Via Department of Civil & Environmental Engineering

TRANSPORTATION INFRASTRUCTURE AND SYSTEMS ENGINEERING (TISE)

INFORMATION, DEGREE REQUIREMENTS, AND ADVISING MANUAL

2023

(applies to all students who do not have a signed Plan of Study as of Fall, 2023)

COLLEGE OF ENGINEERING
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

TABLE OF CONTENTS

PREFACE

This handbook is designed to assist graduate students and faculty in the Transportation Infrastructure and Systems Engineering Program. It contains the following types of information:

- General information about the TISE program, key personnel and faculty in the Charles E. Via Department of Civil and Environmental Engineering (CEE) and the Transportation Infrastructure and Systems Engineering (TISE) Program;
- Degree requirements, advising procedures, and Program requirements.

If questions remain after reading this handbook, please see your advisor or any transportation engineering faculty member. Additional information can be found on the CEE Web Site at http://www.cee.vt.edu/.

1. GENERAL INFORMATION

The Transportation Infrastructure and Systems Engineering Program is a graduate program within the Charles E. Via, Jr. Department of Civil and Environmental Engineering (CEE) and provides educational and research opportunities primarily in Blacksburg.

Two degrees, offered and administered by the CEE Department, may be pursued by eligible TISE students: Master of Science in Civil Engineering (MSCE), and Doctorate in Civil Engineering (PhD). Specific requirements for each degree are described in later sections of this manual, the Graduate Policies and Procedures Manual, the Virginia Tech Course Catalog, and in the Civil and Environmental Engineering Graduate Handbook. A third degree at the master's level, the Master of Engineering, is available to students interested in broadening their general knowledge of Civil Engineering rather than specialize in a single area. More information on this option is available in the CEE Departmental Graduate Policies and Procedures Manual.

1.1. Mission

The mission of the TISE program is to: (1) provide high quality education in one of many fields within transportation engineering; (2) create an inclusive environment for students to learn transportation engineering and systems concepts; (3) to develop critical thinking; (4) advance knowledge about transportation infrastructure and systems that sustains Virginia Tech's leadership in research and technology development; and (5) conduct outreach and service activities to disseminate knowledge and actualize positive and practical transportation changes.

The curriculum of the TISE Program has been developed to enable students to plan, design, construct, maintain, rehabilitate, manage, operate, and predict service life of transportation infrastructure and systems. In addition, courses are designed to allow students to master the analytical, experimental, and problem-solving skills needed to excel in their professional careers. We provide a dynamic program that adapts to the current and future needs of a profession that is rapidly changing. Focus areas include but are not limited to pavement design; civil engineering materials; transportation infrastructure assessment, maintenance, and management; traffic operations and engineering; transportation planning; safety and human factors; goods movement; and public and air transportation as fields of study and research.

The TISE Program recognizes the need for engineering planning, design, evaluation, and renewable engineering. Therefore, the program provides a balance between these areas and allows students to design individual course curricula to meet their unique interests. Graduate study within TISE is built on student objectives and mutual agreement between each student and faculty advisor. Specific guidelines are provided later in this document.

1.2. CEE Personnel

The Via Department of Civil and Environmental Engineering offices are located on the second floor of Patton Hall in suites 200 and 211. During their time at Virginia Tech, students may interact with the following individuals:

The Department Head of Civil and Environmental Engineering, 200 Patton Hall, (540) 231-6635
Ms. Sarah Martin, Graduate Student Coordinator, 211-D Patton Hall (540) 231-6069, shmartin@vt.edu
Ms. Sydney Hollandsworth, TISE Program Support, 221C Patton Hall (540) 231-6635, sidneyh4@vt.edu

1.3. Transportation Engineering Faculty

Faculty in the TISE Program include:

Montasir Abbas, PE, Professor, PhD Purdue University, abbas@vt.edu. Dr. Abbas' research interests include traffic management and control, traffic flow theory, ITS, agent-based modeling and simulation, traffic safety, artificial intelligence, and systems optimization.

Alexander Brand, PE, Assistant Professor, PhD University of Illinois Urbana-Champaign, asbrand@vt.edu. Dr. Brand's research interests include materials science of civil infrastructure materials advanced characterization techniques to study the micro- and nanostructure development in cementitious materials, use of recycled and by-product materials in concrete, concrete pavement engineering, and fiber-reinforced concrete.

Gerardo Flintsch, PE, Professor, PhD Arizona State University, flintsch@vt.edu. Dr. Flintsch's research interests include infrastructure condition assessment and performance prediction; pavement evaluation, design and management; application of soft computing, geographic information systems and other emerging technologies to support infrastructure data management, analysis and decision-making; non-destructive evaluation; and life-cycle-cost analysis.

Kathleen Hancock, PE, Associate Professor, PhD Vanderbilt University, hancockk@vt.edu. Dr. Hancock's research interests include freight operations and planning, highway safety, and geospatially enabled decision making for transportation.

