

**CIV E 678 – Behaviour and Design of Steel Seismic Force Resisting Systems (Winter Term 2024/25)****Instructor:** Ali Imanpour ([imanpour@ualberta.ca](mailto:imanpour@ualberta.ca))**Workload:** 4 credits**Schedule:**

Lecture                      Monday                      11:00 – 13:50                      (NREF 2-122)

**Prerequisites (recommended):** CIV E 661 (Dynamics of Structures) and CIV E 670 (Behaviour and Design of Steel Members)**Office hours:** Monday 10:00 – 11:00                      &                      Wednesday 12:00 – 13:00**Course Description:**

The four-credit course is offered by the Department of Civil and Environmental Engineering in the winter term to graduate students in Structural Engineering. Lecture notes give the basics of seismic design for steel structures including general earthquake engineering concepts and associated requirements of the National Building Code of Canada, introduction to seismology, dynamics of structures and modal analysis, structural failures observed in past earthquakes, seismic loading as per the National Building Code (NBC) of Canada, capacity design principles, analysis and design of steel seismic force-resisting systems. Design requirements are given in accordance with the current Canadian steel design standard (CSA S16) and AISC Seismic Provisions (AISC 341). Research studies that support the seismic design guidelines are highlighted. Each seismic force resisting system is followed by a practical example to illustrate the concepts covered and highlight the code provisions.

**Learning Outcomes:**

By the end of this course students will be able to

- Apply seismic hazard analysis
- Apply National Building Code of Canada provisions to compute seismic loads on building structures using static and dynamic procedures
- Identify and describe seismic load paths in steel seismic force resisting systems
- Identify the behaviour and governing failure modes of steel seismic force resisting systems and their connections

- Apply capacity design principles to analyze steel seismic force-resisting systems under seismic loads
- Apply Canadian/American steel design provisions to design members and connections of steel seismic force-resisting systems
- Analyze steel seismic force-resisting systems using nonlinear static procedure
- Apply the principles of performance-based design to assess steel seismic force-resisting systems

### Lecture Topics:

- \* Seismology and seismicity
  - \* Dynamic response of SDOF and MDOF systems (review of CIV E 661 concepts)
  - \* Earthquake engineering and seismic design concepts for building structures
  - \* Equivalent static force procedure and response spectrum analysis
  - Seismic force resisting systems for steel buildings
  - Seismic response and design of steel concentrically braced frames (CBFs)
  - Seismic response and design of steel moment-resisting frames (MRFs)
  - Seismic response and design of steel eccentrically braced frames (EBFs)
  - Seismic response and design of steel buckling-restraint braced frames (BRBFs)
  - Introduction to design of steel plate shear walls (SPSWs)
  - Performance-based design (PBD) of steel structures
  - Application of nonlinear static (Pushover) analysis method for PBD of steel structures
- \* Not included in Final Exam**

### Recommended Textbooks:

1. Filiatrault, A., Tremblay, R., Christopoulos, C., Folz, B., Pettinga, D. (2013) “*Elements of Earthquake Engineering and Structural Dynamics*”, Presses internationales Polytechnique, 3<sup>rd</sup> edition. (Chapters 1, 2, 3, 4, 6, and 7)
2. Bruneau, M., Uang, C.M., Sabelli, R. (2011) “*Ductile Design of Steel Structures*”, McGraw-Hill Education; 2<sup>nd</sup> edition.
3. Metten, A., and Driver, R.G. (2017) “*Structural Steel for Canadian Buildings – A Designer’s Guide*” Structured Solutions Inc., 3<sup>rd</sup> edition, 2<sup>nd</sup> printing.
4. Ziemian, R.D., (2010) “*Guide to Stability Design Criteria for Metal Structures*”, John Wiley & Sons, 6th edition. (Chapter 19)
5. Kulak and Grondin (2021) “*Limit States Design in Structural Steel*” Canadian Institute of Steel Construction, 11<sup>th</sup> edition.

### Design Handbooks:

1. American Institute of Steel Construction. (2018) “Seismic design manual”. 3<sup>rd</sup> Edition. Chicago: AISC. Contains seismic design provisions and examples for the design of steel structures in accordance with 2016 edition of AISC 341.
2. Canadian Institute of Steel Construction (2021) “Handbook of Steel Construction” *Canadian Institute of Steel Construction*, 12<sup>th</sup> Edition. Contains the design provisions for the design of steel structures in accordance with 2019 edition of the CSA S16.

