# TABLE OF CONTENTS

PREFACE .......................................................................................................................................................... i

1. GENERAL INFORMATION ........................................................................................................................ 1
  1.1. Mission .............................................................................................................................................. 1
  1.2. CEE and NCR Personnel .................................................................................................................. 2
  1.3. Transportation Engineering Faculty .................................................................................................. 2
  1.4. Professional Organizations .............................................................................................................. 3

2. DEGREE REQUIREMENTS ......................................................................................................................... 4
  2.0.1. General ......................................................................................................................................... 4
  2.0.2. Admission Requirements ............................................................................................................ 4
  2.0.3. Graduate Programs ...................................................................................................................... 5
  2.0.4. Curriculum Tracks ....................................................................................................................... 5

  2.1. Masters of Science .......................................................................................................................... 5
    2.1.1. Masters of Science Options ...................................................................................................... 6
    2.1.2. Course Requirements ................................................................................................................ 7
    2.1.3. MS Degree Committee ............................................................................................................. 7
    2.1.4. Program of Study ....................................................................................................................... 7

  2.2. PhD Program .................................................................................................................................. 8
    2.2.1. Admission to the Doctoral Program ............................................................................................ 8
    2.2.2. Course Requirements ................................................................................................................ 8
    2.2.3. Competencies ........................................................................................................................... 8
    2.2.4. Doctoral Advisory Committee .................................................................................................. 8
    2.2.5. Plan of Study .............................................................................................................................. 9
    2.2.6. Preliminary Examination .......................................................................................................... 9
    2.2.7. Dissertation Proposal .............................................................................................................. 10
    2.2.8. Progress Reports ....................................................................................................................... 10
    2.2.9. PhD Dissertation ....................................................................................................................... 11
    2.2.10. Dissertation Defense ............................................................................................................. 11

Appendix A. Required Background Courses for Non-Civil Engineering Undergrads ....................... 12

Appendix B. List of Transportation Courses ............................................................................................. 13

Appendix C. Anticipated TISE Course Schedule Through 2010 ................................................................ 16
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 Department of Civil and Environmental Engineering (CEE) and provides educational and research opportunities at the flagship campus in Blacksburg and in the National Capital Region (NCR) at Falls Church and Alexandria. Through the Commonwealth Graduate Engineering Program (http://cgep.virginia.gov/), students can also pursue graduate course work at numerous locations throughout the Commonwealth via distance learning.

Two degrees, offered and administered by the CEE Department, may be pursued by eligible TISE students: Masters 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, in the Graduate Policies and Procedures and Course Catalog of Virginia Polytechnic Institute and State University (Virginia Tech), and in the Civil and Environmental Engineering Graduate Handbook. A third degree at the masters level, the Masters of Engineering, is available to students who want to broaden 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 the highest quality education in one of many fields within transportation engineering. (2) Create an excellent environment for students to learn transportation engineering and systems concepts and to develop critical thinking. (3) Advance knowledge about transportation infrastructure and systems that sustains our global leadership in research and technology development. (4) Conduct outreach and service activities to disseminate knowledge and materialize practical positive 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 which adapts to the current and future needs of a very dynamic profession.

To best meet the needs and interests of our students, we have established two graduate study tracks, (1) Infrastructure and (2) Systems Engineering. The Infrastructure track targets pavement design; civil engineering materials; and transportation infrastructure assessment, maintenance, and management as areas of teaching and research concentration. The Systems Engineering track focuses on traffic operations and engineering; transportation planning; safety and human factors; 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 and NCR Personnel
The Via Department of Civil and Environmental Engineering offices are located on the second floor of Patton Hall in room 200. During their time at Virginia Tech, students may interact with the following individuals:

- Samuel Easterling, Professor, Department Head of Civil and Environmental Engineering, 200 Patton Hall, (540) 231-6635, seaster@vt.edu.
- Donna M. Sanzenbach, Administrative Assistant, 200 Patton Hall, (540) 231-6068, donnas(at)vt.edu.
- Leigh-Anne Byrd, Graduate Student Coordinator, 200 Patton Hall (540) 231-7296, leigha@exchange.vt.edu.
- Merry Gayle Moeller, TISE Program Support, 221C Patton Hall (540) 231-7144, mmoeller@vt.edu.

