist in the display and assessment of key fabrication metrics,
  - d. Write and/or draw diagrammatic analytical and critical assessments of documented design work.
  
4. *Conduct small-scale physical and digital material testing, simulation and analysis*
  - a. Develop hands-on testing methods for material composites and 3d printed test specimens,
  - b. Develop digital tools that effectively simulate material & environmental phenomena,
  - c. Pull key ideas from parametric material testing tools used in class demonstrations,
  - d. Rationalize and balance empirical findings against design requirements and needs.

5. *Conduct technological analysis and exploration in the context of design*
  - a. Develop technology tools to move forward project work,
  - b. Generate a variety of analytical options and responses to project requirements,
  - c. Think through, speculate and rationalize case-uses for project work,
  - d. Express technology ideas in cogent and articulate diagrams, test samples and drawings,
  - e. Document and catalogue in term logbook.

## Learning Resources

### **Required readings, textbooks and learning materials:**

There are no required readings, textbooks and/or learning materials. The instructor will provide a curated set of optional readings and links to appropriate learning resources throughout the term. These resources will be posted to the D2L site and the MS Teams Channel.

### **Required Hardware:**

- Access to a PC that can run Rhino 7/ Grasshopper
  - Please note: Macs can be used for majority of course work but may present issues with PC Only plugins used within the course.
  - Refer to the following link for system requirements:  
<https://www.rhino3d.com/7/system-requirements/>
- Computer Mouse with center wheel (recommended)
- SD Card Reader (recommended)

### **Required Software:**

- Access to Adobe InDesign 2019 and above
- Access to Rhino 7/ Grasshopper
  - Students should be able to access a 90 day trial version for Rhino 7/Grasshopper. Alternatively, students can elect to purchase a perpetual student license for \$195 US.
  - Students can access student licenses here:  
<https://www.rhino3d.com/en/sales/north-america/Canada/>
  - Students can download an evaluation trail here:  
<https://www.rhino3d.com/download/rhino-for-windows/evaluation>
- Bifocals (Grasshopper Plugin) - Free
  - Students can access Bifocals here:  
<https://www.food4rhino.com/en/app/bifocals>
- Karamba3D (Grasshopper Plugin)
  - Students should be able to access free/ trail versions for the course. Perpetual educational licenses are +/- \$45 CAD.

- Students can access Karamba3d Free, Trial and Educational licenses here:  
<https://www.karamba3d.com/buy>
- Notepad (PC) or TextEdit (Mac) - Free
  - Default text editors which should come with operating systems.

### **Workshop Safety Training Requirement**

If a course requires the use of the SAPL workshop, students must complete all online University of Calgary safety courses, the online Trajectory safety training course, as well as in-person workshop training and a grade of pass on the final evaluation project, to be granted access to the SAPL workshop. This training is offered once a year, around the start of the Fall term and has a completion deadline.

## **Additional Classroom Conduct and Related Information**

### **Tutorial, Workshop and Discussion Participation:**

While there is no mark attributed to participation in tutorials, workshops and class discussions, success in the course will be dependent on participation and engagement in these events.

### **Microsoft Teams Use and Conduct:**

Microsoft Teams will be utilized as a platform for information sharing and for inquiries specific to the course, its assignments and associated content. Students must behave in a professional manner on this platform. Students, employees, and academic staff are also expected to demonstrate behaviour in class that promotes and maintains a positive and productive learning environment. Harassment of any kind will not be tolerated.

