CIV E 779 – Performance-Based Design of Structural Systems

Winter Term 2026/27

Department of Civil and Environmental Engineering
University of Alberta

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Workload:

3 credits

Schedule:

Lecture Wednesdays 2:00 pm – 4:50 pm (Location: TBD)

Prerequisites:

Graduate standing in structural engineering, or permission of the instructor. Prior knowledge of structural analysis, structural dynamics, and design is recommended; however, there are no specific graduate course requirements. The basic information for these topics will be provided in the first three sessions of the course.

Office Hours:

By appointment via email; regular office hours will be confirmed at the beginning of the term.

Course Description:

This course introduces the principles and application of performance-based structural design. Students move beyond prescriptive member checks to define explicit performance objectives, characterize structural hazards, develop linear and nonlinear analytical models, evaluate structural response against acceptance criteria, and communicate performance-based design decisions. The course emphasizes performance-based seismic design and extends the framework to robustness, progressive collapse, alternate-path analysis, and performance-based wind design. Examples include concrete, steel, and timber structural systems.

Course Objectives:

The course is designed to develop the knowledge and engineering judgment required to formulate, perform, interpret, and communicate a performance-based structural assessment or design. Students will integrate hazard characterization, nonlinear analysis, material-specific modelling, performance criteria, uncertainty, and practical design recommendations through lectures, computational exercises, and a semester project.

Learning Outcomes:

By the end of this course, you will be able to:

- Explain the philosophy, terminology, benefits, and limitations of performance-based design relative to prescriptive design.
- Formulate performance objectives by relating hazard intensity, structural and nonstructural response, damage states, and decision variables.
- Select and scale ground motions and interpret seismic hazard parameters for performance assessment.
- Develop fit-for-purpose linear and nonlinear models, including material, component, connection, damping, and geometric-nonlinearity assumptions.
- Apply appropriate modelling and acceptance criteria to concrete, steel, and timber structural systems.

- Conduct and interpret nonlinear static and nonlinear response-history analyses and discuss uncertainty and model limitations.
- Evaluate structural robustness using column-removal and alternate-path scenarios and identify potential disproportionate-collapse mechanisms.
- Apply performance-based wind concepts to serviceability, occupant comfort, damage control, safety, and resilience objectives.
- Synthesize analytical results into defensible engineering recommendations and communicate them in professional written and oral formats.

Lecture Topics:

- Fundamentals of performance-based design and performance objectives
- Linear and nonlinear structural dynamics; nonlinear static and response-history analysis
- Seismic hazard, ground-motion selection and scaling, and uncertainty
- Performance modelling and acceptance criteria for concrete, steel, timber systems
- Seismic assessment and rehabilitation of existing structures
- Robustness, disproportionate collapse, column-removal scenarios, and alternate-path analysis
- Performance-based wind design, including drift, acceleration, occupant comfort, damage, and resilience

Software and Computational Tools:

ETABS will be used primarily for building-system modelling and performance-based seismic workflows. SAP2000 may be used for general structural systems and column-removal/alternate-path studies. Final software requirements and access instructions will be confirmed before the first class.

Recommended References:

- National Research Council Canada, applicable Seismic Evaluation Guidelines for Existing Buildings.
- CSA S16, CSA A23.3, CSA O86, and selected journal papers and technical reports provided through Canvas.
- ASCE/SEI 41, Seismic Evaluation and Retrofit of Existing Buildings (current edition).
- ASCE/SEI 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures (current edition).
- FEMA P-58, Seismic Performance Assessment of Buildings.
- FEMA P-695, Quantification of Building Seismic Performance Factors.
- PEER Tall Buildings Initiative guidelines and relevant performance-based seismic design reports.

Instructional Method:

The course will combine lectures, guided examples, software demonstrations, discussions, quizzes, a term paper, preliminary presentations, and a final performance-based design project.

Quizes (30%) :

Evaluations:

Quizes (30%) :

Quizzes	**30%**
Quiz 1 – Lectures 1 to 3	10%
Quiz 2 – Lectures 4 to 7	10%
Quiz 3 – Lectures 9 to 11	10%

Quizzes are open-book. Class notes and reference materials are allowed in the room, but all electronic devices with transmission capability are forbidden unless the Instructor specifically permits them.

No make-up quiz is available.

Project (70%) :

Final project	**70%**
Preliminary presentation	5%
Final presentation	10%
Final term paper (report)	30%
Participation (peer-evaluation)	5%
Progress Reports	10%

The assessment weights and dates will be confirmed in the first class. Quizzes will emphasize core concepts, interpretation, and engineering judgment. There is no final examination.