Md. Sami Hasnine, Assistant Professor, PhD University of Toronto, hasnine@vt.edu. Dr. Hasnine's research interests include passenger and freight travel demand modeling, econometrics, machine-learning, Connected Automated Vehicles, transportation decision making.

Susan Hotle, Associate Professor, PhD Georgia Institute of Technology, shotle3@vt.edu. Dr. Hotle's research interests include travel demand modeling, aviation economics and operational analysis, and benchmarking.

Bryan Katz, PE, Associate Professor of Practice, PhD Virginia Polytechnic Institute and State University, bkatz@vt.edu. His research interests include Traffic Engineering, Transportation Safety, Traffic Control Devices, and Transportation Human Factors

Hesham Rakha, PEng, Professor and Director for Sustainable Mobility VTTI, PhD Queens University, hrakha@vt.edu. His research interests include traffic flow theory and control, traffic modeling, dynamic traffic assignment, optimization, Intelligent Transportation Systems, environmental modeling, and safety modeling.

Antonio Trani, Professor, PhD Virginia Tech, vuela@vt.edu. His research interests include air transportation, simulation and modeling, airport engineering, systems engineering, infrastructure systems.

Adjunct faculty include:

Scott Himes, PhD, PE, Highway Safety Engineer, VHB, himes@vt.edu.

1.4. Professional Organizations

Several professional organizations are available to transportation engineering students and all graduate students are encouraged to become involved. The reduced cost of student memberships to most organizations provide students with an excellent opportunity to join these professional societies or to subscribe to their journals. Two active student chapters within the Department of Civil and Environmental Engineering of interest to transportation graduate students include:

- *INSTITUTE OF TRANSPORTATION ENGINEERS (ITE)* – a global professional organization for transportation professionals with the knowledge, practices, skill and connections to serve the needs of their communities. ITE publishes the ITE Journal and other books and periodicals. (http://www.ite.org).

- *AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)* – includes the Transportation and Development Institute (T&DI) which has a number of technical committees and the Aerospace Division. ASCE publishes the Civil Engineering Magazine and Transportation Engineering Journal. Information about the Virginia Tech student chapter can be found at http://www.asce.cee.vt.edu/.

There are also many other organizations or societies that students may find beneficial and can be found on the University web page at http://www.vt.edu/student_life/.

2. DEGREE REQUIREMENTS

2.1. Overview

The material in this document is provided for the information and guidance of graduate students in the Transportation Infrastructure and Systems Engineering (TISE) program and their faculty advisors and committee members. Regulations governing the degrees come from three levels: the Virginia Tech Graduate School, the Department of Civil and Environmental Engineering, and the Transportation Infrastructure and Systems Engineering (TISE) Program. Faculty advisors assist students in planning their graduate degree programs. **However, ultimate responsibility lies with the student**.

Students should be familiar with the following information:

- The University-level Graduate Policies and Procedures and Course Catalog: http://graduateschool.vt.edu/graduate_catalog/
- **The CEE Departmental Graduate Policies and Procedures Manual: https://cee.vt.edu/content/dam/cee_vt_edu/files/Graduate-Policies-and-Procedures-Manual-Departmental.pdf**.

These provide information about Graduate School regulations, registration, due dates, thesis and dissertation requirements, etc. and about Departmental and University requirements.

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Additional information about the CEE graduate program is available at https://cee.vt.edu/Graduate-menu/graduate_students.html. Links to forms and VT graduate student systems referenced in this handbook can be found at https://cee.vt.edu/Graduate-menu/current_G_students.html under Graduate Information and Forms.

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Information in this document is intended to reinforce and supplement requirements from the other sources, not to replace those requirements.

2.1.1. Admission Requirements

Admission is contingent on meeting all requirements as specified by the graduate school and in the CEE Departmental Graduate Policies and Procedures Manual. Applicants must have either received an earned Bachelor of Science degree in civil engineering or a closely related field, or demonstrate competency in the field through completion of undergraduate courses identified in Appendix A and/or documented and approved professional experience.[1] Applicants without a civil engineering baccalaureate must make up coursework at the basic level of undergraduate engineering as identified in Appendix A to be accepted into the TISE graduate program. No graduate credit is granted for this basic level.

[1] Students who anticipate applying their graduate degree toward professional engineering (PE) registration requirements must have an earned Bachelor of Science degree from an accredited undergraduate civil engineering program.

Recommended minimum scores for acceptance to the TISE graduate program are:

- **GPA**
  Undergraduate: 3.0 or equivalent
  Graduate: 3.5 or equivalent
- **English Proficiency**
  International applicants who have earned, or will earn within 6 months, a baccalaureate or master's degree from a higher education institution that does not use English as the language of instruction will be required to show proof of English language competency through one of the following:
  TOEFL: at least 90 iBT with 20 or better in each subsection; OR
  IELTS: at least 6.5
- **GRE**: The GRE is recommended but not required for applicants seeking admission.

