



GRADUATE HANDBOOK

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1 INTRODUCTION

The purpose of this guide is to provide students with information on the requirements and procedures for pursuing a graduate degree (M. E., M. S., or Ph.D.) in the Department of Civil and Architectural Engineering and Mechanics (CAEM) at the University of Arizona. The Department is active in research in the general areas of Engineering Mechanics, Geomechanics/Geotechnical Engineering, Highway and Transportation, Hydraulics and Water Resources, and Structures. Details of faculty, ongoing research and resources in each area are included in Appendix 1.

This guide is a compilation of current policies, practices, and procedures of the Graduate School and the CAEM. Information found in the [Graduate catalog](#), which the student is expected to be familiar with, is to be used as the basis for the resolution of any special problems, the treatment of any extraordinary conditions, and the source for details not covered by this guide. In some instances, requirements differ between the Graduate College handbook and this document. As a minimum the graduate school requirements must be adhered to, but the Department may have more stringent requirements than the graduate school. If a topic is not covered in this handbook, the Graduate College regulations will be enforced. The requirements listed herein are effective from the handbook publication date.

Contained in this guide are general program information, general administration of the graduate program, and deadlines for the submission to the Graduate College of items such as study programs, reports on examinations, etc. The Graduate College publishes official specific deadline dates. A copy of official deadline dates can be obtained from the CAEM Office or the Graduate College website (<http://grad.arizona.edu/>).

2 GENERAL PROGRAM INFORMATION

2.1 Degree Programs

The Department offers the following graduate degrees:

- Master of Engineering (M.E.) in Civil Engineering and Engineering Mechanics
- Master of Science (M.S.) in Civil Engineering and Engineering Mechanics
- Doctor of Philosophy (Ph.D.) in Civil Engineering and Engineering Mechanics

The M.E. degree is a coursework only program. It is intended to be a terminal professional degree with academic standards equivalent to, but different from, a traditional M.S. degree.

The MS degree has two options: (i) thesis and (ii) report. The M.S. degree thesis option is intended for students who want to gain experience in formulating and researching civil engineering topics and will work closely with a faculty member on a research project. Students planning to pursue a Ph.D. degree are strongly encouraged to choose the thesis option. The M.S. degree report option is intended for students desiring a broad education. The report provides a similar experience to the thesis not intended to be a

research project; rather it is an advanced engineering study. The report topic is generally engineering practice motivated, typically toward implementable design or design process. Both M.S. options are comprised of coursework in several areas, a thesis or report, and a final defense (called a Master's/Specialist Completion Final).

The following background is general for all degree programs.

3 FINANCIAL SUPPORT

3.1 TYPES OF FINANCIAL SUPPORT

Financial support is available in several forms. A limited number of highly selective fellowships are available to PhD students. Faculty recommend exceptional candidates for these awards during the admission process. Fellowships do not have specific responsibilities attached to their funding.

Assistantships and graders, on the other hand, do have job responsibilities.

Research Assistantships (RAs) are provided by CAEM faculty member's research grants. These faculty are responsible for identifying students to work on these projects. In addition, a limited number of CAEM

Teaching Assistantships (TAs) are available to qualified students. Faculty members provide recommendations to the Department Head for these positions. Students are paid based on the standard rate and the hours of the appointment. There is a tuition reduction automatically for an RA or TA with a 1/4-time or higher appointment. A 0.25 time appointment waives out-of-state tuition and half of in-state tuition while a 0.5-time appointment (20 hrs/week) carries a full waiver of in and out of state tuition. Students are responsible for other fees.

Course grader positions are often available and paid hourly. Departmental scholarships are also available but are generally restricted to ongoing students who submit an inclusive scholarship application early in the spring semester. CAEM also has allocated funds for graduate tuition (GTS) and registration (GRS) stipends; primarily for ME students. A GTS waives the portion of the student's tuition and a GRS waives both the in-state and out-of-state fees. These stipends are distributed on a competitive basis. A GTS comes automatically for an RA or TA with at least a 1/4-time appointment.

Graduate students may seek additional funding opportunities announced by the UA Graduate College. A detailed listing is available at: <https://grad.arizona.edu/funding/opportunities>. Graduate students seeking funding for their studies or research can also find helpful information through the Graduate Center Office of Fellowships. Many other funding resources are available to UA students through Scholarship Universe. The Graduate and Professional Student Council (GPSC) also has funding opportunities at <https://gpsc.arizona.edu/grantsawards>. One of the scholarships that may be given by the UA Graduate College is the Thesis & Dissertation Tuition Scholarship for non-resident students who are within two years of completing their MS or PhD degrees and are taking only CE 909, 910 or 920 graduate units. The scholarship can reduce tuition for these students to the in-state resident amount. If you are interested in taking advantage of this scholarship, please contact the graduate program coordinator, as it requires a departmental nomination.

3.2 TA and RA Requirements

To be employed as a RA or TA, a student must be enrolled for a minimum of 12 credit hours. Further, teaching assistants must complete the [mandatory Teaching Assistant/Associate Training Online \(TATO\)](#) online training prior to starting their position.

To serve as a TA, International graduate students must demonstrate high English competency as demonstrated by meeting one of the following requirements.

TOEFL IBT Speaking Section – score of 24

IELTS - total minimum score of 7.5 or above with no score lower than 7 on any section of the test. A score of 8 is the recommended level.

If an International TA has not taken any of the approved tests (listed above) or does not meet the minimum passing score(s), the department can perform an English Speaking Proficiency Evaluation (ESPE). The Graduate College requires that the English Speaking Proficiency Evaluation be completed prior to the student being hired. More details can be found in (<http://grad.arizona.edu/funding/ga/english-speaking-proficiency-evaluation>)

3.3 Tax Information

Students should be aware of current tax laws that may impact salaries or stipends received from graduate teaching/research assistantships, fellowships, and stipends. Contact the Graduate College, Administration Building, Room 322, for additional information, or the IRS at (800) 829-1040 and ask for the Scholarship/Fellowship publication.

4 GRADUATE STUDENT SUPPORT

4.1 CAEM Graduate Coordinator

The CAEM Graduate Program Coordinator is the first point of contact for incoming graduate students (ceem@engr.arizona.edu, 520-621-6564). Upon arrival to campus, she/he will familiarize the students with support and requirements for students. The Program Coordinator supports students during their graduate studies and serves as a conduit to the Graduate School. The Coordinator will collect required forms, help with registration, and all academic process issues.

The **Graduate College** assigns a degree counselor in their office for each major. The name and contact information of the **Graduate College Degree Counselor** assigned to CAEM can be found at: <https://grad.arizona.edu/tools/degrecounselors/>. The degree counselor is the first contact for unresolved departmental issues and performs a preliminary final degree check. Meetings with the counselor and different student support departments can be conveniently scheduled through Trellis-
<https://trellis.arizona.edu/login>.

In the CAEM department, there is currently one individual fulfilling both roles. It is important to be aware that although different documents or websites may refer to these roles separately, they are in fact performed by the same person for all CAEM graduate students.

4.2 CAEM Business Office

The CAEM Business Office handles financial and other non-academic functions including employment paperwork, providing scholarships, and assigning office space to graduate assistants. CAEM does not have expertise to respond financial aid and immigration status question. Support for those questions are addressed by the University Registrar or the ISS. You can also find the financial aid information at <https://financialaid.arizona.edu/>.

4.3 Academic Advisor

Early in the student's academic program, the student identifies an academic advisor who agrees to work with the student. The advisor is the student's primary educational contact. The primary role of the Academic Advisor is to guide the student in coursework and research and to keep the student informed on whether the student is making satisfactory progress. In contrast to undergraduate programs, the academic advisor for graduate students is a faculty member within the department.

Specifically, the advisor's responsibilities include identifying coursework that will benefit the student in reaching the student's academic goals, developing a plan of study, collaborating with the student in identifying the student's thesis/report/dissertation topic, meeting regularly to advance the research, and assisting in writing the final research product. The academic advisor and graduate program coordinator ensure that all degree requirements are satisfied, and the student is progressing toward the student's degree. If the student disagrees with a decision or course of action recommended by the Academic Advisor, the student can appeal the decision. The appeal procedure is as described in the Academic Appeal Policy Section. The process for selecting and confirming an academic advisor is described in Section 9.5.

4.4 Physical Space and Access

At the start of each semester, it is necessary for all new graduate students to receive a designated desk. The CAEM program coordinator will commence the process of assigning desks once the list of final graduate students for the upcoming term has been confirmed. Graduate students should be mindful of the possibility of cohabiting office spaces with fellow faculty members or other graduate students.

Typically, prior to the commencement of the term, the department undertakes the task of updating email lists and catcard access. It is expected that students will be granted general access to the building to facilitate after-hours and weekend work. Should you require any additional access for your work or if you need physical keys to specific rooms within the premises, you are advised to consult your faculty advisor. Students have certain important responsibilities when they are issued physical keys to lab and office spaces. When they are done with the keys, they must return them to the University of Arizona Key Desk (currently housed on the second floor of the Facilities Management Building at 1405 North Ring Road) before graduation.

Failure to do so may result in the withholding of final grades or a bill for the cost of re-keying the space(s). Students may not transfer keys to other students or faculty. If a student anticipates that they will not be able to return the keys to the Key Desk before graduation, they may return the keys to the graduate program coordinator in an envelope marked with their name and their Student ID number, and the graduate program coordinator will return them to the Key Desk on their behalf.

5 GRADUATE PROCESSES AND PROCEDURES

This section provides an overview of administrative processes, procedures, and tools to advance toward a graduate degree in our department. Details on degree specific forms and processes are addressed by program in Section 9 for Master of Science, Section 10 for Master of Engineering, and Section 11 for Doctoral programs.

5.1 GRADPATH

Upon arrival to campus, the Graduate Coordinator will introduce the incoming graduate student to **GradPath** (<http://grad.arizona.edu/gradpath>). **GradPath** is the Graduate College's paperless degree audit process that tracks and monitors student progress. Students can fill in and submit forms online through **UAccess Student** (<https://grad.arizona.edu/gsas/forms/gradpath-forms>).

At the outset of the student's program, the graduate student should become familiar with the steps required for achieving the degree, and consult the checklist periodically (<https://grad.arizona.edu/gsas/degree-requirements>). Details for CAEM graduate programs including recommended timing to complete each step are given by program in Sections 9, 10, and 11. Required forms can be found at: <https://grad.arizona.edu/gcforms/academic-services-forms>.

5.2 Selecting an Academic Advisor

An Academic Advisor must be chosen prior to the beginning of the second semester of study. Incoming graduate students are encouraged to talk to all faculty in the student's area of study before selecting an Academic Advisor. Students who are awarded a research assistantship will usually be assigned a faculty advisor prior to the commencement of the first semester. If a student does not have a faculty advisor before the start of the first semester (such instances may involve self-supported students or those with fellowship support), it is required for them to arrange meetings with all faculty members whose research interests align with their own and who have research projects available. After the advisor has been selected, the Advisor Selection Form (available in the Graduate Coordinator's Office, see Appendix 3) is completed and retained in the student's file.

If an incoming student has not identified a faculty advisor prior to arriving on-campus, the Department Head will assign a faculty member as a temporary advisor to help select classes during the student's first semester.

A student for good reason may choose to change the student's Academic Advisor. In this case, the old and the new Academic Advisors and the Student's Advisory Committee must agree to the change with at most one dissenting vote. A new Advisor Selection form is then filed with the final approval of the Department Head. Once the approval is obtained, the student will do one of the following:

MS or ME Student

1. If the student has already completed a Plan of Study in GradPath, then the student will submit a new Plan of Study with the new faculty advisor listed.
 2. If the student has not already completed a Plan of Study, then the student will simply list the new faculty advisor on the Plan of Study at such time as it is submitted to the Graduate College.
- Information for New and Continuing Students

PhD Student

1. If the student has completed a Plan of Study but has not completed the Comp Exam Committee Appointment form in GradPath, the student must submit a new Plan of Study with the new faculty advisor listed.
2. If the student has completed the Comp Exam Committee Appointment form in GradPath but has not completed the Oral Comprehensive Exam, then the student must submit a new Comp Exam Committee Appointment form listing the new faculty advisor as the Chair of the Comprehensive Exam Committee.
3. If the student has completed the Doctoral Comprehensive Exam, then the student will list the new faculty advisor as the Chair of the Doctoral Dissertation Committee on the dissertation committee appointment form in GradPath.

5.3 Academic Advising

It is the student's responsibility to arrange an appointment with the Academic Advisor to organize a tentative study program. The student and Academic Advisor should also review the proposed study program and discuss the selection of a research topic for the degree.

The student should meet with the student's Academic Advisor frequently, but at least twice per semester to discuss research plans, progress in coursework, etc.. More frequent meetings should be held as the student progresses in his research. It is the student's responsibility to arrange these meetings.

5.4 Course Registration

Registration for each semester in residence should be completed after meeting with an Academic Advisor. Course registration is completed using **UAccess**, the University's web-based password-protected self-service portal. While GradPath monitors and accepts forms for degree progress, UAccess is the main student portal to access personal information, enroll for classes, perform university-related transactions, and

check financial aid status. The **Schedule of Classes** and course catalog are linked to UAccess each semester (<https://www.arizona.edu/registering-classes>).

5.5 Registration Requirements/Supplementary Registration

During the fall and spring semesters, full-time status consists of enrollment for 9 units of graduate credit for domestic and international students without RA/TA support. CAEM requires all students supported with a RA/TA to take twelve (12) units per semester. The minimum units required for graduate students vary depending on students' status, academic progress, and semester. A summary of the CAEM minimum and maximum units for graduate students is summarized in Table 5.1. Only 500, 600 and 900 level courses are counted toward the minimum enrollment required by University of Arizona.

Table 5.1 Departmental requirements of Graduate Credits for Graduate Students

Student Status	Registration Limit	Spring or Fall Semester				Summer Semester	Winter Semester
		No-aid	Hourly worker	RA/TA	No-aid-in last semester	all graduate students	
Domestic	Minimum	1	6	12	1	See Note	
	Maximum	19	19	19	19	6-7 units	3-4 units
International	Minimum	9	9	12	1-3 units depending on the student's country of origin	See Note	
	Maximum	19	19	19	19	6-7 units	3-4 units

Note: Graduate students who have maintained continuous enrollment, fulfilled all their other degree requirements, and were enrolled in thesis or dissertation unit(s) in the prior semester may defend and file for the degree in the summer or winter term without registration. If, however, students need library privileges or plan to use other University facilities or need significant faculty time during the summer or winter session, enrollment is required. Enrollment in the non-credit GRAD 922 to allow access to the Library during the summer or winter terms will now be available for eligible master's as well as doctoral students.

