GRADUATE HANDBOOK

CIVIL AND ENVIRONMENTAL ENGINEERING

by

Civil & Environmental Engineering Department

A guideline for graduate school in Civil & Environmental Engineering

Brigham Young University

To help you fulfill all requirements for the degrees of

Doctor of Philosophy or Master of Science

Department of Civil and Environmental Engineering

Brigham Young University

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ABSTRACT

GRADUATE STUDIES IN CIVIL & ENVIRONMENTAL ENGINEERING HANDBOOK

Department of Civil and Environmental Engineering

The graduate programs build on the foundation of a strong undergraduate education to achieve greater competency in civil and environmental engineering. A graduate education provides the opportunity to learn the discipline in greater depth, and to specialize in one or more subdisciplines. In short, a graduate education helps students develop the skills needed to truly excel in their profession. Specifically, students will do one or more of the following:

1. Master design and analysis methodologies from both historical and current perspectives.
2. Undertake advanced and systematic study through the completion of courses that address the state-of-the-art in design and analysis of civil engineering systems.
3. Develop a deeper level of understanding and thought, and the ability to express that understanding in both written and oral form.
4. Contribute to the profession through discovery and creativity by consistent and effective mentoring from his/her advisor and advisory committee.

It is expected that all students will develop/maintain a commitment to live a life of integrity, founded upon the principles expressed in the gospel of Jesus Christ, with the purpose of serving family, community, church, and profession.

TABLE OF CONTENTS

LIST OF TABLES

1 Graduate Programs

The BYU Civil & Environmental Engineering graduate program is ranked in the top 100 in the nation and offers excellent opportunities for graduate studies at both the Master's of Science and Doctor of Philosophy levels.

The purpose of this handbook is to help you understand each of these programs, including admissions, course work requirements, research studies, writing theses, dissertations and reports, financial aid and advisement. It is written in the same style and formats as required for your research writing and is a valuable guide to help you navigate through our graduate program.

1.1 Master's of Science

The Master of Science degree is awarded to students who have mastered professional training in selected areas of civil engineering. Such training is gained through graduate course work which consists of elective courses and directed research with a thesis or project with a report. Students pursuing the thesis option gain the added dimension of participating in research work (usually funded) at the cutting edge of the profession. This research work culminates in high-quality written and oral presentations. Alternatively, the student may elect to complete a directed study

project which also requires both written and oral presentations. Average time of completion is approximately three semesters beyond the bachelor's.

1.1.1 Engineering Management Minor

Students seeking exposure to business practices as part of their Master's degree may elect to complete the management minor option. A total of 9 management hours are required, with some courses being stipulated and others elective. Only 6 of the 9 hours count towards the MS degree; meaning that this option requires an additional 3 credit hours to complete.

1.2 Doctor of Philosophy

The PhD is awarded to candidates who have made a significant contribution to knowledge in a particular specialization of civil engineering. Such a contribution is achieved through research which involves a thorough review of applicable literature, completion of carefully planned work, and a high-quality presentation of the new knowledge, the dissertation. Adequate course work is necessary to provide a foundation of expertise for quality research. The degree normally requires four years beyond the bachelor's degree or three years beyond the Master's degree to complete.

2 Admissions

This chapter summarizes the key information regarding admissions at BYU in general and the Civil & Environmental department specific requirements. The BYU graduate studies website (http://www.byu.edu/gradstudies/admissions) for admissions provides more detailed information and access to the online application form. On applications are strongly encouraged, but the admissions web page has instructions for receiving paper applications if they are needed.

2.1 Deadlines

The Civil & Environmental Engineering department considers applications to graduate school according to the schedule given in reference Table 2-1.

Table 2-1 Application Deadlines

Semester of Admission	U.S. Citizens	International
Fall	May 15	February 27
Winter	September 15	June 30

All parts of the application, including scores from GRE and TOEFL exams, recommendations, etc. must be received by the office of graduate studies prior to the deadline. If you wish to be considered for admissions during spring or summer terms contact the department for further information.

2.2 Application Requirements

It is recommended that students have clear objectives for attending graduate school, including an idea of which sub-discipline the degree will be completed in. Therefore, we encourage students to contact faculty within the department regarding select research programs and possibilities for funding either through scholarships or assistanceships. With a clear idea of the purpose and intent applicants should do the following:

1. Submit a complete application
    a. The application itself
    b. Statement of intent
    c. Official transcripts
    d. Letters of recommendation
    e. Ecclesiastical endorsement
    f. Application fee ($50)
2. Complete the GRE (GRE score in companion with GPA will be evaluated)
3. Agree to maintain BYU standards of conduct
4. Receive a baccalaureate degree from an accredited U.S. or Canadian university before the semester of entry. An official transcript must be received by graduate studies no later than during the first semester of study.
5. Have earned at least a 3.0 GPA (on a 4.0 scale) in the last 60 semester hours of course work for Master's applicants and 3.4 for doctoral applicants. Applicants with a GPA between 2.5 and 3.0 may be considered for provisional status with a strong recommendation from a faculty member which includes a

commitment to serve as the student's advisor. Applicants with a GPA lower than 2.5 are not admissible and might only be considered by petition with an exceptional GRE score.