For students in the National Capital Region, personnel include:
- Susan Merten, Administrative Assistant, Northern Virginia Center, Room 424, (703) 538-8431, smerten@vt.edu.
- Marija Telbis-Forster, Graduate and International Student Advisor, Graduate Student Services Office (GSSO), Northern Virginia Center, Room 203, (703) 538-3743, mtelbisf@vt.edu.

1.3 Transportation Engineering Faculty
Faculty in the TISE Program include:

- Montasir Abbas, PE, Assistant Professor, PhD Purdue University, abbas@vt.edu. Dr. Abbas’ research interests include real-time traffic control, traffic flow theory, ITS, transportation modeling and safety, artificial intelligence, and systems optimization. He is located in Blacksburg.
- Thomas Dingus, Newport News Shipbuilding/Tenneco Professor and Director VTTI, PhD Virginia Tech, tdingus@vt.edu. Dr. Dingus’ research interests include transportation human factors and safety. He is located in Blacksburg.
- Gerardo Flintsch, PE, Professor and TISE Program Area Coordinator, 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. He is located in Blacksburg.
- Kathleen Hancock, PE, Associate Professor and Director of CGIT, PhD Vanderbilt University, hancockk@vt.edu. Dr. Hancock’s research interests include geospatially enabled decision making for transportation, freight operations and planning, and highway safety. She is located in the National Capital Region.
- Antoine Hobeika, Professor, PhD Purdue University, hobeika@vt.edu. Dr. Hobeika’s research interests include transportation planning and evaluation, transportation
simulation and modeling, Intelligent Transportation Systems, and transportation emergency management. He is located in Blacksburg.

Bruan Katz, Professor of Practice, PhD Virginia Tech, bkatz@vt.edu. His research interests include traffic modeling, Intelligent Transportation Systems (ITS), and safety modeling. He is located in Blacksburg.

Pamela Murray-Tuite, Assistant Professor, PhD University of Texas Austin, murraytu@vt.edu. Dr. Murray-Tuite’s research interests include network analysis, risk and reliability analyses, evacuation modeling, location analysis, resource allocation, and infrastructure interdependency modeling and analysis. She is located in the National Capital Region.

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. He is located in Blacksburg.

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

Linbing Wang, Professor, PhD Georgia Tech, wangle@vt.edu. His research interests include multiple-scale microstructure characterization, modeling, simulation and visualization of infrastructure materials; simulative pavement testing and mechanistic pavement design; application of imaging techniques to pavement materials; and remote sensing. He is located in Blacksburg.

Adjunct faculty include:

Sam Tignor, PE, FASCE, retired Federal Highway Administration. His research interests include driver needs and highway safety, freeway management and incident detection, freeway merging control systems, railroad-highway grade-crossing safety, visibility of changeable message signs, condition-responsive work-zone traffic control, and truck overturn-warning systems. He is located in the National Capital Region.

Antti Talvitie, PhD Northwestern University, part time professor at Helsinki University of Technology (TKK) and Consultant to the World Bank. His research interests include institutional analysis of transport organizations, travel demand analysis and modeling, transport planning and transport economics, including public participation. He also has experience in construction, maintenance and financing (PPP project financing) in the road sector, and in restructuring railways. He is located in the National Capital Region.

1.4. Professional Organizations
Several professional organizations are available to transportation engineering students and all graduate students are encouraged to become involved. Listed below are two of the more active organizations at Virginia Tech. There are also many other organizations or societies that the student may find beneficial and can be found on the University web page at http://www.vt.edu/student_life/.

In addition to organization activities, a variety of journals which contain transportation engineering and human factors material are available through these organizations. The reduced
student memberships to most organizations provide students with an excellent opportunity to join these professional societies or to purchase the journals.

