AN OVERVIEW OF THE CORE TRANSPORTATION ENGINEERING COURSES IN THE UNDERGRADUATE CIVIL ENGINEERING PROGRAMS AT CANADIAN UNIVERSITIES

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ABSTRACT

Of the 36 faculties of engineering in Canadian universities, 25 offer undergraduate programs in civil engineering accredited by the Canadian Engineering Accreditation Board (CEAB). Transportation/highway engineering has historically been a substantial component of the field of civil engineering, and therefore of civil engineering curricula at universities everywhere. However, transportation engineering has been losing its significance in the civil engineering programs in Canadian universities. Thus, in 2002 Professor Haas of Waterloo University concluded, "Transportation is far under represented in Canadian universities by any measure, including research funding, proportion of civil [engineering] faculty, and graduate students. All are within 4% to 8% of the total in civil engineering"

With a view to contributing to the effectiveness of transportation courses in civil engineering programs, this paper presents the results of a review of the contents of core transportation engineering courses offered in 2005/06 by the 25 undergraduate civil engineering programs at Canadian universities, and offers suggestions for improving the content of such courses.

Of the 25 civil engineering programs at Canadian universities:

- Four (Laval, Ottawa, Queens, and Western Ontario) do not require a core transportation engineering course. Interestingly, Ottawa's calendar shows a fourth-year elective course "Highway and Transportation Engineering".
- Of the 21 civil engineering programs that require core transportation engineering courses, 15 offer one core course, five (Carleton, Manitoba, Montreal Polytechnique, Toronto, and Windsor) offer two core courses, and one (Ryerson) offers three core courses.
- Of the 21 civil engineering programs that require core transportation engineering courses, 7 offer only the core course(s) while the other 14 offer electives/options in subjects related to transportation engineering and planning.

The author believes that the CEAB should require a core transportation engineering course a condition of accreditation, because: 1) CEAB's own criteria appear to require it; and 2) CEAB's parent body, the Canadian Council of Professional Engineers, requires graduates from unaccredited foreign universities to pass its compulsory examination in transportation engineering, while it accredits Canadian civil engineering programs which do not require a core transportation engineering course!

The relative lack of uniformity in the titles and contents of core transportation courses is surprising. Course titles vary: ten have "transportation engineering" in the title; others range from transportation planning, to highway engineering to highway design. Most deal almost exclusively with the highway mode, and do not, in the author's opinion, include enough about the characteristics of other transportation modes or the linkages between transportation and Canada's socioeconomic wellbeing.

The author suggests that the following would make an effective 24-lecture core course titled Transportation Engineering:

- Four lectures on a comprehensive overview, definitions, concepts, characteristics of the various modes/components/systems of transportation; and, using the road mode, the concept of vehicle flow and capacity level of service.
- Two lectures should then be devoted to present the “big picture” about transportation in Canada and the province/region concerned. This would include discussion of: the importance and the social, economic, political and environmental roles of transportation; a brief history of transportation; transportation costs (as opposed to transport economics); organization of the various components/modes of the public and private transportation sector (e.g. who finances, owns and manages what); various roles and career paths for transportation engineers; and if not already covered in the first two lectures, what moves by what mode. The idea is to present transportation engineering as a truly multi-disciplinary field that interacts with engineering, politics, environmental science, psychology, public relations, etc. Included in the discussion should be the concept of transportation as a derived demand, and the inescapable interaction between land use and transportation, particularly in urban areas.
- The next 10 to 12 lectures can be utilized to teach “planning, location, design, construction, and operation” of highways, with some detailed attention to the geometric design elements, and to basics of pavement design.
- It is suggested that two lectures be devoted to urban traffic engineering and control.
- Two lectures are to be used for other appropriate topics of interest to the university.
- Towards the end of the course, it is suggested that the students be introduced to an overview and basic concepts of advanced topics, such as pavement management, transportation economics, traffic safety engineering, intelligent transportation systems, and others of particular interest in the concerned province/region.

INTRODUCTION AND PURPOSE OF PAPER

Because of Canada’s vast geographic expanse and the importance of trade to its economy, reliable and efficient transportation is vital for Canada’s socio-economic wellbeing. An essential element in keeping Canada’s transportation sector vibrant is the sustained availability of trained professional and technical personnel. All sorts of organizations have a stake in ensuring high quantity and quality of these human resources, including entities such as universities, technical institutes, federal/provincial/territorial departments of transportation, provincial/territorial associations of professional engineers, and associations such as the Transportation Association of Canada (TAC), among others.

Thus, in 2001 TAC established the Education Council to identify the needs and gaps in education and training within the transportation sector and to explore the opportunities and future directions. TAC is also a prime mover in the Education Coalition, a consultative forum for transportation stakeholders with similar or overlapping interests, including other associations and academic institutions.

