This course trains students to incorporate knowledge of the physical properties and engineering characteristics of major civil engineering materials, including portland cement concrete and asphalt concrete, in the structural, durability and sustainability design of civil infrastructure, with focus on flexible and rigid pavements. The general objectives of the course are for the student to become able to:

- Relate the manufacturing of portland cement, its chemical composition, physical properties, and hydration reactions to the engineering properties of cement-based materials.
- Recognize the effects of chemical admixtures and mineral additions on the short- and long-term performance of concrete structures.
- Conduct the mixture design of concrete to meet specific design and performance requirements.
- Identify various mechanisms of degradation of concrete structures and the actions needed to enhance the durability of concrete structures in aggressive environments.
- Perform the mixture design of paving asphalt concrete to meet design specifications; recognize the performance, failure criteria and principles of modern design of rigid and flexible road pavements.
- Carry out the thickness design of flexible and rigid pavements considering specific traffic, soil and environmental conditions.
- Incorporate sustainability and environmental considerations in the use of civil engineering materials, develop awareness of modern advances and novel applications involving civil engineering materials, recognise the need for life-long learning to keep abreast of new design and construction methods involving such materials, and to enhance one’s design abilities.

**Calendar Course Description:** The consideration of the physical properties and engineering characteristics of materials used in Civil Engineering.

**Prerequisite(s):** CEE 2202A/B and CEE 2220A/B.

**Anti-requisite(s):** None.

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

**Instructor:** M.L. Nehdi, PhD, P.Eng., FACI, FCSCE, FEIC, Professor, Office: SEB 3083, email: mnehdi@uwo.ca

**Administrative Assistance:** Sandra McKay (smckay@uwo.ca)
Contact Hours: 2 lecture hours per week; 2 lab/tutorial/design hours per week.
Office hour: Tuesdays 1-2 PM Via Zoom.

Lectures will be delivered asynchronously through pre-recorded videos posted to the course OWL site. The lectures will be organized into learning modules, which students should review on a weekly basis. Quizzes will be used to track participation. Review of lecture material and self-study should take approximately 4 hours per week.

The weekly 2-hour lab/tutorial sessions will be delivered synchronously through Zoom during the scheduled tutorial hours. Students seeking assistance with weekly assignments and design project, or clarification on lecture materials, are strongly encouraged to attend. The link to the Zoom meeting will be posted to OWL.

Class Notes:
Class notes for each chapter of the course will be regularly posted on OWL. Selected additional reference materials will also be posted on the OWL course website.

Recommended References:
(2) Properties of Concrete, by. A.M. Neville, John Wiley & Sons Inc.

Units:
SI units will generally be used in lectures and examinations. Occasionally, imperial units are used.

Specific Learning Objectives:
1. Cement Manufacturing, Chemistry and Hydration: At the end of this section the student should be able to:
   a) Recognise the steps involved in manufacturing portland cement and the various reactions occurring in a cement kiln.
   b) Identify the oxide composition of portland cement and the difference in composition between different types of cements and its effect on the performance of concrete.
   c) Characterise the hydration reactions of the main phases in a cement clinker and the effect on their physical and chemical parameters on cement hydration kinetics.
   d) Identify the major phases in the microstructure of hydrated cement paste.

2. Mineral Additions and Chemical Admixtures in Concrete: At the end of this section the student should be able to:
   a) Evaluate the effect of using supplementary cementitious materials on the sustainable development of civil infrastructure and the built environment.
   b) Identify the effects of using mineral admixtures such as fly ash, slag and silica fume on the workability, mechanical properties and durability of concrete.
   c) Control the properties of concrete mixtures using chemical admixtures such as accelerators, retarders, superplasticizers and air-entraining admixtures.
   d) Design concrete mixtures involving mineral additions and chemical admixtures to meet specific design requirements.
3. Aggregates and their Use in Concrete
   a) Describe the source and geological classification of aggregates
   b) Analyse the physical properties and particle size gradation of aggregates.
   c) Determine the effect of aggregate use in concrete.
   d) Identify harmful aggregates to mitigate their negative effects on the durability of concrete.

4. Workability, Mechanical Properties and Durability of Concrete
   a) Use various tests to characterise the workability of fresh concrete mixtures and recognise the effects of mixture proportions on workability.
   b) Appreciate the time and temperature dependence of the properties of fresh and hardened concrete.
   c) Control the mechanical properties of concrete via controlling its mixture proportioning, consolidation, and curing.
   d) Describe the performance of concrete under compressive and other mechanical loading.
   e) Learn the development of special concretes such as fibre-reinforced concrete, self-consolidating concrete, and high performance concrete.
   f) Identify the mechanisms of deterioration of concrete in different aggressive environments and develop strategies for enhancing the durability of concrete structures.