Allowed exceptions to the above requirements are documented in Section 2.1 of the CEE Departmental Graduate Policies and Procedures Manual. See section 2.2 for additional admission requirements for application to the master's programs and section 2.3 for additional admission requirements for application to the doctoral program.

The TISE program does not waive or subsidize the graduate application fee.

2.1.2. Acceptance Process

Review of applications occurs continuously through the year and is initiated when an application has been identified as Complete by the VT Graduate School. Results of this review are provided to applicants through the Graduate School.

Master of Science Degree: Applications are reviewed by the TISE graduate coordinator and recommendations are submitted to the Graduate School. Accepted applications are then reviewed by TISE faculty for consideration for individual research teams. Interested faculty members contact accepted applicants directly by email for additional information about joining a research team. All other accepted MS students begin their program as a general TISE student.

PhD Degree: Applications are reviewed by the TISE graduate coordinator and those that meet the TISE acceptance requirements are forwarded to TISE faculty members for consideration for specific research teams. Interested faculty members contact applicants directly by email prior to any decision about acceptance. The faculty member then forwards a recommendation to the TISE graduate coordinator and the recommendation is submitted to the Graduate School. PhD applicants are only accepted into the PhD program with the endorsement of a TISE faculty member.

Additional considerations:

- Applicants with non-civil engineering undergraduate degrees are advised, at the time of acceptance, of any undergraduate coursework that must be fulfilled as part of the graduate program.
- Applicants that meet all of the requirements except the English Proficiency requirement may be notified that they can be considered for admission through the Advantage VT-Master's Pathway Program (AVT-M). For more information, see https://lci.vt.edu/Programs/AdvantageVTM.html.
- Applicants who have not completed or will not complete a master's degree prior to the beginning of the application semester will be considered for acceptance to the Masters of Science Degree regardless of requested degree.

2.1.3. Curriculum

Table 1 summarizes the courses that are offered as part of the TISE graduate curriculum, while Appendix B provides more detailed descriptions of transportation courses. All new students must take both seminar courses listed in Section A and a minimum of 50% (typically 4 courses) of required course credits from the courses listed under Section B. The remaining required course credits can come from

Section C or other program areas and/or departments (*i.e.* Statistics, Industrial Engineering, Engineering Mechanics, Materials Engineering, Electrical Engineering, Computer Science, *etc.*) based on individual student's research/project interests and in consultation with their advisor.

Table 1. Transportation Engineering Courses

A. Required Courses			
CEE 5944	Transportation Seminar (Fall)	CEE 5944	Transportation Seminar (Spring)
B. TISE Courses			
Transportation Infrastructure Courses		Transportation Systems Courses	
CEE 4614* **	Concrete Materials	CEE 4604*	Traffic Engineering
CEE 4634* **	Infrastructure Health Assessment	CEE 4654*	Geometric Design of Highways
CEE 4664*	Pavement Design	CEE 4624* **	Planning Transportation Facilities
CEE 5664**	Advanced Concrete Materials	CEE 4674*	Airport Planning and Design
CEE 5674	Advanced Pavement Design	CEE 4684*	Transportation Safety
CEE 5684**	Advanced Infrastructure Health Assessment	CEE 5600	Analysis of Civil Infrastructure Systems
CEE 5754	Pavement & Bridge Infrastructure Mgmt. Systems	CEE 5604	Traffic Characteristics and Flow
CEE 5764	Asphalt Technology	CEE 5614	Analysis of Air Transportation Systems
		CEE 5624**	Transportation and Land Use
		CEE 5634	Analysis & Planning of Mass Transit Systems
		CEE 5640	Highway Transportation Safety
		CEE 5650	Freight Operations and Planning
		CEE 5654	Critical Issues in Transportation
		CEE 5694	Traffic Signal System Operation and Control
C. Recommended Electives			
CEE 5484	Concrete Microstructure	CEE 5204	GIS Applications in CEE
MSE 5124	Design of Experiments	STAT 5615/16	Statistics in Research
CEE 5440	Instrumentation and Signal Processing	CS 5525	Data Analytics
		STAT 5434	Applied Stochastic Processes

** Only **two** 4000-level courses can count toward a graduate degree.*
***Courses are offered concurrently at the 4000- and 5000-levels. Credit is only awarded for one of these courses.*

2.2. Master of Science Degree

2.2.1. Master of Science Program Requirements

Student entering the MS program as part of a research team will be assigned that faculty member as their academic advisor. Students entering the general TISE program will be assigned a temporary academic advisor. During the first semester of the program, these students are encouraged to select a permanent advisor based on a mutual agreement between student and faculty member.

During their MS career, students must meet the following degree requirements:

- Maintain a grade point average of 3.0 or above to remain a degree candidate.
- Satisfy the associated research/technical skills requirement (final exam).
- Satisfy the communication skills requirement.