**Lecture Schedule:**

<b>Week</b>	<b>Dates</b>	<b>Content</b>
<b>1</b>	<b>Jan. 6</b>	Introduction; Seismology and seismicity
<b>2</b>	<b>Jan. 13</b>	Dynamic response of SDOF and MDOF systems
<b>3</b>	<b>Jan. 20</b>	Earthquake engineering and seismic design concepts <b>Homework 1 assigned</b>
<b>4</b>	<b>Jan. 27</b>	Equivalent static force procedure; Response spectrum analysis
<b>5</b>	<b>Feb. 3</b>	General seismic design provisions for steel buildings
<b>6</b>	<b>Feb. 10</b>	Seismic response and design of steel concentrically braced frames (CBFs) <b>Homework 1 due; Homework 2 assigned</b>
	<b><i>Feb. 17</i></b>	<i>Reading week</i>
<b>7</b>	<b>Feb. 24</b>	Seismic response and design of steel concentrically braced frames (CBFs)
<b>8</b>	<b>March 3</b>	Seismic response and design of steel moment-resisting frames (MRFs) <b>Homework 2 due; Homework 3 assigned</b>
<b>9</b>	<b>March 10</b>	Seismic response and design of steel eccentrically braced frames (EBFs)
<b>10</b>	<b>March 17</b>	Seismic response and design of steel buckling-restraint braced frames (BRBFs) <b>Homework 3 due; Homework 4 assigned</b>
<b>11</b>	<b>March 24</b>	Introduction to design of steel plate shear walls (SPSWs)
<b>12</b>	<b>March 31</b>	Performance-based seismic design of steel structures <b>Homework 4 due</b>
<b>13</b>	<b>April 7</b>	Application of nonlinear static (Pushover) analysis method for performance-based seismic design of steel structures

**Instructional Method:**

The methods used in this course will be lectures, group discussions, homework assignments, final project and final exam.

**Learning Exercise:**

Multiple learning exercises following concepts covered during the lectures are highlighted in **Orange**. The students are expected to actively engage in discussions for each of learning exercises.

**Evaluations:**

<b>Homework assignments 1</b>	<b>10%</b>
<b>Homework assignments 2</b>	<b>10%</b>
<b>Homework assignments 3</b>	<b>5%</b>
<b>Homework assignments 4</b>	<b>5%</b>

Assignments should be submitted individually at 11:00 AM in class or by 11:00 AM on eClass. The deadline will be given on the handout.

**Final project** **20%**

Students must submit a final project. The project will be done in a group of two or three students. The final project consists of seismic analysis of a steel MRF part of a 5-storey steel structure. Structural analysis is to be performed using a computer-based program such as S-Frame, SAP2000, and IDEA StatiCa. The evaluation of the final project will be based on the detail of structural modeling techniques, and the analysis results submitted by each group. Any assumptions not provided but required as part of design and analysis steps must be clearly stated in the final report *The building information including geometry, loading, and material properties together with the outline of the report to be submitted by each group is provided on eClass.* The deadline to submit the report is **5:00 PM on April 15, 2025**.

**Final exam** **April 11, 2025, 9:00 – 12:00** **Location TBD** **50%**

Final exam will include the topics covered starting from *seismic force-resisting systems lecture* (lectures without asterisk mark in Lecture Topics above). The final exam is limited open book. Class notes, labs, assignment solutions and reference materials available on eClass are allowed in the exam. There will be **a bonus question** worth 5% of total course grade from additional documents/papers shared on eClass.

If you miss the final exam, you can apply for a deferred exam through Faculty of Engineering.

## Final grade

Students' grades on each evaluation will be weighted according to its assigned percentage and combined into a final grade. This final grade will then be converted to a letter grade using the following distribution ([Grading System Explained | Office of the Registrar](#)):

Final Marks			Letter Grade	Grade Point Value	Description
95	–	100	A+	4.0	Excellent
88	–	94.99	A	4.0	
81	–	87.99	A-	3.7	
78	–	80.99	B+	3.3	Good
75	–	77.99	B	3.0	
72	–	74.99	B-	2.7	
69	–	71.99	C+	2.3	Satisfactory
66	–	68.99	C	2.0	
63	–	65.99	C-	1.7	
60	–	62.99	D+	1.3	Failure
50	–	59.99	D	1.0	
0	–	49.99	F	0.0	

The final grade distribution is determined using a blended approach that is neither based strictly on an absolute numerical scale (e.g., > 90% of total marks for a 4.0) nor strictly on a grading curve (e.g., the top x% of students receive a 4.0). Instead, it considers historical averages for structures graduate-level courses and natural breaks in the score distribution.

### Attendance:

Regular attendance in class is expected.

### Calculator Policy:

All programmable and non-programmable calculators approved by [Faculty of Engineering](#) are permitted in the course.

### Miscellany:

Please turn off your cell phone and set it on silent model during lectures.

### Time zone

All times referenced in the lecture/lab schedule are local Edmonton time (GMT-6).

**Course Policies:****What you can expect from me**

I am 100% committed to your learning, and you can expect from me feedback on your work and email response within two days on weekdays. I will not read emails on the weekends, except the days preceding the final exam. Finally, you can expect from me, fair, unified, and consistent grading.

**What I expect from you**

I expect that you engage in all learning activities in this course. This means that it is critical that you read thoroughly the lecture notes assigned, engage in lecture sessions, submit the assignments, and participate in the class discussions. You must display honesty and engagement through the class as per the Department of Civil and Environmental Engineering and School of Mining and Petroleum Engineering Graduate Studies Handbook (see [here](#) for more information).

**Academic Integrity**

The University of Alberta places a very high value on academic integrity. Code of Student Behaviour (COSB) outlines what students are prohibited from doing and gives the rationale for those rules. All work submitted, including assignments, must be your own. Misconduct will be treated seriously according to the policy of Faculty of Engineering. See “[Code of Student Behaviour](#)”