A holistic civil engineering approach to accessibility: Addressing systemic barriers in the built environment

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Abstract

Civil engineers have many responsibilities to the public, among them designing safe, efficient, and reliable structures and infrastructure. But what is the responsibility of civil engineers towards ensuring that intended users can use these structures and infrastructure without encountering barriers? This research looks at the intersection of universal design (UD) and civil engineering to find if civil engineering students should learn about accessibility and UD during their undergraduate education and if civil engineering professionals should be held accountable when barriers are designed and constructed into the built environment.

To answer these questions a survey was distributed to 222 building design professionals to gather their opinion and experience on the subject. Results show that civil engineers have limited knowledge of UD and accessibility requirements in the built environment and that they overwhelmingly believe that students should learn about these subjects during their civil engineering education. Furthermore, most participants agree that civil engineers do have a responsibility to ensure that the built environment is accessible to everyone. Based on the survey results, it is recommended to integrate a course about accessibility and UD in civil engineering curriculums. The curriculums of undergraduate civil engineering programs at Canadian universities were analyzed and it was found that no course discussing these subjects currently exist, but that there is space to implement them in a broader “social impacts of civil engineering” course. It is recommended that the CEAB recognizes accessibility and UD as useful and necessary subjects of education for civil engineering students. Finally, case studies of recent accessibility assessments of buildings are presented. It was found that while progress is being made in designing and constructing accessible structures, many are still not meeting all possible UD recommendations. The participation of professional civil engineers who have learned about accessibility and UD during their civil engineering education could improve the outcome of these projects. The findings of this thesis indicate that it is time to acknowledge civil engineers’ responsibility towards society and the need for a consistent approach to education about its social impacts, in particular about accessibility and universal design.

Table of contents

List of figures

List of tables

1. Introduction

1.1. Purpose

Civil engineers play vital roles in the communities in which they practice their profession. They are tasked with designing and supervising the construction of essential infrastructure and services such as roads, bridges, buildings, etc. Civil engineers are involved throughout a design project and have a responsibility towards the public to ensure that the outcome of the project is safe and serves everyone that it was intended to serve. Large engineering and architectural design firms are embracing the benefits of taking an integrated approach to building design, meaning that engineers and architects work together, from the beginning of the project, towards completion (Jaegerman, 2021) (EllisDon, 2020). As a traditional STEM (Science, Technology, Engineering and Mathematics) program, most of the civil engineering curriculum is comprised of technical courses such as mathematics, physics, engineering mechanics, mechanics of materials, geotechnical design, wastewater management, etc. While these classes are important, the social impacts of civil engineering are not addressed consistently despite being arguably of equal importance. One major social impact of civil engineering is the accessibility of the built environment. Indeed, when civil engineers design structures, they are also designing elements such as columns, beams, stairs, ramps, and sidewalks that may impose barriers into the built environment. Such barriers make the built environment a difficult place to navigate for many users such as people with disabilities, older adults, families with young children, etc. While an engineer’s design focuses primarily on ensuring structural stability and feasibility, structures that are not accessible to their intended users do not adhere to the scope of the structure and are therefore not well designed. There is a gap of knowledge in the building design industry as architects are burdened with most of the social aspect of the design, which occasionally results in unsatisfactory outcomes. The goal of this thesis is to investigate the social responsibilities of civil engineers; specifically, this study will focus on the responsibility of engineers to design an inclusive and accessible built environment and will aim to answer the following questions:

- What is the responsibility of civil engineers towards accessibility in the built environment?
- What do current professional engineers think about the importance of accessibility, and what is their knowledge on universal design?
- How could the civil engineering curriculum be changed/reformed to fit education on accessibility, people with disabilities, universal design, and other social impacts of civil engineering?

1.2. Scope & outline

To answer these questions, first, a literature review is conducted (Chapter 2) to assess what current research exists in relation to accessibility, design, standards, education, engineering, etc. The literature review is also used to define important concepts that will be reoccurring in the thesis such as sustainability, universal design, barrier-free design, accessibility, and disabilities.

Following the literature review, results from surveys sent to professionals working in the civil engineering and building design profession are discussed in Chapter 3. The purpose of the survey is to gain knowledge of civil engineering professionals' perception of universal design. More specifically, the survey was distributed to engineers in training, practicing engineers, contractors, project managers and architects. The questions asked during the survey vary from asking the participants about their knowledge on universal design to their opinions on incorporating accessibility into the civil engineering curriculum.

Next, based on the results from the survey, Chapter 4 provides recommendations as to how to improve the awareness of civil engineers towards accessibility in the built environment. These recommendations are presented in the form of an undergraduate civil engineering class that would discuss universal design, accessibility, and other social impacts of civil engineering. To be able to recommend this course, a thorough analysis of civil engineering curriculums throughout Canada was completed to assess if such a course already exists and how, depending on the current curriculum structure, this course could be implemented.

Chapter 5 focuses on a case study of the newly constructed Visitor's Welcome Center (VWC) at the Parliament of Canada which was assessed for its accessibility in

2020. The new structure was designed using universal accessibility best practices which aimed to improve its access to all users. To better analyze the influence of civil engineering design on such accessibility improvements, several elements of the VWC are discussed, specifically those that would require structural changes to be considered accessible. Additionally, elements that succeeded in promoting an inclusive environment are highlighted. The chapter also looks at the accessibility assessments that were conducted on Colonel-By Hall and STEM, two Faculty of Engineering buildings at the University of Ottawa. The comparison of the accessibility of these two buildings, one newly built and one built in 1970, shows the evolution of accessibility requirements in building codes and standards. Furthermore, it highlights barriers present for students pursuing their studies in civil engineering. The goal of these assessments is to show the role of civil engineers towards the accessibility of a structure as well as convey the importance of tackling barriers from the initial design stage since they can be extremely difficult to remove once built.

2. Background

2.1. Introduction

There is a lot of research and literature about the responsibilities of architects towards accessibility in the built environment. The Cambridge dictionary defines accessibility as “the quality or characteristic of something that makes it possible to approach, enter, or use it.” (“Accessibility,” 2022). While this research focuses mostly on the physical accessibility of structures, it also recognizes that for a building to be meaningfully accessible it also needs to have accessible communication systems within the building (emergency systems, signage, etc.) and accessible transportation to the building (public transport, exterior routes, parking). Jones (2014) indicates that while architects learn about accessibility and universal design (defined in Section 2.2.1 below), this education, and the resulting design of accessible spaces, is made more meaningful by the involvement of users with lived-experienced (i.e. people with disabilities). Similarly, Ergenoglu (2015) researched the implications of universal design teaching in architecture schools and found that, to ensure life-long interest and learning, schools should teach in a way that makes students observe the issues, solve problems, and ultimately see barriers in the built environment as everyone’s problem. Additionally, a study at Deakin University in Australia concluded that architecture students who learn about universal design during their university education have more positive attitudes towards people with disabilities than architecture students who had not learned about universal design (Hitch et al., 2013). These papers all discuss the importance of making architecture students aware of their responsibilities towards designing an accessible built environment. However, there are few such documents discussing the responsibilities of civil engineers and there is a lack of consensus about what those responsibilities include. Among the currently established responsibilities of civil engineers is the duty to ensure that the structures and infrastructure they design are safe to use. There are few documents demonstrating to what degree civil engineers also have a responsibility to ensure that these structures can be used by everyone. These documents include an article by Kimberly Bigelow discussing the advantages of implementing universal design education in engineering design classes (discussed further in section 2.2.2) and an article by

Rodolfo Valdes-Vasquez discussing the advantages of incorporating social impacts in civil engineering education (though it does not discuss accessibility specifically) (Bigelow, 2012) (Heylighen et al., 2017). It is not clear whether civil engineers are equipped with the necessary tools to deal with this responsibility.

The goal of this literature review is to assess the current understanding of civil engineers towards accessibility in the built environment and to define important terms such as universal design, accessibility, and sustainability. It will also discuss statistics related to disabilities in Canada and around the world and the accessibility standards that are being developed to ensure an inclusive future.

2.2. Universal design

2.2.1. History and premise

Universal design has been a topic of debate and discussion since the 20th century. It is Ronald Marc that is attributed with first using the term Universal Design (UD) in 1985. The American architect defines UD as “a way of designing a building or facility, at little or no extra cost, so that it is both attractive and functional for all people, disabled or not” (Heylighen et al., 2017). The UN re-defined the term in 2006 during the United Nations Convention of the Rights of Persons with Disabilities as “the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” (United Nations, 2006). For this thesis, the term universal design will primarily be used. It is important to note that some researchers and documentation also use the term “inclusive design” interchangeably.

UD differs from barrier-free design. A project that is barrier-free will have been designed so that there are not barriers for people with disabilities (Cambridge Dictionary, 2021). UD focuses on everyone, not only persons with disabilities. Populations that do not identify as having a disability but might still experience barriers in the built environment include: Families with young children; older adults; people who do not speak the official language(s) of the place they visit; people of varying sexual orientations, gender identity and gender expression; people of varying religious and cultural beliefs (University of Washington, 2021).

UD incorporates design solutions in the mainstream which benefit everyone and improves from barrier-free design since it treats everybody in an equitable way and avoids stigma (Heylighen et al., 2017). Imrie (2012) describes seven principles of universal design which are presented in Table 2-1.

Table 2-1 - Principles of Universal Design (Imrie, 2012)

Principle	**Description**
Principle one: Equitable use	The design is useful and marketable to people with diverse abilities
Principle two: Flexibility in use	The design accommodates a wide range of individual preferences and abilities
Principle three: Simple and intuitive use	Use of the design is easy to understand, regardless of the user’s experience, knowledge, language skills of current concentration level
Principle four: Perceptible information	The design communicates necessary information effectively to the user, regardless of ambient conditions or the user’s sensory abilities
Principle five: Tolerance for error	The design minimizes hazards and the adverse consequences of accidental or unintended actions
Principle six: Low physical effort	The design can be used efficiently and comfortably and with a minimum of fatigue
Principle seven: Size and space for approach and use	Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user’s body size, posture, or mobility

Heylighen et al. (2017) attempted to answer the very complex question “Why does inclusive design concern all of us?” by emphasizing the two premises that inclusive design starts from:

1. *“There is such considerable diversity in mental and physical capability both across the population and over the length of the life-course that the association of ‘normality’ with ‘able-bodiedness’ is neither accurate nor acceptable”* and
2. *“Disability arises from interactions with the surrounding environment that are amenable to design and structural interventions, and not inherently from capacity levels, health status or associated degrees of impairment”.*

The second point highlights the difference between the social and medical models of disability. The medical model identifies the person with a disability as being the ‘problem’ and, therefore, they need to adapt themselves to their environment. The social model of disability is now employed and used by most accessibility activists and many associations and governments, including the Government of Canada (Furrie, 2018). This new model sees the barriers in the built environment as the problem. For example, if a hard-of-hearing person is in a building without visual fire alarms, it is the fire alarms that are the problem in the case of an emergency, not the person’s hearing disability. The social model puts pressure on society, not the person with a disability, to reduce, and ultimately remove, disabling barriers (University of Leicester, 2015). As Heylighen et al. explains, the social model of disability distinguishes between disability and impairment. Whereas disability refers to a bodily dysfunction and, in many cases, cannot be changed, impairment is socially constructed on top of that (Heylighen et al., 2017).

According to statistics from the World Health Organization, over 1 billion people around the world live with some form of disability. People’s abilities change throughout their lives due to accidents and life changes such as pregnancy, mental illness, and aging. Because of this, most people will experience some form of disability at some point in their lives (World Health Organization, 2020). Universal design goes beyond ability and age, it also ensures that environments are designed to include all cultures, social differences, gender, sexuality, etc.

It is also important to mention that universal design is a crucial piece to building a sustainable built environment. According to the International Institute on Sustainable

Development, sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs (International Institute for Sustainable Development, 2021). According to this definition a universally accessible structure is also sustainable since designing a built environment that is not universally accessible compromises the ability of future generations to access said environment. Furthermore, sustainability is often described as having three equally important and connected pillars: environmental sustainability, economical sustainability, and social sustainability. Accessibility fits in the social pillar of sustainability. The 17 Sustainable Development Goals (SDGs) published with The 2030 Agenda for Sustainable Development by the United Nations (UN) were adopted by all UN members in 2015 (United Nations Department of Economic and Social Affairs, 2021). These goals are far reaching, from education and clean water to gender equality. Furthermore, 4 of the 17 goals also reflect the importance of accessibility, accessible cities, and spaces in sustainable development and accessibility awareness in education. A summary of these goals and their targets related to this research are presented in Table 2-2.

Table 2-2 - UN sustainable goals and their targets relating to accessibility (United Nations Department of Economic and Social Affairs, 2021)

Goal	Target
4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	4.7: By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development
	4.a. Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all
9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	9.1: Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
10: Reduce inequality within and among countries.	10.2: By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status
11: Make cities and human settlements inclusive, safe, resilient and sustainable.	11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
	11.7: By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

2.2.2. Universal design education

While many design professionals such as civil engineers, architects, project managers and contractors, have no problem incorporating universal design principles in their projects, others are wary to adopt UD principles for several reasons. Heylighen et al. suggest that these reasons include the perception that it will increase costs, reduce aesthetics and innovation, lack of knowledge, involves a more complex design process, and is only put in place for people with disabilities (Heylighen et al., 2017).

Bernardi and Kowaltowski (2010) investigated the impact of universal design education for design professionals. The authors explain that there needs to be a shift in priorities by design professionals who too often prefer focusing their design solutions on aesthetics and economics rather than social impacts. They state that there is a lack of basic interest and knowledge about human beings since the curriculum focuses a lot more on science. Furthermore, the authors acknowledge that there is a need to deepen the knowledge of students about sustainability and UD since decisions about these concepts are more often made based on intuitions rather than science (Bernardi & Kowaltowski, 2010). This is brought up in the context of architectural education but could apply just as well to the education of other building design professionals such as civil engineers. While these professionals are sometimes made aware of accessibility requirements in codes, it is important to go beyond the code, to teach students about how people are affected by the built environment. This is necessary because building codes represent the minimum requirements of differing elements in a project including barrier-free design. For example, the *Ontario Building Code* requires a slope of less than 1:10 for exterior ramps while *CSAB651-18 Accessible Design for the Built Environment* requires a slope of less than 1:12 for exterior ramps. These slopes are the steepest a ramp can be before it can be considered not accessible according to the codes and standards. However, ramps with slopes that are less steep than the required slope can be useful for some users of manual wheelchairs, for example. The codes and standards provide quantitative dimensions; accessibility is translated into facts, indicators and averages (minimum corridor width, recommended signage height, stair riser height, handrail extension length, etc.). Qualitative information about accessibility is also important when designing the built environment, and therefore the education provided should encourage students to go beyond minimum standards (Heylighen et al., 2017). Such qualitative information can include understanding why handrails need to be extended when a staircase finishes on a landing (to indicate to people with sight impairments that the stairs have ended) and why low-pile carpets are recommended instead of high-pile carpets (they provide better acoustics for people with hearing impairments without impeding people with mobility devices) (Canadian Standards Association, 2018).

There are many strategies discussed to teach building design professionals about Universal Design. One investigated by Bernardi & Kowaltowski (2010) is role playing: making students experience what people with disabilities experience when using buildings, devices, and environments that the students are in every day. Role playing is useful since it allows students to develop their own ideas and understanding based on their new experiences. Role playing should be made in the presence of a person with a disability so that discussion about ethics and respect can arise in a safe environment and was found to be a very useful exercise to increase students' awareness (Bernardi & Kowaltowski, 2010). During their career, civil engineers might work on a variety of projects varying from water treatment plants to private city offices, to a streetscape, to a rural municipal library. These projects have differing user groups which is why it is essential that all design professionals, including engineers, understand the degree of diversity among the humans for whom they are designing, and how to respect their needs and abilities. Another strategy discussed in literature is to incorporate Universal Design principles in the design classes of undergraduate students. This strategy was researched by Kimberly Bigelow at the University of Dayton (Bigelow, 2012). The students in the "Engineering Innovation" class, studying a variety of engineering disciplines, were asked to incorporate the principles of UD in the design of a laboratory. The research showed that students not participating in the universal design project were a lot less likely to consider UD principle in their designs than those who were. The researcher proposed including more UD education in the curriculum to ensure that students understand that UD should be considered for all design projects but that the design project model is a good one to introduce the principles of UD to students (Bigelow, 2012).

2.3. The diversity of humans

In 2017, the Canadian Survey on Disability was distributed to Canadian citizens by Statistics Canada. Its goal was to collect data on the demographic, employment, and income profile of Canadians with disabilities aged 15 years and over (Morris et al. 2018). The results from the survey revealed some startling facts about disability in Canada. First, it was found that one in five Canadians aged 15 years and older (22%) had one or more disabilities. Another important finding was that this number increased to 47% for Canadians aged 75 years and older. It is important to note that these results are expected to be higher due to several limitations to the survey. First, the survey relies on self-identification which excludes people who are in denial that they have a disability. Furthermore, the survey was only distributed to Canadians aged 15 years and over who were living in private dwellings, therefore excluding those living in institutions, on Canadian Armed Forces bases, on First Nations reserves, and those living in collective dwellings. The survey found that the most common types of disability included pain, flexibility, mobility, and mental health. Regarding employment, people with disabilities had a 59% employment rate which is lower than the 80% employment rate of Canadians aged 15 years and older without disabilities (Morris et al., 2018).

These findings resonated with those published by the World Health Organization in December 2020. According to their factsheet on disability and health, approximately 15% of the world's population live with disabilities, or about 1 billion people (World Health Organization, 2020).

Although persons with disabilities are often grouped together, their conditions are extremely diverse. For example, disability can be present at birth, occur due to an accident of life circumstance, be permanent or temporary, be progressive, static or intermittent (Centers for Disease Control and Prevention, 2021). The different types of disabilities recognized in Canada are pain-related, flexibility, mobility, mental health-related, seeing, hearing, dexterity, learning, memory and developmental. The Canadian Survey on Disability also recognizes that some disabilities can't be easily categorized and therefore records 155810 Canadians with an "unknown" type of disability (Morris et al., 2018). Due to those different types of disabilities and to the overall diversity of the human condition, there is a need to make sure that the society we live in is accessible to all.

Advances are already being done towards that goal, among them the implementation of Universal Design.

As explained in Section 2.2, Universal Design goes beyond the consideration of only people with disabilities. Universal Design is about designing for everyone, including other frequently marginalized groups such as indigenous communities, people of varying ethno-racial communities, low-income groups, people with varying gender identities and sexual orientations, among several others. Ensuring the consideration of these groups in engineering falls under the emerging topic of Equity, Diversity, and Inclusion (EDI). Several works have been published about EDI in STEM that highlight the improvements that need to be implemented to make the experiences of marginalized groups within the STEM education more equitable. In 2020, Engineers Canada released a three-part article series on EDI in the engineering profession which included conversations with several engineers that support EDI from across the country (Engineers Canada, 2020a). While the contributors of the series mention several times the importance of ensuring EDI for women, racialized groups and LGBTQIA+ people in engineering, there is no mention of people with disabilities as a group that would also greatly benefit from being included in this discussion. It can be difficult to include people with disabilities in the EDI in engineering discussion since there are not a lot of people with disabilities in engineering to discuss their experiences. There is also a lack of a group/association to represent people with disabilities in engineering. These types of groups such as the Canadian Coalition of Women in Engineering, Science, Trades and Technology (CCWESTT, 2021), the Canadian branch of the National Society of Black Engineers (NSBE, 2021), the Association of Chinese-Canadian Architects and Professional Engineers (ACCAPE, 2021), the Canadian Indigenous Advisory Council to the American Indian Science and Engineering Society (AISES, 2021) and EngiQueers Canada (EngiQueers Canada, 2021), among several others, are important resources for engineering students and professionals that need tools, support and representation. The lack of such an important group for support and representation of people with disabilities in engineering highlights the importance of ensuring that other engineers without disabilities, from any background, include people with disabilities in the EDI discussion. Furthermore, there must be a recognition that while people with disabilities face similar systemic and attitudinal barriers as other marginalized groups, they also face several physical barriers that are present in their physical environments such as on university campuses, in engineering laboratories, in offices, etc.

2.4. Engineering and accessibility

2.4.1. Social impacts and ethics of civil engineering in the curriculum

Passow and Passow (2017) aimed to answer the question "*Among generic engineering competencies, what is the relative importance for professional practice across disciplines and work contexts?"*. Their research analysed thousands of job postings to establish the importance of generic engineering competencies. They found Ethics to be the 4^{th} most important competency, coming after problem solving, communication, and teamwork. Ethics is deemed more important than math, science, and engineering tools (Passow & Passow, 2017). A 2020 study by Bielefeldt et al. supports these claims stating that, given the social and environmental impacts of civil infrastructure, it is very important that civil engineering students learn about ethics and social issues (Bielefeldt et al., 2020). The goal of the study was to research the role of co-curricular activities on ethics and social impact education in civil engineering students. While they found that 91% of students that participated in such activities and groups reported to have been made aware of ethics and social impact topics during their involvement, they also emphasize that participation in these activities is voluntary. Therefore, ethics and social impacts education should be integrated into the curriculum (Bielefeldt et al., 2020).

In Canada, civil engineering departments create their own curriculum which is then verified and accredited by the Canadian Engineering Accreditation Board (CEAB) at Engineers Canada. Every year, the CEAB publishes their Accreditation Criteria and Procedures which include 12 "graduate attributes" (GAs). Among these attributes, several relate directly to the topics of ethics, the social impacts of civil engineering and accessibility, such as GA 9 (*Impact of engineering on society and the environment)* and GA 10 (*Ethics and equity)* (Engineers Canada, 2021a). Given these necessary graduate attributes, the need to incorporate further discussion about ethics, social impacts of civil engineering and accessibility in undergraduate civil engineering programs throughout Canada is investigated in this research.

2.4.2. Civil engineers' responsibilities towards accessibility

In his 2012 essay in Viewpoint, a publication by the Professional Engineers of Ontario (PEO), Luke Anderson, a professional engineer and wheelchair user, emphasizes the importance of including engineers in the discussion about universal design. According to Anderson, engineers are actively involved in the design process and are aware of the multiple resources needed to design a project. The author states that "*by investing in changes that follow inclusive design principles, we can bring about an increase in productivity of services, products and environments*" (Anderson, 2012). The Canadian Society for Civil Engineering (CSCE) also believe that engineers should start being more involved in the accessible design of structures. In 2017, they formed the CSCE President's Task Force on Accessibility which promotes Universal Design to CSCE members and the Canadian engineering community (Canadian Society for Civil Engineering, 2021). Efforts made by this group includes the creation of design pamphlets for accessible housing and hotels rooms, which highlights the importance of going beyond the current accessibility building codes. The task force has also hosted a Panel Discussion on Accessibility and Universal Design in Civil Engineering at the 2019 CSCE Annual Conference. Furthermore, the task force has participated in webinars offered to CSCE members, in the effort of raising awareness on accessibility issues to members of the civil engineering community in Canada (Canadian Society for Civil Engineering, 2021).

As was seen during this literature review, there is a lot more focus on architects being made aware of universal design and other design professionals such as civil engineers are often ignored. This can be explained by examining the different roles of architects compared to civil engineers. First, civil engineers don't only work on buildings; many work on a variety of infrastructure such as roads, dams, water systems, etc. In contrast, an architect's work is heavily focused on the design of structures such as houses, skyscrapers, libraries, etc. Therefore, while it is not every civil engineer that works on projects that require accessibility consideration, most architects do. Furthermore, architects are a lot more involved in the pre-construction work than civil engineers are. According to the Royal Architectural Institute of Canada, architects are not only involved in the aesthetic (visual appearance) design of building but also in its technical design (Royal Architectural Institute of Canada, 2021). Meanwhile, civil engineers involved in the design of a building work more specifically on the technical aspects and on overseeing the planning and construction of the project. The fact that civil engineers are only minimally involved in the aesthetic design of a building could be an indication that they have no say on the accessibility of the project. However, architects and engineers work closely together during a project to ensure that their visual and technical design work together to allow the intended users to access their building safely and adequately. Several large design firms such as AECOM, ARCUS and NORR provide both engineering and architectural services to their clients, knowing that these two professions work better together than apart (AECOM, 2021) (ARCUS Consulting LTD, 2021) (NORR, 2021). This collaboration could be improved if civil engineers were also made aware of accessibility requirements during their education. This could allow them to look at an architect's initial design not only with a technical perspective but with an accessibility lens as well.