2.2.2. Master of Science Options

Two options are available for pursuing the Master of Science degree: the thesis option for students that are supported by research projects and/or teaching assistantships, and the non-thesis option for part-time

students or students pursuing a terminal masters for the purpose of expanding professional expertise within the transportation field. In addition to the information provided below, all graduate students are required to complete the departmental Academic Ethics and Diversity and Inclusion Requirements.

Thesis Option. Students are required to successfully complete a total of 32 credit hours as follows: a minimum of 21 credit hours of course work, two credit hours of seminar, and six to nine credit hours of CEE 5994 "Research and Thesis". To satisfy the Research and Thesis requirement, students are required to conduct work involving researching a particular subject in depth to produce findings which are not readily apparent at the commencement of the work. Upon completion of the proposed work, the student prepares a written thesis, which can be in the traditional format or the manuscript format (refer to the VT graduate catalogue for details). The thesis is a complete document that describes the student's work. A draft of the thesis is submitted to the Advisory committee at least two weeks prior to the oral thesis defense. The draft is reviewed and approved by the major advisor prior to distribution to the advisory committee. The student then defends the thesis during the oral presentation and defense. The thesis is modified based on comments from the defense and the final thesis is approved by the advisory committee and submitted electronically by the student to the Graduate School.

Non-Thesis Option. Students are required to successfully complete a minimum of 32 credit hours, of which, 2 credits are seminar credits and up to 6 credit hours can be CEE 5904 Project and Report. A presentation and defense of the project and report will be made to complete the requirements for CEE 5904. If the student opts for completing 32 credits of course work only, an oral examination will be administered to complete the requirements for graduation.

2.2.3. Course Requirements

A total of 32 graduate credit-hours must be completed to satisfy the M.S. degree requirement. A maximum of 6 credit hours of 4000-level courses approved for graduate credit can count toward this requirement. A minimum of 50% of course credit hours must come from approved transportation engineering courses (table 1). Two credit hours of seminar are required.

The two 1-credit seminars (CEE 5944) focus on (1) computational tools used in the remainder of the student's graduate career and (2) transportation professional practice and should be taken as soon as possible. One is offered in the fall and one is offered in the spring. The content is different and, although they can be taken in any order, both seminars must be completed, *i.e*. students cannot take two computational tools seminars or two professional practice seminars to meet this requirement.

2.2.4. MS Degree Committee

Prior to the completion of 15 credit hours of coursework, a chairperson and an M.S. committee (chosen by the student with the agreement of the chairperson) will be recommended by the Department to the Graduate School as part of the plan of study. The academic advisor will become the chairperson of the M.S. committee and shall, along with the committee, provide overall guidance for the candidate's M.S. program. The M.S. committee shall consist of two or more members of the Virginia Tech Graduate Faculty. The majority of the committee must be in the TISE program.

2.2.5. Plan of Study

In the second semester and/or prior to completion of 15 credit hours of coursework, the student, in conjunction with the M.S. committee advisor, will formulate a Plan of Study. The plan shall reflect the student's probable area of research or professional expertise and the coursework needed to accomplish the degree. Any subsequent revisions to the program of study shall be approved by the M.S. committee and Department representative using the Plan of Study Change Form. The final Plan of Study must reflect the actual program of study completed by the student.

2.2.6. Progress Reports

A written annual progress report is required of all graduate students at the end of each spring semester unless the student is graduating. Each student will electronically submit a one-page report (instructions are emailed to the graduate student listserv each year) to their advisor/committee which summarizes coursework and research activities, achievements over the past 12 months or from their date of admission (if in their first year), and plans for future progress.

The advisor reviews the report and determines whether or not progress was judged to be satisfactory. If the student's performance is deemed unsatisfactory, the reasons should be described in a memo that is appended to the report. This memo should describe the specific performance concerns and provide a required plan for remedial actions required of the student, a timeline for the next review of performance, and a description of repercussions up to and including dismissal from the Master's program if expectations are not met prior to the next performance review. A copy should be given to the student, who should be allowed to respond to the committee.

2.2.7. Application for Degree

The Application for Degree must be submitted at the beginning of the final semester of a student's program after the final approved Plan of Study has been submitted.

2.2.8. Committee Meetings

Degree candidates are required to meet with their advisory committee at least three months prior to the final examination to ensure that the committee is aware of and can provide input to the student prior to the completion of their program. The student should provide a short summary of their research/project prior to this meeting. For coursework only students, this requirement is met by the committee approving the final Plan of Study.

2.2.9. Final Examination

The final examination shall be an oral defense of the Thesis, Project Report and/or Master's Degree curriculum depending on the student's type of degree. The thesis or project report, approved by the student's advisor, must be submitted to the committee members at least two weeks prior to the date of the examination. The candidate's graduate committee will conduct the examination in accordance with Graduate School requirements. The student must be registered when the examination is taken. The "Request to Admit Candidate to Final Exam" must be submitted online to the Graduate School at least two (2) weeks before the requested exam date.