5.6 Continuous Enrollment Requirements

A student should visit <https://grad.arizona.edu/policies/enrollment-policies/continuous-enrollment> about the most current Continuous Enrollment Policy. The requirements below are current as of February 2022.

Unless excused by an official graduate **Leave of Absence** (which may not exceed one year throughout the student's degree program), all graduate students are subject to the **Continuous Enrollment Policy**. If the student fails to obtain a **Leave of Absence** or maintain continuous enrollment, he or she will be required to apply for re-admission and to pay the Graduate College application fee. There is no guarantee of re-admission. Tuition or registration waivers cannot be applied retroactively.

5.6.A ME and MS Students

A student in the ME or M.S. degree program must register every fall and spring semester from initial matriculation until all degree requirements are met. If not graduating in the summer term, M.S. candidates do not have to register for graduate units during summer sessions unless they plan to make use of University facilities or faculty time, where they must enroll for a minimum of one (1) unit of graduate credit in the term(s) in which they are using facilities or faculty time.

MS Students who have completed all the degree course requirements and still must register to meet the requirements of M.S Report (3 units) or Thesis (6 units) credit hours. Report CE 909 is for the non-thesis option, CE 910 for thesis, and CE 920 for dissertation. Such registration may be used to reach the one (1) unit minimum for the final academic semester for MS or ME students or the summer/winter session.

5.6.B PhD Students

A student admitted to a Ph.D. program must register every fall and spring semester from initial matriculation until the completion of all course requirements, written and oral comprehensive exams, and eighteen (18) dissertation units. When these requirements are met, doctoral students not on financial assistance and/or needing to maintain appropriate visa status, may register for a minimum of one (1) unit every fall and spring semester until all course and dissertation requirements are met.

Student completing requirements for PhD degree must be a continuous student during the semester in which the final exam is completed. However, students can have the final exam in the following summer or winter session without enrollment if no library privilege, faculty time, or university facility is needed, otherwise, the student needs to enroll in GRAD 922. This includes any semester during which a preliminary or final examination is scheduled.

5.6.C Funding requirements

Note that students receiving funding such as assistantships, fellowships, loans, grants, scholarships, or traineeships may be required by their funding source to register for more than one (1) unit to meet full-time status requirements (see Table 5.1) and should check with their program advisor regarding such requirements to ensure that they remain qualified for funding. Summer or winter session registration is not required for doctoral and master students who will be taking comprehensive exams, the final oral exam (i.e., defense) and/or will be graduating during that session. However, if they plan to make other use of University facilities or faculty time during summer/winter sessions, doctoral students must enroll for a minimum of one (1) unit of graduate credit in these terms. If degree requirements are completed during the winter or summer session, the student must have been registered for a minimum of one (1) unit during the preceding semester.

5.7 Leave of Absence Policy

The status, Graduate Student **Leave of Absence**, may be approved for up to two consecutive semesters for graduate degree program students for extraordinary situations. Graduate students that do not return at the end of the approved leave of absence or students that miss a semester without being granted official leave of absence are required to apply for readmission and are subject to all rules and regulations in force. The right to use University facilities is suspended while the leave of absence is in effect. The petition of **Leave of Absence** forms and policy may be obtained at the Graduate College website (<https://grad.arizona.edu/policies/enrollment-policies/leave-absence>). The form must be submitted no later than the last day for adding classes via **UAccess** for the semester the leave of absence is to start. No retroactive **Leave of Absences** will be accepted.

5.8 Satisfactory Academic Progress

A high level of performance is expected of all students in the CAEM graduate degree programs. Students must maintain a minimum of a 3.0/4.0 cumulative GPA throughout the program and must consult with both their faculty advisor and the graduate program coordinator to discuss issues pertaining to unsatisfactory progress, such as a GPA below 3.0/4.0 at the end of a given semester. Students failing to meet GPA requirements will be placed on probation by the Graduate College for one semester. If the cumulative GPA is not raised to the required minimum in the following semester, the student's faculty advisor and the relevant graduate studies committee will decide whether to: (1) academically disqualify the student from the program; or (2) with Graduate College approval, allow the student to continue probation upon approval of a remediation plan. The student is expected to work with the student's faculty advisor and the graduate program coordinator to improve their academic standing.

5.9 Incomplete Policy

Students earning a grade of Incomplete, “I,” for a course must submit a completed Report of Incomplete Grade form to the CAEM graduate program coordinator for inclusion in their academic record. Incomplete grades should be completed in a timely manner and are submitted at the discretion of the course instructor. According to the Graduate College (<https://catalog.arizona.edu/policy/grades-and-grading-system#incomplete>), any incomplete grade must be completed no later than one year from the last day of the term of the course for which the student received the incomplete unless a one-year extension has been approved by the student’s instructor and the Graduate College dean prior to the one-year deadline. A student must not re-enroll in a course the following year to fulfill an Incomplete grade – doing so will result in a failing grade for the Incomplete.

5.10 Adding MS/ME to a PhD

A student may also determine, upon the advice of the student’s faculty advisor, to add an MS degree to the student’s PhD program. To add the MS to the PhD program, the student must complete a Change of Program Form to be signed by the student and the program’s Graduate Studies Chair. The completed form must be submitted via email to the CAEM degree counselor at the Graduate College. The graduate coordinator can provide a copy of the form to the student. The student does not need to apply for the MS or pay an application fee. <https://grad.arizona.edu/policies/enrollment-policies/program-changes>

5.11 Help with Academic and Other Issues

In most circumstances, graduate students should first pose questions on academic matters to their faculty advisor. Other members of their thesis or dissertation committee should also provide guidance and mentoring. The Graduate Studies Committees can help with advice, especially on curriculum questions and deadlines. Students may also contact the department chair at any time concerning issues related to their graduate studies. For non-academic questions and issues (e.g. navigating GradPath or required benchmarks), the best resource is the graduate program coordinator, or the Graduate College Degree Counselor for CAEM. See also the Academic Grievance Procedures of this handbook for additional information.

5.12 Graduate Student Academic Grievance Procedures

A student with any type of grievance should first communicate with their graduate faculty/research advisor or chair of the Graduate Studies Committee, based on which is more appropriate in the student’s view depending on the matter at hand. In some instances, the student may decide that the issue cannot be addressed adequately by either of these faculty. Then the student may bring the matter to the attention of the graduate program coordinator and/or the department chair. This process aims to resolve grievances informally within the department. When issues cannot be resolved informally, the graduate student is encouraged to read the Grievance Policy of the University of Arizona on the Graduate College website. The Summary of Grievance Types and Responsible Parties website lists grievance types and links to offices where the student can report grievances and have them addressed more formally. Here the student will find information on where and how to report grievances related to academic policy/procedures, grades, research ethics and inappropriate behavior by students, faculty or staff. If a student would like support from outside

of the department for bias they have experienced or witnessed, they can share their experience with the University of Arizona's Bias Education & Support Team (BEST). BEST is not an investigative or punitive campus unit, but rather provides education, support, and/or resources to any students, faculty, or staff who have been impacted by bias on campus. Sharing someone's experiences and ideas helps us all do better in creating a more equitable and inclusive environment in the department and at the university. Additionally, if a student believes that they have been the subject of discrimination or harassment based on race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity or genetic information, they can report this at the Office of Institutional Equity, University Services Building, Room 113, (520) 621-9449.

5.13 Course Offerings

To assist students in developing their study plans, CAEM has developed and will continue to update a *5-year* plan for graduate course offerings (i.e., those numbered 500 and above). The most recent plan is available at <https://www.caem.engineering.arizona.edu/grad-programs/advising>.

5.14 Courses

Some courses have only a 400-level number (4xx). These courses are NOT available for graduate credit. Some 400 level numbered courses may be taken as deficiency courses when appropriate but will not receive graduate credit or be included in the graduate GPA.

Co-convened courses, which are numbered 4xx/5xx, will normally meet at the same time in the same room, and there will be substantial additional requirements for graduate students as identified in the catalog and the course syllabus. CAEM graduate students must enroll in the 5xx version of all co-convened courses whether they are in the major or not.

Cross-listed (e.g., CE676/CHEE676) courses will have identical course titles for both numbers. The catalog description for each course will also include a reference to the cross-listed course. The student should check the titles for verification.

5.15 Seminar

The CAEM Department requires that all full-time M.S. and full-time Ph.D. if funded through CAEM students take the CE596A Seminar each semester, each seminar announcement will be posted. Part-time M.S. and Ph.D. students require to take this course at least once. The purpose of these seminars is for the faculty and students to gain knowledge in the different research areas of civil engineering. One (1) unit of credit will be applied to the graduate program for all semesters enrolled in Seminar for an M.S. or M.E. student. Ph.D. students will be granted one (1) unit of credit if the student has taken Seminar one to four times and one additional unit if the student takes the course five or more times.

5.16 Manual for Theses and Dissertations

A manual describing proper format for thesis and dissertations is available online (<https://grad.arizona.edu/gsas/dissertations-theses/dissertation-and-thesis-formatting-guides>). Each student should read this manual before attempting to prepare a thesis or dissertation and discuss the proper format with the student's Academic Advisor.

5.17 Use of Copyrighted Material in Theses and Dissertations

The use of copyrighted materials in a thesis, dissertation or document requires formal permission. Any exceptions, sometimes pertaining to small fractions of a musical score or other documents, are governed by the concept of "fair use". Here, the following factors must be weighed: purpose and character of the use, including whether such use is of a commercial nature or is for non-profit educational purposes; the nature of the copyrighted work as a whole; and the effect of the use upon the potential market for or value of the copyrighted work. According to the Association of American University Presses, permission is required for quotations of sections of books, maps, charts, graphs, tables, drawings, or other illustrative materials. **If there is any doubt, the student should obtain permission from the publisher.**

Permission to use copyrighted material should be in writing and retained by the author with a copy being submitted to the CAEM Department for retention in the student's records. The release letters should indicate that permission extends to Internet use, microfilming and publication by **University Microfilms International** (UMI) and the copyright owners are aware that UMI may sell on demand, single copies of the thesis, dissertation or document, and other materials, for scholarly purposes.

The process of obtaining permission to use copyrighted material may be both time-consuming and expensive and should be initiated as early as possible during the conduct of the thesis, dissertation, or document. It is good practice to obtain permission to use non-copyrighted material, which may or may not be acknowledged in the text (note phraseology in Statement by Author required for any thesis, dissertation, or document).

Additional information about copyrighted material may be obtained from the Copyright Public Information Office (<http://www.copyright.gov/>) in Washington, DC.

6 ACADEMIC APPEAL POLICY

It is recognized that the varied backgrounds, objectives, and needs of students may occasionally require interpretation of these guidelines. Under these circumstances, the Student's Advisory Committee may recommend limited adjustments in the requirements. The Student's Advisory Committee must recommend any changes in writing to the Graduate Studies Committee that makes the final judgment. There must be no more than one dissenting vote.

If there is disagreement with any interpretation made by the Academic Advisor, the appeal process is as follows: the Student's Advisory Committee may review an advisor's decision and adjudicate the disagreement with a maximum of one dissenting vote. If this committee's decision is found unacceptable, the matter is then referred to the CAEM Graduate Studies Committee for a final decision. All appeals and approvals must be given in writing.

7 SUPPLEMENTAL INFORMATION

Additional information regarding Graduate College and University regulations, Student Services, phone directories, and the Code of Academic Integrity are included in the Supplementary Material to this document and available online. (<https://grad.arizona.edu/policies>)

8 CERTIFICATE NON-DEGREE PROGRAMS

8.1 Geotechnical Engineering

Course requirements - 12 units

Courses:

- CE 540 Foundation Engineering (3)
- CE 541 Earth Structures in Geotechnical Engineering (3)
- CE 542 Ground Improvement (3)
- CE 544 Special Topics in Geomechanics (3)
- CE 545 Geoenvironmental Engineering (3)
- CE 546 Geotechnical Earthquake Engineering (3)
- CE 548 Numerical Methods in Geotechnical Engineering (3)

8.2 Hydraulics and Water Resources Engineering (Certificate NDP)

8.2.1 Program Description

- Students will have a working knowledge of detailed hydraulic and hydrologic design and planning and operation of water resources systems and be prepared to apply these concepts in practice.
- Provide a curriculum of study for Graduate students that explores hydraulics and water resources engineering topics.
- Introduce basic features of hydraulic and water resources engineering principles that are relevant to professional practice in the field.
- Provide the opportunity for research in particular areas of interest related to hydraulics and water resources engineering.

Educational Aims

- Introduce the principles of fluid mechanics, hydraulic engineering and water resources systems to professional practice.
- Familiarize students with experimental and research techniques that are applicable to hydraulics and water resources engineering.

8.2.2 Program Requirements

Incoming and graduation GPA are 3.0 in the last 60 undergraduate units and in the 12 units in the certificate.

Twelve units of graduate coursework is to be completed from:

Core Courses (minimum of 9 units)

- CE 522 - Open Channel Flow
- CE 523 - Hydrology
- CE 525 - Sediment Transport Analysis
- CE 526 - Soil and Water Conservation Engineering
- CE 527 - Computer Applications in Hydraulics
- CE 529 - Special Topics in Hydraulics & Water Resources Engineering
- CE 555 - Soil and Water Resources Engineering
- CE 556 - Irrigation Systems Design
- CE 558 - Soils, Wetlands and Wastewater Reuse
- CE 655 - Stochastic Hydrology
- RNR 573 -Spatial Analysis and Modeling

Elective Coursework (maximum of three units)

- CE 522 Open-Channel Flow
- CE 523 Hydrology
- CE 527 Computer Applications in Hydraulics
- CE 529 Special Topics in Hydraulics and Water Resources Engineering
- CE 549 (HWR) - Statistical Hydrology
- CE 655 (HWR) Stochastic Methods in Surface Hydrology

8.3 Advanced Transportation Engineering Certificate (NDP)

8.3.1 Program Description

The Advanced Transportation Engineering (ATE) certificate will provide our students with the opportunity to develop an enhanced understanding of the transportation engineering field. The goal is to prepare them to practice in this more specialized field.

This program prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of total systems for the physical movement of people, materials and information, including general network design and planning, facilities planning, site evaluation, transportation management systems, needs projections and analysis, and analysis of costs.

8.3.2 Program Requirements

The certificate requires that students take four-3 unit courses (12 units) from an approved list of courses in the area of Transportation engineering in the CEEM department. Students must earn a GPA of 3.0 in these courses.