In 2004, Transport Canada sponsored a "Study of Professional and Technical Transportation Training in Canada" (HDP Group, 2004), which was an update and expansion of a similar study in 2000. In 2002, TAC and the Education Council held a workshop on "Transportation Education and Training Workshop" at which one of the papers ((Haas et al, 2002) concluded, among other findings, that:

> "Transportation is far under represented in Canadian universities by any measure, including research funding, proportion of civil [engineering] faculty, and graduate students. All are within 4% to 8% of the total in civil engineering"

Of the approximately 70 universities in Canada, 36 have a faculty/school/college of engineering/applied science, of which 25 offer an accredited undergraduate program in civil engineering (Canadian Engineering Accreditation Board, 2005).

Transportation/highway engineering has historically been a substantial component of the field of civil engineering, and therefore of civil engineering curricula at universities everywhere. However, as indicated above, transportation engineering has been losing its significance in the civil engineering programs in Canadian universities. Indeed, several civil engineering programs in Canadian universities do not include any core (compulsory) course in transportation engineering! Also, the contents of the core courses in transportation engineering offered by the various universities appear to be in need of revising, updating and harmonizing.

To redress this situation and with a view to contributing to improving undergraduate education in transportation engineering, this paper has two basic purposes:

1. Based on the course information published in the 2005/06 Calendars of the 25 undergraduate civil engineering programs at Canadian universities, the paper presents an overall picture of what is offered as core courses in transportation engineering, and makes the argument that for a civil engineering program to be accredited, it must include a core course in transportation engineering; and
2. Based on the author's 35-year experience in the practice, research and teaching of transportation engineering, and a study and comparison of the course descriptions of the core courses in transportation engineering published in the 2005/06 Calendars of the 25 civil engineering programs at Canadian universities, the paper presents some suggestions that could be useful in updating and harmonizing the contents of such courses.

The scope of the paper excludes a discussion of graduate programs and research in transportation engineering, or of any transportation-related courses that may be offered by faculties other than engineering. It makes a note, but does not deal with the details, of the elective undergraduates courses in transportation engineering offered by selective civil engineering programs. It is not the intention of this paper to evaluate or critique the transportation courses at particular universities; rather it is hoped that the basic overview and discussion presented in the paper would lead to further research and discussion of transportation engineering education and research at Canadian universities in the context of transportation engineering's important role in the socioeconomic life of the country.

IMPORTANCE OF TRANSPORTATION

Civil Engineering is the oldest branch of engineering. Indeed, for nearly two centuries after the industrial revolution started, all engineering was considered civil engineering -- the description "civil" engineer arising from the need to distinguish engineering work performed for the public good from that of a purely "military" nature.

Thus, when the Institute of Civil Engineers in Britain, which was established in 1818, applied for its charter in 1828, the charter defined the scope of civil engineering as follows:

> "That species of knowledge which constitutes the profession of a Civil engineer; being the art of directing the great sources of powers in nature for the use and convenience of man, as the means of production and of traffic in States both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange; and in the art of navigation by artificial power for the purpose of commerce; and in construction of ports, harbours, moles [jetties], breakwaters and lighthouses, and the construction and adaptation of machinery; and in the drainage of cities and towns." (Quoted in Pannell, 1964, p. 11)

Besides acknowledging the then all-encompassing scope of civil engineering, the statement clearly shows the predominant significance of transportation infrastructure in civil engineering. (Interestingly, the statement does not specifically refer to rail transportation, which had been introduced in England the early 1820s.) Since then, other disciplines of engineering (e.g. mechanical, electrical, chemical, computer, etc.) have achieved separate standings, and sub-specialties in civil engineering (e.g. geotechnical, environmental, structural, etc.) have been developed. However, because of transportation infrastructure's importance to the social and economic life of the modern society, transportation engineering remains a vital component of civil engineering.

The importance of transportation has only increased with time; and it would not be an exaggeration to state that modern life and economy would grind to a halt without reliable transportation. Transportation is involved in, and to a considerable degree shapes, almost all human activities. Everything we trade, eat, wear or otherwise use must be transported. A few statistics would be helpful to illustrate the point:

- Transportation accounts for 16% of our household spending, and is second only to the cost of housing. (WESTAC, 1999)
- Annual government expenditures on transportation (mainly provincial and municipal, and some federal) governments reached nearly $20 billion in 2003/04, the majority being spent on highways and streets. (Transport Canada, 2004)
- Provincial governments invest more annual *capital* on transportation infrastructure (highways and municipal grants for transit and streets) than on any other function such as hospitals and schools. (e.g. Alberta Capital Plan, 2006).
- Transportation is the single largest source of greenhouse gas emissions in Canada, accounting for 25 per cent of the total, 73 percent coming form road vehicles. (Transport Canada, 2004)
- In 2003, there were 160,000 reported road traffic accidents, causing 2,900 fatalities (Transport Canada, 2004). Many victims are young and traffic collisions are a leading cause of premature death and long-term disability.