A sure way to increase the awareness of civil engineers towards universal design is to ensure that civil engineering programs are accessible to increase the diversity of design professionals. However, many engineering programs contain multiple barriers that make it challenging and very intimidating for students with disabilities to enrol. Examples of this problem were highlighted by Mayat and Amosun (2011) through an investigation of the perceptions of civil engineering university staff towards accommodating students with disabilities. The authors found that some universities discouraged students with disabilities from registering to certain courses because of field work that is often not accessible. The participating universities admitted to not having a plan to accommodate students with disabilities in the civil engineering programs and to instead solve problems as they arose. The paper emphasized the importance of such programs to be proactive in order to create a supportive and safe environment for students from their enrolment. The universities are also recommended to host regular disability awareness workshops/seminars since the staff were found to have limited knowledge about disability (Mayat & Amosun, 2011).

In the same way that the engineering community has taken strides in being more gender inclusive in the past years, it needs to be open to accepting people with disabilities into the profession. McCall et al. (2020) investigated the experience of three women that identify as having disabilities and are no longer enrolled in civil engineering programs. Interviews were conducted with the participants and, among the overarching themes discussed, they discussed experiencing conflicts with dominant civil engineering culture, encountering barriers within the civil engineering curriculum, and navigating intersecting stereotypes and compounding marginalization (McCall et al., 2020).

Preliminary research conducted by the author in 2020 showed that civil engineering students are interested in learning about accessibility and believe that it is important to do so. The research surveyed 23 civil engineering students at the University of Ottawa and found that an overwhelming number of participants (87%) believe that they should be taught about accessibility requirements in the built environment during their undergraduate degree program and that only 61% of them have thought about accessibility when designing structures during class projects. Furthermore, a survey sent to Canadian universities revealed that all but one of the participating civil engineering departments are aware that there is a need for education about accessibility in the programs and that students should be made aware of accessibility requirements (Leclair, 2020).

It is important to note that there are a lot of modern projects that strive to be meaningfully accessible and current infrastructure owners that are looking to retrofit their designs to allow better access. For example, in 2018, VIA Rail hired Bombardier to upgrade 17 of its train cars to allow for better accessibility. These cars are now equipped with wheelchair lifts, accessible spaces with anchoring devices, accessible toilets, and announcement screens throughout (Global Railway Review, 2018). Furthermore, VIA Rail is scheduled to receive 32 new trains by 2022. The new fleet is set to be universally accessible and its design is said to “exceed industry standards among accessible modes of transportation” (VIA Rail, 2021a). The crown corporation is not only looking to make its trains more accessible, but its stations too. In 2019, $15 million renovations were completed at the Ottawa station which included universal access to all platforms, tactile indicators throughout the platform, and an access ramp that is level with the train door

(VIA Rail, 2019). The center ramp and elevator added to the station can be seen in Figure 2-1 (VIA Rail, 2021b).

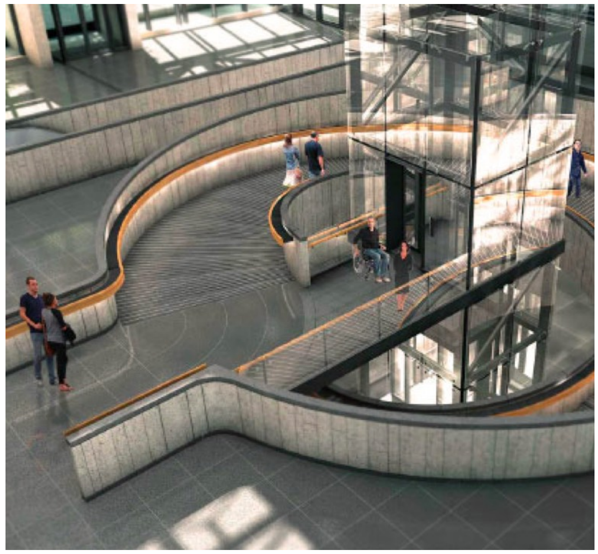

Figure 2-1 - Ottawa VIA Rail station, accessible curved ramp and elevators (VIA Rail 2021b)

Another project that went above and beyond accessibility standards is the newly renovated Canada Science and Technology Museum. The new building has level flooring through the exhibitions, a universal washroom, and exhibits that accommodate users with sensory, motor, and cognitive impairments (Ingenium Foundation, 2021). The Vancouver International Airport is also a prime example of universal design. Accessibility features in the airport include adaptive speakers throughout the building, pet relief areas for assistance animals, textured flooring for wayfinding, and universal seating throughout the terminals (Chan, 2018). An image of the pet relief area at the Vancouver International Airport is presented in Figure 2-2 (Chan, 2016).

Figure 2-2 - Pet relief station at the Vancouver International Airport, (Chan, 2016)

Although many designers are working towards building projects that can be enjoyed by all, many public infrastructures still fail to be fully accessible. For example, the Hunters Point Library in Queens, New York opened in 2019 and has since been taken into a lawsuit by the Disability Rights Advocates for violating the Americans with Disabilities Act (ADA). The main complaint is that the library contains book stacks, a rooftop terrace, and panoramic views of Manhattan that are only accessible by stairs (Stone, 2019). The book stacks only accessible by stairs at the Hunters Point Library are portrayed in Figure 2-3 (Gibson, 2019).

Figure 2-3 – Hunters Point Library interior, book stacks only accessible by stairs (Gibson 2019)

Another project that has been critiqued by disability rights advocates is Ryerson University's Students Learning Centre, which was built in 2015 in Toronto, Ontario. Flaws in this building include angled pillars next to a ramp that is difficult to detect with a walking stick, a large pillar in the center of stairs, and an exterior ramp without handrails (Katawazi, 2017). An image of a concrete pillar in the circulation path on a staircase in Ryerson University's Students Learning Centre is presented in Figure 2-4 (Katawazi, 2017).

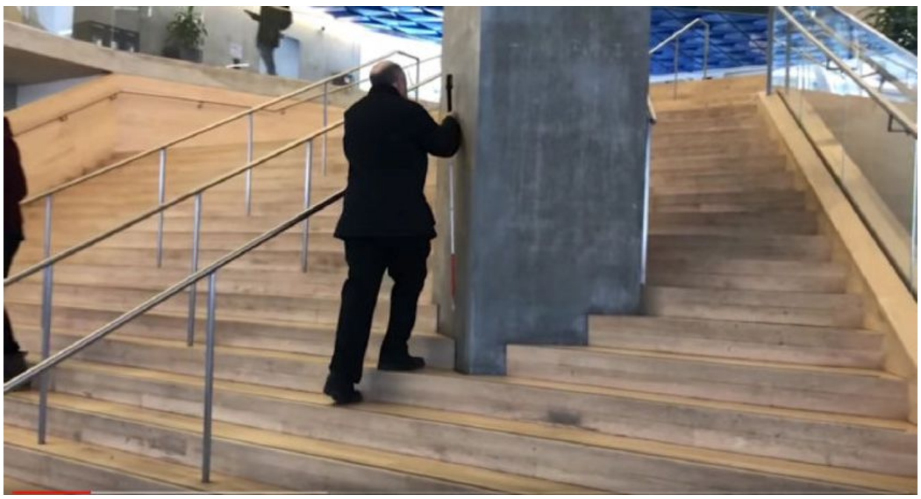

Figure 2-4 – Ryerson University Student Centre stairs with pillar (Katawazi, 2017)

2.4.3. Accessibility Standards in Canada

The need to teach civil engineering students about universal design is becoming increasingly evident as standards and acts about accessibility are being passed and published. The Accessible Canada Act (ACA) was passed in 2019 and states that its purpose is *to benefit all persons, especially persons with disabilities, through the realization, […], of a Canada without barriers, on or before January 1, 2040, particularly by the identification and removal of barriers, and the prevention of new barriers (Minister of Justice Canada, 2019).* The act then specifies the areas where the barriers should be removed and includes employment; the built environment; the procurement of goods, services and facilities and transportation, among others. All of these areas apply directly to civil engineering. Upon the passing of the ACA, the Canadian Accessibility Standards Development Organization (CASDO) was established. The mandate of CASDO is to *contribute to the realization of a Canada without barriers, on or before January 1, 2040*

(Minister of Justice Canada, 2019). One of the ways they are expected to achieve this is through the development and revision of accessibility standards. The primary accessibility standard in Canada at this time is CSA B651-18, the *Accessible design for the built environment* which is a National Standard of Canada (Canadian Standards Association, 2018). This standard specifies several requirements that can impact the structural design of civil engineers such as necessary corridor widths and minimum floor area (can be influenced by structural columns), minimum headroom (can be influenced by structural beams), slope of accessible routes, doorway widths, stair requirements, ramp requirements, sidewalk requirements, outdoor circulation drainage, curbs, etc. The Accessible Canada Act applies to Parliament, Crown corporations, the federal government and private sector businesses under federal jurisdiction (banking, telecommunications, transportation, etc.) and these entities must adhere to the requirements stipulated by the CSA B651-18 standard.

Some Canadian provinces, such as the Province of Ontario, passed their own acts before the ACA. The Ontario act, named the Accessibility for Ontarians with Disabilities Act (AODA), was published in 2005. The AODA brought major changes to the Ontario Building code through the addition of the *Section 3.8. Barrier-Free Design* (Government of Ontario, 2005) which all public and private sector projects must adhere to. The National Building Code of Canada, adopted by many provinces (New Brunswick, Manitoba, Saskatchewan, Newfoundland and Labrador, Prince Edward Island and the territories), also has *Barrier-Free Design* requirements under *Section 3.8* (National Research Council Canada, 2015). The provinces of Manitoba and Nova Scotia also have accessibility acts, the *Accessibility for Manitobans Act (2013)* and the *Nova Scotia Accessibility Act (2017)*, respectively (Government of Manitoba, 2013) (Government of Nova Scotia, 2017). Furthermore, the Province of British Columbia passed the *British Columbia Accessibility Act* in July 2021 (Legislative Assembly of British Columbia, 2018). Other laws that are in place in Canada and promote accessibility and inclusivity include the *Canadian Charter of Rights and Freedoms* (Canadian Human Rights Commission, 1981), the *Canadian Human Rights Act* (Minister of Justice Canada, 1985) and the *Employment Equity Act (Minister of Justice Canada, 1995)*.

2.4.4. Cost of designing accessible structures

According to a research study conducted in 2017 that sought to answer ten questions concerning inclusive design of the built environment, there are several reasons why the uptake of inclusive design has been limited so far (Heylighen et al., 2017). Among these reasons is the belief that incorporating inclusive design in a project increases costs and that there are little economic incentives since it is perceived that there are not a lot of people that need inclusive design. This barrier was also reflected by manufacturers and retailers that were surveyed for a 2015 study by researchers at the University of Cambridge for their research on perceptions of inclusive design (Dong et al., 2015). More specifically, “perception that inclusive design is more expensive” was tied with “perception that it can be complex to design inclusively” as the main barrier to inclusive design for retailers. The cost barrier was also expressed by manufacturers alongside “lack of business case”, “perception that inclusive design represents a niche market”, “lack of interest in inclusive design” and “lack of awareness of inclusive design” (Dong et al., 2015).

Entities interested in increasing the accessibility of the built environment have conducted studies to attempt to calculate the economic impact of increasing the accessibility of a project. Such studies include *Releasing Constraints: Projecting the Economic Impacts of Increased Accessibility in Ontario* which was commissioned by the Government of Ontario and written by the Martin Prosperity Institute in 2010 (Martin Prosperity Institute, 2010).

The study commissioned by the Government of Ontario specifically investigated the impact of the Accessibility for Ontarians with Disabilities Act which applies to the built environment. They found that increasing the accessibility of workplaces and schools would increase the workplace participation by people with disabilities. Additionally, businesses in Ontario would also benefit from a growth in the retail and tourism sector from new opportunities and from education institutions educating future generation of workers. It is concluded that “*every day that people who want to learn cannot, people who want to work do not, and businesses that wish to serve these markets must wait to see what will be required, Ontario is losing extremely valuable contributions from its citizens”*

(Martin Prosperity Institute, 2010). The study concluded that the implementation of the Accessibility for Ontarians with Disabilities Act (AODA) could:

1. Reduce the rate of poverty in Ontario, and increase employment.
2. Lead to the development of new products and services which can serve a larger market and increase the revenue of Ontario's tourism and retail sectors.
3. Support the Ontario economy by allowing more individuals to participate in the social and economic life which could also increase the diversity of the market (which could lead to innovations and creativity).

2.5. Summary

Universal Design (UD) is a term that was first defined in 1985 by Ronald Marc and was re-defined in 2006 during the United Nations Convention of the Rights of Persons with Disabilities as "a way of designing a building or facility, at little or no extra cost, so that it is both attractive and functional for all people, disabled or not" (Heylighen et al., 2017). There are seven guiding principles to UD varying from *Principle one: Equitable use* to *Principle seven: Size and space for approach and use* (Imrie, 2012). UD is not to be confused with Barrier-free Design which refers to a design which presents no barriers for people with disabilities (Cambridge Dictionary, 2021). UD instead focuses on everyone, not only people with disabilities.

While UD focuses on designing for everyone, people with disabilities are a group that must be focused on since they can face several barriers in the built environment. In Canada, one in five person aged 15 years and older reported having one or more disabilities (22%) (Morris et al., 2018). People with disabilities were also found to have a lower employment rate that those without disabilities and the rate of people with disabilities significantly increases for Canadians aged 75 years and older (47%). There are a wide variety of types of disabilities ranging from mobility, to pain-related to mental health-related. This wide diversity highlights the importance of designing for all, to ensure that this 22% of the population, and other equity seeking groups (parents with young children, people with differing gender identities, people with language barriers) can access services and buildings.

Incorporating UD in a project is perceived as costly, as reducing aesthetics and innovation, and as requiring a more complex design process. People also believe that UD is only put in place for people with disabilities (Heylighen et al., 2017). This highlights the importance of Universal Design Education to building design professionals (civil engineers, architects, project managers, contractors, etc.). Research has investigated the potential of role playing as a way to increase the awareness of students towards universal design and the idea was received with favourable results as long as the activity was made in the presence of a person with a disability and that it also involved a discussion about ethics and respect (Bernardi & Kowaltowski, 2010). While architects have classes about UD during their studies, civil engineers don't. This is surprising since literature shows that Ethics is a very important competency to engineering employers (more than math, science and engineering tools) (Passow & Passow, 2017) and that, given the social and environment impacts of civil infrastructure, it is very important that civil engineering students learn about ethics and social issues (Bielefeldt et al., 2020). The accredited civil engineering programs in Canada are required to ensure that their students graduate with the "*Impact of engineering on society and the environment*" and "*Ethics and equity*" graduate attributes but do not go into detail on how this should be incorporated in the curriculum (Engineers Canada, 2021a). As part of a preliminary research about UD education in civil engineering undergraduate education, 23 civil engineering students were asked if they were interested to learn more about accessibility requirements in the built environment. An overwhelming number of participants answered yes (87%).

While several projects such as the rehabilitation of the Ottawa Via Rail station (VIA Rail, 2019), the Canada Science and Technology Museum (Ingenium Foundation, 2021) and the Vancouver International Airport (Chan, 2016) incorporate innovative UD elements, other projects still fail to offer basic accessibility to its users. These projects include the Hunters Point Library in Queen New York (Gibson, 2019) and the Ryerson University's Students Learning Centre in Toronto Ontario (Katawazi, 2017). It is only in 2019 that the Accessible Canada Act (ACA) was passed into law. This act enforces the importance of accessibility in the built environment and aims for a "*Canada without barriers, on or before January 1, 2040*" (Minister of Justice Canada, 2019). The ACA applies to Parliament, Crown corporations, the federal government and private sector businesses under federal jurisdiction (banks, telecommunications, transportation, etc.). Furthermore, two important documents reinforce accessible design in Canada, the barrier-free section of the National Building Code (National Research Council Canada, 2015) and the *Accessible Design for the Built Environment* National Standard of Canada (CSA B651-18) (Canadian Standards Association, 2018).

Based on the results of this literature review, several knowledge gaps exist with respect to the roles and responsibilities of civil engineers that will be addressed by this research. These include identifying the need for universal design education in the civil engineering curriculum and investigating the accessibility of the civil engineering profession (both as a student and as a professional civil engineer).

3. Accessibility Survey

3.1. Design

3.1.1. Goal and organization

To determine the perspectives of current civil engineers towards accessibility in the built environment, a survey was designed and distributed to current building design professionals (engineers, architects, contractors, etc.). The goal of the survey was to analyze the responsibilities of civil engineers towards making the built environment more accessible and the potential of undergraduate education in raising awareness within the profession. To achieve this goal, survey participants were asked to answer the following seven questions, grouped into two themes:

Theme 1: Experience and awareness of accessibility in civil engineering and other building design professions

1. As a member of the building design profession, how often do you consider issues related to accessibility during your work (for completing a design, etc.)?
2. What is your current familiarity with accessibility standards in Canada (Accessible Canada Act, Accessible Design for the Built Environment CSAB651-18, etc.)?
3. Do you think that code requirements related to accessibility are always adequate to address all accessibility barriers?
4. In your opinion, who is responsible to ensure that a structure is accessible to all its users?

5. Do you think there are barriers for people with disabilities who want to become civil engineers?

<u>Theme 2: Education of accessibility in the civil engineering profession</u>

6. In 2019, the Accessible Canada Act passed into law. The act aims to create an accessible and barrier-free Canada by 2040. This includes transportation and the design of public spaces. Do you think that, during their university education in civil engineering, students should learn about the new requirements and efforts put into place to achieve this goal?
7. How interested would you be to learn more about accessibility issues related to the design of structures?

Furthermore, participants were asked three questions to identify them demographically: whether they identified as a person with a disability, in what field of the design profession they worked, and how many years of experience they had.

The survey was designed on SurveyMonkey, an online survey builder. The questions were arranged in a logical order and the survey was translated to be available in English and French. Furthermore, to cater to the needs of design professionals, the survey was built so that it took an average of 3 minutes to complete (and at most 5 minutes). The survey passed a thorough ethics review by the Office of Research Ethics and Integrity of the University of Ottawa. Participants answered the survey anonymously and were asked to read and acknowledge a consent form before completing the survey.

3.1.2. Recruitment

The targeted audience for the survey was any building and civil infrastructure design professionals working in Canada, with a focus on professional civil engineers. An initial objective was set to obtain a minimum of 75 responses from participants having a varied amount of experience and coming from different design fields (civil engineering, architecture, construction, etc.).

Participants were recruited by email and by using LinkedIn, an online networking platform. First, emails were sent to 57 different companies, firms, organizations, and groups that worked in the design industry. These emails invited the recipients to share the survey with working professionals. In order to obtain more responses, LinkedIn was used to contact potential participants individually, sending them a short message explaining the survey and including a survey link. The invitations were sent to LinkedIn users who were not previous connections. To ensure optimal diversity and representation of the building design industry, professionals were found by reaching out to employees from different engineering firms, architectural firms, construction companies and municipalities across Canada. Outreach was conducted for one month, approximately 1000 participation messages were sent and a total of 222 participants answered the survey.

3.1.3. Data analysis

The survey was closed approximately one month after outreach started, after 222 responses were collected. Once closed, the data was analyzed using SurveyMonkey and Microsoft Excel. While individual responses were collected and analyzed, survey "groups" were also compared such as:

- Participants with less than 20 years of experience and participants with more than 20 years of experience.
- Participants working as civil engineers and participants working as architects.
- Participants identifying as having a disability and participants identifying as not having a disability.

The survey results can be found in Section 3.2 and are discussed in Section 3.3. Furthermore, Figures 3-1 to 3-9 represent charts of the survey results.

3.2. Results

Table A-1, summarizing the results of all the questions in the survey, can be found in Appendix A.

3.2.1. Survey demographics

The survey received 222 participants. The participants were all professionals working in the field of building design in Canada. Of the 222 participants, the majority (132) identified as civil engineers, followed by 33 project managers, 29 construction professionals, 9 architects, and 19 participants in "other" fields (structural engineering, academia, urban planning, transportation engineering). Figure 3-1 shows the repartition of the participants based on their occupation.

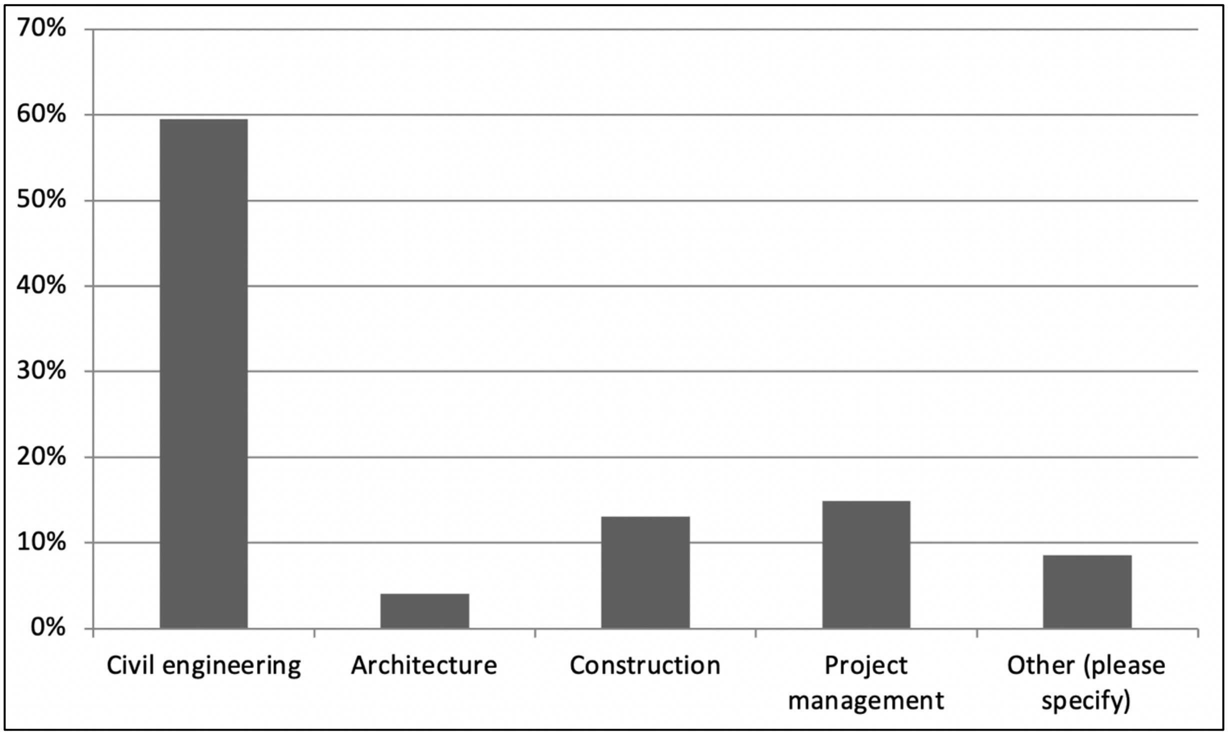

Figure 3-1 – Occupation of participants

Furthermore, participants were asked about their years of experience in the design industry. The largest subset of participants (80) had 0 – 5 years of experience, followed by 5 – 10 years (46), 10 – 20 years (45), 20 – 30 years (33), and 30+ years (18). Figure 3-2 shows the distribution of participants based on their years of experience.