2.3. PhD Degree

2.3.1. Degree Requirements

Once accepted, students must satisfy the following PhD degree requirements:

- Maintain a grade point average of 3.0 or above to remain a PhD student.
- Satisfy the residency requirement, which allows students to concentrate focused time on their scholarship. Refer to the Graduate School catalog under "Credit Hour Requirements for Degrees and Certificates" for exact requirements.
- Satisfy the research skills requirement.
- Satisfy the communication skills requirement.
- Successfully complete the **preliminary examination** prior to the dissertation proposal.
- Successfully prepare and present a proposal for dissertation research prior to the dissertation. This is equivalent to the **qualifying examination** in the Department Manual.
- Prepare and orally defend the **PhD dissertation**.

2.3.2. Credit Hour Requirements

A minimum of 90 post-baccalaureate credit-hours are required to satisfy the PhD degree requirement. The program must include at least 27 credit hours of 5000-level and higher coursework. A limit of 6 credits of 4000-level courses can be approved for graduate credit. In addition, all TISE students are required to take 2 one-credit-hour seminars (CEE 5944). The two 1-credit seminars focus on (1) computational tools used in the remainder of the student's graduate career and (2) transportation professional practice and should be taken as soon as possible. One is offered in the fall and one is offered in the spring. The content is different and, although they can be taken in any order, both must be completed, *i.e*. students cannot take two computational tools seminars or two professional practice seminars to meet this requirement. Between 30 and 63 hours of CEE 7994, Dissertation Research must be included in the program. The number of research and dissertation credits for which the student registers should reflect the time spent by the student on activities directly related to their research including analyzing data and writing the dissertation. The student is expected to maintain continuous registration throughout the program.

2.3.3. Competencies

Research Skills. Since the Doctoral degree is a research degree and students are expected to continue research activities after graduation, the student should demonstrate competence in research skills. Specific skills should be commensurate with the student's specialty area and career goals and should be identified jointly by the student and his/her Doctoral committee chairperson and dissertation advisor.

Communications Skills. The doctoral committee will evaluate the student's ability to use written and oral forms of the English Language appropriately for scientific research dissemination. International students may be required to take remedial courses in oral or written English.

2.3.4. Major Advisor and Advisory Committee

The faculty advisor who endorsed the student for acceptance to the program is assigned as the major advisor and will be the chairperson of the Advisory Committee. The major advisor is responsible for overseeing the dissertation work that will be completed as part of the doctoral program. The student and major advisor will establish the PhD Advisory Committee consisting of a minimum of four members of the graduate faculty, two of which must be full-time tenure or tenure-track CEE faculty members. The chairperson and the committee will provide overall guidance for the student's doctoral program. See the CEE Graduate Policies and Practices Manual for more details about make up of committees. Committee members are formalized with submission of the Plan of Study.

2.3.5. Plan of Study

After the establishment of the PhD Advisory Committee and before the completion of 15 credit hours beyond the MS degree at Virginia Tech, the student, in conjunction with the doctoral committee chairperson will prepare a Plan of Study. The course plan shall reflect the student's probable area of research and any coursework recommendations made by the doctoral committee. More detailed information about transfer credit, credit earned while completing a master's degree, required grades, and coursework over 5 years old is provided in the CEE Graduate Policies and Practices Manual.

The student shall meet with the Doctoral Committee as soon as practical to review the student's course plan and plan for satisfying the degree requirements. Any subsequent revisions to the program of study shall be approved by the Advisory Committee and Department representative using the Plan of Study Change Form. The final Plan of Study must reflect the actual courses and research hours completed by the student.

2.3.6. Progress Reports

A written annual progress report is required of PhD students at the end of each spring semester that the student is enrolled. Each student will electronically submit a one-page report (instructions are emailed to

the graduate student listserv each year) to their advisor/committee which summarizes coursework and research activities, achievements over the past 12 months or from their date of admission (if in their first year), and plans for future progress.

The major advisor reviews the report and determines whether or not progress was judged to be satisfactory. If the student's performance is deemed unsatisfactory, the reasons should be described in a memo that is appended to the report. This memo should describe the specific performance concerns and provide a required plan for remedial actions required of the student, a timeline for the next review of performance, and a description of repercussions up to and including dismissal from the PhD program if expectations are not met prior to the next performance review. A copy should be given to the student, who should be allowed to respond to the committee.

2.3.7. Preliminary Examination

The purpose of the examination is to evaluate the potential of the student to conduct independent scholarly research with technical proficiency. The student is expected to be competent in technical skills and be able to apply these skills to the analysis of complex engineering problems. The examination should specifically test the student's ability to (1) demonstrate proficiency in the student's research area of expertise, (2) identify and characterize a problem, (3) select proper analytical strategies, and (4) apply appropriate research methodologies. The areas of competence shall be determined by the chairperson of the Doctoral Committee and should be consistent with the student's planned dissertation research. The student has the right, and is so encouraged, to discuss the material upon which the student will be examined with individual committee members.