Semester Project:

Students will complete a performance-based design or evaluation case study in teams of two, subject to instructor approval. The project will culminate in a final technical report prepared in the form of a term paper. Each team will select a structural system, building, or well-defined engineering problem and apply performance-based engineering principles to evaluate its response and/or develop design recommendations.

The final report should be organized as a technical paper and include, at a minimum, an introduction and problem description, a focused literature review establishing the technical background and relevant performance-based approaches, a clear methodology describing the hazard inputs, modelling assumptions, analysis procedures, engineering demand parameters, and acceptance criteria, presentation and discussion of the results, and conclusions and practical design recommendations. Students should also critically discuss the key assumptions, uncertainties, and limitations of their study and appropriately reference relevant literature, codes, standards, and guidelines.

Possible case studies include seismic assessment or rehabilitation, timber and mass-timber systems, hybrid structures, progressive collapse, performance-based wind design, or another approved topic. Since robustness and wind engineering are covered toward the end of the semester, students are strongly encouraged to select a seismic-focused case study unless they have previous experience with performance-based wind design or column-removal analysis.

Semester Project deadline: April 9; 11:59pm

Lecture Schedule (Wednesdays 2:00 – 4:50 pm):

Week	Date	Topic	Milestone
1	Jan. 6	Introduction to performance-based design	-
2	Jan. 13	Linear structural dynamics	-
3	Jan. 20	Nonlinear structural dynamics	Project Progress Report 1
4	Jan. 27	Hazard and ground-motion selection	Quiz 1 (Lectures 1 to 3)
5	Feb. 3	Performance modelling of concrete	
6	Feb. 10	Performance modelling of steel	
—	Feb. 17	Reading Week	No class
7	Feb. 24	Timber and mass timber modelling	Progress report 2
8	Mar. 3	Preliminary presentations	Preliminary presentation
9	Mar. 10	Performance-based design for robustness evaluation I (progressive collapse mitigation)	Quiz 2 (Lectures 4 to 7)
10	Mar. 17	Performance-based design for robustness evaluation II (progressive collapse mitigation)	Progress report 3
11	Mar. 24	Performance-based wind design I	
12	Mar. 31	Performance-based wind design II	Quiz 3 (Lecture 9 to 11)
13	Apr. 7	Integration and final presentations	Final presentations; course synthesis

Course Resources:

Lecture notes, example problems, software guidance, selected references, and project requirements will be posted on Canvas.

Attendance:

Regular attendance and active participation are expected because software demonstrations, discussions, and project feedback are integral to the course. Students who must miss a class should notify the instructor as early as reasonably possible and remain responsible for missed material.

Submission and Late Work:

Progress reports and project deliverables must be submitted through Canvas by the stated deadlines. Requests for extensions should be made before the deadline whenever possible. Late work without an approved extension may be subject to the deduction stated with the assessment.

Use of Generative AI:

Generative AI tools may be used only as specifically permitted for an assessment. When allowed, students remain fully responsible for technical accuracy, originality, verification, and disclosure of how the tool was used. AI-generated text, code, references, models, or results must not be submitted as the student's own work without acknowledgement.

Professional Engineering Practice:

Models, calculations, and conclusions must be transparent, traceable, and supported by engineering judgment. Students must distinguish verified results from assumptions, preliminary findings, and tool-generated output. Software use does not replace independent checking.

Academic Integrity and Student Support:

Students are responsible for complying with current University of Alberta policies on academic integrity, student conduct, accommodations, absence and deferred assessment, copyright, privacy, and respectful learning environments. The Faculty of Engineering and University policy information on the following pages forms part of this course outline.

UNIVERSITY OF ALBERTA

Faculty of Engineering

University and faculty policies

Respect and professionalism

The Faculty of Engineering is committed to fostering and protecting an equitable, inclusive, and respectful work and study environment in line with University of Alberta policies and professional engineering industry standards.

The faculty prepares students to uphold industry standards to become a Professional Engineer (P.Eng). Therefore, respect, professionalism, and accountability must be upheld within the Faculty of Engineering and the University of Alberta.

Academic integrity and student conduct

The University of Alberta is committed to the highest standards of academic integrity and honesty, as well as maintaining a learning environment that fosters the safety, security, and the inherent dignity of each member of the community, ensuring students conduct themselves accordingly. Students are expected to be familiar with the standards of academic honesty and appropriate student conduct, and to uphold the policies of the University in this respect.