2.2.1 International Applicants (all non-US)

In addition to the above requirements, international applicants must do the following:

1. For applicants whose native language is not English and have not received a bachelor's degree from an accredited U.S. university (or the equivalent from an English speaking country) are required to submit official IELTS or TOEFL test scores to be considered.
    a. IELTS a total band score of 7.0 with a minimum band score of 6.0 on each module.
    b. TOEFL computer based minimum of 237, paper minimum of 550, and iBT minimum of 85 with a minimum of 22 in the speaking section and a minimum of 21 in all other sections.
2. Submit completed Financial Certification form (I-1), with acceptable supporting documents.
    a. Master's applicants must provide proof of sufficient funds for two years.
    b. PhD applicants must provide proof of sufficient funds for three years.
3. Submit an official transcript from each institution attended, with accompanying official English translation

4. Submit an official copy of degree certificate showing completion of at least an equivalent U.S. bachelor's degree, with accompanying official English translation.

2.3 Applicants without a Civil Engineering Bachelor's Degree

Students who do not have a bachelor's degree in civil engineering will have to fill all of the criteria outlined in this handbook as well as fulfilling the following:

2.3.1 Basic Skills Requirement

Students must complete the equivalent of the following courses at BYU or at another institution:

- Math 112 Calculus 1 (4 hrs)
- Math 113 Calculus 2 (4 hrs)
- Math 302 Mathematics for Engineering 1 (4 hrs)
- Math 303 Mathematics for Engineering 2 (4 hrs)
- CEEn 103 Engineering Mechanics-Statics (2 hrs)
- CEEn 203 Engineering Mechanics of Materials (3 hrs)
- CEEn 270 Numerical Methods in Civil Engineering (3 hrs)

Students must choose one of the options below and complete all of the required courses listed in Table 2-2 (and any prerequisites to these courses). These courses may be taken at BYU or transferred from another institution.

- Structures and structural mechanics Option (1)
- Transportation Option (2)
- Water Resources and Environmental Option (3)

- Geotechnical Option (4)

Table 2-2 Skill Course Requirements for Applicants without a Civil Engineering Degree

Course	Hrs	Description	1	2	3	4
CEEn 305	(3 hrs)	Civil Engineering Materials	X	X		
CEEn 321	(3 hrs)	Structural Analysis	X			X
CEEn 332	(3 hrs)	Hydraulics and Fluid Flow Theory			X	
CEEn 341	(3 hrs)	Elementary Soil Mechanics		X		X
CEEn 351	(3 hrs)	Environmental Engineering			X	
CEEn 361	(3 hrs)	Introduction to Transportation Engineering		X		
CEEn 424	(3 hrs)	Reinforced Concrete Design	X			X
CEEn 431/433	(3 hrs)	Hydrology / Hydraulic Engineering			X	

2.4 Standards of Personal Conduct

All students admitted to BYU must agree to live by the BYU Honor Code as established by the university and the board of trustees. To know the substance and essence of that code is to know that BYU is unique among universities. Governed by principles basic to its sponsoring church, The Church of Jesus Christ of Latter-day Saints, it purposefully creates and nurtures an environment in which faith and intellect join together in the pursuit of truth. A student must be in both good Honor Code standing and good academic standing to graduate from BYU.

As a matter of personal commitment, students, faculty, and staff of Brigham Young University seek to demonstrate in daily living on and off campus those moral virtues encompassed in the gospel of Jesus Christ, and will:

- Be honest
- Live a chaste and virtuous life
- Obey the law and all campus policies
- Use clean language
- Respect others
- Abstain from alcoholic beverages, tobacco, tea, coffee, and substance abuse
- Observe dress and grooming standards
- Participate regularly in church services (for members)
- Encourage others in their commitment to comply with the BYU Honor Code

There is not a requirement to be a member of BYU's sponsoring church, only a commitment to live by the moral values and ideas espoused by it. An ecclesiastical endorsement is required each semester from the student's religious leaders. Members of the LDS church should be endorsed by the bishop of the ward where their current membership records are held. Non-LDS students may be endorsed by the local leader of their preferred religious denomination, the bishop of the LDS ward in which they live, or the nondenominational BYU chaplain.

3 Advisement

Graduate studies require a much deeper sense of independence than do undergraduate studies, yet selecting the proper advisor, or committee chair, can make a lot of difference. Don't wait until you are well into your program to identify your selected specialty area and advisor, in fact ideally this will be done prior to admission. Be respectful of faculty time commitments, but do not hesitate to seek them out for help in your research and evaluation of results.

3.1 Selecting a Committee Chair (Advisor)

You must select a committee chair and create an official study list during your first semester. A few ideas (adapted from published documents by the Graduate School at the State University of New York at Stony Brook and the University of Pittsburgh) to consider when selecting a chair are:

- Is the advisor an expert in the area of research that you intend to pursue? Is his or her critical orientation consistent with yours?
- What is the reputation of the advisor within the discipline?
- How responsive is the advisor to written and other work?
- How accessible for discussion is the advisor?

- How many students does he/she advise? If none, why? If a large number will this detract from the attention paid to individual students?
- How much time does he/she spend away from campus? Is he/she available during the spring/summer terms?
- How long do students take to complete their degrees with this advisor?
- What is the placement record of his/her students? Where do they get jobs?
- Does the advisor publish with the student as first author?
- Do the advisor's students attend conferences and make presentation of their work there?
- How much interaction is their with other students of the advisor? Does the advisor have a research group rather than a series of individuals?
- How much of the research is collaborative?
- Is the advisor's work funded to a level that includes student support?
- Does the advisor have good relations with the other faculty in the department?
- Are the advisor's work habits comparable with your own?