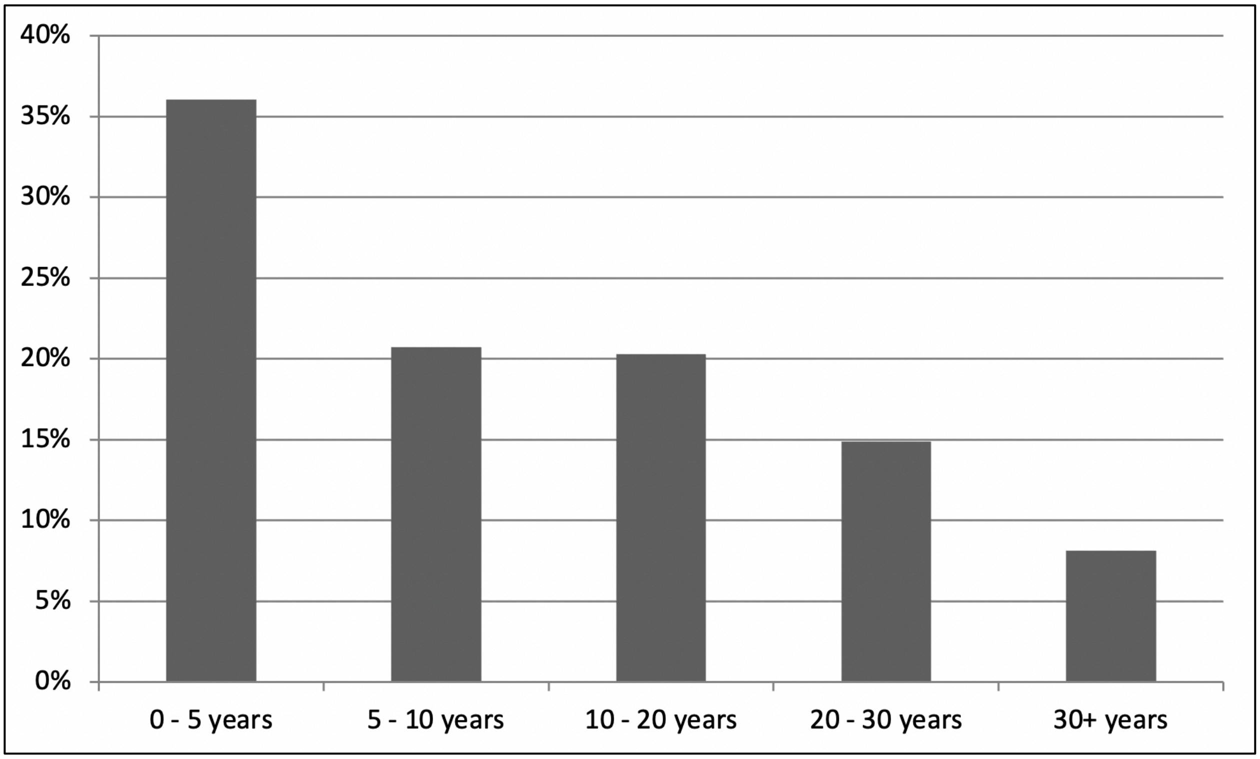

Figure 3-2 – Years of experience of survey participants

Finally, the participants were asked if they self-identified as a person with a disability. Of the 222 participants, 5 answered yes (2%) while the 217 others answered no.

3.2.2. Theme 1: Experience and awareness of accessibility in civil engineering and other design professions

In questions 1 to 5, participants were asked about their experiences working as a design professional and interacting with the topics of accessibility in their profession. These questions were formulated to try to observe how design professionals, especially civil engineers, saw their responsibilities towards ensuring an accessible built environment. Questions 1 and 2 asked the participants about their personal knowledge and incorporation of universal design in their work. Meanwhile, questions 3 to 5 interrogated the participants on their perception of accessibility in their profession.

<u>Question 1: As a member of the design profession, how often do you consider issues related to accessibility during your work (for completing a design, etc.)?</u>

Several participants answered “always” (30%) followed closely by “usually” (29%) and “sometimes” (23%). Furthermore, 28 participants answered that they rarely considered issues related to accessibility during their work (13%) and 11 participants answered that they never did (5%). Figure 3-3 presents the results of this question.

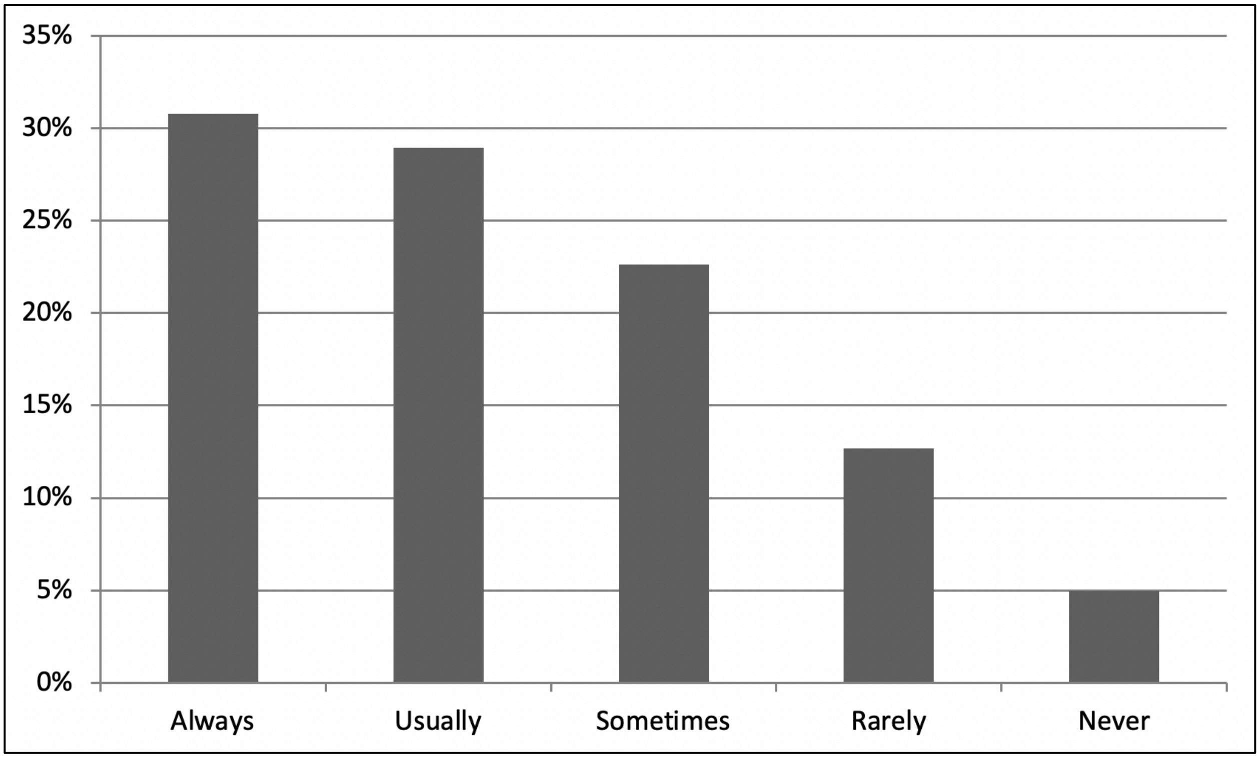

Figure 3-3 – Question 1 chart: Consideration given to accessibility during work

<u>Question 2: What is your current familiarity with accessibility standards in Canada (Accessible Canada Act, Accessible Design for the Built Environment CSAB651-18, etc.)?</u>

Only 40 of the 222 participants answered that they were either “extremely familiar” (4%) or “very familiar” (14%) with the current accessibility standards in Canada. Many participants responded that they were “somewhat familiar” with the standards (39%) followed closely by participants stating that they were “not so familiar” (30%). 30 of the 222 participants (14%) admitted to being “not at all familiar” with the current accessibility standards in Canada. Figure 3-4 presents the results of this question.

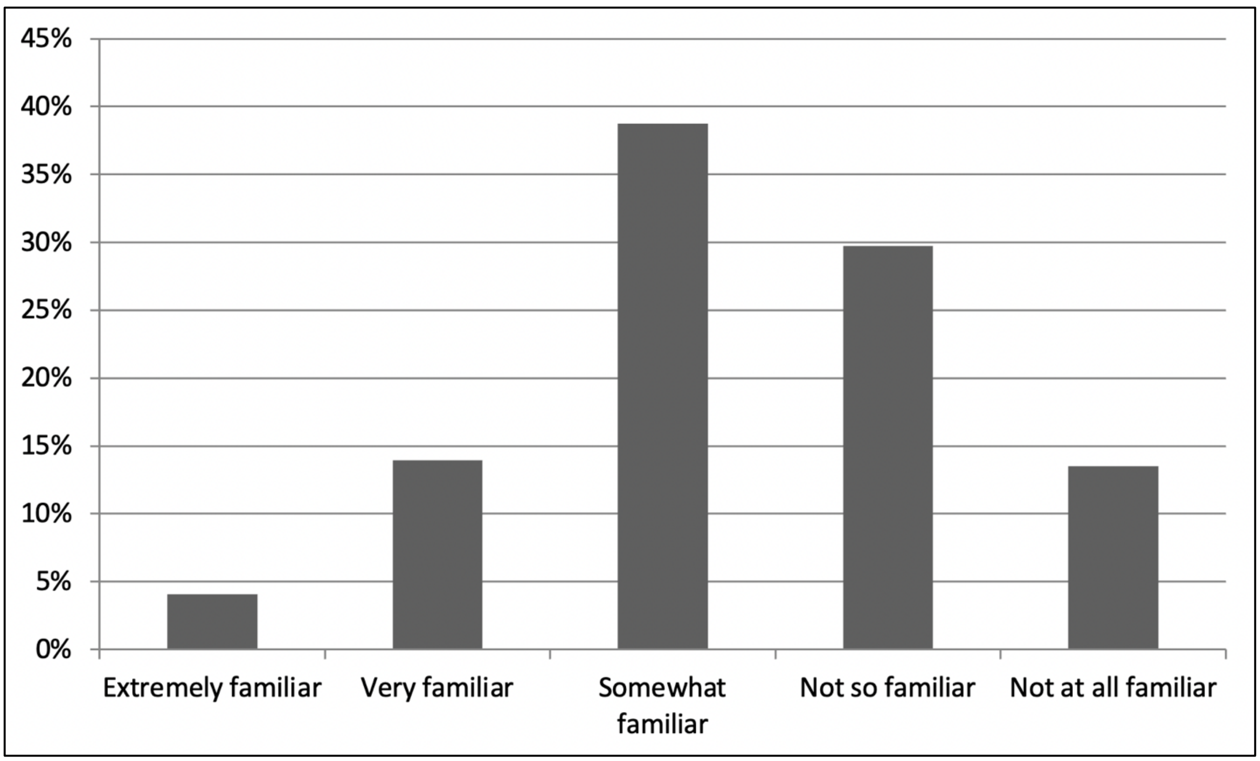

Figure 3-4 – Question 2 chart: familiarity with accessibility standards in Canada

Question 3: Do you think that code requirements related to accessibility are always adequate to address all accessibility barriers?

Several participants (37%) answered that code requirements related to accessibility were “sometimes” adequate to address all accessibility barriers. This was followed by 61 of the 222 participants answering “usually” (27%) and 20 answering “rarely” (9%). Only 7 participants answered “always” (3%) and 3 answered “never” (1%). Additionally, participants were always given the option “I don’t know” which 47 answered (21%), making it the third most popular response. Figure 3-5 presents the results of this question.

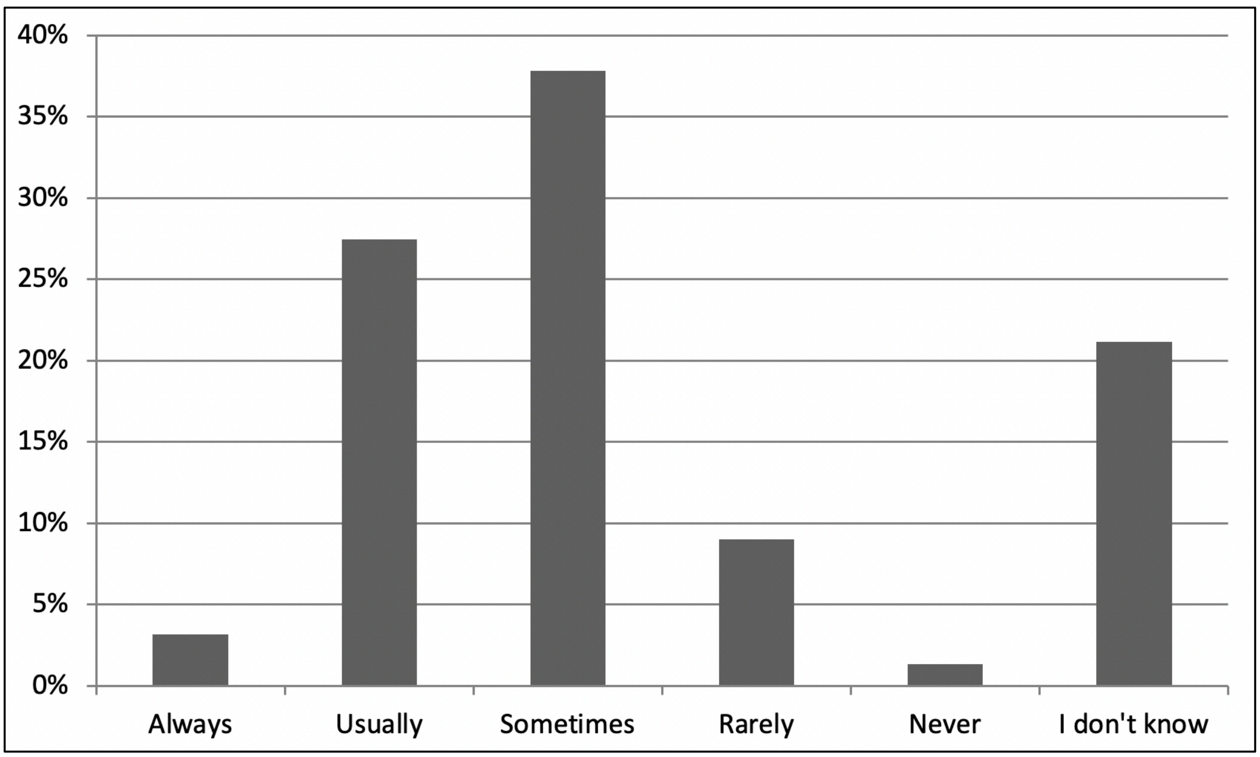

Figure 3-5 – Question 3 chart: Adequacy of code requirements related to accessibility

Question 4: In your opinion, who is responsible to ensure that a structure is accessible to all its users?

When answering this question, participants could select all professions that they believed were responsible to ensure that a structure is accessible to all its users. The answers were cumulated, and the results showed that most participants (88%) thought that the architect(s) were responsible, followed by the owner (76%) and the engineer(s) (67%). Less than 50% of participants answered that the contractor and/or the inspector was responsible to ensure that a structure is accessible to all its users (42% and 49% respectively). Twenty-one participants also answered "other" and specified parties that were not in the available answers; these answers will be explained in the discussion section. Figure 3-6 presents the results of this question.

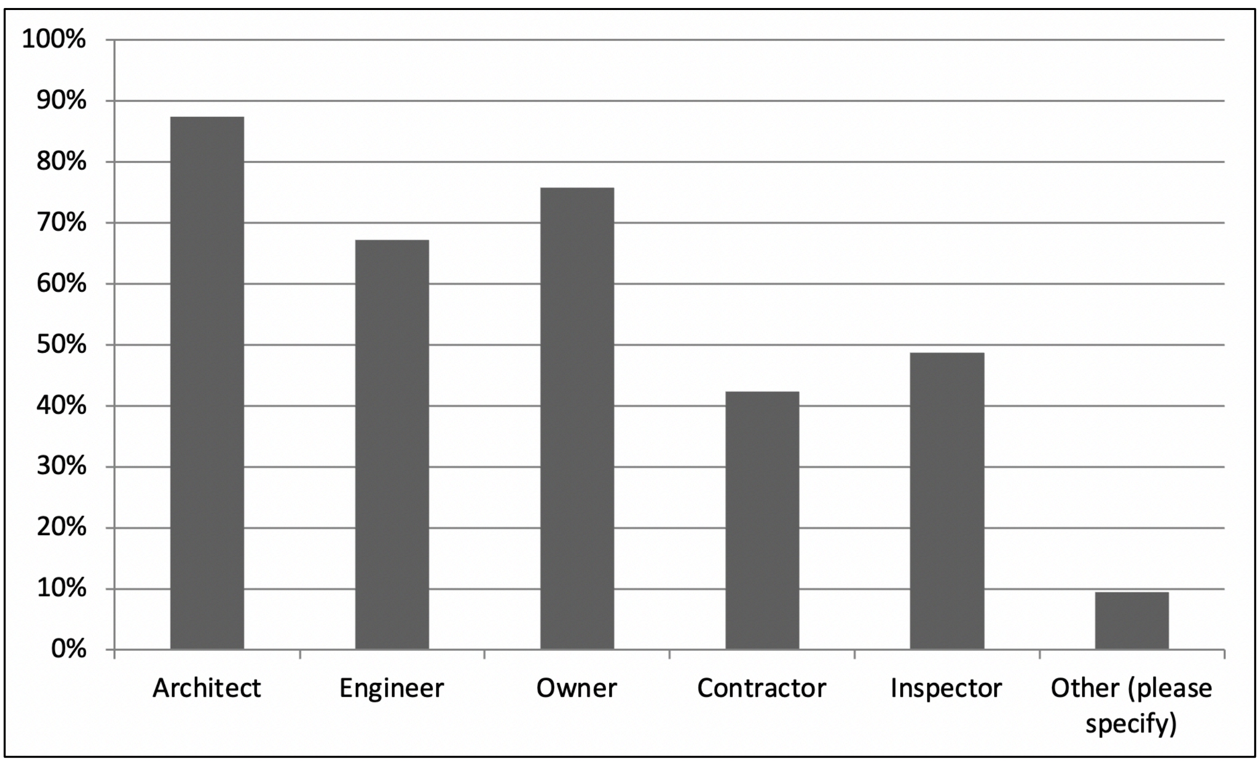

Figure 3-6 – Question 4 chart: Who is responsible to ensure that a structure is accessible

Question 5: Do you think there are barriers for people with disabilities who want to become civil engineers?

Of the 222 participants, 97 (44%) answered that they believe that there are barriers for people with disabilities who want to become civil engineers while 48 (22%) answered that they did not believe so. Furthermore, 77 participants (35%) answered "unsure". Figure 3-7 presents the results of this question.

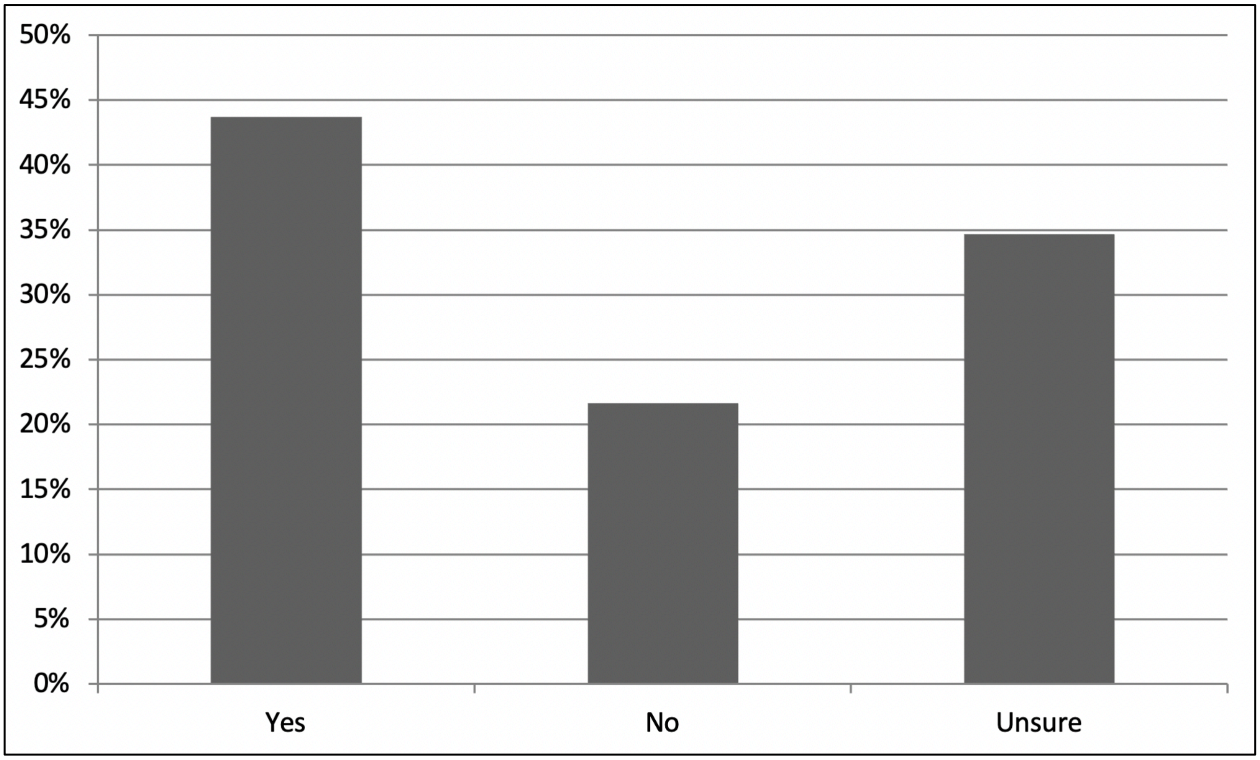

Figure 3-7 – Question 5 chart: Barriers to becoming a civil engineer

3.2.3. Theme 2: Education of accessibility in the civil engineering profession

In questions 6 and 7, participants were asked to give their feedback about the education of accessibility-related topics to design professionals. These questions were formulated to try to observe how design professionals, especially civil engineers, saw the importance of education towards removing barriers in the built environment.

Question 6: In 2019, the Accessible Canada Act passed into law. The act aims to create an accessible and barrier-free Canada by 2040. This includes transportation and the design of public spaces. Do you think that, during their university education in civil engineering, students should learn about the new requirements and efforts put into place to achieve this goal?

An overwhelming amount of participants answered “strongly agree” (57%) and “agree” (30%). Meanwhile, 17 participants answered “neither agree nor disagree” (8%), 8 answered “disagree” (4%) and 3 answered “strongly disagree” (1%). Figure 3-8 presents the results of this question.