To deal with these issues, a steady supply of properly educated and trained transportation engineers is therefore required to plan, design, build and operate Canada's transportation system. These trained engineers are needed not only by the provincial and municipal transportation authorities and private infrastructure providers, but also by the consulting engineering sector, which provides the bulk of planning, design and construction services to the public and private infrastructure owners. And universities must be at the forefront of teaching and research in this endeavour.

THE PROCESS OF ACCREDITATION OF UNIVERSITY ENGINEERING PROGRAMS IN CANADA

Canadian Accreditation Criteria

In Canada, the 12 provincial and territorial associations/ordre regulate, within their respective jurisdictions, the practice of engineering and licensing of the country's more than 160,000 professional engineers. The Canadian Council of Professional Engineers (CCPE) is the national organization of these 12 provincial and territorial associations (ordre in Quebec).

The CCPE established the Canadian Engineering Accreditation Board (CEAB) in 1965 to accredit undergraduate engineering programs, which provide engineers with the academic requirements necessary for registration as a professional engineer in Canada. To be eligible for licensing as a Professional Engineer in Canada requires a degree from an engineering program that meets the criteria established by the CEAB (CEAB, 2005, is a CCPE report outlining CEAB's accreditation criteria and procedures, and it also lists the Canadian undergraduate engineering programs that are currently, or have ever been, accredited by CEAB. In Canada, 36 educational institutions currently offer accredited undergraduate engineering programs leading to a bachelor's degree in engineering, and there are 236 accredited engineering programs.).

According to CEAB, 2005, the purpose of accreditation is to identify to the constituent members of CCPE those engineering programs that meet the criteria for accreditation. Among other factors, the CEAB criteria (emphasis added)

> "are intended to reflect the need for the engineer to be adaptive, creative, resourceful and *responsive to changes in society, technology and career demands";* …..and
>
> "to ensure that students are made aware of the role and responsibilities of the professional engineer in society and the *impact that engineering in all its forms makes on the environmental, economic, social and cultural aspirations of society*."

CEAB, 2005, should be consulted for a full description of CEAB accreditation criteria. In summary, the curriculum content required by CEAB must add up to a minimum number of total Accreditation Units (AU) which must include a minimum number of AUs in "Mathematics and Basic Sciences", "Engineering Sciences", "Engineering Design", and "Complementary Studies", the latter encompassing studies in humanities, social sciences, arts, management, communication, engineering economics and the impact of technology on society.

Other than the above curriculum content criteria, the CEAB allows flexibility and understandably does not explicitly state that a particular engineering program must include particular courses in specific subjects. However, the author of this paper contends that the absence of a core course in transportation engineering would violate CEAB's own general purposes and particularly the criteria italicized above.

This argument is supported by the fact that applicants without accredited degrees must pass professional examinations conducted by one of the 12 provincial and territorial associations/ordre, based mainly on CCPE's Examination Syllabus (CCPE, 2004), which, for civil engineering applicants, includes the compulsory course titled "98-Civ-A6: Transportation Planning and Engineering"!

American Accreditation Criteria

In this vein, it is interesting to compare the CEAB policy and criteria with those of its American counterpart, which are in part as follows (emphasis added):

> *"Program Breadth - Broad programs that will prepare a student to take advantage of as many different career opportunities as possible are encouraged. Further, programs which omit instruction in a significant portion of a subject in which a professional in a particular field may reasonably be expected to have competence should not be accredited."* (ABET, [United States] Accreditation Board for Engineering and Technology, (2004))

and for civil engineering programs,

> *"Curriculum. The [civil engineering] program must demonstrate that graduates have: proficiency in mathematics through differential equations, probability and statistics, calculus-based physics, and general chemistry; proficiency in a minimum of four (4) recognized major civil engineering areas; ……."* (EAC, [United States] Engineering Accreditation Commission, 2004)

According to the American Society of Civil Engineering (ASCE), which sets the standards for curriculum content for accredited civil engineering programs in the US, there are seven "recognized major civil engineering areas": structural, geotechnical, environmental, transportation, sanitary, surveying, and construction (May 30, 2006 phone conversation with an ASCE official). The American curriculum content standards thus appear to be more stringent than the Canadian standards.

Discussion

It is the contention of the author of this paper that the absence of a core course in transportation engineering would violate CEAB's own accreditation rationale and general criteria as described earlier in this section, e.g. "*responsive to changes in society, technology and career demands", and "impact that engineering in all its forms makes on the environmental, economic, social and cultural aspirations of society*".

This argument is bolstered by the fact that civil engineers without CEAB-accredited degrees from overseas who apply for Professional Engineering designation in Canada must pass professional examinations conducted by one of the 12 provincial and territorial associations/ordre, based on CCPE's Examination Syllabus (CCPE, 2004), which, for civil engineering applicants, includes the compulsory course titled "98-Civ-A6: Transportation Planning and Engineering"! It would seem ironic if it were not unfair.