The preliminary examination is usually taken when the student is nearing completion of required coursework, and must be passed at least nine months before taking the final exam. The exam shall consist of both a written and an oral component. The oral component of the exam must be scheduled with the Graduate School at least two weeks prior to the exam date. The student must be registered at the time of the scheduled exam.

> ***Written Examination****:* Each committee member will prepare one or more questions covering a given area of competence. These will be forwarded to the chairperson who will establish the exam schedule and will distribute questions accordingly to the student. The written examination will be open-resource and shall be completed within seven consecutive days. Following the examination, the Chairperson will forward the student's responses to the respective committee members for evaluation. The committee members shall evaluate the student's response to their respective questions and report their evaluation to the chairperson prior to the oral examination. Additional information may be requested from the student by a committee member before the exam date.
>
> ***Oral Examination****:* The oral examination shall be conducted after completion of the written examination, preferably within the same semester. A two-hour examination period is recommended. The oral examination is a continuation of the written examination and allows the student to amplify and clarify written responses. However, questions will not necessarily be confined to the subject matter covered on the written examination.

Unsatisfactory Performance on Preliminary Examination: A vote by all members of the committee will determine satisfactory performance on both the oral and written parts of the preliminary examination. One negative vote is permitted on a preliminary examination. Unsatisfactory performance will result in one of the following:

- A requirement for additional coursework and/or reexamination. One full semester must lapse (a minimum of 15 weeks) before the administration of a second examination. The preliminary examination cannot be attempted more than twice.

- Dismissal from the PhD program. Appeals shall be submitted in writing to the Department representative who, together with the committee chairperson, shall render a decision regarding the student's continuation in the program.

2.3.8. Dissertation Proposal (qualifying exam)

For the TISE graduate program, the dissertation proposal is considered to be the qualifying exam and will be completed after successful completion of the preliminary exam. The purpose of this exam is to determine the feasibility and originality of the proposed research, to examine the student's familiarity with the literature and background materials involved, and to offer suggestions to the student regarding the proposed research. The proposal will consist of a written document and an oral presentation.

The student shall develop a formal written research proposal that independently details the proposed doctoral research. The proposal must be submitted to each member of the dissertation committee for review no later than two weeks before the oral presentation and defense. The proposal will be judged by the committee on its technical merit as well as the feasibility and originality of the proposed research.

Once accepted by the committee, a copy of the proposal, along with any corrections or additions requested by the committee, will become a permanent part of the candidate's record. Approval of the proposal, by vote of the entire committee, will be recorded using the CEE completion of the proposal exam form.

Upon successful completion of the dissertation proposal examination, the student officially becomes a candidate for the PhD Degree.

2.3.9. Dissertation Progress Reports

During the dissertation work, the advisory committee must be kept informed of the student's progress. This may be accomplished by committee meetings, by meetings of the student individually with members of the committee, or by written progress reports by the student to the committee. This notification of progress should be carried out at least every six (6) months after the dissertation proposal has been presented.

2.3.10. PhD Dissertation

The dissertation should be an original contribution to the literature in an area of Transportation Engineering. It should describe the execution and results of the research effort in detail. The format of the dissertation should be either in the traditional detailed written presentation or as a series of Journal Articles (see the Graduate School dissertation requirements).

Electronic dissertation submission should be completed within two weeks following the final defense. The student is responsible for obtaining the signatures of the advisory committee on the Electronic Submission Approval Form prior to submitting the final dissertation electronically to the Graduate School (http://etd.vt.edu/etdsubmn.html). A delay in the submission of the dissertation may cause a delay in awarding of the degree, and the student may incur fees for late submission.

2.3.11. PhD Final Exam: Dissertation Defense

The final examination shall be an oral defense of the candidate's doctoral dissertation. The draft dissertation must be vetted through iThenticate, reviewed, and approved by the major advisor prior to being submitted to and approved by the committee members. Major revisions to the dissertation should be completed before the oral examination. The dissertation should be in final draft form, with appropriate notes, references, bibliography, tables, etc., at the time of the oral examination; both the content and style should be correct and polished by the time this final draft is submitted to the committee.

This draft dissertation should then be submitted to the advisory committee *at least* two weeks prior to the date of the examination. The candidate's doctoral committee will conduct the examination in accordance with Graduate School requirements. The student must be registered when the examination is taken. **The electronic version of the "Request to Admit Candidate to Final Exam" must be submitted online to the Graduate School at least two (2) weeks before the requested exam date** (https://ess.graduateschool.vt.edu/pages/login.php**).**

The committee must approve the final exam through the online system within three (3) days of successful completion of the exam per Graduate School rules. It is the responsibility of the student to verify that committee members have approved the final exam in the electronic exam system.

