TECHNOLOGY SEMINAR: STRUCTURAL DESIGN

Dalhousie University School of Architecture
Arch 5298.03 Section 2; Fall 2017
Meets Thursdays 9:00 – 12:30 in HA18
Emanuel Jannasch

Calendar Description

This course focuses on an advanced topic in architectural technology. The topic changes from year to year. It may emphasize materials, environmental strategies, or building details.

Overview

This course consolidates and develops your understanding of structures, mainly through building dynamic models, whether physical or digital. A module reviewing basic structural principles and models is followed by an investigation of structural refinement and elegance. Finally, you’ll explore an open research question or a personal interest.

Additional intentions and emphases

Our minds are very good at catching curveballs and dodging cars, but they’re poor at assessing the behavior of static structures. Math, diagrams loaded with arrows, and even static 3d models don’t really help much. Performative models, on the other hand, that move enough to illustrate structural behavior, are a powerful learning tool. By observing, manipulating, designing, and making them, the learning is maximized.

The best of our demonstrations will be kept for use as teaching aids in other courses. You may discover that learning something well enough to teach it is a good way to build your own knowledge and self-knowledge – which in turn nurtures the self-confidence you’ll need in professional practice.

In keeping with the needs of professional practice, very little math is required for this course. However, if you have an interest in the numerical or computational side of things, this course will support your explorations.
The course would be ideal for students engaged as or interested in becoming technology TA's, for those involved in design-build, and for those who hope to make structures a significant part of their thesis work or their professional tool-kit.

**Formal Learning Objectives**

**KNOWLEDGE**

At the end of the course, students should
- understand and correctly employ the basic glossary (as developed in class) of structural design,
- refer to key examples of structural design according to their particular importance. (The canonical list will be reviewed and expanded through class discussion).
- discuss and evaluate structural experiments and demonstrations in light of their particular purpose. (this discussion will be ongoing)
- discuss the inherent virtues and limitations of basic physical and mathematical modeling methods  (this discussion will be ongoing)

**ABILITIES**

By the end of the course students should be able to
- identify the structural forces and actions at work in simple and moderately complicated structures.
- Differentiate between systems of structural diagramming, and work coherently within any one of them.
- design workable and effective physical and possibly virtual demonstrations
- explain structural concepts using whatever media they are comfortable with and that are suited to a given situation.
- apply simple arithmetic to structural problems.
- conduct their own structural experiments and investigations

**AWARENESS**

Over the course of the term students should demonstrate an increasing awareness of
- varied forms of professional relationship among architects and engineers
- contested senses of structural efficiency, efficacy, economy, and optimization
- divergent taxonomies and categorizations of structural types, actions, and forms
- material and conceptual limits of accuracy, reliability, safety, and certainty
- the many possible roles of structure in architecture (organizational, instrumental, integrative, iconographic...)
- and the many aesthetic attitudes to structural form: instrumentalist, expressivist, expressionist, mannerist, etc.
SCHEDULE

Thursday  Wk.  Theme

<table>
<thead>
<tr>
<th>Date</th>
<th>Week</th>
<th>Theme</th>
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<tbody>
<tr>
<td>Sep. 14</td>
<td>1</td>
<td>Equilibrium</td>
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<tr>
<td>Sep. 21</td>
<td>2</td>
<td>Structural Actions and Considerations</td>
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<tr>
<td>Sep. 28</td>
<td>3</td>
<td>Structural Types</td>
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<tr>
<td>Oct. 5</td>
<td>4</td>
<td>(Presentations I – 25%)</td>
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<tr>
<td>Oct. 12</td>
<td>5</td>
<td>Least-Weight Form</td>
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<tr>
<td>Oct. 19</td>
<td>6</td>
<td>Connections and Movements</td>
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<tr>
<td>Oct. 26</td>
<td>7</td>
<td>Structural detailing</td>
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<tr>
<td>Nov. 2</td>
<td>8</td>
<td>(Presentations II – 25%)</td>
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<tr>
<td>Nov. 9</td>
<td>9</td>
<td>Study Week</td>
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<tr>
<td>Nov. 16</td>
<td>10</td>
<td>(Quiz – 20%) Masonry Shells</td>
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<tr>
<td>Nov. 23</td>
<td>11</td>
<td>Form Finding</td>
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<tr>
<td>Nov. 30</td>
<td>12</td>
<td>Economy, Efficacy, Ecology</td>
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<tr>
<td>Dec. 7</td>
<td>13</td>
<td>Presentations III and Exhibit – 30%</td>
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SEQUENCE OF TOPICS

The term falls into three modules: I. Fundamentals, II. Structural Refinement, and III. Research and Exploration. Each module includes three lectures and one review session; the last module accommodates a quiz.

MODULE I. FUNDAMENTALS

In this module we work with and modify existing models to review and consolidate fundamental concepts of structural behavior and design.