TRANSPORTATION ENGINEERING COURSES IN CIVIL ENGINEERING PROGRAMS

Findings

"Core" courses related to an engineering program (e.g. civil, electrical, etc.) are compulsory for all students studying for a degree in that program, and are generally offered in the third and fourth year of a four-year degree program. The "elective" courses which permit specialization or "majoring" in a specialty of the program (e.g. environmental, transportation, structures, in the civil engineering program) are generally offered in the fourth year.

Table 1 summarises the data from the Appendix. The following conclusions can be drawn from Table 1 and the Appendix.

1. Of the 25 civil engineering programs at Canadian universities four (Laval, Ottawa, Queens, and Western Ontario) do not require a core transportation engineering course. Interestingly, Ottawa's calendar shows a fourth-year elective course “Highway and Transportation Engineering” with a course description very similar to the third-year core transportation engineering courses at other universities.

2. Of the 21 civil engineering programs that require core transportation engineering courses, 15 offer one core course, five (Carleton, Manitoba, Montreal Polytechnique, Toronto, and Windsor) offer two core courses, and one (Ryerson) offers three core courses.

3. Of the 21 civil engineering programs that require core transportation engineering courses, 7 offer only the core course(s) while the other 14 offer electives/options in subjects related to transportation engineering and planning. In addition, as mentioned above, Ottawa offers an elective transportation engineering course even though it does not offer a core transportation engineering course.

4. Although a discussion of environmental engineering programs is outside the scope of this paper, the data in the Appendix shows that 10 of the 25 civil engineering departments offer specialization or major in environmental engineering; and of these 10, only six require a core course in transportation engineering as part of the environmental engineering degree.

Discussion

Universities have limited monetary and staff resources. For example, a quick perusal of the calendars shows that the majority of the 25 civil engineering departments in Canadian universities have 12 to 18 full-time faculty members. A discussion of the funding for universities and the myriad of other factors that influence a university's course offerings and research emphases is outside the scope of this paper. In the context of this paper, what is apparent is that many civil engineering departments must be selective in which fields they wish to offer options or electives in. Therefore, it's not surprising that not all 25 offer transportation engineering electives.

What is surprising and disappointing is that four of the 25, nearly one in six, do not even require a core course in transportation engineering. A phone conversation with the staff of one of the Ontario universities which does not require a core transportation engineering course elicited the following rationale: that the transportation professor had retired some ago; they couldn't find a full-time replacement; the core course was taught by a part-time faculty; then the department's research emphasis changed and the faculty position was filled by a specialist in the current are of research emphasis; and the department then decided to not require an doffer the core course in transportation engineering.

This rationale may be understandable from the point of view of a funding strapped department, particularly one that does not offer transportation electives or a graduate transportation program, thus making it unattractive to a transportation expert to come to such a department.

As discussed above, it seems obvious to the author that the absence of a core course in transportation engineering would violate CEAB's other general purposes and criteria italicized above. It is rather ironic that the associations/CCPE requires civil engineers with degrees from unaccredited universities to pass the compulsory professional examinations in CCPE's compulsory course titled "98-Civ-A6: Transportation Planning and Engineering" before they can apply for Professional Engineering registration in Canada.

CONTENT OF CORE COURSES IN TRANSPORTATION ENGINEERING

Findings

The course descriptions in the calendars are of necessity short, and it is difficult, in the absence of detailed course outlines or lecture material, to make substantive comments on the course contents. However, it is possible to draw the following tentative general conclusions from the titles and short descriptions of the core transportation courses in the Appendix.

1. As can be expected, the title and content of the core course(s) appears to depend upon whether the program has more than one core course, or whether it offers elective courses in transportation.
2. The course titles vary: ten have "transportation engineering" in the title; other range from transportation planning, to highway engineering to highway design.
3. Most core courses in transportation emphasize highway engineering, although other modes or aspects get a brief mention in some descriptions, e.g. rail transit at British Columbia; air transportation at Saskatchewan; transportation planning at the Royal Military College; urban and rural systems at Dalhousie.

Discussion and Some Suggestions for Core Course Content

Transportation engineering is one of the oldest subjects in civil engineering. Therefore, even after allowing for some local/regional imperatives and the "desire for independence and academic freedom", one would have expected to see more uniformity and agreement among the universities as to the scope and content of a core introductory course in transportation engineering than that is the case (from the information in the Appendix).

The scope of this paper does not include the complete design of a 15-week core course in transportation engineering. However, the author believes that incorporating the following ideas, some of them perhaps somewhat heterogeneous and sketchy, into the course content of a 24-lecture core course in Transportation Engineering would improve its effectiveness.