3.2 Supervision Requirement

During the first semester, the student works with the graduate coordinator to form an advisory committee. The committee is comprised of a chair and at least two other members. As a minimum students must meet with their advisory committee each semester while at BYU, but more frequent meetings are recommended. The

responsibility is on the student to schedule meetings and to bring pertinent materials necessary for evaluation of the student's progress to the meeting as directed by the advisory committee chair. The department secretary will provide the committee with the student's file. The committee should evaluate and counsel the student with respect to the following requirements:

1. Course work/Study List
2. Thesis or Project
3. Skill requirements
4. Minimum registration
5. Seminar participation
6. Record keeping
7. Examination requirements

Once each semester, the advisor will submit the department's evaluation form to the graduate secretary. The graduate student will also have an opportunity to sign and make comments regarding his or her progress. Progress as determined by the advisor (and where appropriate committee) will be classified as:

1. **Satisfactory**
2. **Marginal** - In this case the student may continue provided that requirements specified by the advisory committee are met.
3. **Unsatisfactory** - In this case the graduate degree program of the student is terminated.

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4 Master's of Science Degree Requirements

There are two options of study in the MS program: a thesis option and a project option. Both the thesis and project options require a total of 31 credit hours, unless completing the management minor which requires an additional 3 credits or a total of 34 credit hours. Each program is designed to go beyond the level achieved in the undergraduate curriculum in order to better prepare students to excel in their profession. In the graduate program, the subject material is covered at an accelerated rate with an increased responsibility on students to become independent thinkers. A graduate course in the Department of Civil and Environmental Engineering at BYU includes the following components:

- Recent research findings and required readings from the literature.
- A significant communications experience such as writing of reports and projects and/or presentations.
- Use of advanced mathematics and/or numerical modeling.
- Increased interaction with graduate faculty members.
- Prerequisites from the undergraduate and/or 500-level graduate courses.

Each student, with the help of his/her advisor in the first semester, chooses a specialty from one of the five civil engineering areas with a study list designed to provide in-depth learning in that area. Specialization at the Master's level can be chosen from the following:

- Environmental Engineering
- Geotechnical Engineering
- Structural Engineering
- Transportation Engineering
- Water Resources Engineering

4.1 Coursework Requirements

A base of 25 credit hours of graduate courses must be taken in each program. One of the 25 hours must be the graduate seminar (.5 credits per semester); however, students are expected to register for the seminar each semester they are enrolled in the graduate program and on campus. The following rules apply to course work included on the MS study list:

- A maximum of 25% of the coursework requirement can be met by approved transfer courses from another institution(s)
- Courses must be applied to the MS degree within five years of taking the course
- Credit will not be given for courses where a D or E grade is earned
- Double counting of courses taken as an undergraduate student toward both the undergraduate and graduate degree is not permitted

- No additional seminar credit beyond the required one hour can be counted towards the hours required for graduation
- It is possible to complete a nine-hour minor, such as business management, however only 6 credits can be included towards the coursework requirements of the Master's degree (and only if they are graduate level courses).
- A cumulative GPA of 3.0 for all graduate courses must be maintained

4.2 Thesis Option

Students choosing the thesis option complete the remaining credit hours (above the 25 credit hours required of all MS students) with 6 hours of thesis credit. The student must complete an original research study and prepare a written thesis under the direction of a faculty member and a graduate advisory committee. The thesis is then defended orally before the committee, although additional faculty and others may be in attendance. All university requirements and deadlines for the thesis apply.

4.2.1 Thesis preparation

The content of your thesis will be reviewed by your committee. However, just because your committee approves the content does not automatically qualify the document for submission to the university. The format of your thesis document must be approved at the department and college level and be advised that the staff WILL NOT format it for you, nor will they review it if little to no attempt is made to satisfy the rigid formatting guidelines. It is YOUR responsibility to see that the formatting requirements are satisfied. The department and college review should be done only

after you believe the document is 100% compliant with the guidelines. To aide in the process we have prepared some important information, including an MS Word template as outlined in the next paragraph.

The format of this document adheres to the guidelines and is an example of what is expected by the university, college and department. The college provides a list of detailed guidelines at: http://www.et.byu.edu/thesis-dissertation_guidelines.htm. An MS Word template can be downloaded from this site. The same template, with all of the guideline comments stripped out can be found at the seminar web page at http://frontpage.et.byu.edu/ce691. This same template includes instructions on how to use key formatting features of MS Word including use of styles for formats, inserting figure and table captions that can be cross referenced, cross references, auto generation of a table of contents and lists of tables and figures, and more. Taking a few minutes to review the instructions in the template, and then using it will save time and headaches as you near the completion of your writing.

The college requires that all theses and dissertations be submitted electronically. For the most part you should be able to convert your MS Word (or other electronically formatted thesis/dissertation to a .pdf file and meet the requirements. You can get more information and help on submitting your electronic thesis or dissertation in .pdf format at: http://etd.byu.edu/.

4.3 Project Option

Students choosing the project option must take one more graduate course (total of 28 hours of coursework) as approved by the advisor on the study list. In addition,

each student completes a project for the remaining 3 credit hours. The project represents an opportunity to apply the principles learned in the classroom and typically requires synthesis of information from several sources and/or the comprehensive design of an engineering facility. A project report is required of each sdent choosing this option, and must meet the satisfaction of the graduate committee. The project option also requires presentation of the results before the graduate committee and a group of peers. Only a limited number of projects are available and any student desiring to use this option must obtain prior approval from his/her advisor and the department.

4.3.1 Project Preparation

While the written project is not submitted to the university and therefore does not require the department and college formatting checks you should still use the template provided at http://frontpage.et.byu.edu/ce691 for projects which includes all of the same formatting guidelines as a thesis. See section 4.2.1 on thesis preparation for more instructions.