5. Asphalt
   a) Recognize the chemical composition of asphalt cements, their physical structure, aging, rheological properties, and classification.
   b) Recognize the structure of asphalt concrete, ingredients, fillers and additives used in its making, its response to loads, desired properties, effect of temperature and moisture, durability, etc.
   c) Design aggregate mixtures for paving asphalt concrete.
   d) Design asphalt-aggregate mixtures to meet particular road design specifications.

6. Pavement Design
   a) Discuss and use the principles of pavement design including the concept of design life and failure criteria.
   b) Compute stresses and deflections in pavements using linear elastic-layered systems
   c) Rationally design flexible (asphalt) and rigid (concrete) pavements using different methods (e.g. AASHTO, Asphalt Institute, or PCA) given specifications and properties of pavement materials including soil foundation, sub-grade, sub-base, and surface characteristics.
   d) Evaluate the performance of road pavements.

General Learning Objectives

E=Evaluate, T=Teach, I=Introduce

<table>
<thead>
<tr>
<th>Problem Analysis</th>
<th>T</th>
<th>Team Work</th>
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<th>Ethics and Equity</th>
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<tbody>
<tr>
<td>Investigation</td>
<td>E</td>
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<td>Design</td>
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<td>Professionalism</td>
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<td>Life-Long Learning</td>
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<td>Engineering Tools</td>
<td>E</td>
<td>Impact on Society</td>
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Evaluation: The final mark will be determined as follows:

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<tr>
<th>Component</th>
<th>Percentage</th>
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<tr>
<td>Quizzes</td>
<td>10%</td>
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<tr>
<td>Midterm Test</td>
<td>15%</td>
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<tr>
<td>Design Project and Lab Reports</td>
<td>30%</td>
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<tr>
<td>Final Examination</td>
<td>45%</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
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Important Notes:

- Faculty policy states that **students must pass the final examination to pass this course**. Students who fail the final examination will be assigned the aggregate mark, as determined above, or 48%, whichever is less.
- **Students who have failed an Engineering course (i.e.<50%) must repeat all components of the course.** No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted for grading by the student in subsequent years.
- Should a quiz conflict with a religious holiday that a student wishes to observe; the student must inform the instructor of the conflict no later than one week before the scheduled test. For further information on Accommodations for Religious Holidays see: [http://www.uwo.ca/univsec/handbook/appeals/religious.pdf](http://www.uwo.ca/univsec/handbook/appeals/religious.pdf)

1. **Quizzes and Examinations**
   Quizzes will be conducted during tutorials with a one-week notice. Students shall be up to date with the course material to do well in the quizzes. The **midterm test** will be CLOSED BOOK and scheduled in the week following the Spring Reading Week. The **final examination** will be 3 hours and will be OPEN BOOK in which class notes and approved handheld calculators may be used.

2. **Tutorials and Laboratories:**
   Tutorial problems may be assigned, but will not be marked. Solutions will be posted on OWL to assist students in their learning. Students shall attend virtual laboratories. **Lab reports should be integral part of the final design project report.** Lab data and knowledge should be used in the design project. Lab and project group membership will be assigned by the instructor, and may be revised during the term. All group members must sign the cover page of group submissions and clearly state the contribution of each team member. Late project submissions will receive a mark of zero. Extensions are to be negotiated with the instructor, not with the teaching assistants.

4. **Use of English:**
   In accordance with Senate and Faculty Policy, students may be penalised up to 10% of the marks on all assignments, projects, reports, tests and examinations for the improper use of English. Additionally, poorly written work with the exception of final examinations 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.

**Cheating:**
   University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties that might include expulsion from the program. If you are caught cheating, there will be no second warning. For more information on scholastic offenses, please see: [http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf](http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf)
**Attendance:**
Any student who, in the opinion of the instructor, is absent too frequently from class or lab/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 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. 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

**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.

Students that are in emotional/mental distress should refer to Mental Health@Western http://www.uwo.ca/uwocom/mentalhealth/ for a complete list of options about how to obtain help

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, course website (https://owl.uwo.ca) and notices posted outside the Civil and Environmental Engineering Department Office

**Consultation:**
Students are encouraged to discuss problems with their teaching assistant and/or the Instructor in tutorial sessions. Office hours will be arranged for the students to see the Instructor and teaching assistants. Other individual consultation can be arranged by appointment with the instructor.

**Course Breakdown:** Engineering Science = 50% = 18.9 AU’s, Engineering Design = 50% = 18.9 AU’s

The attached document “INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED” is part of this course outline.