**VIRGINIA TECH STUDENT TRANSPORTATION ALLIANCE (VTSTA)** - is the umbrella under which two student chapters (ITE & ARTBA) perform. The major goal of the alliance is to promote the dissemination of knowledge and information related to transportation infrastructure and systems issues, problems and solutions. Information about VTSTA can be found at [http://www.cee.vt.edu/tise/vtsta.htm](http://www.cee.vt.edu/tise/vtsta.htm).

- **Institute of Transportation Engineers (ITE)** - a national professional organization for transportation systems and operations. ITE publishes the ITE Journal and other books and periodicals. ([http://www.ite.org](http://www.ite.org)).

- **American Road and Transportation Builders Association (ARTBA)** – a national professional organization for the design and construction of physical transportation infrastructure and facilities. ([http://www.artba.org](http://www.artba.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://asce.cee.vt.edu/](http://asce.cee.vt.edu/).

# 2. DEGREE REQUIREMENTS

## 2.0.1. General

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

Documents that students should be familiar with in addition to this one include:

- **Graduate Policies and Procedures and Course Catalog** ([http://www.grads.vt.edu/academics/gcat/index.html](http://www.grads.vt.edu/academics/gcat/index.html))


These documents provide information about Graduate School regulations, registration, due dates, thesis and dissertation requirements, etc. and about specific Departmental and University requirements. Information in the TISE document is intended to reinforce and supplement requirements from the other sources, not to replace those requirements.

## 2.0.2. Admission Requirements

All students must submit their applications to the Graduate School. For admission to a Master’s Degree program in TISE, students should have earned a bachelor's degree in civil engineering from an accredited program. Students 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 Masters program in TISE. No graduate credit is granted for this basic level work and students are not part of the graduate program during this time.

In addition to Graduate School and CEE requirements, the TISE graduate program requires:

- Students who graduate from non-English speaking universities must score the following minimum on the TOEFL:
  - Masters Applicants: 235 points
  - Doctoral Applicants: 250 points

- All students must have a minimum combined analytical and qualitative score of 1100 on the GRE.

2.0.3. Graduate Programs

The TISE Program offers the following degree options:

- **Masters of Science**: This degree has two options: Non-thesis Option and Thesis Option. For the Non-thesis Option, graduate students take at least 27 credit hours of coursework and 3 credit hours of CEE 5904 “Project and Report”. Students who choose the MS Thesis Option are required to conduct research in a specific area and register for a minimum of six semester credit hours of CE 5994 "Research and Thesis".

- **PhD Program**: The PhD requirements have been adopted by the Graduate Faculty of the TISE Program to supplement the graduate degree requirements stated in the Graduate Degree Programs Bulletin. Responsibility for complying with graduate school and departmental requirements rests with each student.

2.0.4. Curriculum Tracks

The TISE curriculum consists of two tracks: (1) **Infrastructure** and (2) **Systems Engineering**. All Systems Engineering graduate students are required to take three core courses and a minimum of one elective course from the Systems Engineering cluster and any one course from the Infrastructure cluster. Similarly, Infrastructure graduate students are required to take three core courses and a minimum of one elective course from the Infrastructure cluster and any one course from the Systems Engineering cluster. Table 1 lists the core and elective courses in each cluster. Appendix B gives a detailed description of courses in the TISE program. Appendix C provides sample schedule of courses for Fall and Spring Semesters.

Based on the plan of study prepared by the student and his/her main advisor, courses from other program areas and departments may be taken. It is suggested that at least one course is taken from other program areas. Courses from other departments (Statistics, Industrial Engineering, Engineering Mechanics, Materials Engineering, Electrical Engineering, Computer Science, etc.) are determined based on each student’s thesis/project and his/her interests.