The availability of a suitable textbook is the universal wish of all teachers. That wish, as in the case of a textbook on introductory transportation engineering, unfortunately cannot always fulfilled. In the author's opinion the textbook "Introduction to Transportation Engineering and Planning" by Edward Morlok (Morlok, 1978) comes the closest to footing the bill. However, like most American textbooks used in Canadian universities, it does not include a discussion of Canadian transportation systems. Moreover, it was published in 1978 and apparently has not been reissued. Some of the following comments are influenced by this textbook.

1. A basic purpose of a single core-course in transportation engineering should be to provide the students with a comprehensive overview, definitions, concepts, characteristics of the various modes/components/systems of transportation, e.g.

    - Road, rail, air, marine, pipeline
    - Freight, passenger
    - Rural (inter-city), urban
    - Public transit

    The first three or four lectures should therefore be devoted to these items, and the concept of vehicle flow and capacity level of service, using the road mode as an example, and referring as appropriate to other modes as well.

    An effective technique to compare and contrast the characteristics of various modes is to use the "terminals, way, vehicle" categorization.

    The "road" mode, being the most ubiquitous, can then be used in later lectures to elaborate on and apply the concepts and deal with appropriate details of the "planning, location, design, construction, and operation" sequential hierarchy.

    Covering the concepts and characteristics more thoroughly than is currently the case in core-courses will take up more time. Therefore, advanced topics, such as urban transportation modeling, intersection design, traffic signal synchronization, pavement design and management models, etc., can be introduced but their details left to be covered in elective or graduate courses for students who go on to major in transportation.

2. Once the students understand the characteristics of the various transportation modes, and the basic definitions and concepts, two lectures should then be devoted to present the "big picture" about transportation in Canada and the province/region concerned. This would include discussion of: the importance and the social, economic, political and environmental roles of transportation; a brief history of transportation; transportation costs (as opposed to transport economics); organization of the various components/modes of the public and

private transportation sector (e.g. who finances, owns and manages what); various roles and career paths for transportation engineers; and if not already covered in the first two lectures, what moves by what mode. The idea is to present transportation engineering as a truly multi-disciplinary field that interacts with engineering, politics, environmental science, psychology, public relations, etc. – the list is nearly endless!

At this point in the course, some students might complain that they seem to be in a humanities or history course rather than in an engineering course where they were expecting formula after formula! In answer, the author can only point to the comments he has received from his former students in an introductory course in transportation engineering to the effect that the big picture aspects of the course had proved the most useful in the students' career. A student recalled the author's advice that reading the local paper was one of the most useful transportation planning aids!

A most fundamental concept in transportation is that "transportation is a derived demand", and not an end in itself. A related and perhaps more important in a practical sense, is the inescapable interaction between land use and transportation, particularly in urban areas. Students need to be reminded of this inter-dependence and correlation frequently.

3. The next 10 to 12 lectures can be utilized to teach "planning, location, design, construction, and operation" of highways, with some detailed attention to the geometric design elements, and to basics of pavement design.

4. It is suggested that two lectures be devoted to urban traffic engineering and control, including specific reference to traffic safety.

5. Two lectures are to be used for other appropriate topics of interest to the university in the context of provincial and urban transportation issues in the province and city in which the university is situated.

6. Towards the end of the course, it is suggested that the students be introduced to an overview and basic concepts of advanced topics, such as pavement management, transportation economics, traffic safety engineering, intelligent transportation systems, and others of particular interest in the concerned province/region.

SUMMARY AND CONCLUSIONS

Of the 25 civil engineering programs at Canadian universities:

- Four (Laval, Ottawa, Queens, and Western Ontario) do not require a core transportation engineering course. Interestingly, Ottawa's calendar shows a fourth-year elective course "Highway and Transportation Engineering".
- Of the 21 civil engineering programs that require core transportation engineering courses, 15 offer one core course, five (Carleton, Manitoba, Montreal Polytechnique, Toronto, and Windsor) offer two core courses, and one (Ryerson) offers three core courses.
- Of the 21 civil engineering programs that require core transportation engineering courses, 7 offer only the core course(s) while the other 14 offer electives/options in subjects related to transportation engineering and planning.

The author believes that the CEAB should require a core transportation engineering course a condition of accreditation, because: 1) CEAB's own criteria appear to require it; and 2) CEAB's parent body, the Canadian Council of Professional Engineers, requires graduates from unaccredited foreign universities to pass its compulsory examination in transportation engineering, while it accredits Canadian civil engineering programs which do not require a core transportation engineering course!

A full summary of the paper is provided in the Abstract at the beginning of the paper.

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The information for this paper was obtained from university calendars (paper copies or Internet sites). Although reasonable care has been taken to report the information correctly, it is subject to errors and omissions. It's important that the university civil engineering departments be consulted to obtain the most up to date information. The views expressed in the paper are those of the author and do not necessarily represent the views of any of the universities.

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TABLE 1. UNDERGRADUATE TRANSPORTAION ENGINEEIRNG COURSES OFFERED BY THE 25 CIVIL ENGINEERING DEPARTMENTS AT CANADIAN UNIVERSITIES (BASED ON THE INFORMATION IN THE CALENDARS FOR 2005-06)

(See NOTE/DISCLAIMER at the end of the Appendix.)