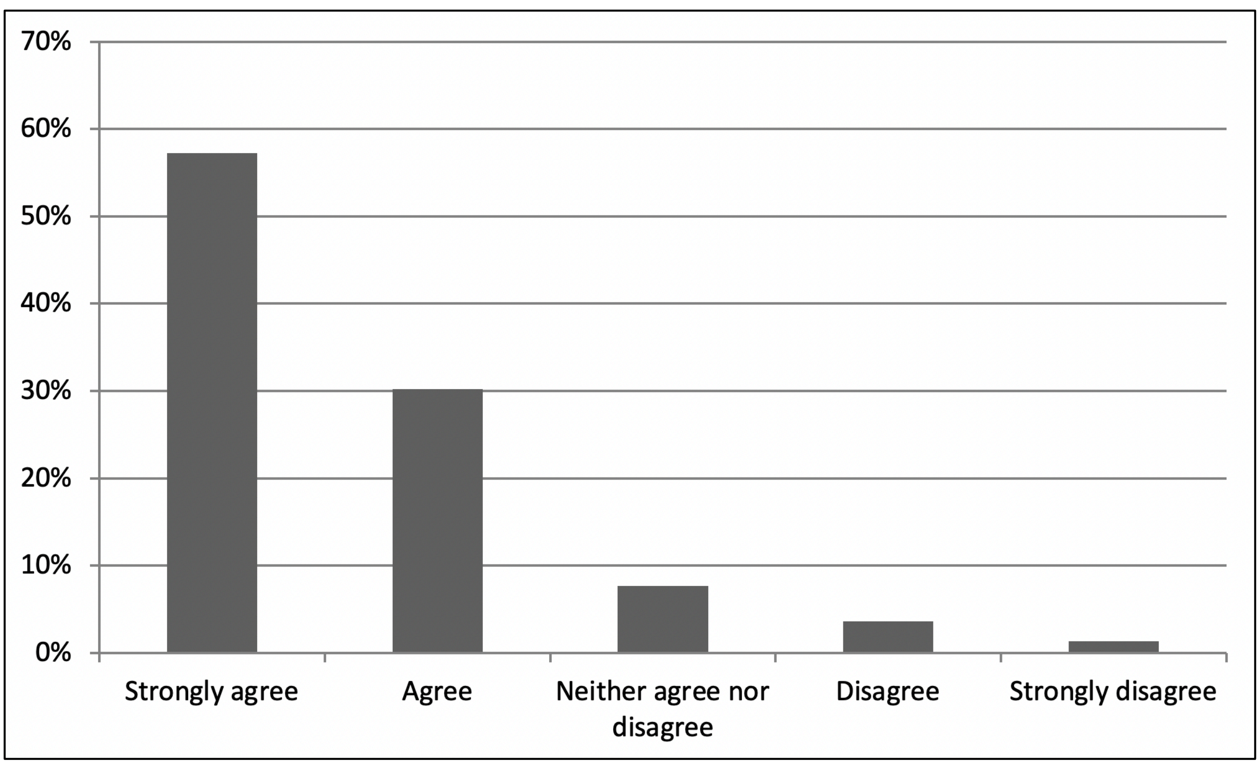

Figure 3-8 – Question 6 chart: Should civil engineering students learn about accessibility

<u>*Question 7: How interested would you be to learn more about accessibility issues related to the design of structures?*</u>

Of the 222 participants, 86 answered “interested” (39%), 64 answered “somewhat interested” (29%) and 52 answered “very interested” (23%). Meanwhile, 18 participants answered “not so interested” (8%) and 2 participants answered “not at all interested” (1%). Figure 3-9 presents the results of this question.

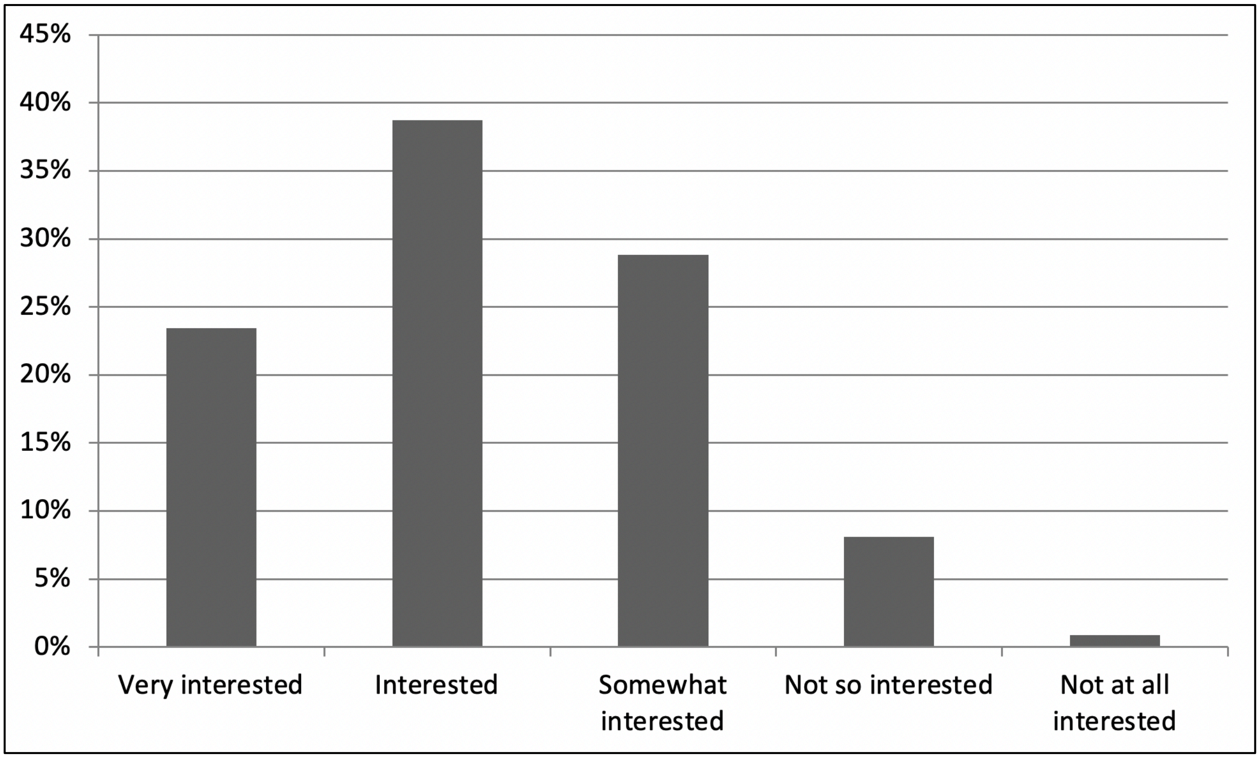

Figure 3-9 - Question 7 chart: Interest towards learning more about accessibility

3.3. Discussion

3.3.1. Demographics and barriers for people with disabilities who want to become civil engineers

The survey distributed to practicing design professionals in Canada revealed important results that conveyed the opinions of the participants about civil engineering and accessibility.

In total, 222 participants contributed to the survey. Most participants were civil engineers (59%); however, feedback from other design professionals was also obtained (architects – 4%, construction professionals – 13%, project managers – 15%, other – 9%). Most of the participants that answered *Other* belonged in a sub-category of civil engineering such as structural engineering, transportation engineering, geotechnical engineering, and academia. It was important to receive participation from not only civil engineers since the perception of other design professionals towards the responsibilities of civil engineering in making a structure accessible could provide a different perspective to the issue. Participants were also asked about their years of experience, and the results had an expected distribution. Most of the participants had 0 – 5 years of experience (36%) which can be attributed to the heavy outreach that was done on LinkedIn, a social networking application that many newly graduated students use to find employment. While several participants having 5 – 10 years and 10 – 20 years of experience were contacted as well (21% and 20%, respectively), it was harder to reach participants with 20 – 30 years of experience and 30+ years of experience (15% and 8%, respectively). The results obtained from participants that have more than 20 years of experience is still very valuable since that can give their perspective as to how accessibility practices have evolved since they have started working. Many of the previously mentioned participants also hold “senior” and managerial positions which will give a good indication of what employers are looking for in new graduates from civil engineering programs. Figure 3-10 showcases the distribution of participants based on their years of experience for different professions. Participants working in architecture were the only ones that weren’t primarily in the 0 – 5 years of experience bracket, seeing most participants having 5 – 10 years of experience and 20 – 30 years of experience (33% each). Furthermore, participants working in architecture had the highest percentage of participants in the 30+ years of experience bracket (22%). Overall, civil engineering participants were the least present in the 30+ years of experience group having a total of 5% of participants compared to 22% for architects, 14% for construction professionals and 12% for project managers.

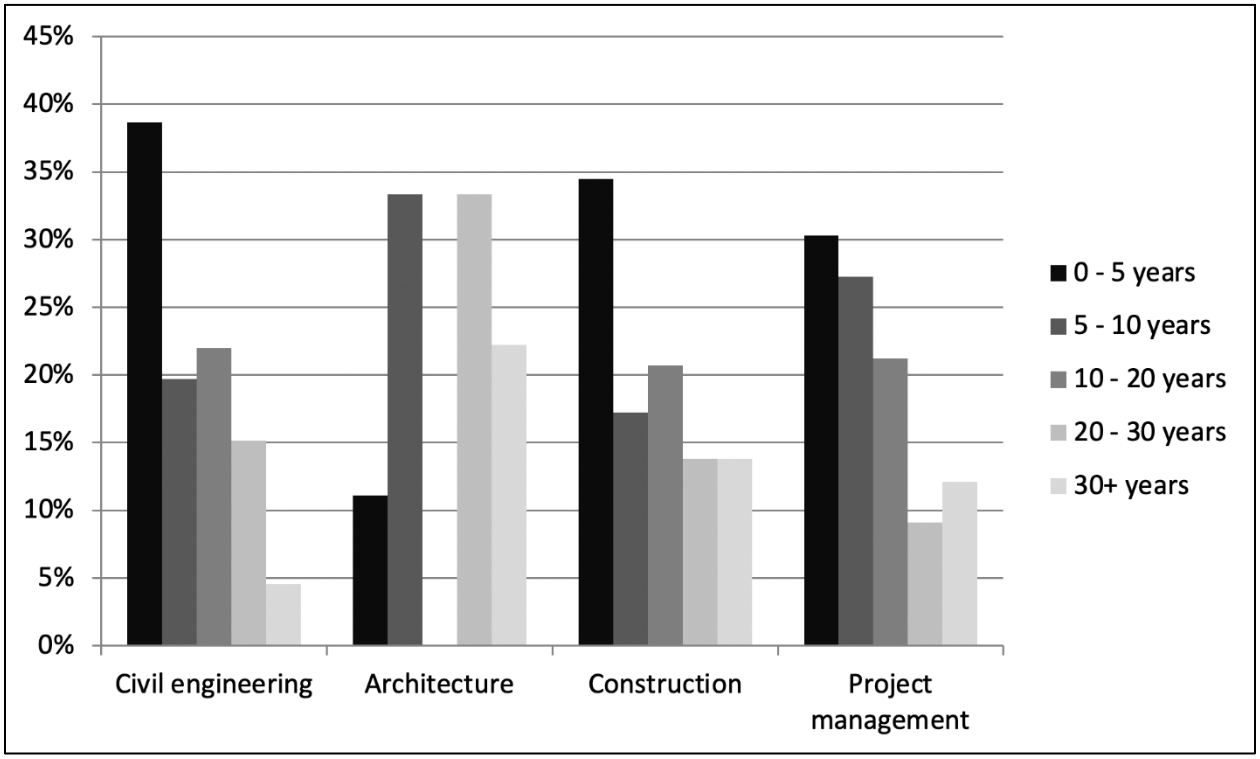

Figure 3-10 - Participant years of experience for specific professions

Participants were also asked if they identified as a person with a disability. Of the 222 total participants, only 5 (2%) answered yes. Furthermore, out of the 131 civil engineers that participated in the survey, only one answered that they identified as a person with a disability (1%). Of the four other participants that answered “yes”, two worked in architecture, one in construction, and one in project management. These percentages are very low, compared to the national percentage of people with disabilities of 22% (Morris et al., 2018). The Canadian Survey on Disability published by Statistics Canada in 2017 shows this trend in employment for people with disabilities. The report shows that persons with disabilities were less likely to be employed (59%) than those without disabilities (80%) (Morris et al., 2018). Moreover, while many participants had 0 – 5 years of experience (36%), only 1 of the 5 participants that identified as having a disability fell into this group. In fact, 2 had 20 – 30 years of experience and 2 had 30+ years of experience even if these groups have the least number of participants (15% and 8% respectively). While these results have a limited number of participants and it can be hard to draw conclusions, they do raise the question of whether employers are employing building design professionals with disabilities or if the participants that answered "yes" to having a disability developed this disability later in life.

Question 5 of the survey asked participants if they thought there were barriers for people with disabilities who want to become civil engineers. While the largest subset of participants (44%) answered yes, 22% answered no and 35% answered unsure. These results demonstrate that a high percentage of design professionals are not aware of barriers and disabilities that one-fifth of Canadians live with every day. While several large civil engineering firms in Canada promote diversity and inclusion in their workplace, only one firm (CIMA+) was found that presents statistics on their employment of people with disabilities. In 2018, the firm—which has more than 1800 employees—reported having only 10 employees with a disability (0.5%) (CIMA+, 2018). Two other firms, WSP and EXP, stated in reports and press releases that they strive to be inclusive in their employment and to have a diverse workspace but neither present statistics on current employees with disabilities (WSP, 2019) (EXP, 2021).

Participants that answered "yes" to Question 5 of the survey (*Do you think there are barriers for people with disabilities who want to become civil engineers?*) were also asked to provide examples of potential barriers present for people with disabilities who want to become civil engineers. A total of 95 participants provided examples which were organized into 5 categories:

- Site access/visits (76 comments).
- Education (17 comments).
- Attitudinal barriers (15 comments).
- Office access and communication/technology at work (9 comments).

Most participants, 80% of those who provided comments, stated that there are barriers for people with disabilities who want to become civil engineers on the construction site. It was noted often that people with physical disabilities would have a difficult time navigating sites due to physical barriers such as ladders, lifts, heavy materials, tight spaces, trenches, etc. These physical barriers would also be hazardous for people with vision and/or hearing impairments since construction sites usually don't have alternate methods of communication to warn of the hazards. It is important to note that those barriers are not only hazardous for people with disabilities. In 2019 the Association of Workers' Compensation Boards of Canada reported 204 work-related fatalities in the construction industry in Canada, more than any other industry (Association of Workers' Compensation Boards of Canada, 2019). Many participants that provided feedback on these barriers shared that field work is very physical and that the attitudes of persons on the site tend to increase barriers. Furthermore, they noted that field work is often assigned to newly graduated engineers and is prominent in several entry-level jobs. Construction sites are also often used for essential learning and experience and it was stated several times that site visits are necessary to get a full grasp of a project. While many participants recognized the barriers present and related to construction, site inspections and surveys, these were often said to be "impossible" to remove.

The second most mentioned barriers were those related to the education of future civil engineers. Of the participants who commented, many attributed these barriers to university campuses not being entirely accessible, the lack of alternate formats for learning materials, and the non-accessibility and hazards present in laboratory settings. Several participants also discussed how several computer programs used for school projects and design work might not be accessible for people with disabilities. Furthermore, comments were made on the style and organization of the education. Learning was said to still be very traditional and not offer many alternative methods for people with learning or developmental disabilities. Civil engineering programs were also described as very rigorous and intensive, which can prove to be overwhelming for people with disabilities especially with the strict structure of the programs that makes it hard for students to reduce their course load. Finally, public transport and commuting to and from campus was stated as a potential barrier to civil engineering education.

Many participants also mentioned attitudinal barriers as being present in the civil engineering industry. Many mentioned that there is still bias and discrimination in the hiring process and that the civil engineering profession still has a long way to go to achieve acceptance. They revealed that there is stigma and negative perceptions associated to people with disabilities such as fear of a slower work pace and not being able to do certain aspects of the job. One participant attributed some of these attitudinal barriers to some senior engineers still being “old-minded” and stuck in their ways.

Finally, while not mentioned as often, some participants stated that some office spaces are not as accessible for people with disabilities as they should be. Employees were also said to be expected to use software that could be very difficult to navigate by people with vision impairments and documentation that is not always compliant with communication accessibility standards.

Several personal statements about physical barriers on construction sites, attitudinal barriers, and barriers in the office were shared in the survey and are included in Table A-2 in the Appendix.

3.3.2. Perceived responsibility and awareness of accessibility

Question 1 to 4 of the survey were related to the perceived responsibility and awareness of building design professionals (particularly civil engineers) towards accessibility. First, Question 1 asked participants how often, as building design professionals, they considered issues related to accessibility during their work. Of the 222 participants, 68 answered “Always”, 64 answered “Usually” and 50 answered “Sometimes”, these three answers accounting for 82% of responses. These results indicate that design professionals are aware of accessibility issues, and they consider them during their designs. However, as will be showcased later, the results don’t mean that the consideration that they bring is sufficient to avoid barriers in the built environment. Additionally, 39 participants answered that they rarely (13%) or never (5%) considered issues related to accessibility which is a significant portion of participants given the importance of the question.

Next, participants were asked what their current familiarity with accessibility standards in Canada was (Accessible Canada Act, CSAB651-18, etc.). Of the 222 participants, only 9 answered “extremely familiar” (4%) and 31 answered “very familiar” (14%). The remaining 182 participants answered “somewhat familiar” (39%), “not so familiar” (30%), and “not at all familiar” (14%). It is also interesting to point out that, of the 9 architects that participated in the survey, all of them answered “extremely familiar” (33%) or “very familiar” (67%). This is compared to 4 of the 132 civil engineers that responded to the survey answering “extremely familiar” (3%) and 9 answering “very familiar” (7%). This stark difference is likely due to the Canadian Architecture Certification Board requiring that a student graduating an accredited architecture program “*must have an understanding of the applicable building codes, regulations, and standards for a given building and site, including universal design standards”* (The Canadian Architectural Certification Board, 2017). While Engineers Canada, the organization that accredits undergraduate engineering programs, has “*impact of engineering on society and the environment”* and *“ethics and equity”* as part of their 12 Graduate Attributes, they do not specifically mention that students should learn about universal design principles, accessibility standards in Canada, or people with disabilities (Engineers Canada, 2021a). While question 1 seemed to indicate that participants considered accessibility-related issues during their work, the lack of familiarity towards accessibility standards that should be used to address those issues is concerning.

Question 3 asked participants if they believed that code requirements related to accessibility were adequate to address all accessibility barriers. These requirements include *Section 3.8* of the National Building Code of Canada and the Barrier-free Design sections of some provincial Building Codes (for Alberta, British Columbia, Ontario, and Quebec). Many participants answered “sometimes” (38%) followed by “usually” (27%) and “rarely” (9%). Only 7 participants answered “always” (3%) and 3 answered “never” (1%). Finally, 47 participants (21%) answered “I don’t know”. The high number of participants answering “I don’t know” reflects the results from Question 2, which showed that participants, especially civil engineering participants, were not familiar with current accessibility standards in Canada. Indeed, of the 132 participating civil engineers, 25% answered “I don’t know” compared to 15% of project management participants, 7% of construction participants and 0% of architecture participants. With the creation of Accessible Standards Canada, following the passing of the Accessible Canada Act in 2019, there will be significant modifications to current accessibility standards in Canada such as the CSA B651-18. While the use of these standards is voluntary, the new requirements will apply to organizations under federal rule (parliament, courts, banks, etc.) (Accessibility Standards Canada, 2021). These new standards could influence the barrier-free sections of building codes. As building codes become more representative of what people need to navigate a built environment, it will become easier for civil engineers to consider accessibility in their designs (see Question 1 discussed above) and trust that the code requirements are adequate to address all accessibility barriers. Nevertheless, in the same way that it is important for civil engineering students to learn why they must ensure specific load resistance in structures depending on snow accumulation or wind levels, it is also important for them to understand why different accessibility requirements are present in the building code.

Question 4 asked participants who they thought were responsible to ensure that a structure was accessible to all its users. The participants were invited to select as many answers as they thought were necessary among the following: architect, engineer, owner, contractor, inspector, other. “Architect” got the most responses with 194 of the 222 participants selecting this answer (87%). This was followed by “owner” with 168 selections (76%) and “engineer” with 149 selections (67%). Furthermore, participants were invited to select “other” and specify other parties that were responsible to ensure that a structure was accessible to all its users. Of the 21 participants that specified other parties, 12 added that they believed that governmental agencies and regulatory bodies that establish and enforce building codes are also responsible. Other parties mentioned include the stakeholders, plan examiners, urban planners, and local legislators. In total, 77 of the 222 participants (35%) selected all available options indicating that they believed that all parties involved in a project have a responsibility to ensure that it is accessible to all its users. The results from this question seem to indicate that design professionals believe that architects, engineers, and owners all have responsibilities in ensuring an accessible built environment.

3.3.3. Accessibility education to building design professionals and civil engineering students

Questions 6 and 7 of the survey were related to accessibility and universal design education for building design professionals, and civil engineering students.

Question 6 introduced participants to the Accessible Canada Act, which was passed into law in 2019 and aims to create an accessible and barrier-free Canada by 2040 (Minister of Justice Canada, 2019). It then asked participants if, given the passing of this Act, they think that civil engineering undergraduate students should learn about the new requirements and efforts put into place to achieve the goal to be barrier-free by 2040. Of the 222 participants, 127 answered “strongly agree” (57%) and 67 answered “agree” (30%) for a sum of 87% of participants. Additionally, 17 participants answered, “neither agree nor disagree” (8%), 8 answered “disagree” (4%) and 3 answered “strongly disagree”. These results show an overwhelming support to provide accessibility education and awareness to undergraduate civil engineering students. It should also be noted that, of the 28 participants that answered, “neither agree nor disagree”, “disagree” or “strongly disagree”, 21 of them were civil engineers (75%) while they make up only 65% of participants. Civil engineer participants also account for all the “strongly disagree” answers. Comparatively, 1 out of the 9 architecture participants answered “disagree”, 1 out of the 29 construction participants answered “disagree” and 3 out of the 33 project management participants answered, “neither agree nor disagree” or “disagree”. Therefore, 75% of the three discussed options were chosen by civil engineer participants, 4% by architecture participants, 4% by construction participants and 11% by project management participants. This can be compared to the distribution of participants by profession of 65% for civil engineers, 4% for architects, 14% for construction professionals and 16% for project managers. Looking at these results it can be observed that civil engineering participants disproportionately believe that accessibility education is not necessary for undergraduate civil engineering students compared to participants from other professions. This could be due to several reasons such as civil engineering professionals being aware of the current structure and inflexibility of the civil engineering curriculum or believing that what is learnt on the field is adequate to understand accessibility requirements.

Question 7 discusses accessibility education for all building design professionals by asking participants if they would be interested to learn more about accessibility issues related to the design of structures. Of the 222 participants, 202 answered either “somewhat interested’ (29%), “interested” (39%) and “very interested” (23%) for a total of 91% of answers. There were also 18 participants that answered “not so interested” and 2 that answered “not at all interested”. These results show that design professionals are generally interested about learning more on accessibility issues related to the design of structures. Considering the results of question 6, this learning could be done during a civil engineer's undergraduate studies and could introduce the Accessible Canada Act, the barrier-free building codes, and different disabilities of the Canadian population.

3.3.4. Additional comments provided by participants on the survey

At the end of the survey, participants were asked to leave any further comments or feedback they might have about the survey and its research subject. A total of 52 participants left comments, 27 of them being comments wishing success in the research and 7 being comments specifying a participant's work area. Furthermore, 14 participants left detailed feedback/opinion and 4 participants left questions about the research.

The 14 comments can be found in Table A-3 in the Appendix. They include suggestions to simplify accessibility codes and standards, increase accessibility and diversity of the engineering practice, and increase public awareness. Some comments also include criticism towards teaching about accessibility to students at the university level, claiming that it would detract from other "more relevant" subjects and towards opening civil engineering careers to all given that some tasks would be impossible and too dangerous to perform.

The 4 questions that were asked by participants were the following:

1. Who will be enforcing the law? What would be the fines for engineers and architects failing to abide to the law?
2. How does the Accessible Canada Act work with provincial guidance like AODA (*Accessibility for Ontarians with Disabilities Act*), does it further empower enforcement and compliance at the provincial level and encourages efforts above and beyond AODA to meet federal targets? How do we make this happen in the meantime while the ACA's 2040 deadline approaches?
3. Are there any organizations who could advise engineers on how to make their designs more accessible?
4. What are the maximum expectations for improving the accessibility of the site that can be approved by the government?