To satisfy the 32 credit hours for Masters level study, students will typically take at least six courses within the TISE Program. In addition, all TISE students are required to take two one-credit-hour seminars (CEE 5944), one in the fall and one in the spring. The fall semester seminar focuses on computational tools used in the remainder of the student’s graduate career and in transportation professional practice. The spring seminar encourages students to think and communicate effectively. It allows students to present their research and become better informed about ongoing research across the TISE Program. It is designed to sharpen skills in written and
oral presentation of technical materials. The seminar is a cooperative teaching effort by the faculty in the Program and allows the students to get to know the faculty areas of expertise. Practitioners and faculty from other program areas and other departments may participate. **All TISE graduate students are expected to attend this seminar regardless of whether you are enrolled in it or not.**

Table 1. Transportation Courses by Track

<table>
<thead>
<tr>
<th>INFRASTRUCTURE CLUSTER</th>
<th>SYSTEMS ENGINEERING CLUSTER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Core</strong></td>
<td><strong>Core</strong></td>
</tr>
<tr>
<td>CEE 4634 Infrastructure Condition Assessment</td>
<td>CEE 5600 Analysis of Civil Infrastructure Systems</td>
</tr>
<tr>
<td>CEE 4664 Pavement Design</td>
<td>CEE 5604 Traffic Characteristics and Flow</td>
</tr>
<tr>
<td>Advanced Pavement Design</td>
<td>CEE 5624 Transportation and Land Use</td>
</tr>
<tr>
<td>Pavement &amp; Bridge Infrastructure Mgmt. Systems</td>
<td>Elective</td>
</tr>
<tr>
<td><strong>Elective</strong></td>
<td></td>
</tr>
<tr>
<td>CEE 4614 Advanced Structural Concretes</td>
<td>CEE 4604 Traffic Engineering</td>
</tr>
<tr>
<td>CEE 5684 Rehabilitation of Transportation Structures</td>
<td>CEE 4654 Geometric Design of Highways</td>
</tr>
<tr>
<td>CEE 5764 Asphalt Technology</td>
<td>CEE 4674 Airport Planning and Design</td>
</tr>
<tr>
<td>CEE 5984 Mech. of Asphalt Concrete &amp; Pavement Modeling</td>
<td>CEE 4684 Transportation Safety</td>
</tr>
<tr>
<td></td>
<td>CEE 5614 Analysis of Air Transportation Systems</td>
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<tr>
<td></td>
<td>CEE 5630 Transportation Networks Analysis</td>
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<tr>
<td></td>
<td>CEE 5634 Analysis &amp; Planning of Mass Transit Systems</td>
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<td></td>
<td>CEE 5640 Highway Transportation Safety</td>
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<td></td>
<td>CEE 5644 Transportation System Planning</td>
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<td>CEE 5664 Intercity Transportation</td>
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<td></td>
<td>CEE 5984 Treatment of Uncertainty in Transportation and Infrastructure Analysis</td>
</tr>
<tr>
<td></td>
<td>CEE 5984 Advanced Signal System Control</td>
</tr>
<tr>
<td></td>
<td>CEE 5984 Transportation Risk, Reliability, and Security</td>
</tr>
</tbody>
</table>

2.1. MASTERS OF SCIENCE DEGREE

2.1.1. Masters of Science Options

Two options are available: 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.

**Thesis Option.** Students are required to successfully complete a minimum of 24 credit hours of course work, 2 credit hours of seminar, and six credit hours of CEE 5994 “Research and Thesis”. They 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. The scope and definition of the work should be clearly stated in a written proposal submitted to the graduate student's committee as soon as practical after establishing the committee and program of study. The proposal should be orally presented to and approved by the committee. Upon completion of the proposed work, the
student prepares a written thesis. 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 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 (http://etd.vt.edu).

Non-Thesis Option. Students are required to successfully complete a minimum of 30 credit hours of course work, of which, up to 6 credit hours can be CEE 5904 Project and Report, and 2 credit hours of seminar. Within 60 days of anticipated graduation, the student is required to successfully complete a 6-hour written exam spread over three days. If students successfully complete at least 3 hours of CEE 5904, the written exam is reduced to 3 hours taken in one day. Based on the results of the written exam, the committee may require that the student successfully complete an additional 3-hour oral exam.

2.1.2. Course Requirements
A total of 32 credit-hours are needed to satisfy the M.S. degree requirement. A minimum of 12 credit hours of 5000-level or higher coursework must be completed. A maximum of 6 credit hours of 4000-level courses approved for graduate credit can count toward this requirement. A one-credit hour of seminar is required. All TISE graduate students are expected to attend the Fall Semester seminar.

