

TRANSPORTATION ENGINEERS OF 2020: What Skills Will They Need?

The transportation engineering field is currently undergoing continuous changes in technology, financing, communications, environmental requirements, climate change adaptations, administrative and governance structures, information, globalization, market characteristics, human resources, management tools and the need for sustainability in all its forms. Private, public and academic sectors must respond to this changing world in a well-planned, forward thinking and effective way. In order to meet the challenge of change, engineers must possess the appropriate skill sets.

As part of its annual conference in September 2008, the Transportation Association of Canada convened a workshop to address the critical issue of what skills and knowledge transportation engineers will need in 2020 and beyond. This briefing provides a synopsis of the topic and a summary of the discussion at the workshop.

This briefing does not reflect a technical or policy position of TAC.

Background

The need for transportation engineers to respond to continuing change is very important for the transportation industry. At the same time, engineering programs must meet accreditation requirements. Moreover, in some provinces, mandatory practice area examinations are required (e.g., British Columbia, Alberta, Saskatchewan, New Brunswick, Prince Edward Island, Newfoundland and Labrador). In essence, there is a more structured system move toward mandatory continuous training.

This briefing was developed following a workshop sponsored by the Education and Human Resources Development Council during the Annual Conference of the Transportation Association of Canada in September 2008 which asked the question "What Skills will the Transportation Engineer of 2020 Need to Have?" The briefing presents a cross-sectional representation of industry and professional practice in identifying prioritized skill set requirements for the civil engineer of 2020, ranging from the early to mid career to senior levels. It is assumed that basic academic skill requirements will have been met in graduating from an accredited engineering program, and/or achieving professional registration, as well as passing mandatory practice area examinations where applicable.

Civil Engineering

Skill sets should be related to the activities civil engineers will likely practice over the short to long-term.

- Short-term, 10 to 30 years (e.g., secondary and tertiary roads)
- Medium-term, 30 to 70 years (e.g. primary highways)
- Long-term, 70 to 100 years + (e.g., bridges)

While the breakdown is arguable, the real question examines the civil engineering and associated societal needs and prospects over the long-term. Table 1 illustrates some of the needs and prospects for which there is a reasonable degree of certainty, and a second set for which the future is more uncertain. While the list is subjective, even for the uncertain items, it is still useful for skill sets requirements to recognize the possibility that these will occur to some degree.

Table 1 – Civil Engineering Needs and Prospects

Time Horizon	Reasonable Degree of Certainty (short to long-term)	Uncertain Future
Short-term	<ul style="list-style-type: none"> ■ Need for clean water ■ Need for human habitat ■ Need for waste treatment/disposal 	<ul style="list-style-type: none"> ■ Sufficient funding for infrastructure ■ Extent of climate change adaptations ■ Rate of environmental degradation ■ Effectiveness of security ■ Nanotechnology applications
Medium-term		<ul style="list-style-type: none"> ■ Globalization of water market ■ Less transport of people ■ More non-conventional energy ■ Extent of infrastructure backlog ■ Climate adaptation needs ■ Population growth levels off
Long-term		<ul style="list-style-type: none"> ■ Availability of quantum computing ■ Building infrastructure on other planets ■ Replacement of CE functions by robots ■ Global water shortages and conflicts ■ Wide use of non-conventional energy

Contributing Areas to Skill Requirements

Discussion with workshop participants from the public, private, and academic sectors suggests that there are three areas of teaching and training which contribute to skill requirements for civil engineers, particularly in the area of civil infrastructure, including transportation.

Contributing areas include:

- Lasting effectiveness
- Inadequate coverage
- Major challenges

Table 2 assumes that the fundamentals of science, mathematics, humanity, social sciences, economics, as well as applied subjects are adequately addressed in the accreditation requirements which engineering schools must meet.