CIVIL ENG. PROGRAM AT THE GIVEN UNIVERSITY	Number of Transportation Engineering Courses		
	Core	Elective	Total
1. **Alberta**	1	0	1
2. **British Columbia**	1	2	3
3. **Calgary**	1	5	6
4. **Carleton**	2	0	2
5. **Concordia**	1	2	3
6. **Dalhousie**	1	2	3
7. **Lakehead**	1	2	3
8. **Laval**	0	0	0
9. **Manitoba**	2	2	4
10. **McGill**	1	2	3
11. **McMaster**	1	3	4
12. **Memorial**	1	0	1
13. **Moncton**	1	2	3
14. **Montreal Ecole Polytechnique**	2	0	2
15. **New Brunswick**	1	4	5
16. **Ottawa**	0	***1***	1
17. **Queen's**	0	0	0
18. **Royal Military College**	1	0	1
19. **Ryerson**	3	0	3
20. **Saskatchewan**	1	2	3
21. **Sherbrooke**	1	***1***	2
22. **Toronto**	2	2	4
23. **Waterloo**	1	4	5
24. **Western Ontario**	0	0	0
25. **Windsor**	2	0	2

<u>APPENDIX.</u> UNDERGRADUATE TRANSPORTAION ENGINEEIRNG COURSES OFFERED BY THE 25 CIVIL ENGINEERING DEPARTMENTS AT CANADIAN UNIVERSITIES (BASED ON THE INFORMATION IN THE CALENDARS FOR 2005-06)

(See NOTE/DISCLAIMER at the end of the table.)

UNIVERSITY, CIVIL ENG. PROGRAM	**CORE TRANSPORTATION COURSE TITLE AND DESCRIPTION**	**ELECTIVE TRANSPORTATION COURSE TITLES**
1. **Alberta** Civil Eng Option	**CIV E 315 Transportation Engineering:** Transportation systems and their elements. Principles of transportation planning. Traffic volume, capacity, speed, density, and safety. Fundamentals of traffic control. Principles of highway planning. Highway and terrain. Vehicular motion. Horizontal and vertical geometric design. Cost/benefit analysis in highway design. Earthwork and mass diagram. Flexible and rigid pavement design.	None
Civil (Envtl) Eng Option	None	None
2. **British Columbia** Civil Eng	**CIVL 340 Transportation Engineering I** The analysis and design of the elements of transportation facilities in development of transport technology; vehicle motion; vehicle/pavement interaction; elements of road design; principles of queuing and roadway capacity; rail transit performance and capacity analysis; economics as applied to transport.	CIVL 440: Transportation Engineering II CIVL 441: Transportation Planning and Analysis
Envtl Eng	As above.	None (subject to confirmation)
3. **Calgary** Civil Eng (Regular, Envtl, Structural and Transportation) Options	**ENCI 473: Transportation Planning** Goals and Objectives of urban and regional transportation planning; the transportation planning process' trip generation, trip distribution, modal split, traffic assignment; transportation surveys	ENCI 573: Highway Eng**.** ENCI 575: Operation of Transportation Systems

	and data collection; fundamentals of traffic flow; capacity and level of service; urban transportation technology; computer simulation models of urban transportation; environmental impacts; transportation systems management; energy consideration; pedestrian movement systems; urban goods movement; impact of transportation system on city growth; urban transportation policy and financing in Canada.	ENCI 577: Modelling of Transportation Systems ENCI 579: Asphalt Pavement Design and Mgmt. ENCI 599: Independent Research in Transportation Issues
4. **Carleton** Civil Eng. Envtl Eng	**CIVE 3304: Transportation Engineering and Planning** Transportation and the socio-economic environment; modal and intermodal systems and components; vehicle motion, human factors, system and facility design; traffic flow; capacity analysis; planning methodology; environmental impacts; evaluation methods. **CIVE 4209: Highway Engineering** Highway planning; highway location and geometric design; traffic engineering; highway capacity; soil classifications; subgrade and base materials; highway drainage; frost action; structural design of rigid and flexible pavements; highway economics and finance; maintenance and rehabilitation. Basics of pavement engineering and design. None	None (subject to confirmation) None
5. **Concordia** Civil Eng (Infrastructure Option)	**CIVI 372: Transportation Engineering** Fields of transportation engineering; transportation's roles in society; planning and design of road, rail, air, and water-way system components: terminals, right-of-way; control systems: evaluation of alternative modes and decision-making process; introduction to computer-aided design and management of	CIVI 471: Highway and Pavement Design CIVI 474: Transportation Planning and Design