5 Doctor of Philosophy Degree Requirements

The PhD is awarded to candidates who have made a significant contribution to knowledge in a particular specialization of civil engineering. Such a contribution is achieved through research which involves a thorough review of applicable literature, completion of carefully planned work, and a high-quality presentation of the dissertation. The degree normally requires four years beyond the bachelor's degree or three years beyond the Master's degree.

5.1 Coursework Requirements

Adequate course work is necessary to provide a foundation of expertise for quality research. The number of credit hours required depends on whether the PhD is pursued after first achieving an MS degree or continuing directly from a BS.

5.1.1 Students with a Master's Degree

Fifty-six hours of course work and 2 hours of seminar are required. A 3.4 cumulative GPA must be achieved in order to be granted a degree. Of the total hours they must include:

- 18 hours of graduate course work (500 level and above courses)
- 18 hours doctoral dissertation (CEEn 799R)

- 20 hours of graduate course work transferred from the master's degree (500 level and above courses)
- These hours may include up to 4 hours of Master's thesis credit (CEEn 699R)

The graduate committee may also require additional advanced math, statistics, and science (300 and above). All science courses must be outside of the Civil & Environmental Engineering Department.

These hours **may not** include:

- Any courses with D or E grades
- Any skill requirement courses required of non-CE bachelor's/Master's students.
- Any course credit applied to a BS degree
- More than 7 hours of transfer or non-degree courses from another university (transfer and non-degree credit must be from graduate-level courses and have a grade of B or better).

5.1.2 Students Without a Masters Degree

Fifty-four hours of course work and 2 hours of seminar are required. A 3.4 cumulative GPA must be maintained. These hours include:

- 36 hours of graduate course work (may not include any 100-499 level courses)
- 18 hours of doctoral dissertation (CEEn 799R)

The graduate committee may also require additional advanced math, statistics, and science (300 and above). All science courses must be outside of the Civil & Environmental Engineering Department. These hours may not include:

- Any courses with D or E grades
- Any skill requirement courses (see below)
- Any course credit applied to a BS degree
- More than 7 hours of transfer or non-degree courses from another university (Transfer and non-degree credit must be from graduate-level courses and have a grade of B or better.)

5.2 Study List Courses

Directions in preparing the study list:

5.2.1 Course work

- 18 hours dissertation (CEEn 799R)
- 2 hours seminar (CEEn 691R)
- 20 hours transfer from Masters (for Masters students)
- Balance of 18 hours in 500+ elective hours

5.2.2 Mathematics/Statistics/Science

These courses may be any post-Bachelors work and are optional as required by advisory committee.

5.2.3 Basic Math (Skills)

18 hours prior course work. These are 100-300 level courses of basic math which can be bachelors-level courses.

5.3 Seminar Requirement

Students must register for and attend the weekly graduate seminar (CEEn 691R) during fall and winter semesters while at BYU. Official announcements regarding graduate study are made at this seminar. The seminar serves to broaden graduate education through exposure to technical ideas through sharing within specialty groups by faculty, students, and invited specialists from industry. While attendance is expected each semester, only 2 credit hours will count towards the coursework requirements.

5.4 Comprehensive Examination

To achieve candidacy for the PhD, the student must pass a departmental comprehensive examination. Typically, the student will take the comprehensive examination in the second year of study when the course work requirements have been completed. The examination must be successfully completed within three years of entrance into the PhD program. The examination is administered by the student's faculty advisor and is prepared and graded by the instructors of courses taken in the student's specialty area. Examinations are given in the following areas:

- Environmental Engineering and Water Resources
- Geotechnical
- Structures and Structural Mechanics
- Transportation

The examination will consist of six questions, of which the student may answer three or four. The examining committee will grade a maximum of four questions as pass or fail. In order to pass the examination, the student must receive a grade of pass on at least three of the questions. Should the student fail to receive a passing grade on three

questions, the student may retake the entire examination one additional time within the next year. If the student fails to pass the comprehensive examination on the second try, the student's program will be terminated.

Each examination question will consist of analytical and written parts. The examination is open book. It is expected that students will spend approximately two hours on each question: one hour in review of texts and other written materials and one hour in writing an answer to the question. A question from a past examination is given below as an example.

5.4.1 Example problem:

A 40-ft high embankment is to be constructed as a dike across a lake. The water depth during construction will be 20 ft. Side slopes of 3H to 1V and a crest width of 30 ft. are contemplated for the fill. The in-place fill will have a saturated unit weight of 135 pcf and a moist unit weight of 125 pcf. Drained strength parameters of the fill are estimated to be φ = 36 degrees and c = 0. The foundation consists of a soft clay (saturated unit weight of 115 pcf) with an unconfined compressive strength increasing from 500 psf at ground surface to 1,000 psf at a depth of 30 ft. Consolidated drained tests on the clay indicate a drained friction angle of 27 degrees with no cohesion. The clay is underlain by a dense sand (N>50) to a depth of at least 120 ft.

Questions:

1. Define the conditions under which you would use undrained and drained parameters for the clay.
2. Determine the factor of safety against failure for the given conditions immediately following construction. Use approximate stability charts or computer programs (UTEXAS2 manuals and program disk are available from the secretaries).

3. Assume the computed factor of safety is very close to or slightly below one. Discuss several possible design options which would allow construction of the embankment to the same height. How would you evaluate the suitability of each option? Which would you recommend?

4. Indicate in some detail what role calculated risk and the observational method could play in the construction. Would the SHANSEP method proposed by Ladd and Foote provide any benefits with regard to the observational method?