Courses:

- CE 560 Special Topics in Transportation Engineering (3)
- CE 562 Traffic Engineering and Operations
- CE 563 Traffic Flow and Capacity Analysis (3)
- CE 565 Transportation Data Management and Analysis (3)
- CE 566 Highway Geometric Design (3)
- CE 567 Traffic Safety
- CE 569 Travel Demand Modeling (3)
- CE 568 (PLNN) Urban Transportation Planning (3)
- CE 564A Integrated Highway Bridge Design w/LRFD Method (3)

9 MASTER OF SCIENCE (M.S.) DEGREE IN CIVIL ENGINEERING AND ENGINEERING MECHANICS

This section summarizes the requirements and steps for completing a master's degree. The requirements for Master's Degrees on the Graduate College website (<https://grad.arizona.edu/gsas/degree-requirements/masters-degrees>) provides additional details. Appendix 4A supplies the deadlines of completion for various steps in the Master's program.

9.1 Credit Requirements

An M.S. degree requires a minimum of thirty (30) units. Each student must take the Graduate Seminar course at least one semester. Regardless of the number of semesters enrolled in the Graduate Seminar course, a student will only receive one (1) unit of credit for the course toward their degree requirement. There are two M.S. program options, and the requirements for each option are listed below:

Plan A (thesis option)

Coursework: Twenty-four (24) units of 500 or 600 level courses and six (6) thesis units (CE/EM 910). The final examination is an oral defense of the thesis.

Plan B (technical report option)

Coursework: Twenty-seven (27) units of 500 or 600 level courses and three (3) units for a written engineering report (CE 910/EM 909). The final examination is an oral defense of the report.

All coursework must be in courses graded A, B or C except for one independent study course. To complete the degree requirements, the cumulative GPA in graduate level courses must be equal to or greater than 3.0. A student whose GPA falls below 3.0 for the courses needed for the degree will not be permitted to register for additional courses (see Graduate College Policies online at <https://grad.arizona.edu/catalog/>). Course credits up to 12 units from Accelerated Master's Program or from other departments can be used for MS degree requirements with faculty approval.

A master's thesis is a piece of original scholarship written that attempts to answer a research question. A master's thesis is similar to a doctoral dissertation, but it is generally shorter and more narrowly focused. The thesis requires a thorough literature review, identification of the research question, data collection, analysis, and discussion on the resolution of the question. An engineering report, on the other hand, focuses on a design or analysis for a specific field condition or development of an engineering methodology for addressing a specific problem.

9.2 Time Limitation

All requirements for the master's degree must be completed within six (6) years. The time-to-degree begins with the earliest course to be applied toward the degree, including credits transferred from other institutions. Coursework more than six (6) years old will not be accepted toward meeting the degree requirements.

9.3 Transfer Credit

Up to six (6) units for a master's degree may be transferred from other accredited institutions. To transfer, the coursework must have been taken for graduate credit, and an A or B grade must have been earned. These grades will not be included in the student's GPA.

9.4 Master's Plan of Study Form

Each student, in consultation with the student's Academic Advisor and Master's Advisory Committee (Section 10.7), will select a program of study for the degree by the second semester in residence. The CAEM Graduate Studies Committee must approve the program of study prior to submission to the Graduate College.

Students may obtain a **Plan of Study Form** at UAccess GradPath in the Student Center online. To assist in planning a program of study, the department maintains a continuously updated schedule of graduate courses to be offered over a **5-year** span. Graduate courses offered are posted at the department web page at <http://caem.engineering.arizona.edu/>. The Five Year Academic Schedule is available under the **Graduate Programs/advising** menu. This list is frequently updated with new courses and adjustments to the existing courses. The schedule is also available in the CAEM Department Office. Students choosing the M.S. thesis option must complete six (6) units of CE 910/EM 910 (Thesis), while the technical report option must complete three (3) units of CE 909/EM 909 (Report).

9.5 Academic Advisor

The Department Head will designate a faculty member to serve as an interim Academic Advisor before a permanent Academic Advisor is selected. The permanent Academic Advisor must be chosen by the end of the first semester of study. After the Academic Advisor has been selected, the Advisor Selection Form (Appendix 3) must be filled out. The Academic Advisor will act as the student's mentor who will be responsible for helping the student in selecting Masters Advisory Committee members, as well as developing and completing a Plan of Study. The primary role of the Academic Advisor is to guide the student in coursework and to keep the student informed on whether the student is making satisfactory progress.

9.6 M.S. Advisory Committee Members

The Master's Advisory Committee consists of the Academic Advisor, who must be a tenure-track CAEM faculty member, and at least two additional members. At least one of the two additional members must be a tenure-track faculty member and holds a faculty appointment in CAEM. One of the two additional members can be from another academic unit within the University or someone from outside the University. The latter is called a Special Member. "If the third member is not a current tenure-track UA faculty member, he or she must be approved by the Graduate College as a special member."

(<https://grad.arizona.edu/policies/academic-policies/graduate-student-committee-service>) A Special Member form must be completed and submitted to the Graduate College. The student's Academic Advisor must approve the Master's Advisory Committee members.

The Master's Advisory Committee must approve the program of study, the master's thesis/report and participate in the final oral examination for the master's degree.

9.7 Final Oral Examination

Scheduling of the final oral examination and the satisfaction of all requirements relating to this examination are the sole responsibility of the student. The final oral examination must be scheduled through UAccess GradPath after the thesis/report has been reviewed by the examining committee (i.e., the Master's Advisory Committee), provided that the student has completed the student's coursework or is in the student's final semester. The examination is scheduled in consultation with the examining committee members. Each of the examiners for the final oral examination must receive a copy of the thesis/report approved by the student's Academic Advisor (not necessarily library-ready copies) at least two weeks prior to the oral examination.

The examination is composed of two parts. The first part is open to the public, the advisory committee members as well as other faculty, students, colleagues, can attend the first part. In the first part, the student gives an oral presentation of the thesis/report. The presentation may be interrupted to permit questions to clarify points and questions concerning fundamental principles that are directly related to the thesis/report. The second part of the examination is by the committee members only after the non-committee members have left the exam room. This part consists of questioning the student on graduate courses, particularly as they relate to the thesis/report.

The results of the examination are reported at UAccess GradPath after the examination. Results must be reported to the Graduate College at least three weeks before the date on which the degree is to be conferred; specific deadlines are posted on the Graduate College website:
<https://grad.arizona.edu/gsas/degree-requirements/important-degree-dates-and-deadlines>.

Following a successful defense, the candidate must submit a copy of the thesis/report to the Graduate College through the Dissertation/Thesis Submission website: <http://dissertations.umi.com/arizona/>. The thesis/report must be submitted as a hardbound copy and a readable CD or a thumb drive to the CAEM department's office. The candidate's Academic Advisor and Master's Advisory Committee may require copies of the thesis/report as well, either in electronic format, or hardbound copy. The candidate needs to check with the student's Academic Advisor for any special requirements.

In the event of a failure, the candidate must choose to have a second exam or exit the program within one week. If the student decides to continue, the examining committee will determine what the student must do before a second examination may be scheduled. Upon recommendation of the Examining Committee, and approved by the Department Head, a second examination will be granted after a lapse of at least four months. The examining committee must be the same as for the first examination. The results of the second examination are final.

9.8 Thesis Work In Absentia

Students are discouraged from doing their thesis or report work in absentia. They should consult with their advisor before doing so.

10 MASTER OF ENGINEERING DEGREE IN CIVIL ENGINEERING AND ENGINEERING MECHANICS

The Master of Engineering Program requires the completion of at least thirty (30) graduate credits, which include at least three (3) credit hours of courses in each of the following engineering subject areas, and eighteen (18) credit hours of major requirements and elective courses.

Category 1. Engineering management/business

Category 2. Applied engineering mathematics

Category 3. Entrepreneurship/Innovation/Design

Category 4. Advanced Engineering Science

The engineering subject areas are intended to be broadly interpreted. The remaining eighteen (18) credit hours of courses should be in student's major area. A typical program study plan is outlined in Table 10.1.

Table 10.1 Program of study framework

Course Requirements	Credit Hours
Engineering Management/Business (Category 1)	3
Applied Engineering Mathematics (Category 2)	3
Entrepreneurship/Innovation/Design (Category 3)	3
Advanced Engineering Science (Category 4)	3
Major Requirements and Electives	18
Total	30

10.1 CAEM Program Specific Requirements

Major requirements and electives (18 units, 1 unit of Graduate seminar)

The courses in major area should be proposed by the student and approved by the advisor. The majority of these units are expected to be Civil Engineering and Engineering Mechanics courses that include:

A maximum of three (3) units of independent study may be applied

- These courses must 500 or above with course approval from the advisor (see Section 11.3)
- one (1) unit of CAEM Graduate Seminar
- Practice-oriented project (0 units)

No project is required for this degree and a three (3) unit independent study can be used to provide this experience.

A student must focus on one emphasis area choosing from geotechnical, hydraulics, structures, transportation, or engineering mechanics, but may take elective courses from more than one emphasis. A general timetable for completion is in Appendix 4B.

10.2 Engineering Subject Area Courses

Below is a list of courses in each category. Deviations from this list may be permitted if they are reviewed and approved by the advisor. Any deviation should still be generally consistent with the general category definitions.

<p>Category 1 – Engineering management/business (3 units) – Valid for all emphases</p> <ul style="list-style-type: none"> • SIE/ENGR 514 Law for engineers/scientists • SIE/ENTR 557 Project Management • Other courses may be approved by the Advisor 	<p>Category 3 – Entrepreneurship/Innovation/Design (3 units)</p> <ul style="list-style-type: none"> • CE 540 Foundation Engineering • CE 527 Computer Applications in Hydraulics • CE 537 Advanced Structural Design in Concrete • CE 560 Special Topics in Transportation Engineering • Other courses may be approved by Department Advisor
<p>Category 2 – Applied engineering mathematics (3 units)</p> <ul style="list-style-type: none"> • CE/EM 502 Introductory Finite Element Method • Other courses may be approved by Department Advisor 	<p>Category 4 – Advanced Engineering Science (3 units)</p> <ul style="list-style-type: none"> • CE 510 Probability in Civil Engineering • Other courses may be approved by Department Advisor

Category 1 – Engineering management/business (3 units) – Valid for all emphases

- SIE/ENGR 514 Law for engineers/scientists
- SIE/ENTR 557 Project Management

Category 4 – Advanced Engineering Science (3 units)

- CE 510 Probability in Civil Engineering
- Other courses may be approved by Department Advisor

10.2.1 Major Requirements and Elective Courses

Major requirements and elective courses are approved by the student's academic advisor, and checked and confirmed by the Director of Graduate Studies Committee. Representative courses are listed below by specialization.

<p><u>Engineering Mechanics and Materials</u> CE/MSE 431/531 Sustainable Materials Design Lab CE/EM 502 Introductory Finite Element Method CE 510 Probability in Civil Engineering CE/EM 606 Wave Propagation in Solids & Ultrasonic NDE EM 504 Theory of Elasticity EM 508 Fracture Mechanics EM 633 Structural Dynamics and Earthquake Engineering EM 634 Advance Structural Dynamics</p>	<p><u>Hydraulics</u> CE 510 Probability in Civil Engineering CE 522 Open Channel Hydraulics CE 523 Hydrology CE 524 Sedimentation Engineering CE 526 Watershed Engineering CE 527 Computer Applications in Hydraulics CE 529 Numerical Methods in Hydraulics CE 549 Statistical Hydrology CE 655 Stochastic Hydrology</p>
<p><u>Geotechnical</u> CE 510 Probability in Civil Engineering CE 540 Foundation Engineering CE 541 Earth Structures in Geotechnical Engineering CE 542 Ground Improvement CE 544 Special Topics in Geomechanics (Mine Tailings) CE 544 Special Topics in Geomechanics (Critical State Soil Mechanics) CE 545 Geoenvironmental Engineering CE 546 Geotechnical Earthquake Engineering CE 548 Numerical methods in Geotechnical engineering</p>	<p><u>Structural</u> CE 510 Probability in Civil Engineering CE 532 Advanced Structural Design in Steel CE 534 Design of Wood and Masonry Structures CE 535 Prestressed Concrete Structures CE 537 Advanced Structural Design in Concrete CE 638 Structural Stability</p>
<p><u>Transportation</u> CE 510 Probability in Civil Engineering CE 560 Special Topics in Transportation Engineering CE 562 Traffic Engineering and Operations CE 563 Traffic Flow and Capacity Analysis CE 565 Transportation Data Management and Analysis</p>	

CE 566 Highway Geometric Design CE 567 Traffic Safety CE 568 Urban Transportation Planning CE 569 Travel Demand Modeling CE 663 Advanced Traffic Modeling and Engineering SIE 561 Traffic modeling and simulation	
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11 DOCTORAL PROGRAM IN CIVIL ENGINEERING AND ENGINEERING MECHANICS

Attainment of a Doctor of Philosophy (Ph.D.) degree at University of Arizona requires outstanding scholarship and demonstration of distinguished research leading to a dissertation that contributes significantly to the general pool of knowledge in the discipline. This section describes the requirements for completion of the Ph.D. degree within the CAEM Department. A general timetable for completion is in Appendix 5.

11.1 Academic Advisor

The primary role of the Academic Advisor, also known as major professor or committee chair, is to guide the student in coursework and to keep the student informed on whether the student is making satisfactory progress. The Academic Advisor will act as the student's mentor and will be responsible for helping the student select Doctoral Advisory Committee members, as well as developing and completing a Plan of Study.

Upon arrival on campus, if a student has not selected an academic advisor, the Head of the Department will designate a faculty member to serve as an interim Academic Advisor. A permanent Academic Advisor must be chosen by the end of the first semester of study. Once the permanent Academic Advisor has been selected, the Advisor Selection Form (Appendix 3) must be filled out.

11.2 Doctoral Advisory Committee

The Doctoral Advisory Committee consists of at least three faculty members who represent the major subject area and one or more faculty members who represent the minor subject area. The Doctoral Advisory Committee approves the Doctoral Degree Study Program and constitutes the examining committee for the Comprehensive and Final Oral Examinations. Since the Doctoral Advisory Committee plays such a central role in the doctoral program, it should be formed within five semesters of enrollment in the PhD program. Any tenured or tenure track person may serve on the Doctoral Advisory Committee upon approval by the student's Academic Advisor and the Heads of the major and minor departments. The Graduate Coordinator will complete and submit a Special Member form to the Graduate College for Doctoral Advisory Committee members who are non-tenured or are outside of University of Arizona.