Questions 1, 2 and 4 above all relate to how the current laws and codes in place function to ensure that projects are designed with accessibility in mind. On a federal level, organizations like Accessibility Standards Canada have a mandate to develop and revise accessibility standards for federal private sector organizations and for Government of

Canada departments and agencies (Accessibility Standards Canada, 2021). However, these standards are only enforceable for the sector previously mentioned. Provincially, project designers need to adhere to their provincial building code and many provinces do not have barrier-free or accessibility requirements yet. These are valid causes for questioning and there is a question of whether barriers would be less present in the built environment if there was less separation between the organizations that enforce the law.

Question 3 poses the question of awareness and education for engineers since, as was previously mentioned, engineers are barely taught about accessibility during their university education. While it should be the responsibility of the certification organization (Engineers Canada) to enforce an accessibility and universal design course into the engineering curriculum, education from other organizations would also be a great idea, especially as part of on-going education. Organizations like the Rick Hansen Foundation have programs where a school, community group, or business can request a presentation with an ambassador from the foundation to talk about the importance of building inclusive communities (Rick Hansen Foundation, 2021).

3.4. Summary

The goal of the survey was to analyze the responsibilities of civil engineers towards making the built environment more accessible and the potential of undergraduate education in raising awareness within the profession. The survey was sent to building design professionals (civil engineers, architects, contractors, project managers, etc.); there were 222 responses, 60% of which were from civil engineering professionals. The survey asked 7 questions varying from UD education to their experience applying UD principles to their work. The largest subset of participants had 0 – 5 years of experience (36%) and only 5 participants self-identified as a person with a disability (2%).

Several key findings came from the results of the survey. First, it was found that while participants claim to consider issues related to accessibility during their work (82%) most respondents were at best “somewhat familiar” with the accessibility standards in Canada (83%). Furthermore, when asked if they believed that code requirements related to accessibility were always adequate to address all accessibility barriers, 1 in 5 participants answered, “I don’t know”. The results to these questions indicate a need to broaden building professional’s knowledge on accessibility requirements in the built environment and on building standards related to accessible design. Question 5 asked participants if they believed that there are barriers for people with disabilities who want to become civil engineers. While several participants answered “yes” (44%), many others answered “unsure” (35%). This indicates that there is a need to teach building professionals, especially engineers, about the lived experiences of people with disabilities.

Question 4 asked participants who they believed were responsible to ensure an accessible built environment (they could select as many answers as they believed was necessary). While “architect” got the most selections, there was a significant portion of participants (67%) that selected “engineer”. This indicates that two-thirds of building professionals believe that engineers should be held responsible for ensuring an accessible built environment.

Finally, questions 6 and 7 investigated the participants’ opinion on accessibility and UD education. More specifically, for question 6, 87% of participants agreed that undergraduate civil engineering students should learn about accessibility requirements in the built environment during their studies. Question 7 asked participants more specifically about their interest in learning more about accessibility issues related to the design of structures, 62% were interested.

Some questions collected optional comments from participants. For question 5, participants were asked to specify what barriers exist for people with disabilities who want to become civil engineers. 95 participants provided comments, 76 of which were related to the inaccessibility of construction sites. Other participants commented on barriers present during the education process and on attitudinal barriers held by employers and other professionals. All comments can be found in Table A-2 in the Appendix.

The survey results showed that building professionals agree that engineers have a responsibility to ensure an accessible built environment, and that this responsibility should be supported by accessibility-related education during civil engineering undergraduate education.

4. Universal design in the civil engineering curriculum

4.1. Investigation of current curriculums

4.1.1. Accreditation requirements

Undergraduate civil engineering curriculums in Canada are intensive and regulated by Engineers Canada to ensure that the programs meet accreditation requirements. They include several science intensive and technical classes to ensure that students learn about essential subjects such as mechanics of materials, theory of structures, geotechnical engineering, water management, etc. Students are also required to take classes that build important fundamental knowledge such as mathematics, physics, economics, and communication. Accredited programs also address relevant topics that are deemed necessary before starting to work as a civil engineer, more specifically project management, engineering design (through a capstone project), and engineering law. As mentioned in the literature review, while Engineers Canada lists "*Impact of engineering on society and the environment*" and "*Ethics and equity"* as necessary graduate attributes, it is up to each individual program to demonstrate how these attributes are developed during a student's undergraduate civil engineering education.

To investigate how civil engineers are taught about the impacts of engineering on society during their undergraduate education, a list of all accredited civil engineering programs in Canada was compiled (Engineers Canada, 2021b). Then, the course sequences of these programs were found on their respective institution's websites and thoroughly analyzed to see how their courses responded to the Engineers Canada's accreditation requirements. The results of this analysis are summarized and discussed in the following sections and the full analysis of the programs is included in Table A-4 in the Appendix.

Out of 31 accredited civil engineering programs in Canada, 17 (54%) were found to not have a course that was clearly dedicated to the topics of social impacts of civil engineering or equity. The other 14 programs had a variety of mandatory and optional courses that seemed to vaguely address these topics such as "*CIVL302 – Civil Engineering Impacts*" at the University of British Columbia (The University of British

Columbia, 2021), "*ENGINEER4A03 – Sustainability and Ethics in Engineering*" at McMaster University (McMaster University, 2021), and "*GE449.3 – Engineering in Society*" at the University of Saskatchewan (University of Saskatchewan, 2021), among others. Among the relevant courses identified in this study, none of them specified universal design or accessibility education in the course descriptions on their respective websites.

The results from the survey, discussed in Sections 3.2 and 3.3, showed that many practicing civil engineers believe that undergraduate civil engineering students should learn about accessibility requirements during their studies. For this to be implemented, the importance of universal design education should be reflected in accreditation documentation for civil engineering programs. This is currently challenging because the Canadian Engineering Accreditation Board (CEAB), managed by Engineers Canada, assesses Canadian engineering programs from different disciplines with the same documentation and requirements. This means that the need to teach about universal design and accessibility are assessed the same way for chemical engineering programs as for civil engineering programs, even though these two programs are very different in the way they interact with society. Furthermore, other engineering programs could use universal design courses—such as software engineering and mechanical engineering—but these courses would need to convey very different information than a civil engineering course on the subject. Software engineers should learn about how to design accessible user interfaces and applications, mechanical engineers how to design accessible machines and products, and civil engineers how to design accessible structures and transportation systems.

The accreditation requirements of other countries, such as the United Kingdom (Institution of Civil Engineers, 2021), the United States (Accreditation Board for Engineering & Technology, 2020), Australia (Engineers Australia, 2013), and Singapore (Institution of Engineers Singapore, 2020) were researched and it was found that they were all extremely similar. This is due to all of the above mentioned countries being members of the Washington Accord, an agreement established in 1989 by engineering accreditation organizations around the world (International Engineering Alliance, 2021). The twelve graduate attributes that the member countries, including Canada, base most of their curriculum on is established in the Washington Accord by the International Engineering Alliance (International Engineering Alliance, 2021). However, since accessibility and universal design are relevant to several existing graduate attributes, the Washington Accord does not prevent Engineers Canada from modifying their current curriculum requirements.

4.1.2. Curriculum analysis

Implementing a new course in the civil engineering curriculum of Canadian universities is not a trivial task. The challenge occurs because the curriculum is already heavily loaded with courses and forces all students from 4-year programs to take more than 6 courses per semester if they wish to graduate in time (some universities offer 5-year programs). Therefore, to implement a new course, an old course would need to be replaced or modified. The decision of which course to modify or replace would be an extremely difficult one since civil engineering programs have designed their curriculum and courses carefully to adhere with Engineers Canada requirements.

According to the Engineers Canada requirements for an undergraduate engineering program, a course discussing universal design and accessibility would fall under the “Complementary studies” category. It is mandatory for engineering curriculums in Canada to include “Complementary studies” (CS) in the following subjects (Engineers Canada, 2020b):

a) *Subject matter that deals with the humanities and social sciences*
b) *Oral and written communications*
c) *Professionalism, ethics, equity, and law*
d) *The impact of technology and/or engineering on society*
e) *Health and safety*
f) *Sustainable development and environmental stewardship*
g) *Engineering economics and project management*

According to the 2021/2022 Questionnaire for Evaluation of an Engineering Program by Engineers Canada, students must receive a minimum of 225 Accreditation Units (AU) of the subjects listed above during their studies. A one-hour lecture corresponds to 1 AU; a typical university course has 3 hours of lecture per week for 12 weeks for a total of 36 AU. To evaluate how universities are currently distributing the CS units, an in-depth analysis of all Canadian civil engineering programs was conducted. This analysis included a review of the curriculum and recommended course sequence of each of these programs to see which courses (if any) applied to the specific subjects under the CS requirements. This was done by reading the description of all the mandatory courses in the curriculum and, if available, the course outline, to determine if any of the subjects were discussed. While some examples were very straightforward (such as the University of Ottawa required course *GNG4170 – Engineering Law*, which relates directly to subject *c) Professionalism, ethics, equity, and law*) others were not so precise. For example, some courses like *CIVL200 – Professional Skills I,* which is required for students at Queen's University, addresses professionalism and ethics but also discusses other subjects such as engineering design and communication skills. For the purposes of this study, these types of courses were allocated partial AU scores (18 AU instead of the full 36 AU for the Queen's University example). The AU allocations used in this study may not exactly match those used by the respective programs in their accreditation evaluations; while it was impossible to make the analysis completely accurate, since only a handful of universities provided course outlines, the results will nonetheless be helpful to indicate how units are distributed between the required subjects.

4.1.3. Results

The full analysis of the programs is included in Table A-4 in the Appendix. The universities offering the least CS AUs were McMaster University and l'Université du Québec à Chicoutimi, both with 216 AU, followed by the University of Saskatchewan with 234 AU. These results show that the analysis is somewhat subjective and does not yield exact results since the minimum required AU to be accredited is 225 AU and both McMaster University and l'Université du Québec à Chicoutimi scored below this amount. Therefore, the results should be used mostly for comparative analysis rather than for definitive amounts of AUs offered in each curriculum. The universities offering the most CS AUs were the British Columbia Institute of Technology and l'Université de Moncton, both with 468 AU, followed by the Royal Military College of Canada with 438 AU. It is interesting to note that while these top-three universities require their students to take a lot of Complementary Studies courses, most of these are focused on the same subject: *b) Oral and written communication* for the British Columbia Institute of Technology (4 courses = 144 AU) and *a) Subject matter that deals with the humanities and social sciences* for the Royal Military College of Canada (5 courses = 180 AU) and l'Université de Moncton (3 courses = 108 AU). On average, Canadian universities with accredited undergraduate civil engineering programs offer 313.1 AU of Complementary Studies courses which is the equivalent of more than eight 3-hour per week courses, occurring during a 12-week term.

With an average of 8 courses and 7 CS subjects, one might assume that most universities would offer one complete course per subject. However, the analysis found that this was far from the truth. Programs require students to take on average 102.3 AUs of subject *g) Engineering economics and project management*, which is equivalent to almost 3 courses. Indeed, of the 30 analysed universities, 19 require three courses of this subject while 3 universities require four courses, and 9 require two courses. The analysis included *engineering economics*, *project management,* and the first *capstone* course in these numbers but did not include the several engineering design courses which often also discuss aspects of project management and engineering economics. If these had been included the results would skew even higher.

Following this, the subject with the most required AUs is *a) Subject matter that deals with the humanities and social sciences* with an average of 62.4 AU. In all cases except for the Royal Military College of Canada, these courses are offered in the form of "Complementary Studies Elective" or "Humanities/Social Science Elective" in which universities provide students with a pre-approved list of courses in the faculties of Social Science, Arts, Management, etc. The majority of universities (18 out of 30) require students to take 2 or more of these "elective" courses. As mentioned previously, the Royal Military College of Canada requires students to take 5 specified courses (students are not provided with a list of options) that includes HIE207 - *History of Canada, HIE203 – Introduction to Canadian Military History,* and *PSE301 – Organizational Behaviour and Leadership*.

Furthermore, all universities require students to take at least one course in the subject *b) Oral and written communications* (average of 50.4 AU ≈ 1.4 course) and most universities require one course in the subject *c) Professionalism, ethics, equity, and law* (average of 33 AU ≈ 0.92 course).

The other subjects averaged less than one course-equivalent of AU: *d) The impact of technology and/or engineering on society* (average of 22.4 AU ≈ 0.73 course*), Health and safety* (average of 18.2 AU ≈ 0.51 course*),* and *f) Sustainable development and environmental stewardship* (average of 20.4 AU ≈ 0.57 course*)*. Indeed, one trend that was observed in several programs is that these subjects were all discussed together in one course instead of having their own course. These courses often include guest lectures instead of being a structured university course offered by one “expert” professor. The following course titles and descriptions represented in Table 4-1 represent examples of such a course at the University of Calgary, the University of Windsor, and the Royal Military College of Canada (respectively).

Table 4-1 - Course descriptions from civil engineering curriculums

University	**Course title**	**Course description**
University of Calgary	ENGG513 – The Role and Responsibility of the Professional Engineer in Society	The professional duties and responsibilities of the engineer as they relate to **society**. Ethics and the engineering profession. Public and worker **safety** and **health**. Design for safety. **Sustainable development**. The engineer and the environment. **Environmental stewardship**. Essentials of leadership. Gender issues. Employment equity. Fundamentals of engineering law. Professional Organizations. The Engineering Professions Act. (University of Calgary, 2019)
University of Windsor	85-118. Engineering and the Profession	The Engineering and the Profession course is an introductory professional course for all Engineering students. The students will be introduced to and learn about various professional and academic topics and may include but are not limited to: differences and similarities between the various engineering disciplines; academic performance; […]; **sustainability** considerations; and public **health** and **safety** responsibilities; and how engineering is broadly related to our **society**. (University of Windsor, 2021)
Royal Military College of Canada	GEE291 – Introduction to Engineering Professional Development	The objective of the course is to initiate students to aspects of professional development in Engineering. The course has four modules: (i) roles and responsibilities of engineering in **society** and ethics in engineering; (ii) **environmental stewardship**; (iii) **sustainable development**; and, (iv) **safety**. (Royal Military College of Canada, 2021)

Of the 30 accredited university programs only the British Columbia Institute of Technology and l'Université Laval had a separate course for each of these subjects. Most other programs appeared to discuss the subjects only briefly in generic courses such as the ones presented in Table 4-1.

4.1.4. Discussion

It is necessary to question why there is an imbalance in the distribution of Accreditation Units for Complementary Studies courses and how this imbalance affects the education of future civil engineers. The subjects that were given less units (impacts of engineering on society, health and safety, and sustainable development and environmental stewardship) are still evidently subjects that the CEAB believes to be important for undergraduate civil engineering students to learn about. As we have seen in the literature review presented in Section 2.4.1, problem solving, communication, teamwork, and ethics were found to be the most important generic engineering competencies according to employers, ranking higher than math, science, and engineering tools (Passow & Passow, 2017). A 2020 study on educating students about societal impacts of civil engineering also revealed the importance of learning about these issues given the social and environmental impacts of civil infrastructure (Bielefeldt et al., 2020). While it could be argued that topics such as *health and safety* and *sustainable development and environmental stewardship* should be allotted more units in civil engineering curriculums, they fall beyond the scope of this research; instead this study focuses on accessibility, and therefore on the social impacts of civil engineering.

The results of the survey conducted for this research clearly showed that practicing building design professionals believe that civil engineering students should learn about accessibility during their studies (87% of participants agree or strongly agree) and that there is a need to do so since many participants don't always consider accessibility when completing a design (41% answered sometimes, rarely, or never). While 22.4 AU (0.73 course) were the average accreditation units reserved for the subject *impacts of engineering on society* in civil engineering curriculums in Canada, none of the courses falling into this subject mentioned discussing accessibility or universal design in their description. This is worrisome since building barriers into the built environment is one of the many important impacts that civil engineering brings into society alongside other issues that will be briefly discussed later such as gentrification, environmental racism, and inequities in transportation. There are several things that need to be done before civil engineers can be properly held accountable for these issues but one thing that is evident is that education is the place to start. To hold civil engineers accountable for their responsibilities to society and the environment, universities must first be held accountable for what they teach to their civil engineering students, which requires a closer examination of accreditation requirements for civil engineering programs.

The fact that engineering economics and project management courses are filed under the “Complementary Studies” category for civil engineering programs is a clear sign that there needs to be a distinction between the accreditation regulations for different engineering disciplines. Economics and project management is at the core of the civil engineering discipline and these topics should have a separate requirement category, similar to the evaluation of mathematics or physics courses. Furthermore, with a civil engineering specific accreditation process, CEAB would be able to specify what “Health and Safety” or “The Impacts of Technology/Engineering on Society” entails. This should also be done in other engineering disciplines since how software engineering impacts society is very different than how civil engineering does. For example, software engineers need to learn about how to design accessible software and these discussions will vary greatly from the ones that will teach civil engineers how to build an accessible library. CEAB should ensure that the engineering programs across Canada do not omit valuable information from their engineering curriculums while still allowing faculties to innovate and explore different subjects of interest.

4.2. Strategy of implementation

Given the results of the curriculum analysis discussed in the previous section, the following recommendations are suggested to implement universal design education in undergraduate civil engineering programs:

- Include universal design and accessibility education in a mandatory “Impacts of Engineering on Society” course and accompany the information with other impacts.
- Create separate accreditation requirements for different engineering programs, more specific guidelines for Complementary Studies, and a mandatory course for each of the following subjects:
    - Impacts of Engineering on Society
    - Health and Safety

  - Sustainable Development and Environmental Stewardship
- To create space in the curriculum for these courses, it is recommended to cut the amount of "Complementary Studies Elective" courses that universities require their students to take. These courses are usually chosen by the student from a list of pre-approved courses from the faculties of Humanities and Social Sciences.

The new *Impacts of Engineering on Society* course should, if possible, be taught by a doctorate in Civil Engineering holder that has researched and studied the impacts of engineering on society. However, since this is a not a very common research subject among graduate civil engineering students, a professor holding a doctorate in Sociology or Anthropology would also be adequate, given that they familiarise themselves with the civil engineering discipline, its tasks, and responsibilities.

It could be useful to introduce this course in one of the 30 undergraduate civil engineering university programs in Canada, measure its success by gathering student feedback, and follow from that potential momentum to incorporate the course in other programs and initiate change in the CEAB accreditation requirements.

4.3. Course organization

A typical university course in Canada consists of 3 hours of lecture per week for 12 weeks. Therefore, the course *Impacts of Engineering on Society* will consist of 36 hours of lecture.

The purpose of this course is to not only teach about the impacts of engineering on society but also to instill a curiosity in students, to open their eyes to problems that they may never have thought about. To do this, the course should encourage open discussion and incorporate tools that captivate and inspire students such as guest presentations, informational videos (e.g., Ted talks), and relevant documentaries. It will also be essential to connect students with stakeholders ((accessibility and disability organizations) to facilitate communication and problem solving.

The following subjects are recommended to be discussed in the proposed course; each subject will be explained in the following paragraphs.

1. *Accessibility and universal design (7 weeks)*
2. *Gentrification, environmental racism, and inequities in transportation (5 weeks)*

4.3.1. Accessibility and universal design

The literature review presented in the Chapter 2 of this thesis presents many of the important topics that should be discussed when teaching about accessibility and universal design.

First, students should be made aware of the diversity of humans in Canada and around the world and of the types of disabilities that exist. Here, there is an amazing opportunity to partner with members of the community living with disabilities so that they can convey their experience interacting with the built environment. The course will also encourage students to participate in activities to make them experience what it is like to live with a disability such as maneuvering a building with a wheelchair, listening to videos that simulate hearing loss and using applications that mimic vision loss. In this portion of the course students will learn about the statistics on people with disabilities published by Statistics Canada and how these results are changing due to the aging population. It will also be crucial to define the difference between the medical and social models of disabilities and discuss their impacts on the disability rights movement. Students will also learn about inclusive language to ensure a respectful environment for people with disabilities.

Next, students will learn about universal design and the types of barriers present for people with disabilities. They will learn about the history of universal design and of the disability rights movement, about the seven principles of universal design and about how universal design can be used to design inclusive built environments.

Finally, students will be introduced to how accessibility and universal design interacts with their tasks as civil engineers. They will learn about accessibility codes and standards in Canada and how to design inclusive buildings. They will also be shown good examples of universal design in the built environment and examples that create barriers.

Overall, the 7 weeks focused on accessibility and universal design will be organized as follows:

i. The diversity of the human condition (3 weeks = 9 hours)
    a. Disability statistics in Canada and around the world (2 hours)
    b. Social vs. Medical models of disability and their implications, briefly discuss ableism (2 hours)

   c. Presenting varying types of disability and experience activities (2 hours)
   d. Interactive activity (e.g., watch documentary Crip Camp) and discussion (3 hours)

ii. Universal design (1 week = 3 hours)
   a. Barrier-free design vs. Universal design (1 hour)
   b. Introduce and discuss 7 principles and 8 goals of universal design (2 hours)

iii. Civil engineering and accessibility (3 weeks = 9 hours)
   a. Accessibility legislation, regulations, codes, and standards (3 hours)
   b. Why it is important to go beyond “code-minimum” (1 hour)
   c. The economic costs of making a project accessible (1 hour)
   d. Examples of universal design in existing projects (1 hour)
   e. How to design an accessible structure (3 hours)

4.3.2. Gentrification, environmental racism, and inequities in transportation

The second portion of the proposed course will discuss other social impacts of civil engineering. These include gentrification, environmental racism, and inequities in transportation which are discussed below. There are several other topics which could also be discussed in the proposed course such as inequal access to necessary infrastructure such as clean water, energy, and internet connectivity. Civil engineers also need to be aware and conscious of respecting the lands and resources of Indigenous and First Nation communities while designing and supervising projects. Several of these subjects can also be discussed in parallel with topics in the “Sustainable Development and Environmental Stewardship” course. These topics are outside the scope of the present research study and will not be discussed in detail. While civil engineers’ tasks on a project might not directly affect the outcomes of gentrification, environmental racism and inequities in transportation, their presence in the design process may allow them to intervene if they notice negative impacts to society of a project. Engineers Canada states that engineers must *“hold paramount the safety, health and welfare of the public and the protection of the environment[…]”* (Engineers Canada, 2022). This duty to ensure health and welfare of the public includes ensure that projects do not benefit certain communities while impeding others.

4.3.2.1. Gentrification

According to the Merriam-Webster dictionary, gentrification is defined as "*a process in which a poor area (as of a city) experiences an influx of middle-class or wealthy people who renovate and rebuild homes and businesses and which often results in an increase in property values and the displacement of earlier, usually poorer residents*" (Merriam-Webster, 2021). Civil engineers work on large projects that could be seen as community improvements and it is important that they be conscious of the current habitants of the region where the project is built. By being part of the team designing and building the project they have a chance to push for measures to be put in place to ensure that current communities are not displaced from their neighborhood. These measures include financing for renters to be able to purchase their units, preventing property tax increases for long-term residents, increasing the amount of affordable housing and establishing loans for small business owners (Van Tol, 2019).

4.3.2.2. Environmental racism

Environmental racism is "*any policy, practice or directive that differentially effects of disadvantages (where intended or unintended) individuals, groups or communities based on race*" (Peña-Parr, 2020). For example, water treatment plants situated upstream of a disadvantaged community, cities locating industrial buildings next to low-income neighborhoods, or advantageous green infrastructure projects built in high-income areas. Civil engineers should be cautious when working on projects that have environmental impacts, whether positive of negative, to make sure that these projects do not disproportionately impact minority and disadvantaged communities. Furthermore, they should be aware of the ways that several civil engineering projects are currently impacting these communities. Indigenous leaders could also be invited to lead discussions on respectful engagement and capacity building related to engineering projects affecting Indigenous communities.