5.5 Prospectus

A written prospectus must be submitted to the advisory committee at least one week before the oral defense of the prospectus. The prospectus is prepared at the beginning of the research; typically this is at the completion of the course work. This could occur at approximately the same time as the comprehensive exam.

The prospectus consists of: 1) a thorough review of literature pertinent to the dissertation research, and 2) a detailed plan of the objectives and tasks to be undertaken in the dissertation research. There is no set format or length requirement for the prospectus. It is recommended that the prospectus be included later in the dissertation.

In the oral prospectus defense, the student will spend approximately one-half hour presenting his or her prospectus and approximately one-half hour receiving counsel from the advisory committee. The student will be judged on mastery of the pertinent literature and on the quality of the prospectus. The advisory committee may require revisions to the prospectus and/or another oral prospectus defense.

In no case will a doctoral degree be awarded sooner than one year from the completion of the prospectus requirement.

5.6 Dissertation

The oral dissertation defense is to be made to the advisory committee although additional faculty or others may be in attendance. Draft copies of the dissertation must be distributed to the examining committee at least two weeks prior to the oral dissertation defense.

In the oral dissertation defense, the student will spend approximately one hour presenting the dissertation work and approximately one hour responding to questions from the examining committee. The student will be judged on mastery of the dissertation subject area and on the quality of the dissertation work. The examining committee may vote as follows:

1. Pass
2. Pass with qualifications

   In this case the student must complete the minor revisions or requirements specified by the committee to the satisfaction of the committee chair who then sends a written approval to the Office of Graduate Studies.
3. Recess

   In this case the student must pass a second and final oral dissertation defense from the same examining committee no sooner than one month later.
4. Fail

   In this case the graduate degree program of the student is terminated.

5.6.1 Dissertation Preparation

The content of your dissertation will be reviewed by your committee. However, just because your committee approves the content does not automatically qualify the document for submission to the university. The format of your dissertation document must be approved at the department and college level and be advised that the staff WILL NOT format it for you, nor will they review it if little to no attempt is made to satisfy the rigid formatting guidelines. It is YOUR responsibility to see that the formatting requirements are satisfied. The department and college review should be done only after you believe the document is 100% compliant with the guidelines. To aide in the process we have prepared some important information, including an MS Word template as outlined in the next paragraph.

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formatted thesis/dissertation to a .pdf file and meet the requirements. You can get more information and help on submitting your electronic thesis or dissertation in .pdf format at: http://etd.byu.edu/.

6 Guidelines for Thesis/Dissertation Research and Writing

Getting started early and having a plan for your research and writing is the single most important thing you can do to have a successful and enjoyable graduate experience. It will also go a long ways towards endearing you to your advisor. Whether you are working on a Master's Thesis or Project, or a PhD Dissertation the information in this chapter will be valuable in helping you stay focused and complete a quality write up in a timely fashion.

6.1 Planning

Choose an advisor and identify a topic in your first semester, if you haven't already done so during the application process. Set up a meeting and consult with your advisor as soon as possible about potential topics, a study list and a committee. Faculty are always busy, but they will welcome assertiveness in getting started and developing a good research plan.

After a thesis topic has been selected, meet with your advisor to discuss the nature and scope of the work and identify key words and phrases to begin a formal literature review on the topic. Discuss findings with your advisor once the literature review is substantially completed. With your advisor plan the remaining work to ensure that the results will be a unique contribution to the existing knowledge base. Include in this plan a finalized scope and research objectives, a critical path, an outline of necessary tests and

methods of analysis and discuss possible publication venues such as conferences and/or peer-reviewed journals. All of this should be summarized in a prospectus document that is presented to your committee and other interested colleagues for critique and acceptance.

6.1.1 Committee and Study List

As part of selecting a committee you must determine a study list. Your advisor will help you outline a study list that will provide the best background for your research. The university requires that your committee sign a form indicating that he/she is willing to serve on your committee and okays your study list. This form can be picked up from the Civil and Environmental Engineering office and should be turned in early on in your graduate program. If changes to your committee or study list are required a separate form indicating the change will need to be turned in.

6.1.2 Literature Review

Focus the literature review primarily on research reports and peer-reviewed articles published in well-known journals. Magazine articles and various internet sites may also be consulted for relevant information. Conducting a comprehensive literature review should be the first main task of the research and will allow you to confidently determine areas in which additional research work is needed.

During the extensive reading associated with the literature review, carefully document all pertinent ideas. You may choose to simply write the main ideas, sources, and page numbers on paper at first, but you can achieve greater efficiency by typing the information into a text file for later use in preparing the prospectus and first draft of the thesis or dissertation.

6.1.3 Research Objectives

Together with your advisor finalize the objectives and scope of the research. Articulate research objectives in such a way that they can be answered regardless of the outcome of the study. That is, the objectives should not be postulated in a manner that requires a specific outcome. The scope should clearly describe the extent of the expected project activities. If experimental work will be required, the factors of interest and the levels of each factor should be determined, and an appropriate statistical design should be selected. If previous data are available, they should be analyzed to obtain estimates of sample variability for use in determining the number of samples needed in the new study. Outline any computer modeling and data required to drive those models. List the project specific needs including supplies, software, computing resources, data, equipment, vehicles, and supporting personnel. The availability of laboratory space or field sites should also be considered.