Students are expected to complete the committee appointment form at UAccess GradPath. All committee members are expected to be present and participate in the Comprehensive and Final Oral Examinations. Minor subject area members cannot waive attendance at these examinations.

11.3 Credit Requirements

For a Ph.D. in Civil Engineering or Engineering Mechanics, the minimum total units required including the dissertation is sixty-three (63). A minimum of forty five (45) units of graduate coursework exclusive of the dissertation must be completed. This includes:

1. A minimum of thirty-six (36) units in the major subject that can include a maximum of six (6) units as Independent Study. The student's Academic Advisor must approve independent study courses.
2. A Minimum of nine (9) units in the minor subject. Most minors, however, will require 12 units.
3. Eighteen (18) units of dissertation must be completed. Students cannot take more than 18 unit to count towards their 60 unit total. If a student needs to take more than 18 hours of dissertation they may do so if the 60 unit total has been met by other courses.
4. At least one (1) unit Graduate Seminar course. Students must take the seminar course each semester that they are supported by the department. Students will receive one unit of independent study units towards their unit requirement for the graduate seminar course regardless of how many times that they have taken the class.

Master's thesis credit is not counted in the Ph.D. program. All required units of credit must be at the 500-level or above at University of Arizona or, in the case of transfer units, their equivalent at other institutions.

Up to thirty (30) units of graduate credits earned at other approved institutions, if accepted by the major department and the Graduate College, may be counted toward the requirements of this degree. Students who wish to use transfer credit must submit a request before the end of their first year of study to the Graduate College through Gradpath. At least one-half of the graduate credit must be in courses in which regular grades (A, B, C) have been earned. As for University of Arizona courses, repeated courses, even those taken at other institutions, are not allowed for credit in the graduate program. Verification of courses is the responsibility of the Doctoral Advisory Committee and must be approved by the CAEM Graduate Studies Committee

11.4 Minor Subjects

The minor subject area may be taken within or outside of the Department of Civil and Architectural Engineering and Mechanics. The student may choose one or two minor areas, which are determined in consultation with the student's Academic Advisor. The department in which the minor is sought determines specific requirements. A minor in Civil Engineering or Engineering Mechanics requires twelve (12) units. Students are required to take a written minor exam with the student's minor advisor.

11.4.1 Majoring & minoring in CEEM

Students who are interested in both majoring and minoring in CEEM must choose their major and minor courses from two different focus areas; CE and EM. Thus all major and minor courses cannot be chosen from the same focus area like all from CE (geotechnical, hydraulics, structural or transportation) or all from EM (engineering mechanics). Courses that are common to EM and CE may only be counted toward major or minor (i.e., no double counting is permitted). Courses by area are listed in Section 11.3. Alternative courses from other departments can be included with approval of the student's academic advisor.

11.5 Time Limitation

Students must complete their degree within five years of passing the Comprehensive Examination. A student not finishing within that time period may be allowed to re-take the Comprehensive Examination with permission of the Doctoral Advisory Committee.

11.6 Foreign Language Requirements

No Foreign Language requirement exists for the doctoral degree in the Department of Civil and Architectural Engineering and Mechanics.

11.7 Qualifying Examination

11.7.1 Exam Timing

Each prospective candidate for a doctoral degree must pass a qualifying examination in the proposed major field that is organized and administered by the Graduate Studies Committee. The qualifying examination is typically scheduled to take place on the second Tuesday of each Spring Semester. Summer and Fall entrants must take the exam in the spring semester during the first year of residency. A spring semester entrant may take the qualifying exam upon enrolling or at the beginning of their second year of study. Students should contact their faculty advisor about the exam and scheduling.

11.7.2 PhD Qualifying Exam Structure

Implicit in acceptance to the graduate program is the assumption that the student is knowledgeable in the undergraduate areas that pertain to the graduate work. The Qualifying Examination focuses on graduate studies taken for the Master's degree, yet also includes questions from undergraduate studies. The student is fully responsible for knowledge from the undergraduate areas that are pertinent to answering questions on the Qualifying Examination.

To test the breadth of knowledge, the qualifying exam consists of two sections: (a) CAEM topics areas (2 hours); (c) Specialization exam (3 hours). The exam timetable is as follows.

9:30-11:30 am: CEEM Topic Areas: This portion of the exam will be an open book; students are expected to pass at least 3 questions, but they can answer more than 3 questions.

11:30-1:30 pm: Break.

1:30pm-4:30 pm: Specialization Exam: This portion of the exam will be in the Graduate Student's Area of specialization. It is envisioned that this will be one to two open-ended or creative solution questions.

11.7.3 Content Descriptions

MORNING SESSION: General Exam in CAEM area

Objective: Demonstrate a general knowledge of the broader field of civil engineering

For the CAEM Topic Area, a list of topic areas to be included in the exam is given below.

CAEM Topic Areas: Geotechnical, Hydraulics/Hydrology, Mechanics, Numerical Methods, Transportation, Structures, Construction Materials, Construction Management, Building Science

AFTERNOON SESSION: Specialized Exam in Graduate Student's Area

Objective: Evaluate research potential and demonstrate a depth of knowledge in the field of interest and relevant areas

11.7.4 CAEM Topic Areas

Construction Materials:	Reference book: Metha, P. K., & Monteiro, P. J. (2014) Concrete: microstructure, properties, and materials. McGraw-Hill Education. <i>Chapters 1,2,5,6,7,8,9, and 10</i>
Geotechnical:	Reference book: Soil Mechanics and Foundations, by M. Budhu, John Wiley and Sons, 2010, 3rd Edition. <i>Chapter 2:</i> 2.0 – 2.5 <i>Chapter 4:</i> 4.0 – 4.5, 4.6.1, 4.6.2, and related examples at the end of chapter. <i>Chapter 5:</i> 5.0 – 5.6, and related examples at the end of chapter. <i>Chapter 6:</i> 6.0 – 6.9, and related examples at the end of chapter. <i>Chapter 7:</i> 7.0, 7.9, 7.10, 7.11.6, 7.11.7 <i>Chapter 9:</i> 9.0 – 9.4, 9.5.1, 9.5.2, 9.6 – 9.8, and related examples at the end of chapter. <i>Chapter 10:</i> 10.0 –10.7, and related examples at the end of chapter. <i>Chapter 15:</i> 15.0 –15.5
Hydraulics/Hydrology:	Reference book: Water Resources Engineering, by Larry W. Mays, John Wiley and Sons, Third Edition. Chapters 4, 5, 8.1-8.8, 11, 12, and 13

<p>Mechanics:</p>	<p>Most textbooks on statics and strength of materials cover the following topics: Statics: equilibrium in 2 and 3 dimensions, trusses – method of joints and method of sections, frames, beams – shear force and bending moment diagrams, fluid statics, friction, centroids Strength of Materials: uniaxial stress, uniaxial strain, bar behavior, shear, shaft behavior, beams, shear flow, stress transformation, generalized Hooke's law and plane strain, spherical/cylindrical pressure, combined stress, beam deflections and statically indeterminate beam, columns. Numerical Methods: Reference book: Numerical Methods for Engineers and Scientists: An Introduction with Applications using MATLAB, Authors - Amos Gilat and Vish Subramaniam, Pub. John Wiley, 3rd Edition 1. Roots of Nonlinear Equations (Chapter 3) Bisection Method (Section 3.3) Regula Falsi (Section 3.4) Newton-Raphson Method or Newton's Method (Section 3.5) Secant Methods (Section 3.6) 2. Solving System of Linear Equations (Chapter 4) Gauss Elimination method (Section 4.2) Gauss Elimination with Row Pivoting (Section 4.2) 3. Curve Fitting and Interpolation (Chapter 5) Polynomial Interpolation – Lagrange Polynomial (Section 5.5) Least Squares Polynomial Fit (Sections 5.2 and 5.4) 4. Numerical Differentiation (Chapter 6) Finite Difference Methods – Forward, Backward and Central Difference formulae (Sections 6.2 and 6.3) 5. Numerical Integration (Chapter 7) Trapezoidal, Simpson and Gauss Quadrature schemes (Sections 7.3, 7.4 and 7.5). 6. Solution of Ordinary Differential Equations: Initial Value Problems (Chapter 8) Euler's explicit method (Section 8.2.1) Modified Euler's method and Midpoint method (Sections 8.3 and 8.4) Runge-Kutta methods (Section 8.5.1)</p>
<p>Structures:</p>	<p>Fundamentals of Structural Analysis (Reference book: Structural Analysis, R.C. Hibbeler, 8th Ed., Prentice Hall): Topics:</p> <ul style="list-style-type: none"> • Beam and Frame Moment, Shear and Axial Force Diagrams • Truss Forces: Method of Joints, Methods of Sections • Cables and Arches • Truss Deflections, Beam Deflections and Rotations • Indeterminate Structures: Method of Consistent Deformations

	<p>Basic Structural Design (e.g. Structural Steel Design, 5th Ed: McCormac and Csernak; Design of Reinforced Concrete, 8th Ed: McCormac and Brown)</p> <p>Topics:</p> <ul style="list-style-type: none"> • Steel tension members • Compression Members: Euler buckling • Flexural Members: Reinforced Concrete and Steel Beam Design
Transportation:	<p>Reference books:</p> <p>1. Principles of Highway Engineering and Traffic Analysis, 7th edition, F. Mannering and S. Washburn, Wiley 2019. ISBN # 978-1-119-49396-9</p> <p>More specific topics:</p> <ul style="list-style-type: none"> • Traffic stream flow model • Highway capacity and level of service analysis • Intersection traffic control • Transportation planning and travel demand forecasting
Construction Management:	<p>Reference books:</p> <p>1. Construction Management 4th or 5th Edition. D.W. Halpin and B. A. Senior. Wiley. 2010</p> <p>More specific topics</p> <ul style="list-style-type: none"> • Construction contracts • Project planning/scheduling/cash flow/funding • Equipment ownership/productivity • Estimating process • Safety <p>2. Construction Project Scheduling and Control</p>
Building Science:	<p>Reference Book: Reddy, T. A., Kreider, J. F., Curtiss, P. S., & Rabl, A. (2016). Heating and cooling of buildings: principles and practice of energy efficient design. CRC press.</p> <p>Sub Topics</p> <ul style="list-style-type: none"> • Building physics (Section 2 and 17) • Thermal Comfort (Section 3) • Building system control (Section 11 and 21) • Building energy modeling (Section 10) <p>Reference Book: K.C. Parsons (1993). Human Thermal Environments. CRC press</p> <p>Sub Topics</p> <ul style="list-style-type: none"> • Thermal Comfort (Chapter 1, 2, 7)

11.7.5 Exam Outcomes

Within six weeks of the examination, the Department Head/Director of Graduate Studies will notify the student of the examination results and provide a copy to the Academic Advisor. In the event of a failure, a second qualifying examination may be granted. Third qualifying examinations are not permitted. Only the portions of the exam that students did not pass are re-taken.

If a student fails two qualifying exams, the graduate committee will consult the student's advisor to determine if the student should be allowed to continue in PhD program. If the student is permitted to continue, the GSC and faculty advisor will identify the deficiency courses that the student needs to take. In general, the number of courses is the number of areas the student failed in the exam. For instance, if a student failed two areas in the fundamental test, the student must take a course in each of these areas. After the student's advisor agrees with the GSC recommendation, GSC notifies the student of the deficiency courses. The student needs to complete these courses within one year after receiving the notification.

If the student obtains a B or above grade on all the deficiency courses, the student will be granted a pass in the PhD qualifying exam. If the student did not obtain a B grade on any deficiency course, the student will be disqualified from the PhD program.

11.8 Plan of Study

In conjunction with the Academic Advisor, with input from the results of the qualifying exam, each student is responsible for developing a Plan of Study during their first year in residence. The Plan is to be filed with the Graduate College through the GradPath system no later than the student's third semester in residence. The Plan of Study identifies:

1. Courses the student intends to transfer from other institutions;
2. Courses already completed at University of Arizona which the student intends to apply toward the graduate degree; and
3. Additional coursework to be completed to fulfill degree requirements including the minor program.

The Plan of Study must be approved by the CAEM Graduate advisor, the minor advisor, the student's Academic Advisor, the Graduate Studies Committee, and the Department Head prior to submission to the Graduate College. The Plan of Study must be approved by the Graduate College no later than two months before the Oral Comprehensive Examination.

11.9 Comprehensive Examination

Admission to graduate study does not imply admission to candidacy for an advanced degree. Before admission to degree candidacy, the student must first pass the qualifying examination in the chosen fields of study. Second, the student must pass a comprehensive examination conducted before the Doctoral Advisory Committee members. Full-time students are expected to take the comprehensive exam within the first three years of the PhD program. Part-time students will be given flexibility on exam timing but are encouraged to sit for the exam near the end of or shortly after completing their coursework. The Comprehensive Exam must be completed within three years of initial enrollment in the PhD program and at least six months prior to the date of the Final Oral Defense Examination.

No later than four weeks before the Comprehensive Examination, the student must complete the Application for Comprehensive Examination Form in GradPath in UAccess. It will be the responsibility of the student to schedule the day, time and place for the examination, in consultation with the student's committee and Academic Advisor.

Based on the student's combined performance on the written and oral components of the comprehensive examination, the doctoral advisory committee awards a grade of pass or fail. In the event of a failure, the student may be permitted a second attempt to pass the examination, but only if recommended by the committee. The second attempt is permitted only after the lapse of four months. A third attempt is not permitted.

Upon successfully passing the comprehensive examination, results are reported to Graduate Student Academic Services (GSAS) office and the student will be admitted to Candidacy. Deadlines for the submission of paperwork pertaining to the Comprehensive Examination are available in the GSAS Office.

12.9.1 Structure of Comprehensive Examination

The comprehensive exam consists of three portions: a written proposal in the major area, a written exam in the minor area, and an oral exam.

Major Area – Written proposal

The written proposal for the CAEM Department major area is a properly prepared technical document that describes the proposed Ph.D. research. The proposal is of central importance to the Comprehensive Examination. Its purpose is to indicate the academic preparation of the student and her/his ability to carry out original, creative research and to communicate effectively in a professional manner. Although guidance from the Academic Advisor is permitted, the proposal must essentially be an independent creation by the student.

The proposal may be based on discussions between the student and the student's Academic Advisor, appropriate references, independent research, and other materials such as books, coursework, or input from faculty. All second-hand information must be clearly referenced, and the wording must be that of the student.

Minor Area - Written exam

The written exam in the minor area is scheduled in the department(s) of the Minor Area(s). Scheduling this examination is the responsibility of the student.

