University of Waterloo School of Architecture

Arch 465: Advanced Structures: Design and Analysis // Fall 2018

Fridays from 10 a.m. — 1 p.m. // ARC 1101

SYLLABUS

Instructor and TA Information

Adjunct Professor
Justin Forrest Breg
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Teaching Assistant
Matthew Barker
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Tutorial Instructor
Michael Zwart
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Tutorial: Tuesdays from 6:30 p.m. to 8:30 p.m.
Office Hours: To Be Determined

Course Description

> *There is nothing more noble and elegant from an intellectual viewpoint than this: resistance through form.*[1]
>
> —Eladio Dieste

The relationship between structure and architectural form is ancient, entangled and rich. The delineation of space and the channeling of mass-force must be resolved in any built work.

Through this course, you will develop a deeper understanding of complex and sophisticated approaches to building structure.

The curriculum is presented at three scales. Initially, we analyze the deformation behaviour of isolated structural components. Subsequently, we explore various ways that these components can be arranged to form complex structural systems; and finally, we consider special structural forms.

Part I: Understanding Structure and Deformation

To innovate structurally, one must possess knowledge of essential principles. Your previous structural courses have introduced you to important concepts such as strain, strength, and stiffness. The first series of lectures builds on many familiar themes, with a more concentrated emphasis on anticipating and evaluating how structures will deform.

Calculations are regarded as a vehicle to better understand structures intuitively. It is intended that you will become adept at moving easily between intuition and calculation, to assess and refine structural ideas.

Part II: Advanced Structural Systems

In order to invent, one needs an inventory.[2] The second set of lectures introduces a series of structural systems, i.e., diverse conceptions about the ways that materials can be joined to direct load.

These systems will be considered from many perspectives. We will assess structural advantages, vulnerabilities, and limitations; and we will consider issues of connection and fabrication. Simultaneously, we are also interested in relationships between a structural system and its environmental and cultural conditions, as well as its aesthetic affect.

Ingenious precedents, both historical and contemporary, are organized according to related categories. These categories are by no means mutually exclusive, and it is hoped that students will identify synergies and new combinations or extensions of these systems.

Part III: Advanced Structural Forms

There are certain, special structural forms that can augment the potential of a given structural system. The final series of lectures will examine how these forms can be exploited architecturally.

Course Requirements

Weekly Readings and Assignments

Weekly reading and assignments are an important part of this course. The readings can help in forming a philosophy towards structure, in your own design work. The assignments consist of numeric or intuitive analyses of illustrative examples or of celebrated architectural-structural works. In addition to ensuring that you have the 'hard-skills' to explore structural ideas, it is intended that thinking structurally will become a natural part of your thinking about architecture.

Readings, assignments, and related resources will be provided via Learn.

Final Project

A final project will assess your mastery of advanced structural concepts. More details are provided in the attached description.

Final Test

A final test will assess your ability to 'think on your feet.'

The term mark will be proportioned as follows:

Weekly Assignments	20%
Final Project	40%
Final Test	40%

Regarding Math Skills

The deliverables for this course require that you demonstrate an ability to analyze structures graphically, verbally, and numerically.

It is understood that architecture students come into a structural design course with varying levels of comfort and savvy in mathematics. This course has been designed to be beneficial for all students: those who have great mathematical prowess can be challenged, and those who are less confident need not be intimidated.

Additional help can be provided for subject areas that are difficult. Please keep me informed of any major concerns as the term progresses.

Submission

Please submit weekly assignments in PDF format via Learn, by 10:00 a.m. on their required due dates. Documents should be titled according to the following convention:

[Two-Digit Assignment Number]_[Student ID]_[Last Name]_[First Name]_Arch465

e.g.,

01_20243351_Breg_Justin_Arch465

Please also submit a hard copy of your weekly assignments before the start of the following class, if you would like written feedback on your work. Illegible work will not be marked. Late work will be penalized at 50% per day, unless otherwise agreed upon. Discussion of structural ideas is strongly encouraged, but plagiarism is not permitted. Each piece of copied work will receive the grade earned, divided by the number of copies submitted.

Final projects must be submitted by December 19th (digital submission) and 20th (paper submission). Refer to the attached description.

Objectives

Through this course, students will acquire the following:

- an understanding of how various complex structural systems transmit load
- a vocabulary with which to express sophisticated structural ideas
- an intuitive ability to anticipate how a structure may be vulnerable to deformation or failure
- a sense of confidence in knowing 'where to begin' in evaluating structural ideas numerically
- a general awareness of constraints and challenges in fabrication and construction

Moreover, students will gain insight into the potential of advanced structures to contribute to spatial, aesthetic, social, political, and environmental ambitions in built architecture. Students will be equipped to resolve structural challenges and to exploit structural possibilities in their own work.

Schedule

Understanding Structure and Deformation

September 7	Deformation + Restraint	
September 14	Loading	
September 21	Material	
September 28	Geometry	

Advanced Structural Systems

October 5	Stacked Systems	*trabeation, corbelling*
	Clamped Systems I	*stereotomy, advanced masonry, timbrel vaulting*
October 19	Clamped Systems II	*kumimono, dougong*
	Woven Systems	*wattle, warp + weft, substitution, bias, kagome, 3-D weaving*
	Lattice Systems	*gridshell, diagrid, isogrid, wigwam + aqal, geodesic*
October 26	Truss Systems	*complex trusses, space frame*
	Frame Systems	*Vierendeel, waffle, castellated beam*
	Tensegrity Systems	*floating compression, self-stress, biotensegrity*
November 2	Tension Systems	*suspension, tents, air-supported, tensairity*
	Monocoque Systems	*forming, casting, thin shell, composites, semi-monocoque*

Advanced Structural Forms

November 9	Gaussian + Hyperbolic Forms	
November 16	Pleated + Folded Forms	
	Tubular + Bundled Forms	
November 23	*Week of Major Term Test*	
November 30	Form-finding + Foundations	

***Academic integrity**:* In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check the Office of Academic Integrity for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. [Check the Office of Academic Integrity for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties.

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72, Student Appeals.

Note for students with disabilities: AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Turnitin.com: Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.
It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.

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1 Deiste, E. (1992) "Some Reflections on Architecture and Construction." *Perspecta* (27), p. 203
Cf. Dieste, E. (July 1980) "Arquitectura y construcción." *SUMMA Colección Summarios* (45*)* p. 93.

2 Carruthers, M. (2000) *The Craft of Thought: Meditation, Rhetoric, and the Making of Images, 400-1200.* Cambridge University Press. p. 12