POLYTECHNIQUE MONTRÉAL

affiliée à l'Université de Montréal

Factors Impacting Schedule in Fast-Track, Design-Bid-Build Projects: The Case of Public Colleges

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Mémoire

présenté en vue de l'obtention du diplôme de *Maîtrise ès sciences appliquées*

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Ce mémoire intitulé:

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présenté par

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en vue de l'obtention du diplôme de *Maîtrise ès sciences appliquées*

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DEDICATION

I dedicate my work to my mother, who had sacrificed many months and years supporting me throughout all my academic endeavours. I want her to know how much I appreciate all her care and dedication. My daughter, Maya Elizabeth for being a very patient baby and let me finish this study. My beautiful partner, Danny for always being there for me through good, bad and ugly motivating me to be better, achieving heights I never thought I will. I also want to dedicate this work to my father, who encouraged me to finish and set a great example that everything is possible when he obtained his Ph.D at the age of 68.

Finally, I want to dedicate this achievement to my dog Altai. 10 years of unconditional love. You are deeply missed.

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I want to acknowledge the support of my colleagues from the public college network. I could not have done this without their support and willingness to participate in this study.

RÉSUMÉ

Les approches permettant d'accélérer le déroulement de projets sont de plus en plus en vogue dans le secteur de la construction, tout comme elles le sont depuis longtemps dans les domaines manufacturier et industriel. Dans le contexte particulier des projets de construction réalisés au sein du réseau québécois des collèges publics, le mode accéléré (*fast tracking*) présente un grand intérêt puisqu'il peut répondre à la nécessité de livrer dans des délais relativement courts. En effet, la période estivale constituant une fenêtre temporelle critique pour de tels projets, l'application du mode accéléré pourrait profiter à ce milieu. Cependant, le manque de connaissances, d'outils et de pratiques adaptées à ce mode peut augmenter les risques associés à la livraison finale d'un projet.

Cette étude s'intéresse aux projets réalisés dans les collègues publics québécois (Cégeps) dans le contexte particulier du mode de réalisation dit traditionnel (*DBB - Design Bid Build*). Par définition, ce mode implique l'exécution du projet en trois phases successives et séquentielles, de sorte que le chevauchement tel que proposé par le mode accéléré n'y est pas particulièrement adapté. Or, la réalité est tout autre puisqu'une grande partie des projets de type DBB réalisés dans les collègues publics ont recours au mode accéléré, ce qui n'est pas sans créer des difficultés.

Cette recherche vise à étudier les facteurs qui entraîneront le retard de l'échéancier de référence versus l'échéancier réel des projets réalisés dans le contexte décrit précédemment. Elle repose sur l'étude qualitative de dix-sept projets par le biais d'une enquête exploratoire auprès d'intervenants du milieu. Cette enquête identifie d'abord les deux principaux motifs pour le recours au mode accéléré : les limitations de temps imposées par le calendrier académique et les dates limites fixées par les autorités gouvernementales. Par ailleurs, certains facteurs ont été relevés comme pouvant générer des écarts entre l'échéancier prévue et réalisé : les omissions dans la conception, la définition inadéquate de la portée, l'équipement et la disponibilité des ressources, la pénurie de main-d'œuvre et le nombre de consultants impliqués dans le projet. Finalement, un ensemble de stratégies est proposé en réponse à ces facteurs pour permettre d'améliorer les pratiques utilisées par les professionnels du milieu.

ABSTRACT

The schedule compression techniques are becoming increasingly popular in the construction industry, just as they have been for a long time in the manufacturing and industrial sectors. More specifically in the Quebec public college network, where time plays a critical role, the fast-tracking approach can facilitate projects' delivery and shorten project duration. However, a lack of tools and proper guidance for the fast-track technique used in construction can increase risks, negatively impacting overall project delivery.

This thesis particularly focuses on projects carried out in Quebec public colleges (Cégeps) using the traditional delivery system (DBB - Design Bid Build). By definition, this mode involves the execution of the project in three successive and sequential phases, therefore, the phase overlap used in fast-tracking should make this mode relatively unsuitable. However, the reality is quite different since the DBB delivery system is predominantly used in public colleges, together with a fast-track technique.

This research aims to study factors that will cause potential schedule delay, carried out within the context described above. This paper is based on 17 case studies of relevant projects and exploratory interviews of project practitioners from the public college network. In this research it was found that two main reasons for opting for fast-tracking are time limitations imposed by academic calendar and grant deadlines established by the governmental authorities. The main factors that affect the schedule variation were found to be omissions in design, inadequate scope definition, equipment, and resource availability, labour shortage and the number of design consultants. A set of strategies is suggested to reduce these factors' impact and assist project professionals in executing fast-tracking techniques in future projects.