## **Assessment Components**

Students will be looking at transforming waste material into architectural artifacts via bio-composite slurry development and additive manufacturing pipelines. To do so, will require an uptake and synthesis in key terminology, ideas and concepts surrounding materials, computation, and additive manufacturing. The development of this work will be recorded and presented in a term logbook, which students will develop over the course of the term. The

logbook should be a curated document that illustrates research, bench testing, digital simulation, physical and digital studies, and speculations, as well as provide written observations, findings, and analysis of work. Students should include a variety of captioned images, stills, drawings and/or diagrams as a means of illustrating their project development. The term logbook will not only be a tool to record project development, but will also act as a presentation tool, which students will use to present work at four major project milestones throughout the term:

### **Logbook Entry I: Material Feedstocks | Individual | 15%**

**Description:** In this assignment, students will individually survey and test potential material feedstocks for use in 3d-printable slurries. Students can choose to focus on a variety of aggregates, binders, and additives. Students are expected to perform simple bench tests on potential base materials and/or recipes. Lastly, students are expected to present their findings and speculate on potential case-uses for materials.

**Objective:** To develop a base understanding of LDM slurry formation and home in on potential directions and avenues for the following assignments.

**Aligned Course Learning Outcomes:** 1, 2, 3

### **Logbook Entry II: Soft Body Studies | Group | 25%**

**Description:** In this assignment, student groups will work to iteratively develop initial 3d-printable slurries and geometric scripts for 3d printing. As groups work through their slurry and script development, they will subject their work to simple bench testing studies, that test both physical and digital attributes of slurries. Students are expected to document and record these studies as well as present observations, analysis and findings discovered while working through the work. Lastly students will be expected to present findings and speculate on case-use.

**Objective:** Formulate, test, and validate initial 3d-printable waste-based slurries & the development of initial toolpath and print metrics generator. Students will validate toolpaths and slurries via a variety of wet testing methods.

**Aligned Course Learning Outcomes:** 1, 2, 3, 4 & 5

### **Logbook Entry III: Rigid Specimen Studies | Group | 25%**

**Description:** In this assignment, student groups will work iteratively to refine slurries and scripts. As groups work through their slurry and script development, they will subject their work to simple mechanical testing studies, that test both physical and digital attributes of their 3d printed test specimens. Students are expected to

document and record these studies as well as present observations, analysis and findings discovered while working through the work. Lastly students will be expected to present findings and speculate on case-use.

**Objective:** To refine, test, and validate initial 3d-printable waste-based slurries & the development of initial toolpath and print metrics generator. Students will validate toolpaths and slurries via a variety of dry or cured testing methods.

**Aligned Course Learning Outcomes:** 1, 2, 3, 4 & 5

### **Logbook Entry IV: Material Artifact Studies | Group | 35%**

**Description:** In this assignment, students will use previous findings and speculations to develop a material artifact. This artifact can take the form of either an architectural component, or a proto-architectural object. This material artifact should be backed up or informed through digital simulation and analysis. Simulations should take the form of a FEM simulation. That being said, the assignment remains open to other forms of simulation and/or analysis. The final artifact is only digital, but if time is available students should elect to print their final artifacts. Students are expected to document and record these studies as well as present observations, analysis and findings discovered while working through the work. Lastly students will be expected to present findings and speculate on case-use or aggregation of material artifacts.

**Objective:** To translate previous work into either a digital or digital + material artifact that can be validated through digital simulation.

**Aligned Course Learning Outcomes:** 1, 2, 3, 4 & 5

While much of the term requires group work and a portion of each entry will be assessed on the cohesiveness of a groups project development, the logbook will be an individual endeavor for the most part. Individual logbook entries will be assessed on an individual basis. During group presentations, portions of individual logbooks from group members can either be compiled or sequenced for group presentations. The presentations will make up 30% of the total milestone weight, while individual contributions will make up 70% of total the total milestone weight. Where group work is used within the logbook, please make sure to call out individual and group contributions. Lastly, each logbook entry requiring groupwork will require group-members to fill out, complete, and submit a peer-evaluation form. This is meant to safeguard student contributions to assignments in the face of group conflict. In the case of group conflict, it will be up to the instructor's discretion on how evaluations will be re-adjusted based on the peer-evaluation forms.

\*Please note that a logbook InDesign template will be provided. It is recommended that students utilize this template so that graphic layout and presentation of work is simplified.