6.1.4 Critical Path

Once the objectives, scope of work, and testing needs are delineated, prepare a critical path, or schedule, showing the anticipated starting date and duration of each task. The critical path includes all scheduling constraints on the project and reasonable amounts of time for each proposed activity. Extra time should be given to tasks characterized by comparatively high levels of uncertainty so that unexpected events do not cause undue concern. Go beyond simply displaying data collection or modeling activities, and schedule time for writing, peer reviews, advisor reviews, revisions, committee reviews, thesis defense, departmental and college reviews, final corrections, and manuscript submission. Failure to recognize writing and revising in your research

will result in delaying your graduation and cause frustration for both you and your advisor. The critical path should indicate the dates by which all critical milestones should be achieved in order for you to finish before your target graduation date. The critical path should be included in the prospectus and presented to your advisor or committee for review and approval before you begin formal work on the project. Be cognizant of important deadlines early on so that you can work them into your critical path outline. You can find these deadlines on line, or by asking the Civil and Environmental Engineering office staff. For example in order to graduate in April your thesis will need to be done and submitted to the library by the end of February in order to defend and make final revisions by mid-March.

6.1.5 Outline of Tests and Methods

Following completion of the critical path, design all data collection worksheets, data analysis templates, and modeling studies for review by your advisor. Where applicable, link source data for tables and figures to the original input cells to facilitate efficient updates to tables and figures should errors be identified later. Design a structured system of folders for efficient data management on your J: drive. This folder is the primary repository for all electronic data. Information on the J: drive will automatically be backed up by CAEDM, but retain your own copies of the same information on a jump drive as a minimum backup system of your own. When you start writing save multiple backups of your prospectus. Alumni are full of scary stories about how they have lost weeks of research results and/or writing due to computer disk drive failures. You can't be too safe. File extensions indicating the date of the file creation are a good idea and can be used on all files. For example the month, day, and year can be given in this format: MMDDYY, or similar but be consistent whatever naming

convention you use so that it can be somewhat self-documenting. Provide a README.TXT in the parent folder of your research directory that documents the contents of all files. It might be obvious to you what the files are by their names and dates but when your advisor or a follow-on student needs to access the data it is rarely as obvious and the README.TXT will act as a roadmap to make their work easier.

6.1.6 Publications

Besides your university thesis/dissertation/project, publishing your work in a peer-reviewed journal or conference proceeding can be a difficult, but rewarding process. Gaining the acceptance of peers in the scientific community should be your goal. Make it a priority early on and determine to do excellent writing so your work can be published in such venues.

We can not emphasize enough the importance of learning to write and prepare a manuscript for such publications. You will take great pride in knowing that your work is worthy of publication and presentation in these forums, but the real value you for you will be in the "journey" and not the destination. Good writing is a skill that will bless you in your professional life time and time again.

It is a requirement of all faculty members to publish (have you ever heard the phrase "publish or perish"?) and so you will find your advisor motivated to help you develop your work to the point where it can be submitted to peer-reviewed journals and conference proceedings. Publishing your work is probably the best tool you have to thank your advisor for his/her time and efforts in mentoring your research work. Abstracts for conferences are often due six months to a year in advance and the peer-review process can take several months so talk about possible and appropriate venues of publication for your work in the beginning and include these goals in

6.1.7 Prospectus

The prospectus serves as a contract between you and your advisor (committee). It documents the scope of your work and helps you to avoid "research-creep." Nothing is more frustrating to you and your advisor than to arrive at the time for the defense only to realize that each of you has a different idea about the scope of the research project. Since you should have completed a thorough literature review write this part of your thesis/dissertation now, or at least your first draft of it. Besides your literature review include your objectives, critical path, outline of tests and methods, expected results and anticipated publications. The best time to present your prospectus is at the end of your first semester or beginning of your second semester of graduate school (for PhD students the end of your first year is a good goal). So don't waste time and get started today!

6.2 Research

Six credit hours are set aside for you to do your Master's research and thesis writing. Taking three of these six credit hours your first semester to perform the research (literature review), prepare your prospectus, and get started on your project is a good idea. If you save all six credits until the last your planning and research will suffer. For PhD students you have 18 hours for your dissertation research and writing. You should also spend 3-6 of these hours early on in performing a literature review and preparing a good prospectus. Project students only have three hours, most likely taken towards the end of your program, you should still do enough background research and preparation to adequately define your problem.

There are many sources to search in order to perform an adequate literature review. Generally speaking your advisor will have specific journals and sources that

he/she routinely uses so that is a good place to start. Many of the scientific journals used in engineering are available on line, and when going to these locations from a BYU internet address you will be able to see the full text on line (BYU has purchased licenses for many of these journals). You can use search engines to locate relevant literature. The BYU library has many resources, including a specialist for engineering. His name is Jerry Adams and he can be contacted at: jerry_adams@byu.edu. Be sure to ask about the faculty document delivery service (FDDS). This service is a very useful way to request printed (.pdf) copies of journal articles from a bibliographic references. You can send the FDDS your references, including author names, title, journal, date, etc. and they will locate the article within the library, or from other library archives, scan to .pdf, and email you the file. There is generally a small charge associated with the service (~ $0.10/page) so you will need a university account number to do this. Contact your advisor and see if he/she has funds to support this. Further information on how this works and ordering articles can be found at: http://www.lib.byu.edu/departs/fds.html.

Appendix B has many other tips for performing literature reviews by some of the faculty. The writing reference, "A Writer's Reference" fifth edition by Diana Hacker that we recommend also includes information for your literature review. Consult with your advisor and make a thorough plan for your literature review.

6.3 Writing

Any amount of time spent in developing your writing will pay dividends in your professional career. We strongly recommend the reference "A Writer's Reference," fifth edition by Diana Hacker (http://dianahacker.com/writersref) as a good practical resource for your research and writing. This reference costs about $20.00 (a smaller handbook

reference guide with most of the same information can be purchased for $15), but contains many good examples of common mistakes that will be helpful in improving your writing and save you time in preparing rough drafts and performing revisions.