2.1.3. MS Degree Committee
Prior to the completion of 15 credit hours of coursework, an M.S. committee (chosen by the student) and a chairperson will be recommended by the Department Head to the Graduate School. The chairperson of the M.S. committee will become the student's academic advisor and shall, along with the committee, provide overall guidance for the candidate's M.S. program. The M.S. committee shall consist of three or more members of the Graduate Faculty in the major field.

2.1.4. Program of Study
In the second semester and prior to the completion of 15 credit hours of coursework, the student, in conjunction with the M.S. committee advisor, will formulate a course study plan (http://www.cee.vt.edu/getfile.php?file=Plan_Of_Study.doc). 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 in writing by the M.S. committee and Department Head.
2.2. PhD DEGREE

2.2.1. Admission to the Doctoral Program
Prior to admission, the TISE Program faculty will review the applicant’s records. Applicants with non-civil engineering undergraduate degrees will be advised, at the time of acceptance, of any undergraduate coursework that must be fulfilled as part of the doctoral program. Upon admission to the doctoral program, the student will be assigned an academic advisor selected from the student's specialty area. The student has the right to choose his/her advisor after being enrolled in the program. The following PhD degree requirements must be satisfied:

- The candidate must maintain a grade point average of 3.0 or above to remain a degree candidate.
- Satisfy the associated 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 the dissertation research prior to the dissertation.
- Prepare and orally defend the PhD dissertation.

2.2.2. Course Requirements
A minimum of 90 post-baccalaureate credit-hours are needed to satisfy the PhD degree requirement. The program must include at least 27 credit hours of 5000-level and higher coursework. There is no limit on the number of 4000-level courses that are approved for graduate credit. All TISE graduate students are expected to attend this seminar regardless of whether you are enrolled in it or not. Between 30 and 63 hours of CEE 5994, Thesis and Research, and/or CEE 7994, Dissertation Research, must be included in the program. (Note: CEE 5994 cannot be used if it was on the Plan of Study for an MS degree.) The number of research and dissertation credits for which the candidate registers should reflect the amount of time that is spent by the candidate in the laboratory, in analyzing data, writing the dissertation, or other activities specific to the dissertation. The candidate is expected to maintain continuous registration throughout the program.

2.2.3. Competencies
- **Research Skills.** Since the Doctoral degree is a research degree and candidates are expected to continue research activities after graduation, the candidate should demonstrate competence in research skills. Specific skills should be commensurate with the candidate's specialty area and career goals and should be identified jointly by the candidate and his/her Doctoral committee chairperson and dissertation advisor.
- **Communications Skills.** The doctoral committee will evaluate the candidate’s ability to use written and oral forms of the English Language correctly. International students may be required to take remedial courses in oral or written English.

2.2.4. Doctoral Advisory Committee
Every PhD student must select a Major Advisor who will be the chairperson of the Advisory Committee. The student and Major Advisor will establish the PhD Advisory Committee consisting
of a minimum of five members of the graduate faculty. The chairperson and the committee will provide overall guidance for the candidate's doctoral program. At least one member shall be from outside the Department of Civil and Environmental Engineering and preferably outside the College of Engineering. The student may choose one committee member as a dissertation advisor, usually although not necessarily, the chairperson. The dissertation advisor will guide the candidate in the preparation of the research proposal and in the development and defense of the dissertation.

2.2.5. 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 candidate, in conjunction with the doctoral committee chairperson will prepare a plan of study (http://www.cee.vt.edu/getfile.php?file=Plan_Of_Study.doc). The course plan shall reflect the candidate's probable area of research and any coursework recommendations made by the doctoral committee.

The candidate shall meet with the Doctoral Committee as soon as practical to review the candidate's course plan and plan for satisfying the degree requirements. Any subsequent revisions to the program of study shall be approved in writing by the Advisory Committee and Department Head.

2.2.6. Preliminary Examination
The purpose of the examination is to evaluate the potential of the candidate to conduct independent research with technical proficiency. The candidate 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 candidate's ability to (1) demonstrate proficiency in the candidate’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 candidate's planned dissertation research. The examination shall include at least three but no more than five technical areas of competence. The chairperson should advise the candidate of these areas at least eight weeks before the examination. The candidate has the right, and is so encouraged, to discuss the material upon which the candidate will be examined with individual committee members.