4.3.2.3. Inequities in transportation

Many civil engineers work on transportation projects, from highways to bridges to public transit projects like rail networks or bike paths. These projects often shape communities by adding ways to get around and influencing how residents interact with their environment. Designers working on such projects should be made aware of inequities in transportation. These inequities can present themselves as benefits that marginalized groups don't have access to (public transit, bike paths, etc.) or as undesired effects of transportation (pollution, noise, etc.). As Steven Farber, professor of geography of the University of Toronto explains in an article by Don Campbell "*Transportation goods are things like ease of access to downtown via the subway, how frequent and affordable is the service, and to consider who has access to these good things – is it only the rich? It is mostly white people? People of colour? In terms of transportation bads it's understanding who's suffering from pollution, lack of access, safety issues or congestion.*" (Campbell, 2019). There is a strong history of inequities in transportation in Canada such as the displacement of the population of Vancouver's Hogan's Alley neighborhood in 1967, which consisted mainly of immigrant families and African-Canadians, in order to construct a freeway (Compton, 2019).

These three topics have a very wide reach and civil engineers could benefit from being made aware of their existence. The course *Impacts of Engineering on Society* should dedicate 5 weeks of courses (15 hours of lectures) to discuss these subjects by defining them, giving concrete past and present examples of each, and discussing how the adverse effects of gentrification, environmental racism, and inequities in transportation can be avoided.

4.4. Summary

The goal of the civil engineering curriculum analysis was to investigate the need and feasibility to incorporate a course discussing the social impacts of civil engineering, including Universal Design, in the civil engineering curriculum. This investigation was prompted by the results of the survey presented in Chapter 3, which resulted in an overwhelming agreement from participants (87%) that civil engineering students should learn about accessibility-related matters during their undergraduate civil engineering education.

All course sequences of the 31 accredited civil engineering programs in Canada were analyzed. Of the 31 programs, only 14 (46%) were found to have a course dedicated to the topics of the social impacts of civil engineering or equity. However, none of these courses specified UD or accessibility education in the course description.

For change to occur, the Canadian Engineering Accreditation Board (CEAB) should specify that UD education is important and necessary for undergraduate civil engineering students. Currently, the CEAB, managed by Engineers Canada, requires programs to include Complementary Studies (CS) in their curriculum. The CS courses need to discuss 7 subjects, including “The impact of technology and/or engineering on society” (Engineers Canada, 2020b). However, this subject was found to receive a lot less Accreditation Units (AU) from universities than other subjects included in the CS. While “The impact of technology and/or engineering on society” received an average of 22.4 AU (approximately 0.73 course), other subjects such as “Engineering economics and project management” received an average of 102.3 AU (approximately 2.8 courses) and “Oral and written communications” received an average of 50.4 AU (approximately 1.4 courses). The full analysis of the programs is included in Table A-4 in the Appendix.

CEAB and Engineers Canada should require a more balanced approach to the CS courses by being more specific about the subjects and themes to be discussed in their courses. This would be made possible by developing discipline-specific guidelines for engineering programs in Canada (Engineers Canada, 2021a). All Canadian universities offering an accredited civil engineering undergraduate program should be required to have a dedicated “social impacts of civil engineering” course which would discuss several subjects, including the responsibilities of civil engineers towards achieving a barrier-free built environment. This course can be implemented if CEAB re-structures their CS courses requirements by, among other things, cutting the amount of “Complementary Studies Elective” courses that universities require their students to take. A pilot course should be introduced to a civil engineering program to measure its success and gather feedback before implementing it in other programs.

It is recommended that the course be organized as a typical 12-week university course with 3 hours of lecture per week. The course should encourage open discussion and be interactive so that students be able to visualize how their future work as civil engineers impact society. Among topics discussed it is recommended that most of the course discuss accessibility and universal design while the rest of the course discuss topics such as gentrification, environmental racism, and inequities in transportation.

5. Accessibility audit: Case study

5.1. Introduction

With the passing of the Accessible Canada Act in 2019 (Minister of Justice Canada, 2019), the Government of Canada received a new mandate to make their federally owned buildings barrier-free by 2040. To achieve this mandate many governmental accessibility-focus work groups have been formed such as accessibility teams on major rehabilitation projects and the universal accessibility (UA) team for the Parliamentary Precinct. The previously mentioned group is part of the Science and Parliamentary Infrastructure Branch (SPIB) at Public Services and Procurement Canada (PSPC). The members of this group work alongside professional Universal Accessibility consultants and engage with members of the community, especially people with disabilities, with the goal of making the Parliamentary Precinct a space universally accessible to everyone. The Parliamentary Precinct is a campus in Ottawa, the capital of Canada, that includes more than 30 different buildings. These buildings house many important political spaces such as the House of Commons of Canada, the Senate of Canada, and the Office of the Prime Minister of Canada, among many others. The most widely recognizable buildings of the Parliamentary Precinct are Center Block, West Block, and East Block, all located in a triangular arrangement, surrounding a large public lawn on Parliament Hill. Figure 5-1 shows a visual representation of the parliamentary precinct.

Figure 5-1 – Digitally illustrated representation of the Parliamentary Precinct (Canadian Society of Landscape Architects, 2007)

To achieve their goal of a universally accessible Parliamentary Precinct, the UA experts hired as consultants for the project compiled a set of UA Best Practices that exceed UA requirements from current codes and standards. Following the compilation of the UA Best Practices, the SPIB universal accessibility team conducted universal accessibility audits of buildings on the Parliamentary Precinct including East Block, West Block, the Confederation Building, the Justice Building, and the Visitor Welcome Center. Center Block is currently undergoing a major rehabilitation project; therefore, it has not been audited. The Center Block project involves the work of several architects, engineers, and project managers. The project has a Universal Accessibility team which is working in collaboration with the SPIB UA Team to ensure that the design of the rehabilitated building is as accessible as possible from the beginning. If successful, this will result in a universally accessible building which will not require a UA audit since it will have been completed with UA in mind throughout the design and construction process. For projects of this magnitude the design team must be very innovative especially since Center Block is a Classified Federal Heritage Building of Canada. Therefore, some UA solutions that would be simple to implement in newer buildings, such as replacing stairs or building a ramp in front of the building, are more challenging for this project since it would compromise the heritage character of the structure. Every designer working on the project, including civil engineers, had to be involved in imagining new solutions, such as the underground Visitor Welcome Center, to answer to accessibility challenges. In this section, the audit conducted on the newly built Visitor Welcome Center will be discussed.

To provide additional useful examples, an accessibility audit of two buildings on the University of Ottawa campus, which was initially conducted for an undergraduate thesis (Leclair 2020), will also be discussed in the context of the present study (i.e., existing barriers to civil engineering education). The buildings were assessed in Winter 2020 and included Colonel By Hall (CBY) and the STEM building. These buildings are both used by engineering students at the university and house several services such as lecture halls, laboratories, study spaces, meeting rooms, offices, etc. While CBY was built in 1970, STEM is a new building, opening its doors to students, faculty, and staff in September 2018. This age difference between the two buildings makes it interesting to demonstrate how the accessibility requirements have differed and what changes have been implemented in STEM to make it more accessible than CBY.

5.2. Methodology

Completing a universal accessibility audit of a building on parliament hill is a task that requires the involvement of many people, tools, and resources. The building was audited using Universal Accessibility (UA) best practices compiled as part of the Universal Accessibility Review and Action Plan of the Universal Accessibility Team at the Parliamentary Precinct. These best practices were compiled by researching over 60 accessibility codes, standards, and guidelines from around the world. These best practices go “above and beyond” current accessibility standards in Canada by identifying 1964 UA best practice technical requirements (only 470 of which are CSA B651-18 requirements) (NorrDialog, 2021). The findings of the audit are published in *Universal Accessibility Audit Report: Visitor Welcome Centre (VWC) Phase 1* as part of the *Universal Accessibility Review and Action Plan* by PSPC (NorrDialog, 2021). The accessibility audit was conducted on October 29th 2020 by accessibility consultants Marnie Peters of *Accessibility Simplified* (Accessibility Simplified, 2021) and Ryan Bui of *DesignABLE Environments* (DesignABLE Environments, 2021).

The audit of CBY and STEM on the University of Ottawa campus relied on existing accessibility audit documentation from The Rick Hanson Foundation (The Rick Hanson Foundation Accessibility Certification Handbook) (Rick Hansen Foundation, 2018) and existing barrier-free requirements from the Ontario Building Code (Government of Ontario, 2015). The audit was conducted with the help of staff from the Facilities offices at the University of Ottawa which provided access to several areas in the buildings. Areas assessed were mostly spaces used frequently by civil engineering students such as laboratories, classrooms, and study spaces. Furthermore, the spaces were visited with a person using a power-operated wheelchair to obtain their opinions on the spaces as a person with lived-experience in navigating barriers in the built environment.

5.3. Results

5.3.1. Visitor Welcome Center

The Visitor Welcome Center is an underground space that blends perfectly with the surrounding heritage buildings of the parliamentary precinct and offers many services to members of parliament and guests. It offers an arrival hall, gift shop, security scanning area, information and ticket desk, and other services. Phase 1 of the project started in 2015 and was first opened for visitors in January 2019. Phase 1 provides access to West Block and Center Block (currently closed for the major rehabilitation project) while phase 2 will connect the underground space to East Block (Government of Canada, 2021). Figure 5-2 shows the entrance to the Visitor Welcome Center, located under a bridge on Parliament Hill.

Figure 5-2 – Entrance to the Visitor Welcome Center on Parliament Hill (Government of Canada, 2021)

Before the opening of the Visitor Welcome Center, guests and visitors of Center Block had to enter through temporary ramps on the side of the main entrance of the building (which is only accessible by stairs). Although these ramps provided entry to the building, they were not easy to locate. Furthermore, the entryway leading to the security screening room was narrow and could get crowded. The new Visitor Welcome Center provides an elegant entrance and was designed to provide ease of access for all. Figures 5-2 and 5-3 show the interior of the Visitor Welcome Center including the stairs, escalators and elevators leading to the arrival hall (Figure 5-3) and the arrival hall with the information desk (Figure 5-4).

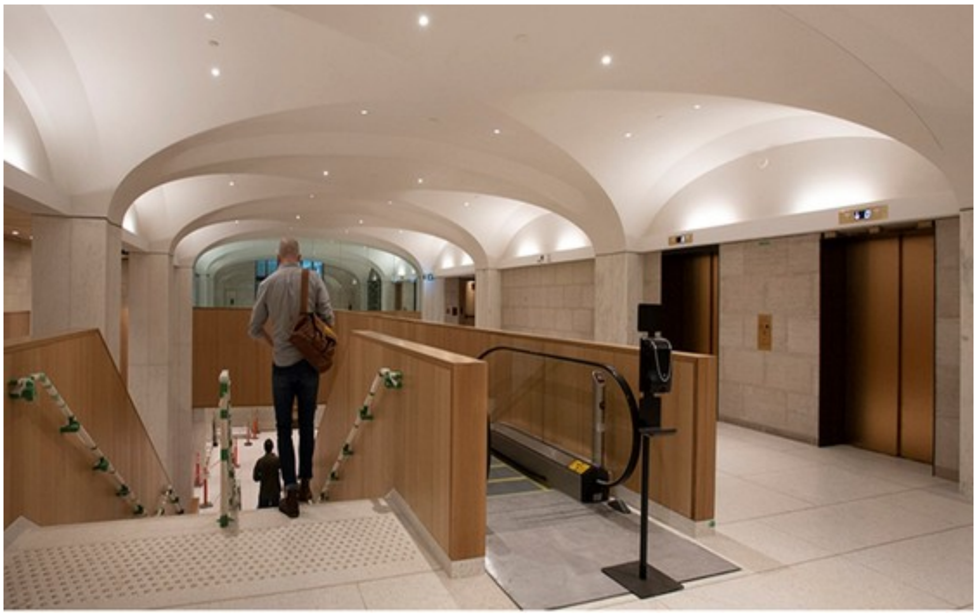

Figure 5-3 – Interior entrance of the Visitor Welcome Center (Government of Canada, 2021)

Figure 5-4 - Arrival hall of the Visitor Welcome Center (Government of Canada, 2021)

The Visitor Welcome Centre was designed and built with accessibility in mind. The improvements made to the main entrances, interior navigation, illumination, elevators, and stairwells compared to the previous locations frequented by visitors are a clear indication of the effort that was put forth towards universal design. However, the audit performed showed that some elements of the new structure still needed some work before the space could be considered universally accessible. These include, among many others, adding signage in key locations, ensuring that the stairs are accessible by installing contrasting strips and non-slip nosing and improving the sound acoustics in the main arrival hall. Other changes of a more structural nature are presented in the following section (5.4 Discussion and implications).

5.3.2. University of Ottawa buildings

5.3.2.1. Colonel-By Hall

The assessment of Colonel-By Hall (CBY) revealed multiple barriers to the built environment present for people with disabilities. The most evident of these barriers is the layout of the building which includes changes of level within several stories and a confusing “blocks” system which makes it hard for users to navigate the large building. The building also has two mezzanine levels which can only be accessed by the secondary elevator and makes the layout confusing for anyone navigating the building. The changes in level on the 1st and 3rd floors can be seen in Figures 5-5 and 5-6, respectively.

Figure 5-5 - CBY 1st floor block A, change of level

Figure 5-6 - CBY 3rd floor block A, change of level

Another significant barrier present in CBY are the interior ramps present on floor 0. According to the Ontario Building Code, ramps must have a maximum slope of 1:12 (Government of Ontario, 2015) while CSA B651-18 recommends a maximum slope of 1:20 (Canadian Standards Association, 2018). The interior ramp leading to block B had a slope of 1:9 while the ramp leading to block C, shown in Figure 5-7 below, had a slope of 1:7.5. The latter ramp also has a large column as an obstruction running through its center.

Figure 5-7 - CBY floor 0 ramp leading to block C, slope of 1:7.5

These two significant barriers, the changes of level/layout of the building and the interior ramps, are enough to classify CBY as being a non-accessible building. The building also lacked a universally accessible (UA) washroom, required improved signage, had permanent workstations that were too high and required more knee space, and had stairs with open risers and no Tactile Attention Indicators (TAI's) which represents a significant hazard for users with vision impairments.

5.3.2.2. STEM Building

The assessment of the STEM Building, which followed the CBY assessment, showed significant promise in how far barrier-free requirements have come since 1970. While the building presented a few barriers, it was mostly accessible for all users.

Among the barriers met in STEM are the lack of proper power-operated door openers on the door leading to the 3rd floor (Figure 5-8 below) from the elevator and on the door leading to the "universally accessible" washroom on the 3rd floor (Figure 5-9 below).

Figure 5-8 - STEM 3rd floor access from elevator

Figure 5-9 - STEM 3rd floor blocked path to "universally accessible" washroom

Additionally, the 1st floor has a very long ramp which should have colour contrasting strips, handrails, and be slip resistant (Figure 5-10). Other barriers present at STEM includes desks, chairs, and counters that are too high in workspaces, classrooms, and laboratories and the lack of tactile information on signage.

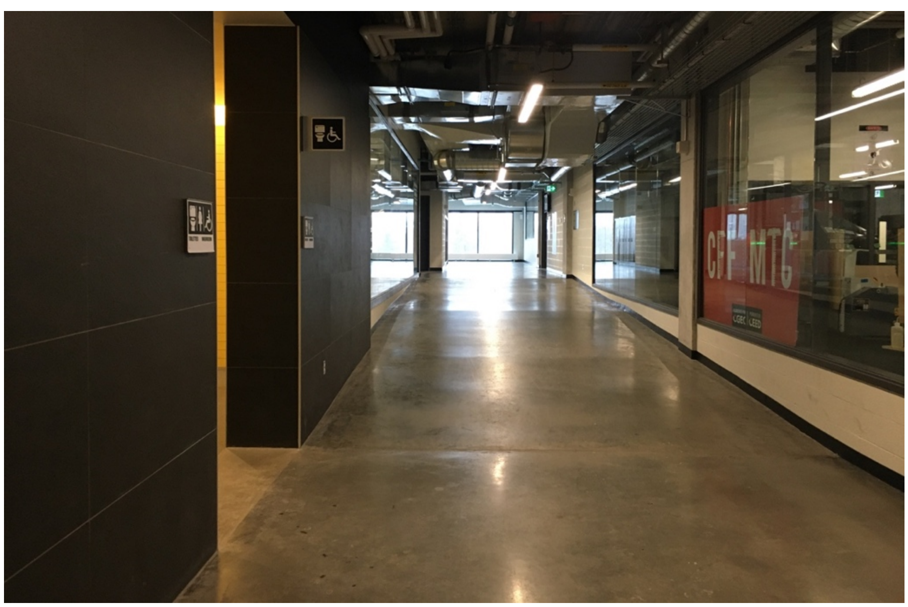

Figure 5-10 - STEM 1st floor ramp

5.4. Discussion and implications

5.4.1. Visitor Welcome Center

In total, there were 704 accessibility requirements at the Visitor Welcome Center that were identified as not compliant with the UA best practices. It is important to note that, while this sounds like a considerable amount of non-compliant elements, most of them go beyond current accessibility requirements in current codes and standards in order to meet UA requirements. Several of these requirements do not require structural changes to the building such as changing the position of a powered-door-operator (PDO) or adding tactile attention indicators (TAIs) at the appropriate location on stairs.

However, other non-compliant requirements might affect structural components of the structure and therefore will require the consultation of civil engineers. There are 30 such requirements which were compiled in Table A-5 in the Appendix. Note that the following examples refer to the CSA B651-18 when specifying accessibility requirements but that all of these requirements, and many other that go beyond current codes and standards, are represented in the SPIB UA Best Practices. One example of these is corridor 06-V which leads to entrances to washrooms 05-V (universal all-gender washroom), 08-V (women’s washroom), and 09-V (men’s washroom). The corridor in this area is too narrow (1570 mm) according to CSA B651-18 accessibility requirements (5.2.2 and 5.1.1) which indicates that primary paths of travel must be at least 2440 mm wide. The corridor and the door to washroom 05-V are shown in Figure 5-11 while Figure 5-12 shows the floor plan to corridor 06-V. These washrooms are expected to be a very busy area used by visitors attending tours and other guests of the building. In addition to their entrance not adhering to CSA standards of accessibility, their accessible stalls also require more depth according to CSA B651-18 6.2.7.1.a (requires a depth of 1830 mm, actual depth of 1485 mm) (NorrDialog, 2021).

Figure 5-11 - Corridor 06-V and entrance to washroom 05-V (NorrDialog, 2021)

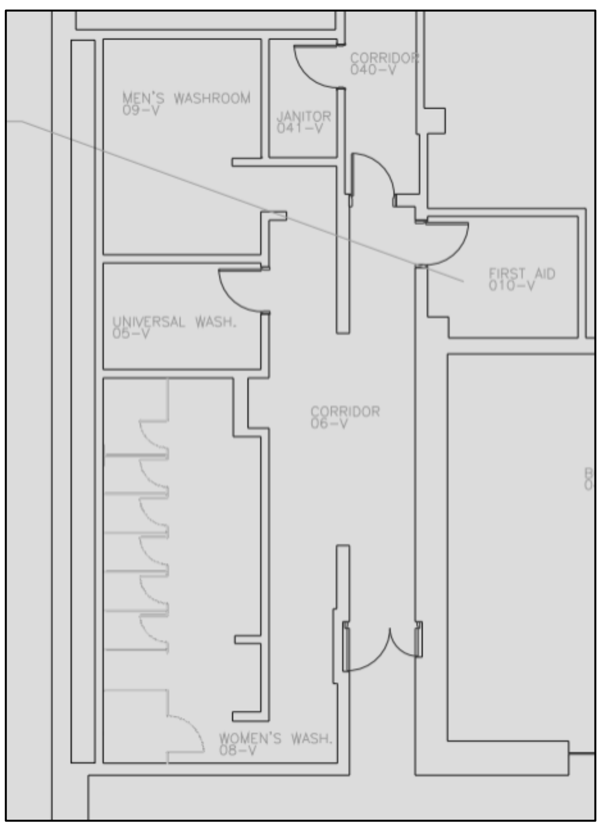

Figure 5-12 - Partial floor place floor 0 VWC showing corridor 06-V and washrooms (NorrDialog, 2021)

The building is also in need of an area of refuge for people requiring assistance in case of an emergency. According to CSA B651-18 5.7.2.1 the area must be smoke protected and served directly by an exit.

Making such structural changes once a project like the Visitor Welcome Center is complete can be very costly and often will be set aside until a major rehabilitation is planned. This shows the importance of incorporating universal accessibility best practices from the planning and design phases of the project, and of not solely relying on current codes and standards, which are often inadequate, to ensure the accessibility of a project. Additionally, it can be assumed that the more knowledgeable people working on the project are about accessibility requirements, the more likely it is that the project will be able to adequately serve everyone, without barriers.

The efforts that the Universal Accessibility team at the Parliamentary Precinct are putting towards investigating and ensuring UA on Parliament Hill is a great indication of things to come. The passing of the Accessible Canada Act (ACA) was a milestone for everyone in the country as it recognizes that everyone should be able to fully participate in every aspect of their lives. The goal of the ACA, to achieve a barrier-free Canada by 2040, is ambitious and will require the effort of everyone involved in designing multiple services such as communications, transportations, and the built environment. If recommendations from the survey and curriculum analysis in the sections above are followed, civil engineers would be well equipped to participate in building accessible structures from the early design stages.

5.4.2. University of Ottawa buildings

The improvements in accessibility of the STEM building compared to the CBY building demonstrated the evolution of barrier-free and accessible requirements in building code and standards. While there could still be changes in STEM that would improve its accessibility, such as adding power-operated door openers at key locations on the 3rd floor, most of these changes were not structural and therefore could be rectified easily. However, for CBY to be considered an accessible building, it would require several structural changes to address the changes in level, the confusing layout, the inadequate size of washrooms, among many other changes. For an aging structure like CBY (50 years old), it is often more cost effective to demolish the structure and build a new one rather than trying to rehabilitate the current structure. Ensuring the accessibility of a structure like CBY is made even more important when looking at who uses the building. Being one of the principal buildings of the Faculty of Engineering, CBY is used by thousands of students, faculty, and staff every day. Furthermore, while STEM adheres to the barrier-free and accessible building requirements now, it does not mean that it will adhere to these ever-changing requirements in the future. This highlights the importance of designing with a Universal Design perspective, not only following code-minimum requirements. The structural changes required to make CBY accessible would be extremely difficult to implement; therefore, it is likely more viable for CBY to be demolished and replaced with a new structure following universal design guidelines.

The continued use of CBY on the University of Ottawa campus is also a significant barrier to people with disabilities that want to become civil engineers. The building is very difficult for a lot of people to navigate and, unfortunately, the people that face the most barriers are people that are direly needed in the civil engineering profession. Increasing the amount of people with disabilities that are civil engineers would foster a greater awareness towards barriers in the built environment since there are no better way to identify these barriers than to ask someone who experiences them every day. Barriers to civil engineering education such as old inaccessible buildings, crowded laboratories, and arduous mandatory field work must be removed through proactive and creative problem solving—hallmarks of the engineering profession—to accommodate the needs of potential students with disabilities. Only then will people with disabilities be able to become civil engineers, in turn diversifying the work force and bringing with them their expertise and valuable lived experience.

5.5. Summary

The goal of this chapter was to present findings from three accessibility audits that were conducted and to showcase the roles of civil engineers in the design of these buildings. The buildings assessed included the newly built Visitor Welcome Center (VWC) at the Parliament of Canada and two buildings from the Faculty of Engineering at the University of Ottawa (Colonel-by Hall (CBY) and the STEM building).

The audit of the VWC was part of the Universal Accessibility project at the Parliamentary Precinct which was made even more pressing by the passing of the Accessible Canada Act in 2019. The construction of the first phase of the VWC was completed in 2019. The purpose of the structure is to offer a space for visitors, members of parliament and guests to access some of the buildings on parliament hill (West Block, Center Block and East Block). Most of the building is underground and includes security scanning, halls, information desks and a gift shop. While several of the 704 non-compliant UA Design requirements of the VWC do not require structural changes to be rectified, some still do. Most of these structural changes involved washrooms which did not meet accessibility requirements for space such as the 05-V, 08-V and 09-V washrooms located along corridor 06-V. Since the building is underground and there is not much space to increase the size of the structure, some of these changes are not possible unless the layout of the structure is modified. This could impact the placement of structural elements such as columns. There are 30 such requirements which were compiled in Table A-5 in the Appendix.