The areas of lasting effectiveness in the first column in Table 2 involve various specific courses, applicable over the full range of short to long-term indicated in Table 1. Areas of inadequate coverage listed in the second column are not normally included in postgraduate civil programs; rather, they are likely acquired in special courses or on-the-job training. Items in the third column are perhaps beyond any conventional approach, and represent major challenges. Essentially, creativity and innovation, judgement and integrity, as well as interpersonal skills are acquired or developed more by exposure and a conducive professional climate than by training per se. As well, the other three challenges in this category are only addressed partially by teaching and training.

Continuing professional development (CPD), in its many forms, is generally regarded as a key element in maintaining an engineer's up-to-date professional competency, and/or the engineer's required skills to practice.

Engineers Canada posts a record of CPD programs in various provincial and territorial associations on their web site. Some of the major observations from this record can be summarized as follows:

- Professional Development Programs (CPD), also referred to as Continuing Professional Excellence or Professional Practice Guideline in associations, are operational in all but one provincial association. About half are mandatory and half voluntary.
- Practice reviews, also referred to as Professional Inspection Program and Continued Competency Assurance Program in two associations, are mandatory in about two thirds of the associations.

Operational details of the foregoing programs can be obtained from provincial or territorial association websites (e.g., some practice reviews work on random selection or emphasize consulting engineers; others have a specified number of engineers annually, etc.). There is a definite move towards ensuring and enhancing professional competency among practising engineers.

The workshop organized by the Human resources and Development Council of TAC, held in Toronto on September 24, 2008, included presentations from a cross section of the public, private and academic sectors. While the event had a transportation context, the perspectives offered were also applicable to civil engineering in general. Some highlights follow.

Table 2 - Contributing Teaching and Training Areas to Skill Set Requirements

Lasting Effectiveness	Inadequate Coverage	Major Challenges
<ul style="list-style-type: none"> ■ Design of experiments (experimental and analytical) ■ Probability and statistics ■ Risk and reliability ■ Performance analysis and modeling ■ Integration of management, design, operations and other processes 	<ul style="list-style-type: none"> ■ Accounting and business practices ■ Communication (verbal and written) ■ Legal considerations and issues ■ Knowledge management ■ Integrative thinking 	<ul style="list-style-type: none"> ■ Creativity and innovation ■ Judgment and integrity ■ Interpersonal skills ■ Handling information overload ■ Dealing with “flavor of the month” technologies ■ Research is more than searching the web

Skill Set Requirements Identified by Public, Private and Academic Sectors

- **An academic perspective on educating the engineer of 2020:** “.....we talked about this at a conference 12 years ago.....and it looks like nothing has changed.....but a lot has.....We have had severe climatic weather events along with terrorism issues which makes our perspective a little different.....through an evolving context of changing climate, infrastructure renewal, northern developments, aging population and globalization.....how should we prepare our students?.....give them a strong foundation on engineering principles along with complementary knowledge in sustainable development, economics, information and communication technologies, risk analysis, cold region engineering.....prepare the students with skills needed such as team working ability to integrate and communicate and to adapt to technology change.”
- **Continuing/upgrading skills in the world of 2020:** “.....Initially traditional academic foundations but now we see the need for more depth of knowledge and more specialization in certain areas.....looks like we are moving to more years of education.....in some provinces there is a mandatory engineering training program of four years.....at Engineers Canada, there is a move towards a more structured system.....what will continuing training need to be?.....with regulators things move very slowly and then, bang there is a change.....for example, in British Columbia if you are designing structures, you need to have exams in structural engineering....if we look around the world we can see the same trends in certification.....”
- **Engineering skills consultants will expect in 2020:** “What we will look for in the consulting engineer will be exactly what we look for today. Engineers like solving problems, have a bias to science, technology and logic.....and need a technical speciality but also a broad range of skills, understand life cycle costing and economics and must have the willingness to continually learn and accept new and different ideas.....In non-technical knowledge, they must be able to understand client and stakeholder concerns, communicate options and look at issues holistically.....must possess project management knowledge; plan the work, communicate the plan, do the work, document the process....and get paid.....”
- **Engineering skills contractors will expect in 2020:** “We need engineers that specialize, can work with people and know about sustainability.....looking for those who are able to implement the changes contractors are facing and who can deliver to customers expectations.....professionalism beyond just getting the work done, leading construction innovation.....engineers have to know various technologies in order to choose the correct ones.....The engineer in 2020 will need specialist technical skills and then more general skills as they learn from experience.....also business skills to understand the implications of technical issues and decisions.....and people interaction skills.....”