## Assessment and Evaluation Information

**Attendance and Participation Expectations:** Students are expected to come to class and present in-progress and final work. Only final work will be assessed in-class. Additionally, while there are no other attendance requirements per se, it is important that students come to class prepared to engage in class lectures, discussions, workshops, tutorials, and presentations.

**Guidelines for Submitting Assignments:** As a rule, work will be presented in-class as well as submitted to D2L prior to in-class presentations.

**Feedback:** Written feedback will be brief; students are encouraged to seek oral elaboration. Feedback for logbook assignments will be provided in-class. Additional written feedback will be provided when assessment for work is posted. Please refer to term schedule for dates of deadlines.

**Team and individual work:** Architectural practice is collaborative, so in preparation for that you'll be doing a fair amount of work in teams of 2 or 3. Care is taken to make the teamwork agreeable and productive, e.g. students help make the teams as equitable as possible. Evident fairness between teams enables us to keep teams consistent, and this gives time for effective group patterns to develop.

**Final Examinations:** There will be no final examinations outside for this class. All course component work will be presented during class time.

**Expectations for Writing** (<https://www.ucalgary.ca/pubs/calendar/current/e-2.html>):

**Late Assignments:** Deductions for late submissions encourage time management and maintain fairness among students. Late assignments will be deducted 1/3<sup>rd</sup> of a letter grade per day late. 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 the student is unable to work, as indicated in the medical note. If more than one course is affected, students should consult with the instructor to set a new schedule of due dates for course.

**Criteria that must be met to pass:** Students must attain a passing grade on all log-book components in order to meet the course requirements. Students should reach out and discuss missing coursework or course components with the instructor in a timely manner.



## Grading Scale

Grade	Grade Point Value	4-Point Range	Percent	Description
A+	4.00	4.00	95-100	Outstanding - evaluated by instructor
A	4.00	3.85-4.00	90-94.99	Excellent - superior performance showing comprehensive understanding of the subject matter
A-	3.70	3.50-3.84	85-89.99	Very good performance
B+	3.30	3.15-3.49	80-84.99	Good performance
B	3.00	2.85-3.14	75-79.99	Satisfactory performance
B-	2.70	2.50-2.84	70-74.99	Minimum pass for students in the Faculty of Graduate Studies
C+	2.30	2.15-2.49	65-69.99	All final grades below B- are indicative of failure at the graduate level and cannot be counted toward Faculty of Graduate Studies course requirements.
C	2.00	1.85-2.14	60-64.99	
C-	1.70	1.50-1.84	55-59.99	
D+	1.30	1.15-1.49	50-54.99	
D	1.00	0.50-1.14	45-49.99	
F	0.00	0-0.49	0-44.99	

A student who receives a "C+" or lower in any one course will be required to withdraw regardless of their grade point average (GPA) unless the program recommends otherwise. If the program permits the student to retake a failed course, the second grade will replace the initial grade in the calculation of the GPA, and both grades will appear on the transcript.

The School of Architecture, Planning and Landscape will not permit the Flexible Grade Option (CG Grade) for any course offered by the School. (<https://www.ucalgary.ca/pubs/calendar/current/salp-3-3.html>)

## CACB Student Performance Criteria

The following CACB Student Performance Criteria will be covered in this course at a primary level (other criteria will be covered at a secondary level): C2: Materials