The audit of the STEM and CBY building were completed for preliminary research to this thesis. While CBY is a relatively old building (50 years), STEM is a new construction on the University of Ottawa campus. This difference in age was reflected in the audit which showed significant accessibility barriers present in CBY while only a few were noticed in STEM. For example, CBY has level changes on some of the floors which presents a significant barrier to users that cannot use staircases. Furthermore, the two interior ramps on floor 0 of CBY are not compliant to the building code requirements. The barriers present in STEM can be rectified by non-structural changes such as adding power-operated door openers at some key doors on the 3rd floors and providing chairs and desk of various heights in workspaces, classrooms, and laboratories.

The three audits showed that great effort is being made to making new buildings accessible. It also showed that older buildings, like CBY, pose significant barriers in the built environment and civil engineers would need to be involved in removing these barriers. Furthermore, the accessibility improvements shown from CBY to STEM and the VWC are an indication of the importance of accessibility in the design of the two new buildings. A design requirement of such significance should be the responsibility of all design professionals involved in the project, as was indicated by the results of the survey shown in Chapter 3. Lastly, barriers to civil engineering education, such as CBY building, must be removed to allow people with disabilities to enter the civil engineering profession.

6. Conclusion and recommendations

The research conducted for this thesis looked to answer three questions:

- What is the responsibility of civil engineers towards accessibility in the built environment?
- What do current professional engineers think about the importance of accessibility, and what is their knowledge on universal design?
- How could the civil engineering curriculum be changed/reformed to fit education on accessibility, people with disabilities, universal design, and other social impacts of civil engineering?

To answer these questions, first, a literature review was conducted to assess the current research available about accessibility, universal design, and civil engineering. Then, a survey was distributed to professional civil engineers, architects, project managers, and construction professionals and asked them about their opinions surrounding the previously mentioned subjects. Following the survey, the curriculums of civil engineering programs at Canadian universities were analyzed to assess if students are being taught about universal design and other social impacts of civil engineering. The curriculum analysis was also a way to evaluate the most effective way to introduce the researched subjects into the current curriculums. Finally, the accessibility assessments of three buildings in Ottawa were analyzed and discussed. The buildings assessed included the Visitor’s Welcome Center on Parliament Hill and Colonel-By Hall and STEM buildings on the University of Ottawa campus. These assessments gave some insights on the involvement of civil engineers in design accessible buildings, on the progress of accessibility building codes and standards, and on the accessibility of civil engineering education.

6.1. What is the responsibility of civil engineers towards accessibility in the built environment?

According to the results of the survey, most building professionals believe that civil engineers are responsible to ensure that the built environment is accessible. It is important to note that participants indicated that several of the parties involved in the design of a project shared these responsibilities including the architects, owners, civil engineers, and project managers. This was also highlighted in the results of the accessibility assessments. While the newly built buildings, the Visitor's Welcome Center and STEM, show a lot of progress compared to CBY, the older building, all three demonstrate space for improvement. Changing the scope of a new building after the start of the construction process or needing to undergo rehabilitation once the project is complete are costly endeavors. One in five Canadians aged 15 and over live with one or more disabilities. These users represent 22% of the population and must be considered when designing elements of the built environment. Civil engineers not only design buildings but also roads, trails, sidewalks, and transportation systems. This infrastructure is often used by the public and, without appropriate consideration for accessibility and universal design, can be hostile environments for many.

The research shows that civil engineers share the responsibility for building an accessible built environment. Due to this responsibility, civil engineers must be held accountable for designing accessible projects, alongside other stakeholders and members of the design team. Cooperation with all building designers would ensure a better chance of noticing barriers from the early design stages.

6.2. What do current professional engineers think about the importance of accessibility, and what is their knowledge on universal design?

Of the 31 civil engineering undergraduate programs investigated during the curriculum analysis, not one was found to offer a course that explicitly discusses accessibility and universal design to their students. This finding, which shows that civil engineering students are not receiving a formal education about these subjects, supports the following results from the survey:

- While participants claim to consider issues related to accessibility during their work (82%) most respondents were at best “somewhat familiar” with the accessibility standards in Canada (83%).
- When asked if they believed that code requirements related to accessibility were always adequate to address all accessibility barriers, 1 in 5 participants answered, “I don’t know”.
- When asked if they believed that there are barriers for people with disabilities who want to become civil engineers, 35% of participants answered “unsure”.

These results demonstrate that there is room for improving the knowledge and awareness of civil engineers towards accessibility in the built environment and accessible design. Furthermore, there is a need to incorporate formal universal design education in the civil engineering curriculum. This is made more pressing by the 2019 passing of the Accessible Canada Act (ACA) which aims for a barrier-free Canada by 2040 and a reinforcement of accessibility requirements in Canada’s building codes and standards.

Additional findings from the survey also indicated that professional civil engineers and other building design professionals believe that current civil engineering students should learn about accessibility and universal design during their university education (87% of participants) and that most of them have a desire to learn about these subjects personally as well (62%).

6.3. How could the civil engineering curriculum be changed/reformed to fit education on accessibility, people with disabilities, universal design, and other social impacts of civil engineering?

The organization of civil engineering programs of Canadian universities, and their curriculum, is heavily influenced by the accreditation requirements of the Canadian Engineering Accreditation Board (CEAB) enforced by Engineers Canada. In their documentation specifying accreditation requirements and essential graduate attributes, CEAB does not mention the necessity for teaching civil engineering students about accessibility and universal design. However, there is a requirement to teach students about “The impact of technology and/or engineering on society”, a subject into which accessibility and universal could fall into. The curriculum analysis found that this mandatory subject is given much less attention than other subjects. On average, universities offered about 0.75 courses discussing “The impact of technology and/or engineering on society”.

To ensure that, as per findings from the survey, civil engineering students learn about accessibility and universal design during their undergraduate education, it is recommended that CEAB and Engineers Canada specify these subjects in their accreditation requirements. One way to do this is to require all Canadian universities offering an accredited civil engineering undergraduate program to have a dedicated “social impacts of civil engineering” course which would discuss several subjects, including the responsibilities of civil engineers towards achieving a universally accessible built environment. A pilot course should be introduced to a civil engineering program to measure its success and gather feedback before implementing it in other programs. Based on the findings from the literature review, the course should encourage open discussion and be interactive so that students will be able to visualize how their future work as civil engineers impacts society. They should learn from people with lived experience in navigating barriers in the built environment. Among topics discussed, it is recommended that the course discuss accessibility and universal design and other topics such as gentrification, environmental racism, and inequities in transportation.

Lastly, to improve the diversity of the civil engineering profession it is essential that university programs are themselves accessible to people with disabilities who want to become civil engineers. There are currently very few people with disabilities that work in the field of civil engineering. This was shown in the survey, as only 2% of participants identified as a person with a disability (compared to the 22% national average). People with disabilities are the most valuable source of information when it comes to identifying barriers in the built environment. Buildings like CBY, whose accessibility assessment concluded that it was not accessible for people with disabilities, present a barrier to civil engineering education for many students.

6.4. Recommendations for future work

The many results presented in this research thesis, discussed above, show a dire need to ensure that civil engineering students learn about accessibility, universal design, and people with disabilities. Civil engineers do have responsibility to ensure that there are no barriers in the built environment. In return, engineering entities in Canada like the CEAB, Engineers Canada and engineering faculties of Canadian universities hold a responsibility to ensure that graduated civil engineering students are aware of who they are designing for, and why it is important to make the built environment accessible for everyone. This will only be possible when these same organizations take accountability for ensuring that their built and systemics environments do not pose barriers for people with disabilities who want to become civil engineers.

To advance this research in the future, several other topics should be investigated. First, it would be useful to assess what is the best way to teach civil engineering students about accessibility and UD to make sure that they can both empathize with people with lived experience while also applying their knowledge on these subjects objectively in their work. To increase Equity, Diversity, and Inclusion (EDI) in the civil engineering profession, it would also be advantageous to assess the physical, attitudinal, and systemic barriers that people with disabilities face in the civil engineering education and profession and to formulate a strategy to dismantle them. Finally, the curriculum analysis of this research found that civil engineering programs do not discuss other social impacts of civil engineering, not only accessibility and UD. There should be further research to identify which other subjects civil engineering students should learn about, to make them more aware of who they are designing for and of how society will interact with their projects.

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Appendix

The following Table A-1 presents a summary of the results of the survey.

Table A-1 – Summary of survey results

Question #	Question Statement	Results						
Question 1	As a member of the design profession, how often do you consider issues related to accessibility during your work (for completing a design, etc.)?	Options	Always	Usually	Sometimes	Rarely	Never	
		Answers (#/222)	68	64	50	28	11	
		Percentage (%)	30.77%	28.96%	22.62%	12.67%	4.98%	
Question 2	What is your current familiarity with accessibility standards in Canada (Accessible Canada Act, Accessible Design for the Built Environment CSAB651-18, etc.)?	Options	Extremely familiar	Very familiar	Somewhat familiar	Not so familiar	Not at all familiar	
		Answers (#/222)	9	31	86	66	30	
		Percentage (%)	4.05%	13.96%	38.74%	29.73%	13.51%	
Question 3	Do you think that code requirements related to accessibility are always adequate to address all accessibility barriers?	Options	Always	Usually	Sometimes	Rarely	Never	I don't know
		Answers (#/222)	7	61	84	20	3	47
		Percentage (%)	3.15%	27.48%	37.84%	9.01%	1.35%	21.17%
Question 4	In your opinion, who is responsible to ensure that a structure is accessible to all its users?	Options	Architect	Engineer	Owner	Contractor	Inspector	
		Answers (#/222)	194	149	168	94	108	
		Percentage (%)	87.39%	67.12%	75.68%	42.34%	48.65%	

Question 5	Do you think there are barriers for people with disabilities who want to become civil engineers?	Options	Yes	No	Unsure		
		Answers (#/222)	97	48	77		
		Percentage (%)	43.69%	21.62%	34.68%		
Question 6	In 2019, the Accessible Canada Act passed into law. The act aims to create an accessible and barrier-free Canada by 2040. This includes transportation and the design of public spaces. Do you think that, during their university education in civil engineering, students should learn about the new requirements and efforts put into place to achieve this goal?	Options	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
		Answers (#/222)	127	67	17	8	3
		Percentage (%)	57.21%	30.18%	7.66%	3.60%	1.35%
Question 7	How interested would you be to learn more about accessibility issues related to the design of structures?	Options	Very interested	Interested	Somewhat interested	Not so interested	Not at all interested
		Answers (#/222)	52	86	64	18	2
		Percentage (%)	23.42%	38.74%	28.83%	8.11%	0.90%

Table A-2 below presents comments that were added to survey responses discussing barriers present for people with disabilities who want to become civil engineers.

Table A-2 – Survey comments, examples of barriers

Physical accessibility barriers on the construction site
"It's a tough one to say yes as it is quite dependant on the type of disability but I'd say even as a designer let alone a builder the individual needs access to active construction sites to expand their engineering abilities and there are physical constraints there, however I strongly believe that we need place higher value on people with disabilities getting involved in reviewing design and addressing their concerns, the people with the disabilities have the most experience with building functionality in relation to their disabilities and it only makes sense to include them in the design process and not only rely on existing codes and standards (which may have been found on the experience of other disabled people, but does not always get context specific). Also, there should be a community where disabled people explore occupied buildings that followed these existing codes and provide their feedback for constant improvement of these codes."
"In my case and in the case of others that I know, entry level civil engineering jobs tend to have many duties requiring to be in-field or onsite. In my experience construction sites are rarely barrier free so anyone with a physical disability such as mobility, vision, or hearing impairment would be at a severe disadvantage."
"Construction is a key part of what we do as civil engineers both as designers and constructors. It is difficult to make the opportunity to directly witness construction available to everyone. "
"Site reviews are an important part of the construction process for Engineers. Not only are they necessary to ensure the construction is being carried out as per the design, but also for the professional development of the Engineer. Physically seeing your design being built and dealing with the site conditions is a valuable experience. Being on site regularly, I see challenges for people with disabilities. While the building being constructed may be accessible, the construction site most often is not. There is much work to be done in this field to make construction sites more accessible."
"In order to become a good engineer a field experience is the best way."

Attitudinal barriers
"There are many barriers, women, people of colour, indigenous people all face barriers as do all people with a disability. This is a very white male dominated field."
"It is a very competitive industry and perceived weakness may put an individual at a disadvantage compared to others."
“There is heavy discrimination within engineering. Showing any kind of disability may be seen as a ‘weakness’ and will potentially lead to poor treatment of that person. Several years ago, at my previous company, I was inspecting bridges and culverts. When I would go to inspect a culvert, I would (for the most part) have pretty severe anxiety/panic attacks while in the culvert. These inspections also took place while there was rushing water through the culvert. I went to my managers to let them know that I couldn’t inspect the culverts from inside anymore and that I was having panic attacks, blacking out and didn’t feel it was safe for myself or my colleagues (as they could potentially try to rescue me during one of these attacks). My concerns were ignored. As a result, I went to my family doctor (who has dealt with my anxiety for years) and she wrote me a note to take to HR letting HR know that the culvert inspections were not okay for my mental health and could potentially lead to something worse. As a result, the company removed me from the structural group entirely and stuck me in a different division. They did not try and work with me to determine my needs, instead they stuck me in linear infrastructure when they knew structural/bridges were my passion. This was just a tiny example regarding anxiety. Now imagine the discrimination of people with physical disabilities. I was also in a car accident and needed a sit down/stand up desk to help mitigate the pain of sitting or standing for long periods of time. It took the company 5 months to provide one. They also were not okay with me buying my own to bring to the office. We’re taught disability awareness and are required to refresh our disability awareness yearly, but I feel the understanding of the barrier-free access is not there. And companies aren’t ready to put the money into making their offices a barrier-free environment.”

Barriers at the office
"My current office is on the second floor. Though there is an elevator, it is frequently out of service. My previous office (previous employer) was on the second floor also and had no elevator. Just one but very blatant example of a barrier."
"Smaller offices, which are frequently found in architecture and engineering, may also have difficulty accommodating disabled new employees, particularly if significant financial costs are required."
"I suspect that there are barriers in the working world that I have the privilege of not noticing, and this is why there have been no people with known accessibility challenges in my career to date."

Table A-3 below presents comments that were provided by survey participants at the end of the survey as additional feedback.

Table A-3 – Survey comments, additional feedback

"I appreciate the survey. I'd like to reiterate that it's not binary: accommodate or don't, in the design process there are 100 variables and priorities, so ensuring it is a fundamental, like safety and environmental protection, will help raise awareness, and providing templates and proven tools will help adoption."
"On construction sites some disabilities are more problematics, but I have seen innovative adaptation over the years. Still some challenges in the perception of the capacities of persons with disabilities in the engineering profession and maybe more in civil. Although, as engineers, we have probably the best training to overcome those barriers."
"Need representation from several disabilities in the form of group or community that can be consulted on design of new buildings and review of existing buildings."
"Maybe look into developing a simplified manual for accessibility design. I find current standards, especially when multiple standards are applicable, sometimes lengthy and even slightly contradictory."
"Increasing the accessibility of and therefore the diversity in engineering will hopefully lead to the development of designs and infrastructure which better serve a diverse public with range of needs and abilities."
"As a structural engineer I'm aware of accessibility standards and requirements but have very little (or no) influence in implementing them in design. Other 'sub-disciplines' of civil engineering such as infrastructure and transportation engineering may have more influence, however I think the onus is primarily on the architect in early planning to implement accessibility requirements and best practice. A sophisticated client/owner is also needed that is willing to pay for additional costs that may be required to implement accessibility features that are beyond minimum requirements in codes or standards. Policy changes reflected in codes and standards to address any short comings in current accessibility requirements would ensure best practices are met."

"People with disabilities cannot do all things. For safety sensitive jobs, certain requirements need to be for cognitive, physical, and senses. In workplaces that are dangerous and accidents and fatalities are possible risk of accidents must be reduced and if that means restricting access to people based on their capabilities that is acceptable."
"Disabilities are rarely taken into account. It's not considered as a part of any business model and they are quite conveniently ignored in society."
"There are few civil engineering careers in the industry that require direct use of accessibility standards, and when required is often learned on the job. Including accessibility in post-secondary civil engineering education curriculums would detract from teaching information that is more relevant to a wider range of civil engineering careers. In my opinion, accessibility design standards are something that should be reserved for Architecture curriculums that specialize in building, landscape, and urban design."
"Civil Engineers are the Engineers who will develop structures of the built environment for years to come. The ability to incorporate accessibility through design in the early stages can make our infrastructure beautiful, while not looking like it was an afterthought. Teaching students to be aware of the current regulatory requirements in design (OBC and AODA) shall be a minimum, however expanding students' knowledge to respect the fact that OBC and AODA are minimum regulatory compliance, and so much more can be done to improve the experience through design, while incorporating best practices such as CSA standards and other documents will ultimately be the foundation of an inclusive environment."
"I see projects that are carried out just for upgrading accessibility of a building, due to code requirements changing or simply was not designed properly. If more awareness and resources are put into it from the get-go in the design process, perhaps it would even save money for the owners? While also being inclusive to the disabled and people in need."

"Based on my experience as a civil engineer in training, I believe codes and standards related to accessibility should be updated more frequently and be applied accordingly. The Accessible Canada Act in July 2019 is a great achievement but there is still a lot work to be done to create a barrier free Canada."
"The construction industry in Canada today has a large number of capital projects, with players from all over the world competing for their shot at taking on the work. I'm mainly pulling from my experience in large infrastructure projects (LRT's and Transportation). I think there needs to be more of an effort from governing bodies with regards to designated sources for materials. Companies competing for these projects often come from different parts of the globe that may not share the same characteristics in their infrastructure that we as Canadians are used to and are often more considerate of the bottom line. I think we can do a better job at developing a better product if we are all working towards a better standard set from the beginning."
"Public awareness is key."

Table A-4 below presents the complete analysis of “Complementary Studies” courses in Canadian civil engineering curriculums.

Table A-4 – In-depth civil engineering curriculum analysis

Institution		Complementary Studies Subject: a) Subject matter that deals with the humanities and social sciences	b) Oral and written communications	c) Professionalism, ethics, equity and law	d) The impact of technology and/or engineering on society	e) Health and safety	f) Sustainable development and environmental stewardship	g) Engineering economics and project management	Total AU (minimum 225)
University of Alberta: **https://calendar.ualberta.ca/preview_program.php?catoid=34&poid=38727**	**Courses (codes, names)**	"Complementary Studies Elective"	ENGL199 - English for Engineering Students **AND** Introduction to Engineering Design, Communication and Profession	ENGG420 - Engineering Law **AND** ENGG400 - The Practice of the Engineering Profession	"Impact of Technology on Society (ITS) Elective"	ENGG404 - Engineering Safety and Risk Management	Adressed in "ENGG100 - Success in Engineering"	CIVE303 - Project Management **AND** (ENGM310 - Engineering Economy **OR** ENGM401 - Financial Management for Engineers)	324
	Total AU	36	54	72	36	36	18	72	
University of British Columbia: **http://www.calendar.ubc.ca/vancouver/index.cfm?tree=12,195,272,37**	**Courses (codes, names)**	"Humanities Elective 1 and 2"	ENGL112 - Strategies for University Writing **AND** CIVL - Technical Communication in Civil Engineering	CIVL402 - Professionalism and Law in Civil Engineering	CIVL302 - Civil Engineering Impacts	Adressed in "CIVL302 - Civil Engineering Impacts"	Adressed in "CIVL302 - Civil Engineering Impacts"	CIVL403 - Engineering Economic Analysis **AND** CIVL300 - Construction Engineering and Management **AND** Capstone Design Project	324
	Total AU	72	72	36	12	12	12	108	
University of British Columbia - Okanagan: **https://engineering.ok.ubc.ca/programs-admissions/civil/**	**Courses (codes, names)**	"Humanities/Social Sciences Elective"	APSC176 - Engineerin communication **AND** APSC201 - Technical Communication	ENGR413 - Law and Ethics for Engineers	APSC169 - Fundementals of Sustainable Engineering Design	Adressed in APSC169 - Fundamentals of Sustainable Design	Adressed in APSC169 - Fundamentals of Sustainable Design	ENGR303 - Engineering Project Management **AND** ENGR305 - Engineering Economic Analysis **AND** Capstone Design Project	315
	Total AU	36	72	36	12	12	12	135	
British Columbia Institute of Technology: **https://www.bcit.ca/programs/civil-engineering-bachelor-of-engineering-full-time-8660beng/#courses**	**Courses (codes, names)**	LIBS7025 - Thinking in Humanities & Social Sciences	COMM1142 - Communication for Civil Engineering 1 **AND** COMM2242 - Communication for Civil Engineering 2 **AND** COMM3342 - Communication for Civil Engineering 3 **AND** COMM4442 - Communication for Civil Engineering 4	CIVL7030 - Civil Engineering Contracts and Law	CIVL1011 - Introduction to Civil Engineering **AND** CIVL7001 - Engineering and Society	Adressed in CIVL7001 - Engineering and Society and CIVL3011 - Issues in Engineering	CIVL3011 - Issues in Engineering	CIVL30333 - Construction Management 1 **AND** CIVL4033 - Construction Management 2 **AND** OPMT7031 - Engineering Economics **AND** Capstone Design Project	468
	Total AU	36	144	36	54	36	18	144	

Institution		Complementary Studies Subject							
		a) Subject matter that deals with the humanities and social sciences	b) Oral and written communications	c) Professionalism, ethics, equity and law	d) The impact of technology and/or engineering on society	e) Health and safety	f) Sustainable development and environmental stewardship	g) Engineering economics and project management	Total AU (minimum 225)
University of Calgary: https://www.ucalgary.ca/pubs/calendar/current/en-4-4.html	Courses (codes, names)	"General Complementary Studies Course"	Engineering 213 - Engineering Communication	Engineering 513 - The Role and Responsibility of the Professional Engineer in Society	Engineering 481 - Technology and Society	Adressed in Engineering 513	Adressed in Engineering 513 and Engineering 481	Engineering 209 - Engineering Economics **AND** Civil Engineering 471 - Project Management I **AND** Civil Engineering 570 - Civil Engineering Design Project	252
	Total AU	36	36	12	18	12	30	108	
Carleton University: https://calendar.carleton.ca/undergrad/undergradprograms/engineering/#Civil_Engineering__Bachelor_of_Engineering	Courses (codes, names)	2 x "Complementary Studies Elective"	CCDP2100 - Communication Skills for Engineering Students	ECOR1057 - Engineering Profession	ECO4995 - Professional Practice	Adressed in ECOR1057 - Engineering Profession	Adressed in ECOR4995 - Professional Practice	ECOR3800 - Engineering Economics **AND** CIVE4400 - Construction/Project Management **AND** Capstone Design Project	288
	Total AU	72	36	18	18	18	18	108	
Concordia University: https://www.concordia.ca/academics/undergraduate/civil-engineering.html	Courses (codes, names)	"General Education Elective"	ENCS282 - Technical Writing and Communications	ENGR201 - Professional Practice and Responsibility	ENGR392 - Impact of Technology on Society	Adressed in ENGR202 and ENGR201	ENGR202 - Sustainable Development and Environmental Stewardship	CIVI390 - Civil Engineering Design Project **AND** BCEE451 - Construction Engineering **AND** ENGR301 - Engineering Management Principles and Economics	288
	Total AU	36	36	18	36	36	18	108	
Dalhousie University: https://www.dal.ca/faculty/engineering/civil-resource/current-students/undergraduate-students/program-curriculums.html	Courses (codes, names)	?	CPST1103 - Technical Communications I **AND** CPST1203 - Technical Communcations II	CIVL3840.02 - Professional Practice in Civil Engineering	HSTC1801 - History of Eng. II **AND** CPST3030.03 - Engineering in Society II	?	?	IENG2005 - Engineering Economics **AND** CIVL4711.02 - Construction Planning **AND** CIVL4702.02 - Senior Project I	288
	Total AU	0	72	36	72	0	0	108	
Lakehead University: http://csdc.lakeheadu.ca/Catalog/ViewCatalog.aspx?pageid=viewcatalog&catalogid=27&chapterid=7989&topicgroupid=26238&loaduseredits=True	Courses (codes, names)	2 x "Complementary studies elective"	English 1015 - Introduction to Academic Writing	Engineering 4539 - Professional Practice and Law	Sociology 2755 - Technology, Society and Indigenous Peoples in Canada	?	?	Civil Engineering 2135 - Construction Practice **AND** Engineering 3336 - Engineering Economics and Project Management **AND** Capstone Design Project	252
	Total AU	72	36	36	36	0	0	72	