- **Expected engineering skills in the public road transportation sector in 2020:** “.....changes in the engineering profession have traditionally followed changes in technology and society; e.g., mass production of cars meant greater demand for mobility.....but today we have for the most part built our infrastructure.....while engineering has been instrumental in creating our standard of living, there is much going on that impacts our lives.....can we again position civil engineering so that our youth and the public recognize it as an exciting profession that addresses societal and technological changes.....means we have to consider the major challenges we face: next technological revolution, do we lead or follow; climate change and natural disasters; globalization of the market place; ageing infrastructure.....by 2020, we will see intelligent infrastructure, real time sensing, smart material, wireless tracking of commodities from origin to destination, and much more.....engineers will require a diverse set of skills in addition to practical ingenuity and strong analytical capability.....exceptional communication skills, life long learning (economics, business, politics), leadership, change and risk management, environmental stewards, innovations, leaders in shaping public policy.....the opportunities are limitless.....”

These perspectives demonstrate a consistency in vision despite the different sectors speakers represented. Recurring themes included: adapting to change, responding to opportunities, requirements for technical plus non-technical skills, life long learning, communication, business, people skills and leadership.

Based on the discussion at the workshop, the following three tables identify, categorize and prioritize skill requirements for the transportation engineer of 2020. The tables depict a shift of priorities depending on the occupied level.

Skill Requirements for the 2020 Entry Level Transportation Engineer

The entry level engineer (Table 3) is expected to possess skills mostly of a useful nature, particularly those in the non-technical, adaptation and sustainability areas. Critical skills mainly relate to graduation from an accredited engineering program, and/or professional registration – applicable to all levels – and those related to ethics and integrity as well as competence in the engineer’s services provision specialization.

Table 3 - Entry Level Engineer

Skill Sets	Critical	Necessary	Useful
<u>Technical</u> <ul style="list-style-type: none"> ■ Graduation from an accredited engineering program and/or professional registration ■ Continued education (voluntary and mandated where applicable) ■ Risk assessment 	*****	***** *****	*****
<u>Non-technical</u> <ul style="list-style-type: none"> ■ Business ■ Economics ■ Communication (written and verbal) ■ Management (project, system, etc.) 		*****	***** ***** *****
<u>Adaptation</u> <ul style="list-style-type: none"> ■ Climate change ■ New technologies ■ Globalization ■ Social/political change 		***** *****	***** ***** ***** *****
<u>Sustainability</u> <ul style="list-style-type: none"> ■ Infrastructure ■ Resources ■ Energy ■ Innovation 		***** *****	***** ***** ***** *****

<u>People</u> ■ Expectations ■ Interactions/interpersonal ■ Teamwork ■ Ethics and integrity	*****	***** *****	*****
<u>Services Provision</u> ¹ ■ Water and/or other services ■ Waste and/or other services ■ Transportation and/or other services ■ Habitat	***** ***** ***** *****	***** ***** ***** *****	

¹ This is sector and specialization dependent

Skill Requirements for the 2020 Mid Career Level Transportation Engineer

Mid career level engineers (Table 4) are expected to possess skills mainly in the necessary category, but are also expected to have some critical management skills, critical people skills related to teamwork, ethics and integrity, as well as competence in the engineer's services provision specialization.