The graduate seminar class web page (http://frontpage.et.byu.edu/ce691) has links to electronic "template" documents for MS Word for project, thesis, and dissertation. Read through these electronic documents, if you haven't already, as they contain important information on using styles, referencing, generating tables of contents, labeling figures, and more. A little time learning how to use these tools will save you headache and frustration at the end of your writing. The templates are set up to mimic the required formatting, but you must understand the content of these documents in order to use them correctly and take advantage of the help they provide in formatting.

The university has fairly strict guidelines about margins, page numbering, etc. for theses and dissertations (projects are not so stringent but we still recommend using the template). The templates provided by the department automate most of this, and if used correctly (read and understand how to use MS Word from the template documents) will save you untold hours towards the end of your writing. As part of preparing your final manuscript (before printing) you will have to have the department and then college secretaries review it for format correctness. They WILL NOT read your work for correctness and grammar – this is your responsibility – they will only check it for format. They will also not make changes to your document, nor should you use them to provide help and guidance for format. You are responsible to know the formatting rules and apply them correctly to your document with one of the templates, or another word processing tool. When reviewing your work the secretary will generally give you "three strikes" and then return it to you for checking so before turning it in for review you

should be quite certain that it already meets formatting guidelines. Again, this is your responsibility and not theirs. Ask in the office for a copy of the guidelines if you are unsure, and for a checklist of common mistakes that students make so that you can proof it yourself before printing and turning in for review. Printing your document can become expensive if done repeated times so we ask you to be careful and thorough in performing your review.

Appendix A. Sub-Discipline Course Work Programs

A.1 Structures

The list of graduate courses for specialization in structures may be selected from among the structures, civil engineering, and mechanical engineering courses listed below. Prerequisites are shown in parentheses.

STRUCTURES CORE COURSES

CE En-Me En 506	Continuum Mechanics and Finite Elements	(CE En 321 or Me En 382)
CE En-Me En 508	Structural Dynamics	(CE En 321 or Me En 372)

STRUCTURES GRADUATE COURSES

CE En-Me En 504	Matrix Structural Analysis and Optimization	(CE En 321 or Me En 372)
CE En-Me En 523	Aircraft Structures	(CE En 321 or Me En 372)
CE En 524	Reinforced Concrete Buildings	(CE En 424)
CE En 525	Bridge Structures	(CE En 424, 422)
CE En 526	Prestressed Concrete	(CE En 424)
CE En 528	Masonry Design	(CE En 424)
CE En-Me En 602	Composite Structures	(CE En-Me En 506)
CE En-Me En 606	Plates and Shells	(CE En-Me En 506)
CE En-Me En 608	Nonlinear Structural Analysis	(CE En-Me En 506, 508)
CE En 622	Seismic Resistant Steel Buildings	(CE En 422, 508)

RELATED CIVIL ENGINEERING GRADUATE COURSES

CE En 505	Materials, Uses, and Properties of Concrete	
CE En 542	Foundation Engineering (CE En 341)	
CE En 545	Geotechnical Analysis of Earthquake	(CE En 321, 341)

RELATED MECHANICAL ENGINEERING GRADUATE COURSES

CE En-Me En 500	Design and Materials Applications	(CE En 321 or Me En 372)
CE En-Me En 501	Stress Analysis and Design of Mechanical	(CE En 321 or Me En 372)

CE En-Me En 503	Plasticity and Fracture	(CE En 203; Me En 250)
CE En-Me En 570	Computer-Aided Engineering Software	(Me En 273 or C program)
CE En-Me En 572	Computer-Aided Geometric Design	(C program)
CE En-Me En 575	Optimization Techniques in Engineering	(linear algebra; program)
CE En-Me En 609	Spectral Analysis of Dynamic Systems	(linear algebra)

SPECIALTY AREAS OF GRADUATE FACULTY IN STRUCTURES

Dr. Balling	Structural Analysis and Optimization
Dr. Benzley	Finite Elements, Nonlinear Mechanics
Dr. Fonseca	Concrete and Wood Structures
Dr. Jensen	Advanced Composite Structures
Dr. Richards	Seismic-Resistant Steel Structures

A.2 Transportation

Students pursuing a Master of Science degree with an emphasis in transportation may choose from one of three emphasis areas: 1) Traffic Engineering, 2) Transportation Planning, or 3) Pavements and Materials. The different core and related courses are listed below with prerequisites for each course shown in parentheses.

TRAFFIC/PLANNING CORE COURSES

CE En 562	Traffic Engineering	(CE En 361)
CE En 565	Urban Transportation Planning	(CE En 361)
Stat 511	Statistical Methods for Research	(Stat 510 or equivalent)

TRAFFIC/PLANNING RELATED COURSES

Stat 512 S	tatistical Methods for Research 2	(Stat 511)
CE En 662	Traffic Simulation & Analysis	(CE En 562)
CE En 664	Transportation Site Planning	(CE En 562)
P Mgt 675	Form of Government and Service Delivery	
P Mgt 676	Planning, Land Use, and Growth	
P Mgt 643	Leadership in Public Organizations	
P Mgt 640	Human Resource Management	
P Mgt 622	Government and Finance	
P Mgt 684	Environment and Process of Public Administration	

PAVEMENTS AND MATERIALS CORE COURSES

CE En 505	Concrete Materials	(CE En 305)
CE En 563	Pavement Design	(CE En 361)
Stat 511	Statistical Methods for Research	(Stat 510 or equivalent)

PAVEMENTS AND MATERIALS RELATED COURSES

Students in the Pavements and Materials area may select courses beyond the required core classes from the traffic/planning core or related courses, the geotechnical engineering course offerings within the CE En Department, classes offered by the Geology Department, or other classes relevant to the course of study as agreed upon by the graduate committee.