**"This course might align with C1: Materials but I'm not sure if this should be included in this elective or not?"**

Topic Areas & Detailed Class Schedule			
Course Schedule Date	Wednesday Topic	Thursday Topic	Assignments/Due Dates
Jan 9 – 13	Course Introduction + Materials and Methods I	Workshop I: Mixing + Hand Extrusion	Assignment I Introduced
Jan 16 - 20	In-progress reviews	Logbook Presentation I	Due: Logbook Entry I – Thursday prior to class
Jan 23 - 27	Lecture: Materials and Methods II	Workshop II: Grasshopper + Testing	Assignment II Introduced
Jan 30 – Feb 3	Workshop III: Toolpath I	Tutorials	
Feb 6 - 10	Tutorials	Logbook Presentation II	Due: Logbook Entry II – Thursday prior to class
Feb 13 - 17	Lecture: Materials and Methods III	Workshop IV: Toolpath II	Assignment III Introduced
Feb 19 -25	Term Break – No Class		
Monday Feb 20	Alberta Family Day Holiday		
Feb 27 – Mar 3	Workshop V: Specimen Testing	Tutorials	
Mar 6 - 10	Logbook Presentation II	Materials and Methods IV	Due: Logbook Entry III – Wednesday prior to class  Assignment IV Introduced
Mar 13 - 17	Winter Block Week – No Class		
Mar 20 - 24	Workshop VI: Karamba3D	Workshop VII: Optimization I	
Mar 27 – 31	Workshop VIII: Optimization II	Tutorials	
Apr 3 - 6	Tutorials	Logbook Presentation IV	Due: Logbook Entry IV – Thursday prior to class

Friday April 7	Good Friday	
Monday April 10	Easter Monday	
Apr 11 - 12	No Class	Friday – Last dates for assignments

## Guidelines for Microsoft Teams

Microsoft Teams is a communication platform that will allow us to communicate, ask questions and share information outside of class time. MS Teams will act as a messaging board and file depository so all information regarding assignments, course deliverables and contents are accessible and share equitably.

To help ensure MS Teams communication threads and content are private, do not share your account information (username + password) with others, or on any social media platforms. Access to the MS Teams course channel is only intended for students registered in the course. MS Teams communications and posted materials, including any teaching materials, must not be shared, distributed or published without the instructor's permission.

The use of and communication platform relies on participants to act ethically, honestly and with integrity; and in accordance with the principles of fairness, good faith, and respect (as per the [Code of Conduct](#)). When using communication platforms (such as MS Teams), you play a role in helping create an effective, safe and respectful learning environment. Please be mindful of how your behaviour in these sessions may affect others. Participants are required to use names officially associated with their UCID (legal or preferred names listed in the Student Centre) when engaging in these activities. Instructors/moderators can remove those whose names do not appear on class rosters. Non-compliance may be investigated under relevant University of Calgary conduct policies (e.g [Student Non-Academic Misconduct Policy](#)). If participants have difficulties complying with this requirement, they should email the instructor of the class explaining why, so the instructor may consider whether to grant an exception, and on what terms. For more information on how to get the most out of your zoom sessions visit: <https://elearn.ucalgary.ca/guidelines-for-zoom/>

## Special Budgetary Requirements

### **Materials and Consumables:**

Students will be required to source materials and consumables for this course. The instructor will make the best efforts to keep costs down where possible. Students should expect to pay +/- \$75.00 CAD for binders, aggregates and mixing consumables. Cost sharing in group scenarios and salvaging materials should reduce student costs and are recommended. Material

lists and/or access to base recipe lists will be provided so an appropriate amount of materials can be sourced for student projects.

**Personal protective equipment (PPE):**

Safety Glasses, N-95 particulate masks and vinyl/latex gloves may be required for mixing materials. Students will be required to purchase PPE, but the instructor will make best efforts to reduce costs around PPE. It is recommended that students cost share to keep costs down.

## University of Calgary Policies and Supports

**COVID-19 PROCEDURE FOR SICK STUDENTS:** <https://www.ucalgary.ca/risk/covid-19-procedure-for-sick-students>

**UNIVERSITY OF CALGARY COVID-19 UPDATES:** <https://www.ucalgary.ca/risk/emergency-management/covid-19-response>

### ACADEMIC ACCOMMODATION

It is the student's responsibility to request academic accommodations according to the University policies and procedures listed below. The student accommodation policy can be found at: <https://www.ucalgary.ca/legal-services/university-policies-procedures/student-accommodation-policy>

Students needing an accommodation because of a disability or medical condition should communicate this need to Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities: <https://www.ucalgary.ca/legal-services/university-policies-procedures/accommodation-students-disabilities-procedure>

Students needing an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, preferably in writing, to their instructor (contact information on first page above).