Table 4 – Mid Career Level

Skill Sets	Critical	Necessary	Useful
<u>Technical</u> ■ Graduation from an accredited engineering program and/or professional registration ■ Continued education (voluntary and mandated where applicable) ■ Risk assessment	*****	***** ***** *****	
<u>Non-technical</u> ■ Business ■ Economics ■ Communication (written and verbal) ■ Management (project, system, etc.)	*****	***** ***** ***** *****	
<u>Adaptation</u> ■ Climate change ■ New technologies ■ Globalization ■ Social/political change		***** ***** ***** *****	*****
<u>Sustainability</u> ■ Infrastructure ■ Resources ■ Energy ■ Innovation		***** ***** ***** *****	*****
<u>People</u> ■ Expectations ■ Interactions/interpersonal ■ Teamwork ■ Ethics and integrity	***** *****	***** ***** *****	
<u>Services Provision</u> ¹ ■ Water and/or other services ■ Waste and/or other services ■ Transportation and/or other services ■ Habitat	***** ***** ***** *****	***** ***** ***** *****	

¹ This is sector and specialization dependent

Skill Requirements for the 2020 Senior Level Transportation Engineer

Skills requirements for senior level engineers (Table 5) exhibit the highest degree of priority variation. This may be largely due to variation in responsibility, type of business or organization, age/years of service, etc. However, the general consensus between the private, public and academic sectors is that more skills are expected of a critical to necessary nature, as compared to the other levels, except for services provision specialization.

Results also suggest that there is an implicit long-term or time invariant aspect to the skills requirements. In other words, they apply to the transportation engineer of today, in 2020 and beyond.