Civil Eng (Envtl	systems. As above.	CIVI 474: Transportation Planning and Design
6. **Dalhousie** Civil (Infrastructure) Eng Civil (Earth & Envtl) Eng	**CIVL 3200.03: Transportation Engineering** This class commences with an introduction to Transportation Engineering in the context of planning, design and operations of urban and rural systems. The class also provides an introduction to route location with special emphasis on Canadian standards and specifications. It also includes detailed study of road design elements, vehicle motion, vehicle/pavement interaction, and principles of roadway capacity. As above	CIVL 4200.03: Transportation Systems CIVL 4250.03: Highway Engineering As above
7. **Lakehead** Civil Eng	**Engineering 3138: Highway Design** Geometric design of highways, including horizontal and vertical alignments, cross-sections, and intersections with safety considerations. Highway capacity and level of service. Subgrade problems. Design of drainage structures. The design of flexible and rigid pavement.	Engineering 0137 - Transportation Systems Engineering 0553 - Traffic Engineering
8. **Laval** Génies civil	None	None (subject to confirmation)
9. **Manitoba** Civil Eng.	**023.379: Transportation Engineering 1** Introduction to transportation. Overview of Canada and U.S. transport systems. Fundamentals of transport systems analysis. Introduction to sequential demand modeling. Analysis and evaluation of uninterrupted flow on highways. Basics of geometric design of highways. Basics of design of at-grade intersections.	023.441: Transportation Systems 023.442: Highway Pavement Design

	Introduction to computer applications in transportation engineering. Basics of pavement engineering and design. **023.440: Transportation Engineering 2** Fundamentals of traffic control for highways. Capacity and level of service analysis on urban streets. Urban supplement to geometric design guide for Canadian roads. Modelling vehicle performance. Elements of railway engineering. Design for trucks. Transportation systems management. Application of intelligent transportation systems. Basic pavement design methods. Introduction to pavement management systems. Highway accidents and design for safety. Legislative and policy framework for transportation engineering.	
10. **McGill** Civil Eng	**CIVE 319 (B) Transportation Engineering** Introduction to design and operating principles and procedures for surface transportation systems, including vehicle motion and performance, pavements, geometric design of roadbeds, vehicle flow and capacity, traffic control, demand, supply and cost concepts.	CIVE-440 Traffic Engineering CIVE-540 Urban Transportation Planning
11. **McMaster** Civil Eng	**CIV ENG 3K03 Introduction To Transportation Engineering** A transportation impact study serves as the focus for group projects, and provides the context for application of material on traffic flow characteristics, capacity and control for signalized and unsignalized intersections, and travel demand forecasting. Safety; social impacts.	Civ Eng 4d04 Geometric Highway Design Civ Eng 4g03 Pavement Materials And Design Civ Eng 4h03 Analysis Of Transportation Systems
12. **Memorial** Civil Eng.	**7745: Highway Eng** Design and construction of highways, including driver, vehicle and road characteristics; highway location and geometrics; soil	None

	classification; subgrade and base materials; highway drainage; flexible and rigid pavements; highway economics; relevant laboratory exercises.	
13. **Moncton** Génie civil	**GCIV4750 - Conception des routes** Conception géométrique des routes. Principes de planification, études économiques, identification des impacts et conception des infrastructures routiers. Le cours est basé sur les normes canadiennes de conception géométrique des routes.engineering.	CIV5710 - Revêtements routiers GCIV5720 - Techniques de la circulation
14. **Montreal Ecole Polytechnique** Génies civil; L'orientation Ouvrages civils et constructions; Systèmes urbains et environnement; Infrastructures routières	**CIV2710: Systèmes de transport** Place des transports en génie civil et organisation institutionnelle des transports dans une région urbaine. Planification des transports. Prévision de la demande de transport à l'aide de modèles classiques (génération, distribution, répartition modale et affectation). Notions de réseau de transport, calcul de chemin et résolution de problèmes de distribution. Demande et offre de transport. Méthodes d'enquêtes en transport et analyse des données. Dynamiques de la circulation. Travaux pratiques informatiques **ELECTIVE?** **CIV4720 Conception des routes** Introduction à la capacité des éléments routiers. Éléments de circulation. Classification des routes. Statistiques. Véhicule et conducteur. Localisation du tracé : consultation des citoyens, protection de l'environnement, esthétique. Analyse économique. Géométrie du tracé : alignements horizontal et vertical; signalisation, éclairage, marquage. Conception des chaussées. Drainage. Résistance au gel et à la fissuration. Techniques de construction. Techniques et gestion de l'entretien des chaussées.	None (subject to confirmation)