Week 1: Equilibrium
loads and reactions, force and moment, balances, bending moments, simplified arithmetic, statics and determinacy
Intro to Assignment I
Working from a list of possibilities, students and instructor will work out a set of assignments for Module I that reflect individual interests and address the needs of the School’s collection.

Week 2: Structural Actions and Considerations
compression, tension and shear; torsion, bending, and surface action; internal and secondary actions
stress, strain, deflection; stability, stiffness, and strength;

Week 3: Structural Categories
Sorting through the confusion: form-resistant vs bulk resistant; various definitions of form-active; “improvement” surface-active vs bulk-active; vector-active. Stiffening and transverse actions as generating further types.
Week 4: Presentations I
Students use their demonstration projects to explain a topic to their peers.
Introduction to Module II

MODULE II. STRUCTURAL REFINEMENT
Refining structural members to reduce mass or energy can generate elegant form. Refining structural connections in balanced consideration of mechanical performance and possible failure modes can generate articulate detail.

Week 5: Least-Weight Form
Minimizing structural weight must be balanced against the materials and the production processes involved.
Select and define Module II projects

Week 6: Connections and Movements
Most structures can be designed or understood as using only moment and shear connections, but larger spans and more complex structures use other connections understood through the six kinematic degrees of freedom. Common designs reflect the motions accommodated and the materials used.

Week 7: Structural Detailing
Understanding and designing elegant connections in timber, steel, concrete, and other materials, or between different materials, can all benefit from the systematic application of a few basic principles.

Week 8: Presentations II
Students use their demonstration projects to explain a topic to their peers.
Introduction to Module III.

MODULE III. RESEARCH AND EXPLORATIONS:
Students are invited to take on a small project that participates in the instructor’s ongoing research in non-funicular masonry, or they may develop a personal (or team) project based on their own interests.

Week 9: Study Week

Week 10: Masonry Shells
A survey of recent research on funicular and non-funicular vaults and domes.

Week 11: Form-Finding
A critical perspective on mechanical, graphical, and numerical form-finding.

Week 12: Economy, Efficacy, Ecology
The difficult relationship between frugality, aesthetics, and sustainability.

Week 13: Presentation and Exhibition
Students use their demonstration projects to explain a topic to their peers.
Exhibition of term’s work.
ASSIGNMENTS

a) format, topics, and requirements

Proposal  
By the middle of the first class of module I, or by the end of the last class preceding modules II and III, students choose a topic from those listed or, with the instructors permission, adopt one of their own. By the end of the first class of the module instructor and students agree upon project. With the instructor’s approval, students may opt to work in pairs or small teams.

Research  
Notable built examples of the principles in question are located, together with a range of definitions, discussions, and explanations. References could include software, games, film, and AV or commercial teaching aids, as well as the literature proper.

Design  
Students come to the second class of each module with work in progress so that a trajectory can be confirmed, amended if need be, and refined.

Execution  
Projects are due at the start of the last class of each module.

Presentation  
Students present their projects. Where schedules permit, the audience will include undergraduate students or others from outside the class.

b) evaluation in each project  will be weighted roughly equally on:

Technical substance and rigor:
   A - thorough understanding of the subject matter taken on
   B - adequate understanding; minor errors of fact or principle
   C - partial understanding; several or major errors of fact or principle

Legibility of primary content
   A - communication design exceptional in graduate design studies
   B - communication design acceptable in graduate design studies
   C - poor choice of communication strategy, inadequate execution.

Depth of presentation
   A - detail decisions and execution support structures learning
   B - detail decisions and execution neutral in effect
   C - detail decisions detract from structures learning

Usability and convenience for the instructor/demonstrator
   A - devices trouble-free and pleasurable to use
   B - devices useable, but with some irritations
   C - devices inconvenient to be adopted for use

Quality of presentation, answers to audience questions
   A - answers to pertinent questions correct, contextualized and transferable
   B - answers correct, but limited in scope
   C - answers

Contributions as audience member.
   A - consistently makes insightful observations; asks relevant questions
   B - seldom contributes to discussions
   C - comments and questions uninformed, irrelevant, or unhelpful
c) relative weighting

Presentation I 25%
Presentation II 25%
Quiz 20%
Presentation III 30%

The final average will be computed using grade point equivalents.

d) late work

Late work will be penalized 10% of the grade point, and 10% per day thereafter.

READINGS

Beyond materials presented in class, students may consult a wide range of sources for alternate explanations of structural phenomena. For their emphasis on dynamic physical models, consider the following:


Good recapitulations of basic structural design include:


More advanced topics are treated in:


The many possible roles of structure in architecture are considered, for example, by:

Charleson, Andrew: Structure as Architecture. Routledge, 2015

For a historical perspective on structural design, you may want to consult:

Mainstone, Rowland: Developments in Structural Form. MIT Press, 1983