The preliminary examination shall consist of a written and an oral part.

**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 select the questions that will be given to the candidate. The written examination will be open-book and shall be completed within fourteen consecutive days. Following the examination, the Chairperson will forward the candidate's responses to the respective committee members for evaluation. The committee members shall evaluate the candidate’s response to their respective questions and report their evaluation to the chairperson prior to the oral examination.

**Oral Examination:** The oral examination shall be conducted after completion of the written examination, preferably within the same semester. A 2-hour examination period is
recommended. The oral examination is a continuation of the written examination and allows the candidate to amplify and clarify the written responses. However, questions will not necessarily be confined to the subject matter covered on the written examination. Note: The Graduate School must be notified in advance of the scheduled date of the oral examination.

Unsatisfactory Performance on Written or Oral Examination: A vote by all members of the committee will determine satisfactory performance on both the oral and written parts of the preliminary examination. Unsatisfactory performance will result in one of the following:

- A requirement for additional coursework and/or reexamination.
- Dismissal from the PhD program. Appeals shall be submitted in writing to the Department Head who, together with the committee chairperson, shall make a decision regarding the candidate's continuation in the program.

2.2.7. Dissertation Proposal
The candidate shall develop a formal written research proposal that independently details the proposed doctoral research. Development of the proposal normally follows the preliminary examination. In certain circumstances, especially when the candidate's research is funded by an external agency, it may be appropriate for the candidate to prepare the proposal in advance of the preliminary examination.

The research proposal shall consist of the following parts:

- Background and literature review that justify the problem statement.
- Statement of the problem and the hypothesis to be tested.
- Objective and Scope.
- Work plan, including proposed scheme for data collection, data analysis, and hypothesis testing.
- Anticipated results.
- Engineering significance.
- Gantt chart showing the key activities and time schedule.
- List of References.

The proposal must be submitted to each member of the dissertation committee for his or her 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 adequacy with which the bulleted items are addressed.

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 by completing the CEE approval and transmittal form (http://www.cee.vt.edu/getfile.php?file=PhD_proposalform.pdf).

2.2.8. Progress Reports
The student must periodically communicate with the Advisory committee to keep it informed of his/her progress. Written or oral progress reports must be submitted at least once every academic year during the time the student is enrolled in the program. A PhD progress report form must be
2.2.9. 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. Dissertations are submitted electronically to the Graduate School (http://etd.vt.edu). The format of the dissertation should be either in the traditional detailed presentation or as a series of Journal Articles (see the Graduate School document).

2.2.10. Dissertation Defense
The final examination shall be an oral defense of the candidate's doctoral dissertation. The dissertation must be submitted to the committee members 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. Major revisions to the dissertation should be completed before this examination. The dissertation should be in its final draft, 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 in the hands of the committee.

Wherever a committee vote is required, a dissenting vote from no more than one member of the committee represents a passing vote.
## Appendix A. Required Background Courses for Non-Civil Engineering Undergraduate Degrees

| Course Description                           | Units | E | R | O | W | C | T | S | G | E | T | I | S | R | E | D | U | T | C | H | U | H | R | T | S | S |
| Chemistry 1074                             | 3     | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Chemistry Lab 1084                          | 1     | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Math 1205 (Calculus)                        | 3     | X | X | X | X | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Math 1206 (Calculus)                        | 3     | X | X | X | X | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Math 2224 (Calculus)                        | 3     | X | X | X | X | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Math 2214 (Differential Equations)          | 3     | X | X | X | X | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Physics 2305                                | 4     | X | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Physics 2306                                | 4     | X | X | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Geology 2104                                | 3     | X | X(3) | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ISE 2014 (Engineering Economics)            | 2     | 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     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 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 | X(1) |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CEE 3424 (Reinforced Concrete)              | 3     | X | X |   | X | X(1) |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CEE 3343 (Steel Structures I)               | 3     | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CEE 3514 (Soil Mechanics)                   | 4     | X | X(3) | X | X | X(1) |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CEE 3604 (Transportation)                   | 3     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CEE 3684 (CEE Materials)                    | 3     | X | X | X | X | X(1) |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CEE 3804 (Computer Applications)            | 3     | X | 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 | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

(1) Required if the student specializes in the transportation infrastructure area.
(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

Graduate Level Courses

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).