Requirements for successful completion of the final examination are the same as for the preliminary examination. The student will have two opportunities to take the final exam. See the Graduate Catalog for more details.

Students who successfully defend their dissertation have two weeks to submit their electronic dissertation (ETD) to the Graduate School through the online final exam registration system.

APPENDIX A. Required Background Courses for Non-Civil Engineering Undergraduate Degrees

	CREDIT HRS	CONSTRUCT	EWR	GEOTECH	STRUCTURES	TISE
Chemistry 1074	3		X	X		
Chemistry Lab 1084	1		X	X		
Math 1205 (Calculus)	3	X	X	X	X	X
Math 1206 (Calculus)	3	X	X	X	X	X
Math 2224 (Calculus)	3	X	X	X	X	X
Math 2214 (Differential Equations)	3		X	X	X	X
Physics 2305	4	X	X	X	X	X
Physics 2306	4	X	X	X	X	
Geology 2104	3	X	X(3)	X		
ISE 2014 (Engineering Economics)	2	X	X		X	X
ESM 2104 (Statics)	3	X	X	X	X	X(1)
ESM 2204 (Deform. Bodies)	3	X	X(4)	X	X	
ESM 2304 (Dynamics)	3		X(4)			
CEE 2814 (CEE Measurements)	4				X	
CEE 3014 (Construction Mgmt)	3	X				
CEE 3104 (Environmental Engineering)	3	X(5)	X			
CEE 3304 (Fluid Mechanics)	3		X	X		
CEE 3314 (Water Resources)	3		X			
CEE 3404 (Theory of Structures)	3	X		X	X	X(1)
CEE 3424 (Reinforced Concrete)	3	X			X	X(1)
CEE 3434 (Steel Structures I)	3				X	
CEE 3514 (Soil Mechanics)	4	X	X(3)	X	X	X(1)
CEE 3604 (Transportation)	3					X
CEE 3684 (CEE Materials)	3	X		X	X	X(1)
CEE 3804 (Computer Applications)	3	X			X	X(2)
CEE 4554 (Hazards)	3	X(5)				
CEE 4804 (Professional & Legal Problems)	3	X				
CS 1044 or 1054 (Programming)	3		X			
STAT 4604 (Statistical Methods for Engr)	3		X			

(1) Required if the student is pursuing advanced knowledge in transportation infrastructure.
(2) Or demonstrated experience.
(3) EWR requires either GEOL 2104 or CEE 3514.
(4) EWR requires either ESM 2204 or 2304.
(5) Construction requires either CEE 3104 or 4554.

APPENDIX B. List of Transportation Courses

Courses with grey highlighting remain in the catalogue but are not scheduled for delivery by current faculty

Graduate Level Courses

5484: CONCRETE MICROSTRUCTURE

Modern cement production. Composition and hydration mechanisms of concrete and other cementitious composites. micro- and nanostructural development of fresh and hardened concrete. Effects of chemical admixtures, mineral fillers, and supplementary cementitious materials. Application of advanced characterization techniques to cement and concrete microstructure. Pre: Graduate Standing. (3H, 3C)

5600: CIVIL INFRASTRUCTURE SYSTEMS ANALYSIS

Systems analysis, modeling infrastructure systems by mathematical programming, measuring infrastructure systems performances, probabilistic analysis of infrastructure systems, multiple attribute decision making in infrastructure systems. Graduate standing in engineering required. (3H,3C).

5604: TRAFFIC CHARACTERISTICS & FLOW

Driver, vehicle, and roadway characteristics; stochastic modeling of traffic processes including queuing theory, headway distributions, and gap acceptance; stream flow characteristics including car-following and multilane traffic models, roadway capacity and bottleneck analysis, network operations, and fuel consumption models. Pre: 4604. (2H,3L,3C).

5614: ANALYSIS OF AIR TRANSPORTATION SYSTEMS

Planning, design and operation of aviation systems with computer aided design tools and computer simulation models. Airline airport operations and practices and their effect in airport planning and design. Air cargo facilities planning and modeling. State-of-the-art computer simulation models used in aviation environmental planning and airspace modeling. Graduate standing in CE required. (3H,3C).

5624: TRANSPORTATION & LAND USE

Interaction between transportation and land use variables, including modeling requirements, impacts, and data needs within the context of good community planning and economic development; elements of transportation and land use that shape the quality of life in urban areas. Pre: 3604. (3H,3C).

5634: ANALYSIS & PLANNING OF MASS TRANSIT SYSTEMS

An overview of mass transit systems; transit system planning including demand and cost analysis and evaluation; transit system design including route design, scheduling, and fare policy; transit networks and marketing; para transit systems; future trends in mass transit. Pre: 3604. (3H,3C).