15. **New Brunswick** Civil Eng	**CE 3201: Transportation Eng**. Principles of transportation engineering: modal characteristics, travel demand functions, traffic flow theories and models, and vehicle-track principles. Highway transportation classification, elements and design principles. Laboratory work is field-oriented and involves elementary traffic studies.	CE 5212: Pavement Design 1 CE 5222: Traffic Engineering CE5232: Transport Fcaility Design CE5241: Intro. to Pavement Management Systems CE 5313: Urban Planning
16. **Ottawa** Civil; Envtl/Water Resources; Structural/Geotechnical Eng	None	CVG4150: Highway and Transportation Engineering
17. **Queen's** Civil (Infrastructure and Envtl Eng Options)	None	None (Students can apparently take as an elective the course "Transportation Planning" at the Royal Military College, although the Calendar does not specifically state so.)
18. **Royal Military College** Civil Eng	**CEE489A: Transportation Planning** For students of the Fourth Year taking Civil Engineering. Characteristics of different modes of transport. The land use/urban transportation planning process. Transportation studies, data collection and analysis, demand models, forecasts. Traffic flow and capacity, level of service and freeway operations.	None

19. **Ryerson** Civil Eng	**CVL 316: Transportation Eng** Introductory level instruction in: Transportation modes, systems and networks; Operating characteristics of transportation vehicles. Terminal characteristics: Transportation studies; Evaluation of transportation options; Trip generation, trip distribution, Mode choice and network assignment models. **CVL 633: Highway Materials** Quality control and quality assurance, End Point Specifications. Sampling methods. Granular materials used in highway construction, geotextiles, insulation materials, soil stabilization types and uses. Performance graded asphalt cements. Super Pave mix design methods. Plant mix, road mix, hot and cold recycling construction methods. **CVL 735: Highway Design** Alignment and cross-section design of roadways; intersection design; earthwork calculations and mass-haul diagrams; pavement design and management for flexible and rigid pavements; rural and urban highway drainage; barriers, guide rail and other highway hardware; Computer applications.	None
20. **Saskatchewan** Civil Eng	**CE 329.3: Transportation Eng.** This course introduces the civil engineering student to planning, design, operation and management of air and road transportation systems.	CE 417.3 Transportation Eng II CE 467.3 Transportation and Regional Development ??
21. **Sherbrooke** Génies civil	**GCI 320: Génie routier** Appliquer les principales notions reliées à la conception des routes et à leur entretien. Éléments de planification du transport routier en fonction de la capacité des routes et des intersections. Études préliminaires. Conception géométrique des routes. Conception structurale des chaussées: charges, climat, matériaux, méthodes de conception des chaussées flexibles et rigides. Procédure de construction. Gestion de l'entretien.	GCI 330: Trafic routier

la concentration en génie de l'environnement	As above	None (subject to confirmation)
22. **Toronto** Civil Eng (General Option) Civil Eng (Envtl Option)	**CIV 231H1: Transport I- Design** This course introduces the fundamentals of transport facility and service design, with emphasis on highway geometric design, pavement design and transit service design. Topics include vehicle performance, horizontal and vertical alignments of highways, earthwork, flexible and rigid pavements, pavement management, transit operations and control, and transit route design. Computer-aided facility design solutions are also introduced. **CIV 332H1: Transport II – Performance** This course focuses on the fundamental techniques of transportation systems performance analysis with emphasis on congested traffic networks. Topics include transportation demand, supply and equilibrium, traffic assignment, network equilibrium, and system optimality, traffic flow theory, shockwaves, highway capacity analysis, introduction to deterministic and stochastic queuing analyses, intersection signal control types and related timing methods, and traffic simulation. The course also provides an introduction to basic elements of Intelligent Transportation Systems (ITS). As above	CIV 531H1: Transport III: Planning CIV 533H1: Transport Operations None (subject to confirmation)
23. **Waterloo** Civil Eng Envtl Eng	**CIVE 342: Transport Principles and Applications** Introduction to basics principles and procedures of transport planning and engineering applied to Canadian intercity transport problems.on traffic flow characteristics, capacity and control for signalized and unsignalized intersections, and travel demand forecasting. Safety; social impacts. None (subject to confirmation)	CIVE 343: Traffic Engineering CIVE 440: Transport Systems Analysis CIVE 444: Urban Transport Planning CIVE 542: Pavement Structural Design None (subject to confirmation)

24. **Western Ontario** Civil and Structural Eng Options	None	None
25. **Windsor** Civil Eng Envtl Eng	**87-314. Transportation and Traffic Engineering** Characteristics of transportation systems; rail, highway, airway, waterway, and pipeline; evaluation of transportation projects and systems, urban transportation analysis and prediction, traffic studies, highway and intersection capacity, characteristics of traffic flow, traffic control principles. **87-414. Highway Design and Construction** Geometric design of highways; drainage; highway soil engineering including soil stabilization; bituminous materials; rigid and flexible pavement design; construction of pavements. None	None None

NOTE/DISCLAIMER: A reasonable effort has been made to reflect the contents of the various university calendars. However, the course listings and descriptions in this table are subject to reporting and transcribing errors. Moreover, course offerings at a given university are subject to change. This table is therefore not a substitute for the information in the most up to date university Calendars, and it is suggested that the respective civil engineering departments should be consulted to obtain the current information.