5610: SOFT COMPUTING IN TRANSPORTATION ENGINEERING
Fuzzy sets, fuzzy arithmetic rules, approximate reasoning, fuzzy mathematical programming, artificial neural networks, fuzzy sets and neural networks; applications in transportation engineering include trip generation, trip distribution, modal split, route choice and traffic assignment, vehicle routing, scheduling, and dispatching, real time ground and air traffic control. Graduate standing in engineering required. (3H,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).

5620: TRANSPORTATION NETWORKS ANALYSIS
Optimal paths in transportation networks, transportation network design, vehicle routing and scheduling, facility location problems, traffic flows on networks, traffic assignment problems. Graduate standing in engineering 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).

5630: PUBLIC TRANSIT DESIGN AND OPERATIONS
This course will focus on a review of selected concepts, principles, and methods associated with the application of information technologies in public transit. Emphasis will be placed on systems and technologies employed to deploy intelligent transportation system (ITS), user services including advanced traveler information systems, traffic signal control and priority, electronic payment systems and public transportation operations. (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).

5644 (UAP 5644): TRANSPORTATION SYSTEMS PLANNING
Advanced consideration of problems dealing with transportation systems as they affect the socio-economic development of cities, regions, and nations; the travel behavior of a populace; the location of economic activity; the use of land; and the allocation of resources. Pre: 3604. (3H,3C).

5654: ADVANCED GEOMETRIC DESIGN & HIGHWAY SAFETY
Design and proportioning of geometric features of urban and rural roadways such as intersections, interchanges, ramp and speed change lanes, vertical and horizontal alignments, climbing auxiliary lanes, pavement cross-section templates, and safety devices. Pre: 4654. (3H,3C).

5664 (UAP 5664): INTERCITY TRANSPORTATION
Inter-city transportation, including trucking, railroads, and aviation industries, as a vital part of the economy. Operation and logistic rules that govern the flow of shipments and dictate costs and freight rates under various regulatory policies and market environments. Pre: 3604. (3H,3C).

5674: ADVANCED PAVEMENT DESIGN
Methods used to characterize, stabilize, and specify pavement materials. Methods for rigid and flexible highway and airport pavement design and analysis. Load equivalence factor and specific design considerations related to environment and traffic characteristics. Pavement overlay design. Software for pavement design and analysis using various models. Pre: 3684, 4664. (3H,3C).

5684: REHABILITATION OF TRANSPORTATION STRUCTURES
Identification of maintenance and rehabilitation needs for transportation structures such as bridges and pavements. Cost effective maintenance and rehabilitation methods. Consideration of bridge and pavement management systems. (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
including design philosophy, performance, and durability. Modern construction with bituminous materials; special mixtures, recycling, and additives. Pre: 4614. (2H,3L,3C).

**Advanced Undergraduate Courses**

**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).

**4614: ADVANCED STRUCTURAL CONCRETES**
Fundamental properties and the physical and chemical aspects of the structure of Portland cement concretes. Emphasis placed on environmental performance aspects and the application of studies of concrete performance under various exposure conditions. Co/Pre: 3684. (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 CONDITION ASSESSMENT**
Infrastructure components and assessment needs; physical and chemical properties of construction materials; deterioration causes, assessment methods, nondestructive evaluation techniques, infrastructure management systems, performance models, service-life-cycle estimates. 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).
### Appendix C. Typical TISE Course Schedule Rotation (First two letters of faculty’s last name).

<table>
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<tr>
<th>Course Number</th>
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<tr>
<td>CEE 3684*</td>
<td>CEE Materials</td>
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<td>CEE 4604</td>
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<td>CEE 4624</td>
<td>Planning Transportation Facilities</td>
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