SPECIALTY AREAS OF GRADUATE FACULTY IN TRANSPORTATION

Dr. Saito	Traffic Engineering
Dr. Schultz	Transportation Planning
Dr. Guthrie	Pavements and Materials

A.3 Water Resources and Environmental Engineering

Students pursuing a Master of Science degree with an emphasis in water resources or environmental can choose from the following tracks: 1) Water Resources, 2) Water and Wastewater Treatment or 3) Geo-Environmental. The different core and related courses are listed below with prerequisites for each course shown in parentheses.

WATER RESOURCES CORE CLASSES

CE En 531	Principles of Hydrological Modeling	(CE En 431)
CE En 535	Hydraulic Design of Channels and Control Structures	(CE En 433)

WATER AND WASTEWATER TREATMENT CORE CLASSES

CE En 535	Hydraulic Design of Channels and Control Structures	(CE En 433)
CE En 551	Water Treatment Facilities Design	(CE En 351)

GEO-ENVIRONMENTAL CORE CLASSES

CE En 555	Environmental Chemistry	(CE En 351)
CE En 547	Seepage and Groundwater Modeling	(CE En 341, CEEn431)

RELATED CIVIL ENGINEERING GRADUATE COURSES

*CE En 531	Principles of Hydrological Modeling	(CE En 431)
*CE En 535	Hydraulic Design of Channels and Control Structures	(CE En 433)
CE En 540	Geo-Environmental Engineering	(CE En 341)
CE En 543	Earth and Rock Filled Structures	(CE En 341)
*CE En 547	Seepage and Groundwater Modeling	(CE En 341, CEEn431)
*CE En 551	Water Treatment Facilities Design	(CE En 351)
CE En 555	Environmental Chemistry	(CE En 351)
CE En 580	Hazardous Waste Management and Control	(CE En 351)
CE En 648	Groundwater Contaminant Transport	(CE En 547)
CE En 651	Wastewater Treatment Facilities Design	(CE En 551)
CE En 654	Advanced Treatment Processes for Water and Wastewater	(CE En 551)
CE En 635	Sediment Transport and River Restoration	(CE En 535)
**CE En 594R	Advanced Engineering Programming	(CE En 270)
**CE En 694R	Two Dimensional Hydraulic Modeling	(CE En 535)

* If not taken as a core requirement in one emphasis can be used as an elective
** Will receive a final course number soon

SPECIALTY AREAS OF FACULTY IN WATER RESOURCES AND ENVIRONMENTAL

Dr. Borup	Water and Wastewater Treatment
Dr. Hotchkiss	Water Resources - Hydraulic Engineering
Dr. Miller	Water Resources - Hydrologic Engineering
Dr. Nelson	Water Resources – Hydrologic Modeling
Dr. Williams	Geo-Environmental Engineering
Dr. Zundel	Water Resources – Hydraulic Modeling

A.4 Geotechnical Engineering

The list of graduate courses for specialization in geotechnical may be selected from courses listed below. Prerequisites are shown in parentheses.

GEOTECHNICAL CORE CLASSES

CE En 542	Foundations	(CE En 341, CE En 424)
CE En 541	Advanced Soil Mechanics	(CE En 341)

RELATED CIVIL ENGINEERING GRADUATE COURSES

CE En 540	Geo-Environmental Engineering	(CE En 431, CE En 351)
CE En 543	Design of Small Dams	(CE En 431)
CE En 545	Geotechnical Analysis of Earthquake Phenomena	(CE En 341)
CE En 543	Earth and Rock Filled Structures	(CE En 341)
CE En 547	Seepage and Groundwater Modeling	(CE En 341, CEEn431)
CE En 644	Advanced Foundations	(CE En 541, CE En 542)

CE En 645	Geotechnical Field Investigations	(CE En 341, CE En 541)
CE En 648	Groundwater Contaminant Transport	(CE En 547)

SPECIALTY AREAS OF FACULTY IN GEOTECHNICAL

Dr. Jones	Groundwater Flow and Transport
Dr. Gerber	Earthquake Engineering
Dr. Rollins	Foundations Engineering

Appendix B Literature Review Tips

This appendix is a compilation of tips for performing a literature review that have been gathered from faculty members.

Dr. Saito

Research

Actually before conducting a literature review, one has to know a fairly decent idea of what he/she wants to conduct research on. Then conduct a literature search. In the transportation area there are useful on-line literature search engines available to the student. They include:

- TRIS = Transportation Research Information Systems from the Transportation Research Board. Visit http://gulliver.trb.org/ and select TRIS and follow the instructions.
- Google Scholar is a very useful search engine.
- Journals of the Transportation Research Board available in the CEEn Conference Room and the Transportation Lab
- NCHRP Reports for highways
- TCRP Reports for transits
- Any other publications, like books and DOT reports, that will help clarify the topic

Then to prepare a prospectus, one should read related reports and published papers and find out what has not been done or what has been not clear to advance the

state of the art of the area where he/she is trying to make a new finding. The original topic may change to a new one after reading related publications, which is perfectly fine.

Writing guidelines:

I tell students to take a look at published papers of the following journals that also give guidelines for manuscript preparation.

- Paper preparation guidelines by the Transportation Research Board
- Paper preparation guidelines by ASCE
  What is important is consistency in the format