Major and Minor Areas - Oral exam

The written exams must be passed before scheduling the oral exam. The oral exam must last a minimum of two hours but no more than three hours and is attended only by the examination committee.

Before the examination commences, the chair reviews procedures with the committee. The oral examination begins with a 30-50 minute presentation by the student on the student's proposed research. Members of the audience may interrupt the presentation with pertinent questions. When such interruptions occur, an appropriate increase in the time allowed for the presentation will be made. The presentation and related questioning usually takes about one hour. During the remainder of the examination, the student is asked to respond to questions on pertinent coursework and fundamentals relating to the student's research.

At the conclusion of the Oral Comprehensive Examination (and after the student has left the room), discussion of the student's performance is initiated. Each member of the examination committee is expected to evaluate the student's performance on the basis of the examination as a whole, not just on a particular area of questioning or only on the student's own field of specialization.

11.10 Dissertation

A candidate for the degree of Doctor of Philosophy must demonstrate the ability to devise and execute a program of study and research, which makes a fundamentally new contribution to their chosen field. The most important aspect of the doctoral program is the dissertation, that is the evidence of this fundamental contribution.

CAEM requires the completion of a dissertation that meets required standards of scholarship and demonstrates the candidate's ability to conduct original research. A collection of facts and information, no matter how carefully organized or described, does not, by itself, constitute a Ph.D. dissertation. A Ph.D. dissertation will often make use of the contributions from a faculty member or others, but it should be clear about the creative contributions that the doctoral candidate has made.

The Ph.D. dissertation must present:

1. The development of new principles, theories, or techniques
2. The use of established principles, theories, or techniques in a new and/or unique manner; and/or
3. The use of available information and the discovery of new findings if it is described in terms of an original model or process.

It should also lead to at least one significant paper published in a peer-reviewed journal. As evidence that the above criterion has been met, it is strongly recommended that a manuscript be submitted for publication before the completion of the doctoral program.

11.11 Format of Dissertation

Instructions relating to the format of the thesis and required abstracts are included in the Dissertation Formatting Guide that is available in the Graduate Office and online:

<https://grad.arizona.edu/gsas/dissertations-theses/dissertation-and-thesis-formatting-guides>.

11.11 Format of Dissertation

Instructions relating to the format of the thesis and required abstracts are included in the Dissertation Formatting Guide that is available in the Graduate Office and online:

<https://grad.arizona.edu/gsas/dissertations-theses/dissertation-and-thesis-formatting-guides>.

11.12 Announcement of Final Oral Defense

When the student has an approved Doctoral Plan of Study on file, has satisfied all coursework, residence requirements, passed the Comprehensive Examination, admitted to candidacy, and completed a draft dissertation, the student must file for an Announcement of Final Defense. This form can be found at the UA GradPath Forms in UAccess link on the Graduate College Forms page:

<https://grad.arizona.edu/gcforms/academic-services-forms>. The completed form is submitted via GradPath.

The Announcement of Final Oral Examination must be filed in UAccess and identify all Doctoral Advisory Committee members on the application form. Submission must provide adequate time for all approvers to grant approval one week prior to the exam to permit a public announcement of the upcoming exam. It is recommended that the process is initiated **no later than three (3) weeks prior to the proposed date** of the Final Oral Examination. Further, prior to approval, the examining committee members must have read the penultimate draft of the dissertation and agree that it is ready to defend.

The Graduate College posts deadlines for holding the Final Oral Defense Examination to graduate in a specified semester.

(<https://grad.arizona.edu/gsas/degree-requirements/important-degree-dates-and-deadlines>).

11.13 Final Oral Defense Examination

The dissertation examining committee is comprised of the Doctoral Advisory Committee. Except for an initial seminar portion during which the student presents the dissertation, the examination is closed to the public. During and after the presentation, the public may ask questions of the candidate and will then be asked to leave. Questioning by the examining committee will then continue. The total examination including the public presentation may last for up to 3 hrs. The exam has no minimum duration.

11.14 Submission of the Dissertation

Following a successful defense, the candidate will submit a copy of the dissertation to the CAEM Departmental office for a format check. After the necessary corrections, the candidate submits the approved dissertation in electronic format to the Graduate College via UAccess - for further instructions check the Dissertation/Thesis Submission site (<https://grad.arizona.edu/gsas/dissertaions-theses/submitting-your-dissertation>). The dissertation must be submitted in PDF format to the CAEM department's office on a CD or thumb drive along with a hardcopy of the dissertation that the student can verify is readable. In addition, the candidate's Academic Advisor and Doctoral Advisory Committee may request copies of the dissertations in electronic format, hardbound and/or loose pages. Check with your Academic Advisor for any special requirements.

11.15 Minor in Civil Engineering or Engineering Mechanics

Nine (9) units of approved coursework are required for a minor in Civil Engineering or in Engineering Mechanics. The minor Academic Advisor will coordinate the written portion with other faculty in the area. Usually, the minor committee member(s) tests the student on coursework taken in the minor. Preliminary minor examinations will be given by the minor advisor. The examination time will be determined between the student and the minor advisor.

11.16 Steps in Completing the Ph.D. Program

A checklist for completing the steps toward your Ph.D. degree is given in Appendix 5 in the Supplementary Material Section

11.17 Additional Information

Additional information on the doctoral program, necessary forms and steps involved can be obtained online at: <https://grad.arizona.edu/gsas/degree-requirements/doctor-philosophy/>

APPENDIX 1

Graduate Programs in CAEM - Civil and Architectural Engineering and Mechanics

GRADUATE STUDY AND RESEARCH IN ENGINEERING MECHANICS & MATERIALS

INTRODUCTION

The Engineering Mechanics and materials program at the University of Arizona offers a broad spectrum of graduate study with emphasis on a wide range of topics in solid and structural mechanics, material modeling, laboratory facility for mechanical and nondestructive testing and computational methods for linear and nonlinear, and static and dynamic problems. The program provides opportunities for course work and research involving a combination of theory, laboratory testing and applications. The student can plan a program of study, with the assistance of faculty advisors, according to the student's interest in basic theoretical work to practical applications. A variety of courses are available in the CAEM Department as well as in other related Departments; e.g., Aerospace and Mechanical Engineering, Applied Mathematics, Mining and Geological Engineering, and Materials Science and Engineering.

The interdisciplinary nature of the program is covered and coordinated through the Engineering Mechanics, Materials Science and Engineering, Geomechanics and Structural Mechanics Programs. Faculty members from the CAEM as well as other Departments participate in these programs through teaching, research and professional activities.

LIST OF RESEARCH TOPICS

Areas of research in which you might become involved also cover a broad range of interesting and important subjects. Some of the recent research topics in engineering mechanics at The University of Arizona include:

- Structural Health Monitoring (SHM) using ultrasonic & electromagnetic waves
- Development of constitutive models for accurate characterization of the mechanical response of solids and composites
- Laboratory determination of material parameters using mechanical and nondestructive testing
- Linear and Nonlinear ultrasonic NDE for crack detection in structures
- Probabilistic and stochastic methods in structural mechanics
- Efficient and robust algorithm for integration with advanced constitutive models, and time integration for dynamic and field problems
- Adaptive mesh refinement, pre- and post-processors including graphics for finite element programs
- Elastic wave propagation in solids
- Static and dynamic response of cracks in composites and homogenous solids
- Smart materials and smart structures
- Additive Manufacturing
- Stability of structural systems
- Fracture mechanics
- Wavelet analysis for multiscale modeling

- Development of sustainable construction materials

GRADUATE COURSE OFFERINGS

A list of courses under this program in the Department of Civil and Architectural Engineering and Mechanics and other departments is given below.

Detailed descriptions of the requirements for these degrees, together with a list of course offerings, can be obtained by writing to:

Dominic Boccelli, PhD
 Head, Department of Civil and Architectural Engineering
 and Mechanics
 University of Arizona
 P.O. Box 210072
 Tucson, Arizona 85721, USA

Related Graduate Course Offerings

<u>Civil Engineering and Engineering Mechanics</u> CE/EM 402/502 Introduction to Finite Element Method EM 50 Elasticity EM 508 Fracture Mechanics EM 605 Advanced Solid Mechanics CE/EM 606 Wave Propagation in Solids EM 633 Structural Dynamics and Earthquake Engineering EM 634 Advanced Structural Dynamics	<u>Aerospace and Mechanical Engineering</u> AME 550 Advanced Dynamics AME 561 Finite Element Methods AME 563 Advanced Finite Element Analysis AME 564A Mechanics of Deformable Solids AME 564B Mechanics of Deformable Solids
<u>Mining and Geological Engineering</u> GEN/MNE Geomechanics 527 GEN 529 Rock Slope Analyses and Design GEN 580 The Mechanics of Fracture in Rock and Other Brittle Materials	<u>Mathematics</u> MATH 456 Applied Partial Differential Equations MATH 475 Mathematical Principles of Numerical Analysis MATH 513 Linear Algebra MATH 520 Complex Analysis MATH 553 Partial Differential Equations MATH 568 Applied Stochastic Processes
<u>Materials Science and Engineering</u> MSE 551 Integrated Computational Materials Science and Engineering MSE 555 Physical Metallurgy MSE 560 Materials Science of Polymers	

FACILITIES

The principal research facilities available include the experimental mechanics in the department and elsewhere on campus. Departmental facilities include the nondestructive evaluation laboratory and the materials laboratory. The facility for testing of solids (geomaterials, concrete, composites, ceramics, space materials, etc.) include some of the most up-to-date and unique equipment for ultrasonic and electromagnetic wave based nondestructive characterization of materials, 3-D concrete printer, Raman spectrometer etc. A list of available equipment is given below.

MECHANICAL TESTING AND CHARACTERIZATION FACILITIES

Several Mechanical testing machines

Optical Microscope, SEM, TEM (on campus)

Freeze Thaw Cabinet

NON-MECHANICAL TESTING FACILITIES

- Ultrasonic Pulser-Receiver: ultrasonic device for measurement of ultrasonic velocity and attenuation of a reference waveform.
- Ultrasonic C-Scanner: Piezoelectric transducer produces converging acoustic waves, which are used for crack detection and characterizing materials.
- EMAT (Electro Magnetic Acoustic Transducer) for pipe inspection
- Acoustic Microscope
- High Temperature Furnace: box furnace for temperatures up to 1700C, for heat processing samples of different sizes and shapes. Non-atmospheric (Argon) environment can be created in the furnace.
- Profilometer for roughness measurements.
- Additive Manufacturing of Metals and non-metals (on campus).
- Confocal Raman Microscope (Integrated confocal Raman-AFM system)
- 3D concrete printer (Robotic arm system)

STRUCTURES TESTING FACILITIES

- Two Hydraulic Actuators: capacity of 110 kips.
- Hydraulic Pump: capacity of 23 gallons per minute.
- Data Acquisition and Reduction System: capable of reading 70 strain gages and 20 Linear Variable Differential Transducers (LVDT's).
- Load Cells: capacities ranging from 5 to 200 kips, single and double action.

FACULTY

CIVIL AND ARCHITECTURAL ENGINEERING AND MECHANICS

ROBERT FLEISCHMAN

(Ph.D., Lehigh University) Professor--Seismic-resistant design of building structures, development of steel connection systems, partially restrained frames, diaphragm flexibility in precast concrete structures, connections for automated construction.

GEORGE FRANTZISKONIS

(Ph.D., University of Arizona) Professor--Mechanics, geomechanics, new materials, damage and fracture, instabilities, advanced material testing.

TRIBIKRAM KUNDU

(Ph.D., University of California, Los Angeles) Professor—Structural Health Monitoring & Nondestructive Testing - Elastic wave propagation, fracture mechanics, acoustics, ultrasonic and electromagnetic wave based NDE techniques, composites, computational mechanics.

HONGKI JO

(Ph.D., University of Illinois) Associate Professor—Structural health monitoring (SHM), wireless smart sensor networks, bio-inspired

sensing technologies, smartphone network for SHM, computer vision-based sensing, big data for structural reliability and risk assessment, structural damage identification, advanced functional materials, wind/bridge engineering, energy harvesting, full-scale dynamic testing.

HAMID SAADATMANESH

(Ph.D., University of Maryland) Associate Professor -- Advanced materials such as fiber composites for strengthening of existing structures, rehabilitation of infrastructure systems, space materials, and behavior of steel and concrete structures.

HEE JEONG KIM

(PH.D. – Korea Advanced Institute of Science and Technology(KAIST), Daejeon, South Korea) Assistant Professor – Multiscale chemo-mechanical characterization on cementitious materials, development of innovative and new efficient construction materials, identifying deterioration, carbonation, hydration mechanism of cementitious materials, digital fabrication, application of new advanced materials in civil engineering, carbon capture utilization and storage, development of sustainable concrete and low-CO₂ concrete, improvement of sustainability and resilience of civil infrastructure.

COLLABORATING FACULTY IN OTHER DEPARTMENTS

S. MISSOUM

Associate Professor, Aerospace and Mechanical Engineering, Computational Optimal Design of Engineering Systems (CODES), Computational design optimization, Uncertainty quantification, Finite element analysis.

GRADUATE STUDY AND RESEARCH IN GEOMECHANICS/GEOTECHNICAL ENGINEERING

INTRODUCTION

The Geomechanics/Geotechnical program in the Department of Civil and Architectural Engineering and Mechanics at the University of Arizona includes such interdisciplinary areas as soil and rock mechanics, foundation engineering, geoenvironmental engineering, recycling and utilization of solid wastes, sustainable and green construction materials, dust control, soil dynamics and geotechnical earthquake engineering, material testing and modeling, and computer methods.

The main objective of the program is to provide an effective connection between the State-of-the-Art and the State-of-the-Practice. The program is designed to provide a balanced education in traditional subjects and advanced topics.

The graduate student may select from a wide variety of courses within the department as well as courses offered in other departments such as Mining and Geological Engineering, Hydrology and Water Resources, Aerospace and Mechanical Engineering, Mathematics, and Computer Science. The courses offered in the department are directed towards fundamentals and applications to practical problems. Our graduates are educated to do more than “Build with Confidence” – they will be able to “Predict the Performance of Advanced Geotechnical Systems.”

RESEARCH PROGRAM

The Faculty in the Geomechanics/ Geotechnical group in the Department of Civil and Architectural Engineering and Mechanics are actively involved in a wide range of Geomechanics/ geotechnical engineering and interdisciplinary research activities. Graduate students invariably gain significant knowledge in new developments by participating in various innovative areas of research.

Most of these areas of research involve integration of theory, laboratory testing and field verification. The latter is achieved through collaboration with various private and government agencies. The laboratory testing programs are designed to calibrate and validate the theoretical analyses either using some of the existing unique devices developed by the faculty or constructing new ones.