Students are particularly urged to familiarize themselves with the provisions of the Student Academic Integrity Policy and the Student Conduct Policy, and avoid any behaviour that could

potentially result in suspicions of academic misconduct (e.g., cheating, plagiarism, misrepresentation of facts, participation in an offence) and non-academic misconduct (e.g., discrimination, harassment, physical assault). Academic and non-academic misconduct are taken very seriously and can result in suspension or expulsion from the University.

All students are expected to consult the Academic Integrity website for clarification on the various academic offences. All forms of academic dishonesty are unacceptable at the University. Unfamiliarity of the rules, procrastination or personal pressures are not acceptable excuses for committing an offence. Listen to your instructor, be a good person, ask for help when you need it, and do your own work – this will lead you toward a path to success. Any academic integrity concern in this course will be reported to the College of Natural and Applied Sciences. Suspected cases of non-academic misconduct will be reported to the Dean of Students. The College, the Faculty, and the Dean of Students are committed to student rights and responsibilities, and adhere to due process and administrative fairness, as outlined in the Student Academic Integrity Policy and the Student Conduct Policy. Please refer to the policy websites for details on inappropriate behaviours and possible sanctions.

The College of Natural and Applied Sciences (CNAS) has created an Academic Integrity for CNAS Students eClass site. Students can self-enroll and review the various resources provided, including the importance of academic integrity, examples of academic misconduct & possible sanctions, and the academic misconduct & appeal process. Students can also complete assessments to test their knowledge and earn a completion certificate.

"Integrity is doing the right thing, even when no one is watching." -- C.S. Lewis

The Faculty of Engineering expects an environment free of harassment, discrimination, and bullying. We encourage you to talk to the Office of Safe Disclosure and Human Rights about experiences, questions, or concerns. Additional resources and support for students are attached below.

Engineering students studying in the province of Alberta must also follow the Code of Ethics set by the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Course outline policies, course requirements, evaluation and grading information can be found in the University Calendar.

Safety during learning activities

In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. In some cases, laboratory work in a program requires high standards for risk management to keep potential hazards safely under control.

Anyone found to be unable to function safely in the class, lab, seminar or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the Student Academic Integrity Policy and Student Conduct Policy. As members, or prospective members, of the engineering profession, it is your responsibility to identify and inform the proper authorities of unsafe work.

Audio and video recording

Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan.

Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

Only those items specifically authorized by the instructor may be brought into the exam facility. Students must not bring any unauthorized electronic device into an examination room, including cell phones or other devices.

Student services and support

Health & Wellness Support

Counselling and Clinical Services
Free, short-term, appointment-based counselling and psychiatric services. Also offers drop-in workshops. Book an initial consultation. Visit uab.ca/CCS to learn more.

Wellness Supports Social Workers
Free one-on-one support for students in the areas of housing, finances, academics, personal wellness, life skill development, family dynamics, system navigation, and any area of life where there is a desire to invite change. Visit uab.ca/wellness to learn more.

Sexual Assault Centre
Free, anonymous, and confidential drop-in counselling. Visit uab.ca/UASAC to learn more.

The Office of Safe Disclosure & Human Rights (OSDHR)
The OSDHR advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy. Visit uab.ca/OSDHR to learn more.

HIAR (Helping Individuals at Risk)
If you're worried about someone, contact HIAR, who can help assess risk and connect individuals to support. Learn more at uab.ca/HIAR.

Immediate External Supports
Health Link Alberta: 811
Suicide Crisis Helpline: 988

Academic support

Academic Success Centre
Access to a variety of services to maximize your academic success. Learn more at uab.ca/ASC.

Accessibility Resources
Connects students with disabilities to accommodations. Learn more at uab.ca/Access under accommodations + accessibility.

Decima Robinson Support Centre
Academic support for 100- or 200-level introductory calculus, linear algebra and statistics courses. Visit uab.ca/DSC to learn more.

Engineering Student Success Centre
The Faculty of Engineering provides drop-in tutoring for first-year courses. Visit uab.ca/ESSC to learn more.

Office of the Student Ombuds
Call for complex problems and conflict mediation. Learn more at uab.ca/ombuds.

Financial support

Student Service Centre
For awards and other funding support. Learn more at uab.ca/ask.

Campus Food Bank
The Campus Food Bank Society is an independent charity supporting University of Alberta students, faculty, staff, and alumni for up to five years. For additional information visit their website at campusfoodbank.com.