SAS will process the request and issue letters of accommodation to instructors. For additional information on support services and accommodations for students with disabilities, visit [www.ucalgary.ca/access/](http://www.ucalgary.ca/access/).

### **ACADEMIC MISCONDUCT**

Academic Misconduct refers to student behavior which compromises proper assessment of a student's academic activities and includes: cheating; fabrication; falsification; plagiarism; unauthorized assistance; failure to comply with an instructor's expectations regarding conduct required of students completing academic assessments in their courses; and failure to comply with exam regulations applied by the Registrar.

For information on the Student Academic Misconduct Policy and Procedure please visit:

<https://ucalgary.ca/policies/files/policies/student-academic-misconduct-policy.pdf>

<https://ucalgary.ca/policies/files/policies/student-academic-misconduct-procedure.pdf>

Additional information is available on the Academic Integrity Website at <https://ucalgary.ca/student-services/student-success/learning/academic-integrity>.

### **COPYRIGHT LEGISLATION:**

All students are required to read the University of Calgary policy on Acceptable Use of Material Protected by Copyright ([www.ucalgary.ca/policies/files/policies/acceptable-use-of-material-protected-by-copyright.pdf](http://www.ucalgary.ca/policies/files/policies/acceptable-use-of-material-protected-by-copyright.pdf)) and requirements of the copyright act (<https://laws-lois.justice.gc.ca/eng/acts/C-42/index.html>) to ensure they are aware of the consequences of unauthorised sharing of course materials (including instructor notes, electronic versions of textbooks etc.). Students who use material protected by copyright in violation of this policy may be disciplined under the Non-Academic Misconduct Policy (<https://www.ucalgary.ca/pubs/calendar/current/k.html>).

### **INSTRUCTOR INTELLECTUAL PROPERTY**

Course materials created by instructors (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the instructor. These materials may NOT be reproduced, redistributed or copied without the explicit consent of the instructor. The posting of course materials to third party websites such as note-sharing sites without permission is prohibited. Sharing of extracts of these course materials with other students enrolled in the course at the same time may be allowed under fair dealing.

### **FREEDOM OF INFORMATION AND PROTECTION OF PRIVACY**

Student information will be collected in accordance with typical (or usual) classroom practice. Students' assignments will be accessible only by the authorized course faculty. Private information related to the individual student is treated with the utmost regard by the faculty at the University of Calgary.

### **SEXUAL VIOLENCE POLICY**

The University recognizes that all members of the University Community should be able to learn, work, teach and live in an environment where they are free from harassment, discrimination, and violence. The University of Calgary's sexual violence policy guides us in how we respond to incidents of sexual violence, including supports available to those who have experienced or witnessed sexual violence, or those who are alleged to have committed sexual violence. It provides clear response procedures and timelines, defines complex concepts, and addresses incidents that occur off-campus in certain circumstances. Please see the policy available at <https://www.ucalgary.ca/policies/files/policies/sexual-violence-policy.pdf>

**UNIVERSITY STUDENT APPEALS OFFICE:** If a student has a concern about a grade that they have received, they should refer to Section I of the Undergraduate Calendar (<https://www.ucalgary.ca/pubs/calendar/current/i-3.html>) which describes how to have a grade reappraised. In addition, the student should refer to the SAPL's Procedure for reappraisal of grades

### **OTHER IMPORTANT INFORMATION**

Please visit the Registrar's website at:  
<https://www.ucalgary.ca/registrar/registration/course-outlines> for additional important information on the following:

- Wellness and Mental Health Resources
- Student Success
- Student Ombuds Office
- Student Union (SU) Information
- Graduate Students' Association (GSA) Information
- Emergency Evacuation/Assembly Points
- Safewalk