Current areas of research include:

- Liquefaction of soils due to earthquake loading;
- Strength-deformation characteristics of frozen-thawed ground behavior;
- Spatial Variability and vulnerability analysis of mine tailings;
- Ice-nucleation and thermal transport process in soil particles;
- Bio-mediated processes to enhance soil behavior;
- Enhanced ground control for improving the safety of underground mining;
- Biopolymer stabilization of soils and mine tailings;
- Eco-friendly control of soil and mine tailings dust;
- Recycling and utilization of solid wastes (fly ash, mine tailings, and C&D wastes);
- Development of sustainable and green construction materials such as geopolymer bricks and concrete;
- Discrete element method (DEM) simulations of soils and rocks;

- Molecular dynamics (MD) simulations of materials;
- Soil behavior and soil properties;
- Three-dimensional (3D) multi-scale characterization and investigation of rock fractures;
- Development of Rock Expert System (RES) for efficient evaluation of rock properties;
- Enhancement of reservoir (oil, water, and thermal) production in rock;
- Sustainable foundation systems including both shallow and deep foundations;
- Retaining walls;
- Geotechnical safety related to underground compressed air energy storage (CAES);

COURSE OFFERINGS

<p><u>Civil Engineering and Engineering Mechanics</u></p> <p>CE 502 Introduction to Finite Element Methods CE 540 Foundation Engineering</p> <p>CE 541 Earth Structures in Geotechnical Engineering</p> <p>CE 542 Ground Improvement</p> <p>CE 544 Special Topics in Geomechanics (Mine Tailings)</p> <p>CE 544 Special Topics in Geomechanics (Critical State Soil Mechanics)</p> <p>CE 545 Geoenvironmental Engineering</p> <p>CE546 Geotechnical Earthquake Engineering</p> <p>EM 508 Fracture Mechanics</p>	<p><u>Mining and Geological Engineering</u></p> <p>GEN 515 Rock Excavation</p> <p>GEN 516 Field Studies in Geophysics</p> <p>GEN 524 Fundamentals of Geotechnics</p> <p>GEN 527 Geomechanics</p> <p>GEN 529 Rock Slope Analyses and Design</p> <p>GEN 548 Geophysical Exploration and Engineering</p> <p>GEN 580 The Mechanics of Fracture in Rock and Other Brittle Materials</p>
<p><u>Hydrology and Water Resources</u></p> <p>HWRS 503 Subsurface Fluid Dynamics</p> <p>HWRS 518 Fundamentals of Subsurface Hydrology</p> <p>HWRS 535 Advanced Subsurface Hydrogeology</p> <p>HWRS 566 Soil and Groundwater Remediation</p>	<p><u>Chemical and Environmental Engineering</u></p> <p>CHEE 573 Biodegradation of Hazardous Organic Compounds</p> <p>CHEE 578 Introduction to Hazardous Waste Management</p> <p>CE/MSE 431/531 Sustainable Materials Design Lab</p>

FACILITIES

LABORATORY

The department has excellent laboratory facilities for conventional soil tests and an array of unique and modern devices. Our traditional devices include triaxial, consolidation, direct shear, and soil identification apparatus. These devices have all been updated to add computerized data acquisition capabilities.

Our major research equipment includes:

- Consolidation equipment with computerized data acquisition system
- Computer controlled direct shear device for soils
- Computer controlled cylindrical triaxial apparatus for soils
- Frozen soil triaxial system
- Automated Resonant column apparatus for geomaterials
- Ice-Nucleation chamber for phase change determination
- Automatic mechanical compactor
- MTS frame and accessories for compression and tension tests
- Cyclic multi-degree-of-freedom shear (CYMDOF) device for translational, torsional, and rocking modes for testing interfaces and joints
- Wind tunnel for testing wind-blown dust

FACULTY

CIVIL AND ARCHITECTURAL ENGINEERING AND MECHANICS

LIANYANG ZHANG

(Ph.D. MIT, P.E. Massachusetts) Professor --

Three-dimensional (3D) multi-scale characterization and investigation of rock fractures; Development of Rock Expert System (RES) for evaluation of rock properties; and Enhancement of reservoir (oil, water, and thermal) production in rock; Recycling and utilization of fly ash, mine tailings and construction and demolition (C&D) wastes through geopolymerization; Bio-enhancement of cementitious material; Dust control with biopolymers; Geotechnical safety related to underground compressed air energy storage (CAES); Piles (especially drilled shafts socketed into rock) under different loading conditions; Dynamic properties of soils and rocks; and enhanced ground control for improving the safety of underground mining.

TEJO V. BHEEMASETTI

(Ph.D. University of Texas at Arlington) Assistant Professor --

Climatic impacts on strength-deformation behavior of geomaterials; Multi-scale characterization of frozen-thawed geomaterials; Development of stabilization techniques through chemicals, bio-polymers, and waste materials; Linear and Non-linear geostatistics to evaluate three-dimensional spatial variability and distribution of geomaterials; Vulnerability analysis of the earthen dams and mine tailings dams to

geohazards; Bio-mediated process using psychrophiles, mesophiles, and thermophiles to control the phase change and thermal transport processes in geomaterials; transportation geotechnics to enhance strength-deformation characteristics of problematic subgrade soils including expansive soils, collapsible soils, frost-susceptibility soils, and dispersive soils; pavement preservation approaches using machine learning techniques; Deep foundation systems; Seismic stability analysis of earthen structures; and Development of three dimensional (3D) visualization civil infrastructure systems.

GRADUATE STUDY AND RESEARCH IN HIGHWAYS AND TRANSPORTATION

INTRODUCTION

Advanced studies and research are available through a broad program of course work and research in the areas of Transportation and Highways in the Department of Civil and Architectural Engineering and Mechanics at The University of Arizona. Students may specialize in such areas, such as traffic engineering, transportation planning, pavement design, and paving materials. The program is structured to allow flexibility for interacting with other programs in the University and in the College of Engineering.

LIST OF RESEARCH TOPICS

A wide range of topics has been investigated and is of interest for future research. Most research has been directed to solving current problems as directed by project sponsors. Research projects or studies are performed by faculty and graduate students, and include the following:

- Traffic flow models
- Driver behaviors/Human factors
- Highway capacity analysis
- Intelligent transportation systems
- Performance measurement
- Big data analytics
- Traffic detection and sensors
- Traffic signal operations and timing
- Traveler information systems
- Public transit service/operations planning
- Long-range transportation planning
- Transportation economics and Pricing
- Travel demand management
- Traveler behavior

GRADUATE COURSE OFFERINGS

<u>Civil and Architectural Engineering and Mechanics</u> CE 560 Special Topics in Transportation Engineering CE 561 Traffic Modeling and Simulation CE 561A Transportation Statistics CE 562 Traffic Engineering and Operations	<u>Systems and Industrial Engineering</u> SIE 522 Engineering Decision Making Under Uncertainty SIE 525 Queuing Theory SIE 530 Engineering Statistics SIE 536 Exp. Design and Regression SIE 540 Survey of Optimization Methods
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CE 563 Traffic Flow and Capacity Analysis CE 565 Transportation Data Management and Analysis CE 566 Highway Geometric Design CE 567 Traffic Safety CE 568 Urban Transportation Planning CE 569 Travel Demand Modeling	SIE 546 Algorithms, Graphs and Networks SIE 562 Production System Analysis SIE 678 Transportation Systems
<u>Planning</u> PLG 501B Introduction to Planning PLG 516B Geographic Information Systems for Geography and Regional Development PLG 559 Land Use and Growth Controls	

FACILITIES

The department has an extensive library, computers and software for use in traffic analyses and transportation planning studies. There is a variety of equipment used for field traffic studies and analysis. The Ryan Research Group, the Smart Transportation Lab, and Urban Ecosystems Lab are three major laboratory facilities housed in the Center for Applied Transportation Sciences (CATS).

FACULTY

CIVIL AND ARCHITECTURAL ENGINEERING AND MECHANICS

YAO-JAN WU

(Ph.D. – University of Washington, Seattle. P.E., Missouri and Arizona) Associate Professor – ITS information technology applications in transportation, advanced safety vehicles (ASV), image processing and computer vision applications in transportation, traffic detection technology development, data management, mining, and analysis, and traffic operations), transportation safety analysis and accident modeling, Geographic Information Systems (GIS), traveler behavior analysis, and sustainable transportation systems (sustainable infrastructure and transit system improvement).

ALYSSA M. RYAN

(Ph.D. - University of Massachusetts Amherst) Assistant Professor - Transportation safety, transportation equity, human factors, driving simulation, data analysis, unmanned aerial systems, automated vehicles, and crash modeling

ALI SHAMSHIRIPOUR

(Ph.D. - University of Illinois, Chicago) Assistant Professor - Smart Mobility, Human-centric Smart Cities, Activity and Travel Behavior Analysis and Analysis, Large-scale Agent-based Simulation of Urban Ecosystems

COLLABORATING FACULTY IN OTHER DEPARTMENTS

LARRY HEAD

Professor, Systems and Industrial Engineering--traffic and transportation systems, traffic signal control, microscopic traffic simulation, traffic flow theory, systems engineering methodology, software engineering, communications, and human factors.

WEI LIN

Professor, Systems and Industrial Engineering--Transportation network optimization, intelligent transportation systems, traffic flow theory, logistics and supply chain management, computer simulation modeling.

GRADUATE STUDY AND RESEARCH IN HYDRAULICS AND WATER RESOURCES

INTRODUCTION

Students interested in hydraulic engineering will find extraordinary opportunities for study and research leading to advanced degrees in Civil Engineering at The University of Arizona, Tucson, Arizona. Courses offered in hydraulics are combined with courses from others areas of the CAEM department and from other university departments to enable students to tailor their programs to their needs and goals. The Master of Science and Doctor of Philosophy degrees emphasize the development and application of theory to solve contemporary engineering problems, and lead to the submission of a research thesis. Ample scope is provided to engage in interdisciplinary studies.

LIST OF RESEARCH TOPICS

Faculty expertise covers a broad range of water resource management, hydrology, and hydraulic engineering topics. Below are recent research topics:

- Resilient and sustainable water distribution system
- Applications of machine learning to water management
- Optimizing pipe flow designs
- Optimal control of pumping facilities
- Burst detection in distribution systems
- Regional groundwater management
- Impact of climate change on local flooding and impacted populations
- Regional water supply modeling and planning
- Premise plumbing design including water quality
- Assessment of Colorado river water management policies
- Computational simulation of flow and sediment transport in rivers, from watersheds, and in coastal wetlands.
- Experimental studies of turbulence flow field around bridge piers and abutments
- Vegetation resistance and sediment transport in vegetated channels and coastal wetlands
- High-speed camera applications to fluid mechanics, image-based flow discharge measurement
- Monitoring erosion and sedimentation using state-of-art technology
- River meandering processes and simulation
- Fate and transport of microorganism (bacteria and virus) in irrigation canals
- Impact of wildfire on surface runoff and sediment transport from arid and semi-arid watersheds

COURSES OFFERED

CE 522 Open Channel Flow

CE 523 Hydrology

CE 527 Computer Applications in Hydraulics

CE 529 Special Topics in Water Resource (Computational Hydraulics)

CE 555 Soil and Water Resources Engineering
 CE 558 Wastewater Treatment Operations and Reuse
 CE 503 Subsurface Fluid Dynamics
 CE 504 Numerical Methods in Subsurface Hydrology.
 CE 525 Sedimentation Engineering
 CE 526 Watershed Engineering
 CE 655 Stochastic Methods in Surface Hydrology

Other Related Courses

In addition to the courses listed above, the student may select from a wide variety of courses offered by other areas within the CAEM department and other departments in the University.

<p><u>CAEM Department</u> CE 502 Introduction to Finite Element Methods CE 541 Earth Structures in Geotechnical Engineering CE 545 Geoenvironmental Engineering</p>	<p><u>Aerospace and Mechanical Engineering Department</u> AME 536(a), 536(b) - Fundamentals of Fluid Mechanics</p>
<p><u>Biosystems Engineering Department</u> BE 526 Watershed Engineering BE 556 Irrigation Systems Design</p>	<p><u>Hydrology and Atmosphere Science Department</u> HWRS 505 Vadose Zone Hydrology HWRS 516 Hydrologic Transport Processes HWRS 518 Fundamentals of Subsurface Hydrology HWRS 520 Fundamentals: Water Resources Policy, Management, Planning and Rights HWRS 521 Water Resource Systems Planning and Management HWRS 531 Hydrogeology HWRS 535 Advanced Subsurface Hydrology HWRS 543a Risk Assessment for Environmental Systems HWRS 545 Introduction to Data Assimilation HWRS 566 Soil and Groundwater Remediation HWRS 582 Applied Groundwater Modeling HWRS 642 Analysis of Hydrologic Systems HWRS 645 Stochastic Methods in Subsurface Hydrology</p>
<p><u>Renewable Natural Resources - Watershed Management</u> RNR 517 Geographic Information Systems for Natural and Social Sciences</p>	

RNR 520 Advanced Geographic Information Systems RNR 573 Spatial Analysis and Modeling WSM 562 Watershed Management	
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RESEARCH FACILITIES

COMPUTERS:

Personal computers are generally used for graduate research. The university also has a high-performance computer (HPC) system with clusters of nodes for students' use when needed for large scale system.

PHYSICAL EQUIPMENT:

A number of flumes of different lengths and capabilities are available for research in open channel flow, sediment transport and erosion around hydraulic structures. Specialized equipment, e.g., a large scale open channel flume has been built for hydraulic and sediment transport research. Advanced 2D and 3D computational hydrodynamic models were developed. Highly advanced as well as standard equipment for conducting research is always available, e.g., Vectrino Velocity Profiler, Micro-ADVs, Drone, and High-speed camera systems, etc.

LIBRARIES:

The University library system contains more than 5,000,000 items, including books, periodicals, microforms, maps, government publications, manuscripts and non-book media. The Science-Engineering library houses material on science and technology has over 360,000 volumes, over a million microforms and displays current issues of 4,500-plus periodicals. The library offers reference service; on-line searching of computerized databases and bibliographic course-related instruction.

FACULTY

CIVIL AND ARCHITECTURAL ENGINEERING AND MECHANICS

DOMINIC L. BOCCELLI

(Ph.D., Carnegie Mellon University) Professor--Systems analysis techniques, and lab- and field-scale experimentation applied to urban water infrastructure systems; applications include real-time modeling, sensor networks, contamination warning systems, disinfectant dynamics and by-product formation; techniques include parameter estimation, uncertainty analysis, Bayesian methods, time series analysis, cluster analysis, optimization, and numerical methods.

