School of Science

GEOG 520

Advanced Course on Permafrost Engineering Applied to Transportation Infrastructure

Term: Summer 2022

Number of Credits: 3 Credits

Course Outline

INSTRUCTORS:

Dr. Guy Doré, Professor, Civil Engineering, Laval University (guy.dore@gci.ulaval.ca)

Dr. Chris Burn, Professor, Geography, Carleton University (christopherburn@cunet@carleton.ca)

Dr. Fabrice Calmels, Research Chair, Permafrost and Geoscience, Yukon University (fcalmels@yukonu.ca)

COURSE DESCRIPTION

This is an advanced, graduate level course on permafrost engineering applied to transportation infrastructure. The course will include a description of permafrost environment and dynamics. Principles and methods for site investigation, design and management of roads, airstrips, railways and other linear structures built in permafrost environments will also be included in the course. Finally, the course will include two field visits on sites where interesting permafrost and engineering features can be observed.

COURSE REQUIREMENTS

Prerequisite(s): Bachelor's degree in engineering or earth sciences.

EQUIVALENCY OR TRANSFERABILITY

Receiving institutions determine course transferability. Find further information at:
https://www.yukonu.ca/admissions/transfer-credit

LEARNING OUTCOMES

Upon successful completion of the course, students will be able to:

- Understanding of the context and the challenges of building linear infrastructures on permafrost.
- Knowledge of the basic principles leading to effective site investigation, design and management of linear structures built on permafrost.
- Understanding of and ability to apply the principles of risk analysis to the development of linear infrastructure in permafrost contexts.
- Ability to analyze a complex situation and propose solutions to stabilize structures in unstable permafrost conditions.

COURSE FORMAT

The course will be an intensive 6-day course including two field trips. Course content will be delivered through lectures, seminars and field trips. The course is offered by Yukon University in cooperation with the Norwegian Research Council (Frozen Canoes program), Sentinelle Nord, Yukon Government Department of Highways and Public Works, Laval University, and Carleton University.

EVALUATION*

3 science papers and 3 engineering papers to review and synthesize before the course	10 %
A 10-page essay on permafrost and engineering problems along the Alaska Highway to be submitted 2 weeks after the course	20 %
Modelling assignment	10 %
Comprehensive Final Exam (Written on Day 6)	60 %
Total	100%

***Evaluations are optional for participants in the professional development course

COURSE WITHDRAWAL INFORMATION

Refer to the YukonU website for important dates.

TEXTBOOKS & LEARNING MATERIALS

Material provided:

- Presentation materials (PowerPoint files)

Recommended references:

- Doré G., and Zubeck H., 2008, Cold Region Pavement Engineering, McGraw Hill/ASCE Press, 416p.
- McGregor R., Doré G., Hayley D., Wilkins G., Hoeve E., Grozic E., Roujanski V., Jansen A., 2010, Guidelines for development and management of transportation infrastructure in permafrost regions, Transportation Association of Canada, 177p.
- Andersland O.B., and Ladanyi B., 2004, Frozen ground Engineering, Second edition, John Wiley and sons/ASCE Press, 363p.
- French H.M., 2007, The Periglacial Environment. Hugh M. French. 3rd edn, John Wiley and sons, 341 pp.

ACADEMIC INTEGRITY

Students are expected to contribute toward a positive and supportive environment and are required to conduct themselves in a responsible manner. Academic misconduct includes all forms of academic dishonesty such as cheating, plagiarism, fabrication, fraud, deceit, using the work of others without their permission, aiding other students in committing academic offences, misrepresenting academic assignments prepared by others as one's own, or any other forms of academic dishonesty including falsification of any information on any Yukon University document.

Please refer to Academic Regulations & Procedures for further details about academic standing and student rights and responsibilities.

ACADEMIC ACCOMMODATION

Reasonable accommodations are available for students requiring an academic accommodation to fully participate in this class. These accommodations are available for students with a documented disability, chronic condition or any other grounds specified in section 8.0 of the Yukon University Academic Regulations (available on the Yukon University website). It is the student's responsibility to seek these accommodations by contacting the Learning Assistance Centre (LAC): LearningAssistanceCentre@yukonu.ca.

TOPIC OUTLINE

Day	Activity	Outline of Activity
1	Lectures	Introduction: The context of northern Canada transportation infrastructure (economic and social role; condition, vulnerability, expected development) The permafrost environment: Essential notions on permafrost environments for engineering considerations (permafrost characteristics and features, thermal regime, permafrost dynamics) Heat transfer: principles and calculation (heat transfer by conduction, convection and radiation; practical methods for calculation of thermal regime, heat transfer, heat balance)
2	Lectures (Morning)	The permafrost environment: (continuation)
	Field trip (Afternoon)	Field trip to permafrost sites around Whitehorse
3	Lectures	Basic considerations for embankment design in permafrost conditions: Thermal implications, mechanical implications, drainage considerations Frozen/thawing soil mechanics: Frost action, mechanical properties of frozen and marginally frozen ground, thaw consolidation, mechanical properties of thawing permafrost and of the active layer

		Site investigation: Key considerations for site investigation, description of geophysical methods, drilling and sampling, in-situ testing Embankment design: Key considerations, embankment materials, embankment geometry, thermal analysis, mechanical analysis, special protection techniques, consideration for frost heave
4	Lectures (Morning)	Slope stability: Stability of natural and cut slopes Drainage: Implications of water concentration and channeling, control of surface water, erosion and thermal erosion, design of cross-drainage systems Construction in permafrost regions: Logistic, environmental considerations, permafrost preservation, working with frozen or thawing materials Management strategies: Risk analysis, preservation strategies, maintenance
	Field Trip	Alaska Highway: Takhini river retrogressive thaw-flow slide
5	Field Trip	Alaska Highway: Drainage design in Destruction Bay; Embankment failure; Slope design and induced thermokarsts the Dry Creek Rest Area; Beaver Creek test site
6	Lectures and Examination	Review: Additional presentations, review of important points and discussion Written examination