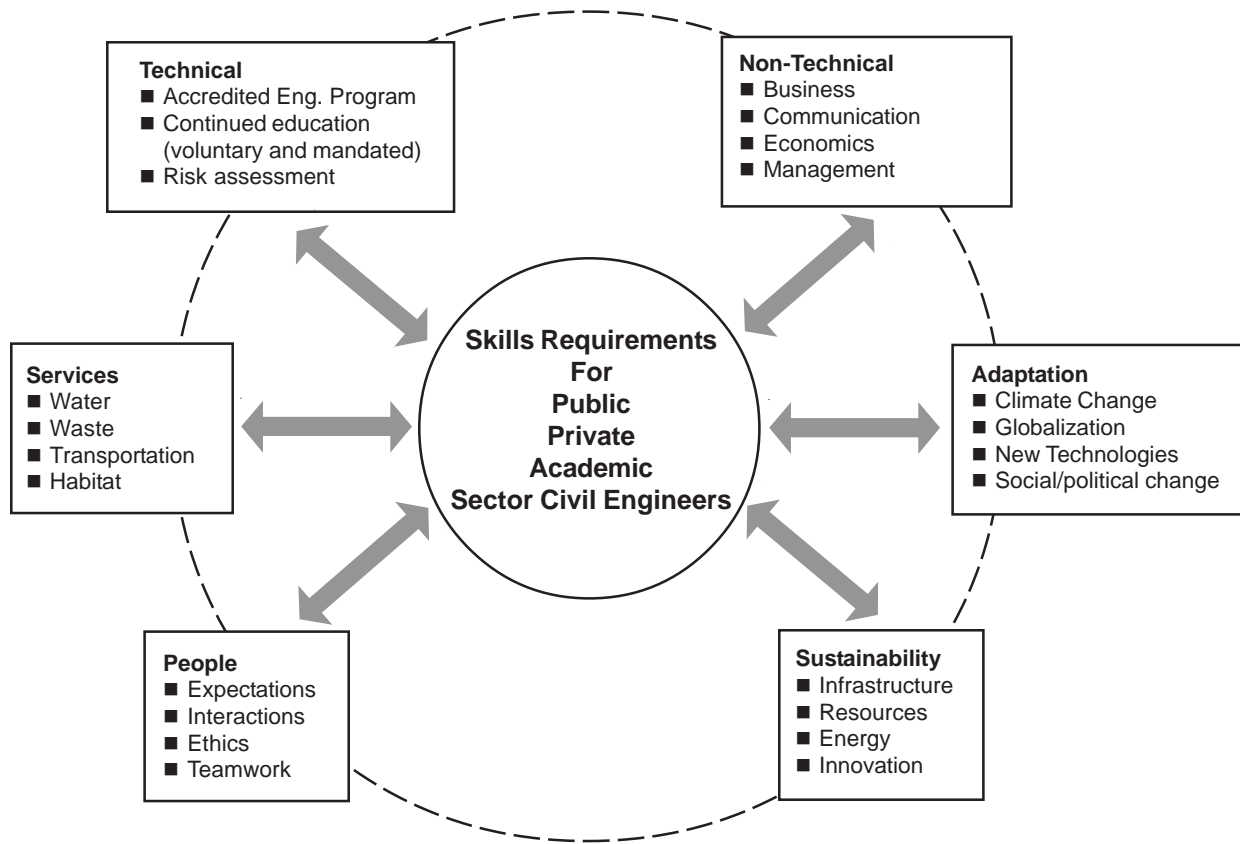
Table 5 – Senior Level

Skill Sets	Critical	Necessary	Useful
<u>Technical</u> <ul style="list-style-type: none"> ■ Graduation from an accredited engineering program and/or professional registration ■ Continued education (voluntary and mandated where applicable) ■ Risk assessment 	*****	*****	
<u>Non-technical</u> <ul style="list-style-type: none"> ■ Business ■ Economics ■ Communication (written and verbal) ■ Management (project, system, etc.) 	*****	*****	
<u>Adaptation</u> <ul style="list-style-type: none"> ■ Climate change ■ New technologies ■ Globalization ■ Social/political change 	*****	*****	
<u>Sustainability</u> <ul style="list-style-type: none"> ■ Infrastructure ■ Resources ■ Energy ■ Innovation 	*****	*****	
<u>People</u> <ul style="list-style-type: none"> ■ Expectations ■ Interactions/interpersonal ■ Teamwork ■ Ethics and integrity 	*****	*****	
<u>Services Provision</u> ¹ <ul style="list-style-type: none"> ■ Water and/or other services ■ Waste and/or other services ■ Transportation and/or other services ■ Habitat 		*****	*****

¹ This is sector and specialization dependent

Summary of Interconnected Skill Requirements

Figure 1 below illustrates the time invariant aspect as an interconnected summary of skill requirements for public, private and academic sector civil and transportation engineers.



Conclusions

In the process of facing continuous changes from technology to climate change adaptations, from society to the need for sustainability, transportation engineers must closely examine expected skill requirements. A cross-sectional representation from the public, private and academic sectors has suggested that these skill set requirements can be categorized as technical, non-technical, adaptation, sustainability, and people and services provision. Moreover, they can be assigned critical, necessary and useful priorities according to the engineer's entry, mid career or senior level.

Acknowledgements

This briefing was prepared by the TAC Education and Human Resources Development Council largely as a voluntary effort. The principal author was Ralph Haas, with input and support received from workshop speakers, participants, as well as Council members.

The participation of the following individuals as speakers during the workshop is gratefully acknowledged:

Cathy Lynn Borbely, Manager of Planning,
Saskatchewan Ministry of Highways and
Infrastructure

Marie Carter, Director, Professional and International
Affairs, Engineers Canada

Carl Clayton, Senior Vice President, Transportation,
Stantec Consulting

Stephen Damp, representing the Canadian
Construction Association

Guy Doré, Professor, Department of Civil
Engineering, Laval University

Disclaimer

While TAC and the authors endeavored to ensure that all information in this briefing is accurate and up to date, they assume no responsibility for errors and omissions.

Transportation Association of Canada
2323 St. Laurent Blvd., Ottawa, ON K1G 4J8
Tel. (613) 736-1350 Fax: (613) 736-1395
www.tac-atc.ca