JENNIFER G. DUAN

(Ph.D., University of Mississippi. P.E., Arizona and Nevada)

Professor – Computational simulation of surface flow and sediment transport in rivers and watershed, river stability analysis, river engineering methods, bridge scour analysis, experimental researches on turbulence flow, vegetated open channel flow, and sediment transport, innovative instrumentation for flow and sediment measurements, microorganism transport in irrigation canals.

KEVIN E. LANSEY

(Ph.D., University of Texas at Austin) Professor--Application of system analysis techniques to water resources and hydraulic systems, water distribution system design and operation, machine learning applied to WDS leak detection, large scale water supply planning, and optimal groundwater management.

COLLABORATING FACULTY IN OTHER DEPARTMENTS

ALI BERANGHI

Professor, Hydrology and Atmospheric Sciences - Remote sensing of precipitation and cloud, high latitude and mountainous rain and snow retrievals and analysis, weather and climatic extremes (drought, flood, fire, tropical storms) and societal interactions, global water and energy budget analysis, hydrologic/watershed modeling and optimization, developing high resolution precipitation products, representation of precipitation in climate models, and evaluation of precipitation products using ground validation data.

CHARLES P. GERBA

Professor, Environmental Sciences - His recent research encompasses the transmission of pathogens by water, food and fomites; fate of pathogens in land applied wastes; development of new disinfectants; microorganisms and their transport in irrigation water; domestic microbiology and microbial risk assessment. He has been an author on more than 500 articles including several books in environmental microbiology, risk assessment, and pollution science.

HOSHIN GUPTA

Professor, Hydrology and Atmospheric Sciences -Surface water hydrology, terrestrial

hydrometeorology, land-atmosphere models, flood-forecasting, model evaluation, diagnostic model correction and learning, multi-criteria analysis, sensitivity analysis, uncertainty analysis, Bayesian estimation, information content of data, data assimilation, model structure estimation, application of remotely sensed data, estimation of precipitation from remotely sensed data, artificial neural networks, global optimization, multi-resolution multi-disciplinary integrated modeling, decision analysis and decision support systems, applications of information theory to modeling and hydrology, bridging natural and social sciences.

PETER TROCH

Professor, Hydrology and Atmospheric Sciences Hillslope and catchment hydrology, remote sensing and data assimilation, hydrological predictions in ungauged basins through advanced measurement, modeling and synthesis methods.

T. C. JIM YEH

(Ph.D.) Professor, Hydrology and Atmospheric Sciences - Numerical modeling, stochastic analysis, and laboratory/field investigation of flow and contaminant transport in variably saturated geologic formations.

GRADUATE STUDY AND RESEARCH IN STRUCTURAL ENGINEERING

INTRODUCTION

The Structural Engineering program in the Department of Civil and Architectural Engineering and Mechanics (CAEM) at The University of Arizona, Tucson, offers excellent opportunities for advanced studies and research in a wide range of topics in structural engineering. The program is flexible and can be developed to fit individual interests, addressing the most recent developments in the area of structural engineering. A program of your choice can be developed to suit your particular needs, emphasizing from a purely professional to a highly research-oriented program of study. Possible areas of study within the structural engineering program may include analysis and design of steel and concrete structures, structural mechanics, probabilistic or risk-based design, new materials for structures, earthquake resistant design, computational mechanics, computer-aided design, infrastructure monitoring, sensors and sensor networks, applications of advanced composite materials in civil engineering structures, response of structures to blast loading, and many similar areas emphasizing both the theoretical and the practical aspects of structural engineering.

The program leads to the degrees of Master of Science with thesis, report and non-thesis options, Master of Engineering, and Doctor of Philosophy in Civil Engineering. Students can select courses from a wide variety offered by CAEM. They are also encouraged to take courses offered in other departments such as Aerospace and Mechanical Engineering, Applied Mathematics, Electrical and Computer Engineering, Statistics, Systems and Industrial Engineering, Materials Science and Engineering, or any other interdisciplinary programs available at The University of Arizona.

LIST OF RESEARCH TOPICS

The faculty in the Structural Engineering program at CAEM is actively involved in a wide variety of research areas, often with interdisciplinary interests from materials science and solid mechanics. The faculty and their current research interests are listed below. Both research assistantships and teaching assistantships are available to qualified prospective students. Prospective students are encouraged to contact the faculty of their choice and explore all possibilities.

- Reinforced and prestressed concrete structures
- Prestressed steel structures
- Stochastic finite element
- Stochastic system identifications
- Nonlinear structural dynamics
- Earthquake resistant design
- Seismic retrofitting of structures
- Reliability-based inspection, maintenance and rehabilitation
- Strengthening and rehabilitation of existing bridges and buildings
- Disproportional Collapse
- Structural health monitoring
- Wireless smart sensor networks
- Bio-inspired sensing
- Bridge scour monitoring and prediction
- Structural vibration control and mitigation

- Smartphone network for Infrastructure monitoring
- Wind engineering
- All aspects of damage
- Applications of advanced fiber composite materials in civil engineering structures
- High strength concrete
- Development of innovative structural components
- Risk evaluation in random-fuzzy environment
- Finite deformation, stability, post-buckling behavior of structures
- Computational mechanics
- Constitutive modeling for concrete, composites and other structural materials
- Interface behavior
- Elastic wave propagation
- Fracture mechanics
- Acoustics, ultrasonics and nondestructive testing
- Damage and fracture
- Nondestructive evaluation of concrete and wood using nuclear magnetic resonance (NMR)

GRADUATE COURSE OFFERINGS

For your ready reference, the structural engineering graduate courses are listed below. For a detailed description of these courses as well as other courses offered at the College of Engineering and at The University of Arizona, please consult the Graduate Catalog.

CE 502 Introduction to Finite Element Methods	EM 504 Elasticity Theory and Application
CE 510 Probability in Civil Engineering	EM 508 Fracture Mechanics
CE 532 Advanced Structural Design in Steel	EM 511 Advanced Finite Element Analysis
CE 534 Design of Wood and Masonry Structures	EM 633 Structural Dynamics and Earthquake Engineering
CE 535 Prestressed Concrete Structures	EM 634 Advanced Structural Dynamics (Experimental Dynamics)
CE 537 Advanced Structural Design in Concrete	EM/CE 648 Constitutive Laws for Engineering Materials
CE 538 Behavior and Design Structural Systems	AME 562 Composite Materials
CE 540 Foundation Engineering	AME 564a Mechanics of deformable Solids I
CE/EM 606 Wave Propagation in Solids	AME 564b Mechanics of deformable Solids II
CE 638 Advanced Structural Stability	
CE 648 Constitutive Laws for Engineering Materials	

FACILITIES

The CEEM has excellent facilities for testing conventional concrete and steel structures. The structural engineering laboratory is equipped with a 3-foot deep strong reaction floor covering an area of 42 feet by 32

feet with tie-down points at 3-foot center-to-center spacing. Modern testing facilities which have been recently purchased include: a closed-loop dynamic testing machine and load frame with a capacity of 110 kips, three hydraulic actuators, two with a capacity of ± 110 kips and one with a capacity of ± 220 kips, a hydraulic pump with a capacity of 23 gallons per minute, and a data acquisition and reduction system capable of reading 60 strain gages and 20 transducers. 3-DOF Seismic shaking table has been built recently, which composed of three dynamic actuators of 4.3kips, allowing up to 40Hz excitation with 1 tonf payload capacity (30Hz excitation with 2 tonf payload), a feed-back controller, a hydraulic service manifold. Another 1DOF electromagnetic shaker also has been purchased for small-scale tests and sensor calibrations. In addition, portable data acquisition equipment with 20 data channels is available in the form of an HP 3421 unit with mass storage devices. The laboratory is also equipped with several smaller hydraulic jacks, reaction frames, and testing machines. The Civil Engineering Department Shop is equipped with tool-making machines, and is supported by two machinists and an electrician. The library, computer, laboratory and other necessary facilities are what would be expected at a major American university.

FACULTY

CIVIL AND ARCHITECTURAL ENGINEERING AND MECHANICS

ROBERT FLEISCHMAN

(Ph.D., Lehigh University) Professor--Seismic-resistant design of building structures, development of steel connection systems, partially restrained frames, diaphragm flexibility in precast concrete structures, connections for automated construction.

GEORGE FRANTZISKONIS

(Ph.D., University of Arizona) Professor--Mechanics, geomechanics, new materials, damage and fracture, instabilities, advanced material testing.

HONGKI JO

(Ph.D., University of Illinois) Associate Professor—Structural health monitoring (SHM), wireless smart sensor networks, bio-inspired sensing technologies, smartphone network for SHM, computer vision-based sensing, big data for structural reliability and risk assessment, structural damage identification, advanced functional materials, wind/bridge engineering, energy harvesting, full-scale dynamic testing

Tribikram Kundu

(Ph.D., University of California, Los Angeles) Professor—structural health monitoring & nondestructive testing - elastic wave propagation, fracture mechanics, acoustics, ultrasonic and electromagnetic wave based NDE techniques, composites, computational mechanics.

DEAN PAPAJOHN

(M.S., University of Illinois, P.E., Arizona & Illinois) Associate Professor of Practice—Alternative project delivery methods, public-private partnerships, sustainable infrastructure assessment.

HAMID SAADATMANESH

(Ph.D., University of Maryland) Professor--Advanced materials such as fiber composites for strengthening of existing structures, rehabilitation of infrastructure systems, space materials, and behavior of steel and concrete structures.

GRADUATE STUDY AND RESEARCH IN BUILDING SCIENCE

INTRODUCTION

The Building Science program in CAEM offers excellent opportunities for advanced studies and research in a wide range of building science and engineering topics. The program is flexible and can be developed to fit individual interests, addressing the latest advancements in the field. A program of your choice can be developed to suit your needs, emphasizing from a purely professional to a highly research-oriented program of study. Possible areas of study within the building science program may include analysis and design of smart buildings, connected communities, human building interaction, grid-interactive effective buildings, advanced building energy modeling, and many similar areas emphasizing both the theoretical and the practical aspects of building science.

The program leads to the degrees of Master of Science with thesis, report and non-thesis options, Master of Engineering, and Doctor of Philosophy in Civil Engineering. Students can select courses from a wide variety offered by CAEM. They are also encouraged to take courses, after discussions with their advisor(s), offered in other departments such as Aerospace and Mechanical Engineering, Applied Mathematics, Electrical and Computer Engineering, Statistics, Systems and Industrial Engineering, or any other interdisciplinary programs available at The University of Arizona.

LIST OF RESEARCH TOPICS

The faculty in the Building Science program at CAEM is actively involved in a wide variety of research areas, often with interdisciplinary interests. The faculty and their current research interests are listed below. Both research assistantships and teaching assistantships are available to qualified prospective students. Prospective students are encouraged to contact the faculty of their choice and explore all possibilities.

- Smart Buildings
- Human Building Interaction
- Grid-interactive Effective Buildings
- Sustainable and Resilient Infrastructure Systems
- Smart and Connected Communities
- Artificial Intelligence in Buildings

GRADUATE COURSE OFFERINGS

For your ready reference, the Building Science graduate courses are listed below. For a detailed description of these courses as well as other courses offered at the College of Engineering and at The University of Arizona, please consult the Graduate Catalog.

Temporary course
 ARCE 597A Human Building Interaction
 ARCE 597B Building Energy Modeling

FACILITIES

COMPUTERS:

Personal computers (e.g., laptops) are generally used for graduate research. The university also has a high-performance computer (HPC) system with clusters of nodes for students' use when needed for large scale system.

THERMAL CHAMBER:

A state-of-the art thermal chamber that can implement advanced control of building systems is available in 116 Civil Building for students.

LIBRARIES:

The University library system contains more than 5,000,000 items, including books, periodicals, microforms, maps, government publications, manuscripts and non-book media. The Science-Engineering library houses material on science and technology has over 360,000 volumes, over a million microforms and displays current issues of 4,500-plus periodicals. The library offers reference service; on-line searching of computerized databases and bibliographic course-related instruction.

FACULTY

CIVIL AND ARCHITECTURAL ENGINEERING AND MECHANICS

WOORYOUNG JUNG

(Ph.D., Virginia Polytechnic Institute and State University) Assistant Professor—Human Building Interaction, Occupant Comfort/Health/Performance, Cyber-Physical Systems, Indoor Environmental Quality, Grid-Interactive Effective Buildings, Smart and Connected Communities.

LIANG ZHANG

(Ph.D., Drexel University) Assistant Professor—Artificial Intelligence in Building Control, Trans-Scalar Building Energy Modeling, Smart and Connected Communities, Fault Detection and Diagnostics.

RONALD DOUGLAS STINGELIN

(M.S., Penn State University) Professor of Practice – Decarbonization.

GRADUATE STUDY AND RESEARCH IN CONSTRUCTION MANAGEMENT

INTRODUCTION

The Construction Management program in CAEM offers excellent opportunities for advanced studies and research in a wide range of construction management. The program is flexible and can be developed to fit individual interests, addressing the most recent developments in construction management. A program of your choice can be developed to suit your needs, emphasizing from a purely professional to a highly research-oriented program of study. Possible areas of study within the construction management program may include analysis of advanced project management methods, smart/artificial intelligence (AI)-driven construction, smart safety, and many similar areas emphasizing both the theoretical and the practical aspects of construction management.

The program leads to the degrees of Master of Science with thesis, report and non-thesis options, Master of Engineering, and Doctor of Philosophy in Civil Engineering. Students can select courses from a wide variety offered by CAEM. They are also encouraged to take courses, after discussions with their advisor(s), offered in other departments such as Aerospace and Mechanical Engineering, Electrical and Computer Engineering, Statistics, Systems and Industrial Engineering, or any other interdisciplinary programs available at The University of Arizona.

LIST OF RESEARCH TOPICS

The faculty in the Construction Management program at CAEM is actively involved in a wide variety of research areas, often with interdisciplinary interests from The faculty and their current research interests are listed below. Both research assistantships and teaching assistantships are available to qualified prospective students. Prospective students are encouraged to contact the faculty of their choice and explore all possibilities.

- Alternative Project Delivery
- Smart/AI-driven Construction
- Smart Safety in Construction
- Sustainable Infrastructure

GRADUATE COURSE OFFERINGS

For your ready reference, the Construction Management graduate courses are listed below. For a detailed description of these courses as well as other courses offered at the College of Engineering and at The University of Arizona, please consult the Graduate Catalog.

