

CEE 9576a – Buried Structures

Objective

The objective of the course is to introduce the basic principles employed in the structural analysis and design of two categories of buried structures; pipelines and culverts. Students who successfully complete this course should be able to calculate the loads, analyze and design both flexible and rigid pipelines in addition to rigid and flexible culvert structures as per the CHBDC and AASHTO-LRFD Codes.

Topics:

1. Introduction to buried structures
 - Vertical and lateral soil pressure and introduction to soil-arching
 - External loads on buried structures due to live loads and truckloads
 - Rigid structure vs flexible one
 - Nonuniform Bedding Support
 - Minimum Soil Cover
 - Embankment vs Trench Conditions and effect of Trench Width
 - Soil Classes
 - Embedment and Compacting Techniques
2. Design of Rigid Pipes (gravity flow)
 - Rigid Pipe Products
 - Asbestos-Cement, Clay, Concrete Pipes
 - Rigid Pipe Analysis
 - Three-Edge Bearing Strength
 - Bedding Factors and Classifications
 - Pipe Design Criteria (AASHTO/CHBDC)
 - Performance Limits
 - Safety Factors
3. Design of Flexible Pipes (gravity flow)
 - Installation
 - Spangler's Iowa Formula
 - Use of the Constrained Soil Modulus
 - Analytical Methods for Predicting Performance
 - Empirical Method
 - Pipe Design Criteria (AASHTO/CHBDC)
 - Performance Limits
 - Safety Factors
4. Design of Pressure Pipes
 - Hydrostatic Pressure
 - External Loads
 - Combined Loading

Longitudinal Stresses
Rigid Pipes
Flexible Pipes
Thrust Restraint

Safety Factors
AWWA Design of Reinforced Concrete Pressure Pipe
Design Procedure for Rigid Pipe
Three-Edge Bearing Design Criteria
The Direct Method
Design Strengths for Concrete Pipes

5. Introduction to Structural Design of Buried Bridges (Non-seismic)

What is a Buried Bridge?
Applications of Buried Bridges
Metal Buried Bridge Fabrication
Precast Concrete Buried Bridge Fabrication
Reduced Labor for Installation
General Design Steps – Buried Bridges
Buried Bridge Structure Geometry
Corrugated Metal
Structure Shapes
Precast Concrete Shapes
AASHTO LRFD and CHBDC Structural Design
Load Combinations
Foundations and Soils
Different Structure Types
Vehicular Live Load

6. Design of Concrete and Metal Buried Bridges

Advanced Analysis of Buried Bridges
Two-Dimensional (2D) Finite Element Analysis (FEA) - CANDE
Sample 2D FEA Model
CANDE 2D FEA SSI Limitations
Three-Dimensional (3D) FEA
Design of Concrete Buried Bridges
Material Components
Design Considerations
Strength Limit State
Service Limit State
Crack Control
Distribution of Wheel Loads through Earth Fills
CANDE Software
Soil Models
ELEMENTS

Buried Bridge Foundations
Design of Flexible Buried Bridges
Bridge Shapes
Material Components
Steel Corrugation Profiles
Design Inputs & Considerations
Strength Limit State
Service Limit State
AASHTO LRFD/CHBDC Design Checks

Prerequisites:

Soil Mechanics I
Design of Reinforced Concrete Structures
Design of Steel Structures

Corequisite:

None

Antirequisite:

None

Note: It is the **student's responsibility** to ensure that all Prerequisite and Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the **student's responsibility** to ensure that they have not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Antirequisite conditions.

Contact hours: 3 lecture hours

Text: Course notes will be available

Project: A design project will be assigned or critical review of some technical papers will be required.

Assignments: Assignments will be assigned through the term and the solutions will be submitted in about two weeks after receiving the assignment.

Examination: A 3-hour examination is held during the examination period on all work covered during the course. The examination is an open book.

Evaluation: The final grade is arrived at as follows:

Assignments	30%
Project	30%
Final Examination	40%

Instructor

TBD

Contact Hours

TBD

Textbook

None

Selected References

- 1- A P Moser & Steven L Folkman, Buried Pipe Design – 3rd Edition, New York: McGraw-Hill, 2008
- 2- George Abdel-Sayed, Baidar Bakht, Leslie G. Jaeger, Soil-Steel Bridges: Design and Construction, McGraw-Hill, 1994

Lecture Notes

Lecture notes prepared by the instructor

Laboratory

NA

Units

Both SI and Imperial units will be used

Computer Usage:

Students to develop Excel sheets and VBA code for the design of the different structural elements
Using CANDE and/or ANSYS to model the behavior of buried structures

Use of English:

In accordance with Senate and Faculty Policy, students may be penalised up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Scholastic Offences:

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site: http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_grad.pdf.

Plagiarism:

University policy states that plagiarism, defined as the “act or an instance of copying or stealing another’s words or ideas and attributing them as one’s own.” (excerpted from Black’s Law Dictionary, West Group, 1999, 7th ed., p. 1170) is a scholastic offence. In submitting any written work as part of the coursework requirements for this course students must ensure that this work is written in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations.

All required papers may be subject to submission for textual similarity review to the commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (<http://www.turnitin.com>).

A student who is found guilty of plagiarism in respect of any written work submitted as part of the coursework requirements for this course will be given a grade of zero for the submitted work. Repeated



acts of plagiarism, either in this course or any other course subsequent to a first offence, will result in the student being given a failing grade for the course in which the subsequent offence occurs, and may also incur further penalties such as requiring the student to withdraw from the program in which they are enrolled in.

Attendance:

Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Accessibility:

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

Conduct:

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Late comers may be asked to wait outside the classroom until being invited in by the Instructor. Please turn off your cell phone before coming to a class, tutorial, quiz or exam.

On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: <http://www.uwo.ca/univsec/board/code.pdf>.

Graduate Students Health and Wellness

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several on campus health-related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. For example, to support physical activity, all students, as part of their registration, receive membership in Western's Campus Recreation Centre. Numerous cultural events are offered throughout the year. For example, please check out the Faculty of Music web page <http://www.music.uwo.ca>, and our own McIntosh Gallery <http://www.mcintoshgallery.ca>. Information regarding health- and wellness-related services available to students may be found at <http://www.health.uwo.ca>. Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Campus mental health resources may be found at http://www.health.uwo.ca/mental_health/resources.html.

Sickness and Other Problems:

Students should immediately consult with the Instructor or Department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor or Department Chair



regarding how best to deal with the problem. Failure to notify the Instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, please see:

http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf.

Notice:

Students are responsible for regularly checking their email, and the course OWL site for new notices related to the course.