5640: HIGHWAY TRANSPORTATION SAFETY

Emphasis is placed on identifying highway safety problems and the discussion of remedial solutions and countermeasures needed to eliminate highway crashes and the associated fatalities and injuries. The course addresses the history of highway safety, the remedial steps that have been taken to improve safety, current research, and the challenge remaining to eliminate all highway crashes. Pre: 4984. (3H, 3C).

5650: FREIGHT OPERATIONS AND PLANNING

Introduction to the operation of modal and intermodal freight facilities. Types of freight movement and handling equipment, freight planning methods, and research. Freight as a multi-modal

transportation system. Role of privately owned and operated freight movement on public sector transportation operations and decision making. Communication of impacts of freight movement. Pre: 3604. (3H, 3C).

5654: CRITICAL ISSUES IN TRANSPORTATION:
Technological, societal, economic, political, environmental, health and energy effects on planning, design, operation, and management of the transportation system. Problem identification, objectives identification, alternatives generation and evaluation, and reasoning process for transportation investment.

5664: ADVANCED CONCRETE MATERIALS
Fundamental properties of portland cement concretes. Concrete mixture design procedures. Testing of fresh and hardened properties of concrete. Durability and degradation mechanisms. Condition assessments, forensic materials engineering, and repair strategies. Pre: graduate standing. (3H, 3C)

5684: INFRASTRUCTURE HEALTH ASSESSMENT
Contact Dr. Flintsch for more information (3H,3C).

5754: PAVEMENT & BRIDGE INFRASTRUCTURE MANAGEMENT SYSTEMS
Management concepts used in civil infrastructure; planning, design, construction, maintenance, and rehabilitation of bridge and highway systems. Prioritization, optimization, and decision-making techniques. Life-cycle-cost prediction. Pre: 3684, 4664. (3H,3C).

5764: ASPHALT TECHNOLOGY
Origin, types and properties of bituminous materials and their use in civil engineering. Asphalt rheology. Theory behind technological processes and procedures for hot-mix asphalt including design philosophy, performance, and durability. Modern construction with bituminous materials; special mixtures, recycling, and additives. Pre: 4614. (2H,3L,3C).

5784: SUSTAINABLE TRANSPORTATION INFRASTRUCTURE
Advanced tools and approaches for supporting more sustainable transportation infrastructure investment decisions by balancing technical, economic, environmental, and social objectives. Selection of sustainable materials, systems and management approaches. Mitigation and adaptation to climate change. Cost and environmental life-cycle assessment methods and tools pertaining to transportation systems. (3H,3C).

Advanced Undergraduate Courses *(a maximum of two 4000-level courses can be applied to an advanced degree.)*

4604: TRAFFIC ENGINEERING
Study of traffic and parking characteristics; application of traffic control devices; principles and techniques used to improve the efficiency and safety of traffic flow systems. Pre: CEE 3604. (3H,3C).

4610: MECHANICS OF COMPOSITE MATERIALS
Properties and mechanics of fibrous, laminated composites. Classical lamination theory, micromechanics, stiffness and strength, fabrication and testing. Thermal stresses. Design, analysis, and computerized implementation. Pre: ESM 2204 (3H,3C).

4614: CONCRETE MATERIALS

Fundamental properties of portland cement concretes. Concrete mixture design procedures. Testing of fresh and hardened properties of concrete. Durability and degradation mechanisms. Condition

assessments, forensic materials engineering, and repair strategies. Pre: C- or better in 3684 or BC 2044. (3H, 3C)

4624: PLANNING TRANSPORTATION FACILITIES
Transportation planning process; urban and regional studies, surveys, data analysis, model development and testing; transportation management, administration, finance, system evaluation, implementation, and integration. Pre: 3604. (3H,3C).

4634: INFRASTRUCTURE HEALTH ASSESSMENT
Contact Dr. Flintsch for more information. Pre: 3684. (3H,3C).

4654: GEOMETRIC DESIGN OF HIGHWAYS
Functional design of highways; curves, intersections, interchanges, drainage, and other features involved in highway safety and traffic efficiency. Pre: 3604. (3H,3C).

4664: PAVEMENT DESIGN
Principles underlying methods for the design of various elements of flexible and rigid pavements for highways and airports; climate and traffic effects; pavement management systems. Pre: 3604. (3H,3C).

4674: AIRPORT PLANNING AND DESIGN
Airport planning and economic justification, site selection, configuration, development and design of terminal areas, demand forecasting, access, traffic control. Pre: 3604. (3H,3C).

4684: TRANSPORTATION SAFETY
Analyses and decision making that affect public safety as part of the transportation system. Pre: 3604. (3H,3C).

4694: FREIGHT OPERATIONS
Modal and intermodal freight facilities, their operation, and types of freight movement and handling equipment in context of a multi-modal transportation system; role of privately owned and operated freight movement within public sector operations and management. Pre: 3604. (3H,3C).