CE 582 Construction Project Planning, Scheduling, and Control
 CE 583 Construction Cost Estimating
 CE 585 Construction Equipment and Methods

FACILITIES

COMPUTERS:

Personal computers (e.g., laptops) are generally used for graduate research. The university also has a high-performance computer (HPC) system with clusters of nodes for students' use when needed for large scale system.

LIBRARIES:

The University library system contains more than 5,000,000 items, including books, periodicals, microforms, maps, government publications, manuscripts and non-book media. The Science-Engineering library houses material on science and technology has over 360,000 volumes, over a million microforms and displays current issues of 4,500-plus periodicals. The library offers reference service; on-line searching of computerized databases and bibliographic course-related instruction.

FACULTY

CIVIL AND ARCHITECTURAL ENGINEERING AND MECHANICS

DEAN PAPAJOHN

(Ph.D.,) Professor of Practice - alternative project delivery, sustainable infrastructure, and construction safety.

WOORYOUNG JUNG

(Ph.D., Virginia Polytechnic Institute and State University) Assistant Professor— Smart Construction, Construction Safety.

APPENDIX 2

MINIMUM COURSE REQUIREMENTS FOR GRADUATE ADMISSIONS

The following guidelines should constitute the minimum requirements for non-civil engineering undergraduates for admission to the graduate program in CAEM. An applicant can show the student's proficiency in any of the following requirements by taking the corresponding courses.

ENGINEERING MECHANICS

Students with a bachelor's degree in any engineering discipline, physics, or mathematics can apply for graduate admission.

GEOMECHANICS/GEOTECHNICAL

Ordinarily, the student will be expected to take basic courses in soil mechanics and laboratory procedures (University of Arizona courses CE 343 and CE 349), and structural analysis (CE 333) and fluid mechanics (CE 218). Additionally, the civil engineering basic and pre/co requisites for these courses should be met.

HIGHWAYS AND TRANSPORTATION

Incoming graduate students in highways and transportation are expected to have the ability to understand and apply engineering principles in the following subject areas: Probability and statistics (CE 310 or SIE 305), Engineering economics (ENGR 211P or SIE 265), Numerical methods or mathematical models (CE 303 or SIE 270), and Transportation engineering and pavement design (CE 363).

HYDRAULICS AND WATER RESOURCES

The prerequisite requirements for an advanced degree in the Hydraulics area are courses covering the following material. University of Arizona equivalent course is shown in parentheses.

Topics

Fluid Mechanics: hydrostatics, conservation laws (mass, momentum and energy) differential and control volume forms, boundary layer theory, friction in pipes (CE 218).

Applied hydraulics: Open-channel flow, natural streams and waterways, hydrologic analysis, fluid measurement apparatus, hydraulic models, economic aspects of water resources (CE 323).

Soil Mechanics: Physical and mechanical properties of soils, shear strength, consolidation, settlement, lateral earth pressures, and bearing capacity (CE 343).

STRUCTURES

Ordinarily, the student will be expected to take basic analysis courses (University of Arizona course CE 333) and design courses (CE 334 or CE 335), and should have a basic understanding in soil mechanics (CE 343). Additionally, the civil engineering basic and pre/co requisites for these courses should be met.

APPENDIX 3

ADVISOR SELECTION FORM

ADVISOR SELECTION FORM

DEPARTMENT OF CIVIL AND ARCHITECTURAL ENGINEERING AND MECHANICS

After consultation with faculty in my area, Dr. _____
and I have agreed that the student will serve as my faculty advisor for my
Master's/Ph.D. program.

Student Name _____

Student I.D. # _____

Student Signature _____ Date _____

Faculty Advisor Signature _____ Date _____

Department Head Signature _____ Date _____

APPENDIX 4

A CHECKLIST FOR COMPLETING THE STEPS IN M.S. DEGREE

Semester 1		
Week 1	Submit Responsible Conduct of Research form in GradPath. Review Graduate College policies. Review CAEM Graduate Student Handbook.	<input type="checkbox"/>
	Read "mentoring"	<input type="checkbox"/>
	Choose your advisor	<input type="checkbox"/>
Semester 2		
	Submit the PLAN OF STUDY on the GradPath in UAccess	<input type="checkbox"/>
Semester 3 – no benchmarks in semester 3 unless you have missed some in earlier semesters!		
Semester 4		
Weeks 1-5	Submit Master's Committee Appointment Form in GradPath	<input type="checkbox"/>
	Review defense procedures from Grad College with faculty advisor.	<input type="checkbox"/>
2-4 weeks before defense	Determine thesis defense date with Master's thesis committee, and start to complete the approval forms - https://grad.arizona.edu/gsas/dissertations-theses/sample-pages	<input type="checkbox"/>
	Submit your thesis/report to your committee for approval and format review	<input type="checkbox"/>
	Schedule the final defense of your thesis/report with your committee	<input type="checkbox"/>
Day of Defense	Make sure all members of Master's defense committee have the evaluation rubric before beginning defense.	<input type="checkbox"/>
Prior to final Graduate College approved submission date for term completion	Complete and acquire approval of any requested committee revisions to thesis. Note that pursuant to Graduate College rules, students have 1 year from defense date to complete any required changes and submit to the Graduate College. However, students must register for at least 1 unit each fall and spring semester during that time.	<input type="checkbox"/>
	Complete and submit Distribution Rights Form to Graduate coordinator.	<input type="checkbox"/>

	Submit completed thesis electronically to Graduate College. Formatting and other instructions are here . Students who miss the deadline for submitting the thesis to the Graduate College must register for at least 1 unit for the following semester and update their completion term. So do not miss the deadline!	<input type="checkbox"/>
	One hardcopy and a thumbdrive of thesis/report submitted to the Department of Civil and Architectural Engineering and Mechanics Office	
After thesis submission but before graduation	Complete any revisions requested by Graduate College (usually minor formatting corrections).	<input type="checkbox"/>
	Make sure faculty advisor informs graduate coordinator that all requirements for MS Thesis have been met so they can request completion in GradPath.	<input type="checkbox"/>
	Turn in any (ALL) keys to Key Desk Clean out desk	<input type="checkbox"/>

**When you can check off every box above, then CONGRATULATIONS!
You've done it!**

APPENDIX 5

CHECKLIST FOR COMPLETING THE STEPS IN M.E. DEGREE

Semester 1		
Week 1	Submit Responsible Conduct of Research form in GradPath. Review Graduate College policies. Review CAEM Graduate Student Handbook.	<input type="checkbox"/>
	Read "mentoring"	<input type="checkbox"/>
	Choose your advisor	<input type="checkbox"/>
Semester 2		
	Submit the PLAN OF STUDY on the GradPath in UAccess	<input type="checkbox"/>
Semester 3 – no benchmarks in semester 3 unless you have missed some in earlier semesters!		
Semester 4		
	Department submits the Completion of Degree Requirements Form	<input type="checkbox"/>
	Turn in any (ALL) keys to Key Desk Clean out desk	<input type="checkbox"/>

When you can check off every box above, then **CONGRATULATIONS!**
You've done it!

APPENDIX 6

CHECKLIST FOR COMPLETING THE STEPS IN PH.D. DEGREE

Semester 1		
Week 1	Submit Responsible Conduct of Research form in GradPath. Review Graduate College policies. Review CAEM Graduate Student Handbook.	<input type="checkbox"/>
	If faculty advisor and research group not determined before start of the semester, meet w/ CHEE faculty to determine research project and advisor - complete Appendix 2	<input type="checkbox"/>
	Meet with your advisor and establish your plan of study (submit transfer credit document if necessary)	<input type="checkbox"/>
Semester 2		
	Qualifying Examination- Beginning of Spring semester	<input type="checkbox"/>
Semester 3		
	Select your committee. Submit Comp Exam Committee Appointment form in GradPath.	<input type="checkbox"/>
	Submit the finalized Plan of Study to the gradpath	<input type="checkbox"/>
	Complete Comprehensive Examination- At least SIX MONTHS prior to Oral Defense	<input type="checkbox"/>
4 weeks before exam	Submit final draft of the dissertation to your committee for approval and for format review.	<input type="checkbox"/>
3 weeks before exam	Submit the Announcement of Final Oral Exam to the Graduate College in UAccess GradPath.	<input type="checkbox"/>
Semester 4		
	Submit Doctoral Dissertation Committee Appointment Form in GradPath immediately after passing Comp Exam.	<input type="checkbox"/>
Semesters 5-7 – no benchmarks in semester 3 unless you have missed some in earlier semesters!		
Semester 8		
Weeks 1-5	Review defense procedures from Grad College with faculty advisor.	<input type="checkbox"/>
2-4 weeks before defense	Determine dissertation defense date with Dissertation committee, and submit a copy of the signed approval page to the graduate program coordinator for departmental archiving after the defense is completed.	<input type="checkbox"/>
	Submit Announcement of Final Oral Defense in GradPath	<input type="checkbox"/>

	Submit dissertation drafts and finals electronically to Dissertation Defense Committee Chair/faculty advisor and all committee members for review.	<input type="checkbox"/>
	Provide evaluation rubric to each member of Dissertation Defense Committee. Committee chair will return all completed rubrics to graduate coordinator for filing with the department after successful dissertation defense.	<input type="checkbox"/>
Day of defense	Make sure all members of defense committee have the evaluation rubric before beginning defense.	<input type="checkbox"/>
Prior to final Graduate College approved submission date for term completion	Complete and acquire approval of any requested committee revisions to dissertation. Note that pursuant to Graduate College rules, students have 1 year from their defense date to complete any required changes and submit to the Graduate College. However, these students will need to register for at least 1 unit each fall and spring semester during that time.	<input type="checkbox"/>
	Submit completed dissertation electronically to Graduate College. Formatting and other instructions are here . If a student misses the deadline for submitting the dissertation to the Graduate College, the student must register for at least 1 unit for the following semester and update their completion term. So do not miss the deadline!	<input type="checkbox"/>
	Complete and submit Distribution Rights Form	<input type="checkbox"/>
	Complete any revisions requested by Graduate College (usually minor formatting corrections)	<input type="checkbox"/>
	Submit electronic copy of the dissertation to the University of Arizona Campus Repository at https://grad.arizona.edu/gsas/dissertations-theses/dissertation-and-thesis-formatting-guides . See published deadlines in your department or on the Graduate College website: http://grad.arizona.edu/Current_Students/Deadlines/	<input type="checkbox"/>
	One hardcopy and one thumb drive of dissertation submitted to the Department of Civil and Architectural Engineering and Mechanics Office	<input type="checkbox"/>
After dissertation submission but before graduation	Turn in any (ALL) keys to Key Desk Clean out desk	<input type="checkbox"/>

When you can check off every box above, then CONGRATULATIONS!
You've done it!

APPENDIX 7
GRADUATE STUDENT DEPARTMENT PETITION

Date:

Student Name:

Student ID Number:

Phone:

Email:

Degree Program:

Request:

Reason for Request:

APPROVED: DENIED:

Approval Signature (Grad Studies or Department Chair): _____

Grad Studies or Department Chair comments:

APPENDIX 8

CAEM PhD Program Assessment

Student Name: _____ Date: _____

Name of Committee Member: _____

Type of Meeting: Oral comp. exam: Proposal Defense Final defense

Directions: Evaluate this student's written material (research proposal, written exam responses, or dissertation) and oral presentation with a score between 1 and 5 for each of the criteria described below. Turn in your completed rubric to the committee chair before leaving the oral comprehensive exam or the final defense.

1: Needs Improvement; 5: Excellent

The critical review/analysis of literature in his/her area of research is performed	○ 1	○ 2	○ 3	○ 4	○ 5
The student formulate and conduct an in-depth original research problem (with preliminary or completed results)	○ 1	○ 2	○ 3	○ 4	○ 5
The material (proposal, dissertation) is well written	○ 1	○ 2	○ 3	○ 4	○ 5
Student's responses to oral exam questions is well-thought-out, and demonstrates sufficient knowledge in the field and critical thinking skills	○ 1	○ 2	○ 3	○ 4	○ 5
The student communicates his/her ideas and results effectively during the oral presentation	○ 1	○ 2	○ 3	○ 4	○ 5

I.4. Graduate Student Learning Outcome Assessments (PhD Program)

I.4.a. Expected Learning Outcomes

By completion of the PhD program in Civil Engineering and Engineering Mechanics, a student will:

- (Outcome 1) acquire CEEM fundamental knowledge
- (Outcome 2) develop skills in critical review/analysis of literature in his/her area of research
- (Outcome 3) conduct an in-depth original research
- (Outcome 4) effectively communicate ideas and results

I.4.b. Assessment Activities

The CEEM PhD program requires a student to pass a written qualifying exam on CEEM fundamental knowledge, topic and specialty areas to continue PhD program. An oral comprehensive exam based on coursework and the student's proposal for research, a written dissertation, two submitted journal publications, and a defense of the dissertation are required to complete the PhD degree. These assessment activities are used together with an exit survey to gather program level assessment data.

Assessment Activities	Outcome 1: CEEM fundamental knowledge	Outcome 2: Critical review/analysis of literature	Outcome 3: Conduct in-depth original research	Outcome 4: Effectively communicate ideas and results
Complete course work				
Graduate seminar				
PhD qualifying exam				
Comprehensive Exam: proposal defense				
Dissertation				
Dissertation oral defense				
Journal article requirement: at least two papers submitted with advisor				
Exit survey				



CAEM BALLOT

FOR PhD **FINAL** DEFENSE FOR –

- Procedures** Minimum time for the Oral Examination is 1 hour and maximum time is 3 hours. All examiners must be present for the entire Oral Examination.
- Prior to the Oral Examination, and in the absence of the student, it is necessary to review the ground rules for the examination and establish procedures to be followed. The Policies and Procedures for Oral Examinations for Phd Candidacy should be distributed at this time. This document summarizes governing policies and procedures. The chair for the examination is identified and the general structure and conduct of the examination is discussed
- Evaluation of Performance** Full discussion of student's performance is important before casting ballots.
- Voting** There is only one official vote, by secret ballot. Straw ballots may be taken and are encouraged when consensus regarding performance is questionable. All committee members must vote pass or fail. Two negative votes are necessary and sufficient for failure. An Abstaining vote counts as a negative vote. A committee member tallies the votes and informs the committee and the student of a pass or fail vote. *Vote numbers are not revealed*
- Reexamination Recommendation** In the event of a first failure, the examining committee must indicate their recommendation regarding a reexamination on the *'Results of the Oral Examination'* form. A second failure is not eligible for reexamination.

Comments from voting committee:

___ *Impressive job. No further comments.*

___ *Additional Comments:*

Circle only one: Pass Fail Abstain