Institution		Complementary Studies Subject: a) Subject matter that deals with the humanities and social sciences	b) Oral and written communications	c) Professionalism, ethics, equity and law	d) The impact of technology and/or engineering on society	e) Health and safety	f) Sustainable development and environmental stewardship	g) Engineering economics and project management	Total AU (minimum 225)
University of Manitoba: **https://umanitoba.ca/faculties/engineering/departments/civil/curr_students/undergrad/programreqtimetable.html**	**Courses (codes, names)**	"Complementary Elective I **AND** II"	"Written English Requirement" **AND** (ENG2030 - Eng Communication **OR** ENGG2040 - Eng Communication)	?	ENG3020 - Tech Soc	?	?	ENG3000 - Eng Economics **AND** CIVL4950 - Design Project	252
	Total AU	72	72		36	0	0	72	
McGill University: **https://www.mcgill.ca/civil/files/civil/non-cegep_entry_curriculum_2021-2022_-_civil_engineering.pdf**	**Courses (codes, names)**	2 x "Complementary Studies Group B"	CCOM206 - Communication in Engineering	FACC250 - Responsibilities of the Professional Engineer **AND** FACC400 - Engineering Professional Practice	"Complementary Studies Group A"	Adressed in "complementary studies"	Adressed in "complementary studies"	FACC300 - Engineering Economy **AND** CIVE324 - Sustainable Project Management **AND** CIVE418 - Design Project	324
	Total AU	72	36	72	12	12	12	108	
McMaster University: **https://academiccalendars.romcmaster.ca/preview_program.php?catoid=41&poid=21892**	**Courses (codes, names)**	2 x "Approved complementary studies electives"	CIVENG2103 - Communications in Civil Engineering	ENGINEER 4A03 - Ethics, Equity and Law in Engineering	?	?	?	CIVENG3RR3 - Engineering Economics and Project Management **AND** CIVENG4X06 - Design and Synthesis Project in Civil Engineering	216
	Total AU	72	36	36	0	0	0	72	
Memorial University of Newfoundland: **https://www.mun.ca/regoff/calendar/sectionNo=ENGI-0409**	**Courses (codes, names)**	"Approved elective course"	English 1090 **OR** English 1020	CIV8830 - Contract Law and Labour Relations	"3 credit hour course on the effect of technology on society and the environment"	ENGI3101 - Engineering Professionalism I	ENGI8152 - Engineering Professionalism II	ENGI4102 - Engineering Economics **AND** CIV6810 - Construction Planning Equipment and Methods **AND** Capstone Design Project	324
	Total AU	36	36	36	36	36	36	108	
University of New Brunswick: **https://www.unb.ca/fredericton/engineering/_assets/documents/civil-8termpattern.pdf**	**Courses (codes, names)**	2 x "Complementary Studies Elective"	ENGG1003 - Technical Communication for Engineers	ENGG4013 - Law & Ethics for Engineers	HIST3925 - Technology & Society **OR** Approved Equivalent course	?	?	ECO1073 - Economics for Engineers **AND** CE3603 - Construction Eng. I **AND** CE4993 - Senior Team Design Project	288
	Total AU	72	36	36	36	0	0	108	

Institution		Complementary Studies Subject							
		a) Subject matter that deals with the humanities and social sciences	b) Oral and written communications	c) Professionalism, ethics, equity and law	d) The impact of technology and/or engineering on society	e) Health and safety	f) Sustainable development and environmental stewardship	g) Engineering economics and project management	Total AU (minimum 225)
University of Ottawa: **https://engineering.uottawa.ca/undergraduate-programs/courses/civil-2020**	**Courses (codes, names)**	"Complementary Elective"	ENG1112 - Technical Report Writing	GNG4170 - Engineering Law	HIS2129 - Technology, Society and Environment since 1800 **OR** PHI2394 - Scientific Thought and Social Values	Adressed in GNG4170 and CVG4175	CVG4175 - Field Investigations and Environmental Impacts Assessments	(ECO1192 - Engineering Economics **OR** GNG2101 - Introduction to Product Developement and Management for Engineers and Computer Scientists) **AND** CVG4001 - Introduction to Civil Engineering Project	270
	Total AU	36	36	36	36	36	18	72	
Queen's University: **https://calendar.engineering.queensu.ca/preview_program.php?catoid=7&poid=406**	**Courses (codes, names)**	2 x "Complementary Studies - Humanities & Social Sciences"	APSC293 - Engineering Communications	CIVL200 - Professional Skills I **AND** CIVL300 - Professional Skills 2 **AND** CIVL400 - Professional Skills 3	Adressed in CIVL200, CIVL300 and CIVL400	Adressed in CIVL200, CIVL300 and CIVL400	Adressed in CIVL200, CIVL300 and CIVL400	APSC221 - Economics and Business Practices in Engineering **AND** "Management Elective" **AND** CIVL460 - Civil Engineering Design and Practice IV	324
	Total AU	72	36	27	27	27	27	108	
Royal Military University: **https://www.rmc-cmr.ca/en/registrars-office/undergraduate-civil-engineering-programme**	**Courses (codes, names)**	PSE103 - Introduction to Human Psychology **AND** HIE207 - History of Canada **AND** HIE203 - Introduction to Canadian Military History **AND** PSE301 - Organizational Behaviour and Leadership **AND** HIE271 - Introduction to Military History and Thought	ENE100 - Introduction to Literary Studies and University Writing Skills	GEE291 - Introduction to Engineering Professional Development **AND** PSE401 - Military Professionalism and Ethics	HIE289 - The Impact of Science and Technology on Society and the Environment	Adressed in GEE291 and PSE401	Adressed in GEE291	CEE418 - Management of Design and Construction of Structures **AND** GEE293 - Managing Engineering Projects **AND** CEE493 - Civil Engineering Project	438
	Total AU	180	36	36	36	30	12	108	
Ryerson University: **https://www.ryerson.ca/programs/undergraduate/civil-engineering/**	**Courses (codes, names)**	3 x "Liberal Studies"	CEN199 - Writing Skills **AND** CMN432 - Communication in the Engineering Professions	CEN100 - Introduction to Engineering **AND** CEN800 - Law and Ethics in Engineering Practice	Adressed in CEN100	Adressed in CEN100	CVL300 - Environmental Science and Impact Assessment	ECN801 - Principles of Engineering Economics **AND** CVL742 - Project Management **AND** Capstone Design Project	396
	Total AU	108	72	48	12	12	36	108	

Institution		Complementary Studies Subject							
		a) Subject matter that deals with the humanities and social sciences	b) Oral and written communications	c) Professionalism, ethics, equity and law	d) The impact of technology and/or engineering on society	e) Health and safety	f) Sustainable development and environmental stewardship	g) Engineering economics and project management	Total AU (minimum 225)
University of Saskatchewan: **https://programs.usask.ca/engineering/civil-engineering/index.php**	**Courses (codes, names)**	"Humanities or Social Science Elective"	GE132.1 - Engineering Communications I **AND** RCM200.3 - Engineering Professional Communication	?	Adressed in GE102.2 - Introduction to Engineering I **AND** GE449.3 - Engineering in Society	?	?	CE495.6 - Capstone Design Project **AND** CE320.3 - Project Engineering	234
	Total AU	36	72	0	54	0	0	72	
University of Toronto: **https://civmin.utoronto.ca/home/programs/courses/**	**Courses (codes, names)**	3 x "Complementary Studies Elective"	CIV282 - Engineering Communications I **AND** CIV382 - Civil Engineering Communication Portfolio	?	APS301 - Technology in Society and the Biosphere I	?	?	CIV280 n- Manageent of Construction **AND** CME368 - Engineering Economics and Decision Making **AND** CIV498 - Capstone Design Project	324
	Total AU	108	72	0	36	0	0	108	
University of Victoria: **https://www.uvic.ca/engineering/civil/undergrad-students/home/courses/index.php**	**Courses (codes, names)**	2 x "Complementary Studies Elective"	ENGR110 - Design and Communication I **AND** ENGR120 - Design and Communication II	ENGR130 - Introduction to Professional Practice **AND** ENGR498 - Engineering Law	?	?	CIVE210 - Sustainability in Civil Engineering **AND** CIBE315 - Environmental Policy	CIVE370 - Construction and Project Management **AND** CIVE400 - Capstone Design Project	360
	Total AU	72	72	72	0	0	72	72	
Waterloo University: **https://uwaterloo.ca/future-students/programs/civil-engineering**	**Courses (codes, names)**	2 x "Approved complementary studies electives"	ENGL191 - Communication in the Engineering Profession	CIVE491 - Engineering Law and Ethics	"Impact Complementary Elective"	?	CIVE230 - Engineering and Sustainable Development	CIVE392 - Economics and Life Cycle Cost Analysis **AND** CIVE332 - Civil Systems and Project Management **AND** CIVE400 - Civil Engineering Design Project I	324
	Total AU	72	36	36	36	0	36	108	
University of Western Ontario: **https://www.eng.uwo.ca/undergraduate/programs/civil.html**	**Courses (codes, names)**	3 x "Non-technical elective"	Writing 2130F/G - Building Better (Communication) Bridges: Rhetoric & Professional Communication for Engineers	Civil and Environmental Engineering 4478A/B - Case Studies in Civil Engineering **AND** Engineering Science 4498F/G - Engineering Ethics, Sustainable Development and the Law	?	Adressed in Civil and Environmental Engineering 4487A/B	Adressed in Engineering Science 4498F/G	Business Administration 1299E - Business for Engineers **AND** Civil and Environmental Engineering 3348A/B - Project Management & Engineering Classes **AND** Civil and Environmental Engineering 4441 - Civil Engineering Design Project	324
	Total AU	108	36	36	0	18	18	108	

Institution		Complementary Studies Subject							
		a) Subject matter that deals with the humanities and social sciences	b) Oral and written communications	c) Professionalism, ethics, equity and law	d) The impact of technology and/or engineering on society	e) Health and safety	f) Sustainable development and environmental stewardship	g) Engineering economics and project management	Total AU (minimum 225)
Windsor University: **http://web4.uwindsor.ca/units/registrar/calendars/undergraduate/winter2020.nsf/982f0e5f06b5c9a285256d6e006cff78/12267bdaaaa7476f852573620060c901!OpenDocument**	**Courses (codes, names)**	2 x "Course from outside Engineering"	85-119 - Technical Communications	85-118 - Engineering and the Profession **AND** 85-421 - Engineering and Society	Adressed in 85-118 **AND** 85-421	Adressed in 85-118 **AND** 85-421	Adressed in 85-118 **AND** 85-250 - Engineering and the Environment	85-313 - Engineering Economy **AND** 87-400 - Capstone Design **AND** 87-482 - Plan and Construction Management	306
	Total AU	72	36	21	21	21	27	108	
York University: **https://civil.lassonde.yorku.ca/undergrad-courses/**	**Courses (codes, names)**	3 x "Complementary Studies Elective"	ENG1101 - Renaissance Engineer 1 - Ethics, Communications and Problem Solving **AND** ENG2003 - Effective Engineering Communication	Adressed in ENG1101	?	Adressed in ENG2001	CIVL4210 - Civil Engineering for a Sustainable Future	ENG2001 - Engineering Projects: Management, Economics & Safety **AND** CIVL4000 - Capstone Design Project **AND** CIVL4110 - Project Engineering and Management	288
	Total AU	72	54	18	0	18	36	90	
Université Laval: **https://www.ulaval.ca/etudes/programmes/baccalaureat-en-genie-civil#section-structure**	**Courses (codes, names)**	2 x "Cours à option"	"Un cours de langue"	PHI-3900 - Éthique et Professionalisme	PHI-2910 - Génie et développement durable	GMn-2902 - Santé et sécurité pour ingénieur III	GCI-3001 - Impacts environmentaux	GMC-3009 - Gestion de projets en ingénierie **ET** ECN-2901 - Analyse économique en ingénierie **ET** GCI3333 - Project de génie civil	360
	Total AU	72	36	36	36	36	36	108	
Université de Moncton: **https://www.umoncton.ca/institutionnel/modules/repertoire/pdf/90.pdf**	**Courses (codes, names)**	3 x "Cours au choix"	FRAN1500 - Communication orale **ET** FRAN1600 - Communication écrite	GCIV5010 - Lois et déontologie	GCIV1011 - Initiation au travail en ing. **ET** SOCI3320 - Technologies et sociétés	Adressed in GCIV1011	Adressed in GCIV1011 **ET** GCIV3011 - Développement durable et ing.	GCIV5975 - Gestion des projets en ing. **ET** ADM4291 - Systèmes administratifs **ET** GCIV5904 - Projet de génie civil **ET** GELE - Économie en ingénierie	468
	Total AU	108	72	36	48	12	48	144	
École polytechnique de Montréal: **https://www.polymtl.ca/futur/civil**	**Courses (codes, names)**	?	CIV3100 - Communication écrite et orale	SSH3501 - Éthique appliquée à l'ingénierie	?	CIV1000 - Gestion des études, intégrité et sécurité	CIV3220 - Impacts environnementaux et developpement durable	SSH3201 - Économique de l'ingénieur **ET** CIV8180 - Gestion de projets de construction **ET** CIV8970 - Projet de conception en civil	252
	Total AU	0	36	36	0	36	36	108	
Université du Québec à Chicoutimi: **https://programmes.uqac.ca/7480/officiel**	**Courses (codes, names)**	"Cours d'enrichissement"	?	6GIN275 - Ingénierie et éthique	6GIN308 - Impact des projets d'ingénierie	6GIN250 - Santé, sécurité et ingénierie	?	6GIN440 - Projet en ingénierie **ET** 6GIN630 - Économie du génie	216
	Total AU	36	0	36	36	36	0	72	

Institution		Complementary Studies Subject							
		a) Subject matter that deals with the humanities and social sciences	b) Oral and written communications	c) Professionalism, ethics, equity and law	d) The impact of technology and/or engineering on society	e) Health and safety	f) Sustainable development and environmental stewardship	g) Engineering economics and project management	Total AU (minimum 225)
Université du Québec à Chicoutimi: https://programmes.uqac.ca/7480/officiel	Courses (codes, names)	"Cours d'enrichissement"	?	6GIN275 - Ingénierie et éthique	6GIN308 - Impact des projets d'ingénierie	6GIN250 - Santé, sécurité et ingénierie	?	6GIN440 - Projet en ingénierie **ET** 6GIN630 - Économie du génie	216
	Total AU	36	0	36	36	36	0	72	
Université Sherbrooke: https://www.usherbrooke.ca/admission/programme/213/baccalaureat-en-genie-civil#structure/	Courses (codes, names)	?	GCI606 - Communication et pratique professionelle	GIN521 - Droit et ingénierie	?	Adressed in GCI609 - Initiation à la pratique professionnelle **ET** GCI615 - Santé et sécurité en génie civil	GCI525 - Infrastructures durables et impacts sur l'environnement	GCI600 - Processus de conception en genie civil **ET** GCI610 - Planification et contrôle des projets **ET** GCI900 - Projet de conception en génie civil **ET** GIN600 - Analyse économique en ingénierie	306
	Total AU	0	36	36	0	54	36	144	
Sum		1872	1512	990	792	546	612	3069	
Average per university		62.4	50.4	33	26.4	18.2	20.4	102.3	
		a) Subject matter that deals with the humanities and social sciences	b) Oral and written communications	c) Professionalism, ethics, equity and law	d) The impact of technology and/or engineering on society	e) Health and safety	f) Sustainable development and environmental stewardship	g) Engineering economics and project management	

Table A-5 below presents the elements of the Visitor's Welcome Center that require structural change to become accessible.

Table A-5 – Structural changes required at the Visitor's Welcome Center

#	Universal Accessibility Requirements	Location	Recommendations	CSA Ref.
1	Shade and weather protection are provided at entrances.	Main entrance	There is no shade or weather protection, which is unfortunate, as when it is busy, people have to wait outside.	
2	Clear and level maneuvering space (depth x width with space beside latch) is provided for latch-side approach to hinged doors is: • Pull side: 1400 x 1600 mm with 700 mm beside latch. • Push side: 1400 x 1525 mm with 700 mm beside latch.	Washrooms 0118, 0119	The access area to the men's washroom and into the women's washroom are both very small, especially for such busy areas.	5.2.2.
3	Clear and level maneuvering space (depth x width with space beside latch) is provided for hinge-side approach to hinged doors is: • Pull side: 2400 x 2400 mm with 700 mm beside latch. • Push side: 1400 x 1830 mm with 700 mm beside latch.	Washroom 120	The access area to unisex accessible washroom is very small, especially for such a busy areas. This is particularly true of the unisex accessible washroom as the women's washroom door opens into the same space as people waiting to enter the unisex washroom.	5.2.2.
4	The clear width of primary paths of travel is at least 2440 mm.	Corridor 0107 to washrooms 0118, 0119, 0120	The clear route for two way traffic is only 1710 mm.	5.1.1.
5	The clear width of primary paths of travel is at least 2440 mm.	Corridor 06-V	The washroom corridor is 1570 mm clear width.	5.1.1.
6	Secondary corridors have a minimum width of **1525 mm** with passing places at least 2000 mm long and with an unobstructed width of at least **1800 mm** at regular intervals no more than 30 m apart.	Coat room	The entry to the coat room has a clear width of 965 mm.	5.1.1.e.
7	Secondary corridors have a minimum width of **1525 mm** with passing places at least 2000 mm long and with an unobstructed width of at least **1800 mm** at regular intervals no more than 30 m apart.	Outer glass - post screening queuing area 119-V	There is a clear width of 1115 mm, this is narrow, but there is only one way, staggered pedestrian flow.	5.1.1.e.
8	Secondary corridors have a minimum width of **1525 mm** with passing places at least 2000 mm long and with an unobstructed width of at least **1800 mm** at regular intervals no more than 30 m apart.	Inside glass - inside screening area 114-V to 116-V	There is a clear width of 1070 mm, this is narrow, but there is only one way, staggered pedestrian flow.	5.1.1.e.
9	Secondary corridors have a minimum width of **1525 mm** with passing places at least 2000 mm long and with an unobstructed width of at least **1800 mm** at regular intervals no more than 30 m apart.	08-V women's washroom - interior route	The interior route of the women's washroom has a clear route of 1395 mm between the face of the stall and the wall. This is a very busy space, as it is the first washroom that people are able to encounter after having stood in line at security screening, so 2 way traffic will be heavy at surge and peak times.	5.1.1.e.
10	Where persons who use wheeled mobility devices need to turn 360°, a clear ground/floor area at least 2440 mm diameter is provided.	Entry to washroom 0120	The washroom lacks a clear turning space of 2440 mm for people going down the corridor and having to turn into the small vestibule and then into the unisex washroom.	
11	Where accessible routes less than 2000 mm wide terminates at a dead end, a turn space of 2440 x 2440 mm is provided at the dead end.	Corridor 0107 to washrooms 0118, 0119, 0120	The corridor narrows as it reaches the end, and is not 2440x 2440 and is not 2000 mm wide - it is difficult for people to make the turn into the women's washroom or unisex washroom and for some people it is impossible to turn around in the space provided.	

#	Universal Accessibility Requirements	Location	Recommendations	CSA Ref.
12	Where there is a half landing or a 180 ° turn, there is never less than 1500 mm width in order to facilitate carrying a person on a stretcher.	Typical exit stairs	The mid level landings are smaller than 1500 mm.	
13	Separate facilities for baby changing, care and feeding; and enlarged unisex washroom(s) incorporating an adult changing table, are provided.	NA	There are no separate facilities for baby changing, care and feeding provided.	
14	Washrooms have a minimum turning diameter space of 1800 mm.	Washroom 08-V	There is only a clear route of 1395 mm from the face of the stalls to the counter.	
15	Washrooms have a minimum turning diameter space of 1800 mm.	Washroom 0119 and 0120		
16	Washroom interior routes have a clear width of 1830 mm	Washroom 08-V	There is only a clear route of 1395 mm from the face of the stalls to the wall opposite.	
17	Washroom interior routes have a clear width of 1830 mm.	Washroom 0118	There is a very narrow area to get past the urinal partition to get to the accessible stall, that is less than 1830 and is only approx. 1000 mm.	
18	Have a minimum 1700 mm clearance between the inside face of an in-swinging entrance door and the outside face of an adjacent washroom stall.	Washroom 08-V	There is only a clear route of 1395 mm from the face of the stalls to the wall opposite.	
19	There is a clear space to approach the stall is provided with a minimum clearance of 1700 mm between the outside face of the accessible stall and any wall-mounted fixture or obstruction.	Washroom 08-V	There is only a clear route of 1395 mm from the face of the stalls to the wall opposite, and the stall door hits the visual strobe alarm.	6.2.7.2.g.
20	There is a clear space to approach the stall is provided with a minimum clearance of 1700 mm between the outside face of the accessible stall and any wall-mounted fixture or obstruction.	Washroom 09-V	When you open the stall door outwards there is a paper towel dispenser at the leading edge of the door, and there is approx. 1200 mm before hitting the wall from the leading edge of the open stall door.	6.2.7.2.g.
21	Accessible stalls have internal dimensions at least 1830 x 1830 mm.	Wahsroom 08-V	Current dimensions of 1715 mm wide x 1485 mm deep.	6.2.7.1.a.
22	Accessible stalls have internal dimensions at least 1830 x 1830 mm.	Washroom 09-V	Current dimensions of 1580 mm wide x 1485 mm deep.	6.2.7.1.a.
23	Accessible stalls have internal dimensions at least 1830 x 1830 mm.	Washroom 0118	Current dimensions of 2445 mm wide x 1460 mm deep.	6.2.7.1.a.
24	Accessible stalls have internal dimensions at least 1830 x 1830 mm.	Washroom 0119	Current dimensions of 2290 mm wide x 1495 mm deep.	6.2.7.1.a.
25	The stall incorporates a clear floor space to allow a person using a wheeled mobility device to make a 180-degree turn of min. 1500 mm in diameter inside the stall.	Washrooms 08-V, 09-V, 0118, 0119	The stalls are not 1500 mm deep, so cannot be deep enough for a turning circle of 1500 mm.	
26	In addition to any accessible public or common use washrooms, at least one universal washroom is provided in all public buildings.	Washrooms 05-V, 120	They are unisex accessible, but not universal (e.g. there is no change table or space for one, and it cannot accommodate a carer).	

#	Universal Accessibility Requirements	Location	Recommendations	CSA Ref.
27	Universal washrooms are located in a way as to not compromise the privacy of the users.	Washrooms 05-V, 120	They are both very near other washrooms and people can see in while the door is opening or closing.	
28	Where required exits from a floor level are not accessible, areas of rescue assistance are provided on the floor level in a number equal to that of the required exits.	NA	There are evacuation chairs, but no designated areas of refuge.	
29	Areas of refuge are smoke protected.	NA		5.7.2.1.e.
30	Areas of refuge are served directly by an exit or by a firefighters' elevator.	NA		5.7.2.1.f.