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LIST OF SYMBOLS AND ABBREVIATIONS

CM	Construction Management
CCQ	Quebec Construction Commission (Commission de la construction du Québec)
DBB	Design-Bid-Build
DB	Design-Build
GC	General Contractor
OIQ	Professional Engineers of Quebec (Ordre des ingénieurs du Québec)
P3	Public Private Partnership
PM	Project Manager
PMBOK	Project Management Body of Knowledge
PWGSC	Public Works and Government Services Canada
RAIC	Royal Architectural Institute of Canada
SEAO	Système électronique d'appel d'offres (Electronic tendering system)
SQI	Société Québécoise des infrastructures (Quebec Infrastructure Society)

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CHAPTER 1 INTRODUCTION

In 1967 the National Assembly of Quebec established a new educational system to increase the average level of education in the province of Quebec. The reform was approved following the Parent Commission's report dated in 1964, criticizing the expensive and challenging access to higher education and the low level of knowledge of Quebecers, in particular those living in remote areas. From 1967 to 1969, across the province, 48 public colleges were founded. Federation of CEGEPS published that currently, there are over 175 000 students on the regular program and 26 000 students admitted to Continuous educational programs. There are over 26 000 administrative and teaching staff members.

Construction of the new campuses peaked in the 1970s and early1980s. Now, with 962 buildings with an area of 2.66 million square meters, public colleges occupy an important position in Quebec's construction industry and economy. There is a constant need for investment in maintaining existing facilities up to present standards and codes and growing demand in college-level studies due to the rise in the demography of the region and the popularity of Quebec colleges internationally. Based on the statistical data on January 1, 2019, the population in Quebec was 8 429 241 compared to 6 882 602 in 1989. The population growth rate in 2018 was at 10.4 per thousand, a rate similar to that of 2017, which was 10.3 per thousand (Quebec, 2019)(Quebec Institute of Statistics 2019). In 2009, there were less than 25 000 registered international students in Quebec, and over the past ten years, this number increased by 70%. It all means an increase in the number of construction projects, which depend on competent planning, scheduling, monitoring and controlling in order to successfully complete the project on time and within the allocated budget.

Thus far, there is a limited amount of information available on public construction delays. However, several studies of Flyvbjerg examined mega public construction projects and the impact of various factors on time and cost. These projects are of a much broader scope and complexity, but they illustrate the overall picture. (Buede & Miller, 2016); Flyvbjerg, Bruzelius, and Rothengatter (2003) Flyvbjerg (2002, 2003) recognized that time and cost increases in public construction demonstrated a global problem. Things do not seem to have improved in the past 70 years, and today the average cost overrun is 28%.

The performance and successful delivery of colleges' projects reflect the college administration's efficiency and ability to achieve the strategic goals set by the government of Quebec and Ministère de l'Éducation et de l'Enseignement supérieur (Ministry of Education and Higher Education) in terms of new construction and renovations. In 2019, the government of Quebec allocated over $185 million for the maintenance and operation of the 48 colleges' buildings. As compared to 2017, the government of Quebec budgeted $139 million to manage the assets. This positive change in recent years compared to the previous years' budget provisions means that colleges need to complete a large number of projects for the same limited period of time.

Project practitioners are increasingly resorting to the fast-tracking technique for projects, expecting that overlapping design, bid, and construction activities can shorten project completion compared with the traditional delivery method. Although fast-tracking has indeed been identified as a practical approach to reduce project duration, up to 70% according to certain studies of Williams (1995) and Delaney (2016), its use remains a significant decision for project professionals giving the lack of developed practices to manage, monitor and control such projects. Researchers Garrido Martins, Valentin, and Bogus (2017) came across an identical issue in their work identifying the same as mentioned above, areas of the method that are yet to be explored. Overlapping phases or activities without proper tools and knowledge can lead to construction delays, cost overruns and can reveal coordination problems between clients, design professionals and contractors.

The use of fast-tracking must be revealed in the broader context of delivery methods that determine the way responsibilities and risks are shared amongst project stakeholders. Delivery methods describe the processes that include all the procedures, actions, contractual relations and obligations to complete the phases of the project. There are several delivery methods that can be used in public construction, including Construction Management, Design-Build and Design-Bid-Build. In a typical Design-Bid-Build delivery system, the client hires design professionals to elaborate on the design. Consequently, the contractor is nominated through a tendering process (bid) after the design is completed. The construction phase (build) follows the tendering process. In such a system, the main three phases are technically separate and executed in sequence. According to authors such as Fisher (1990), Cho et al. (2010), and Moazzami, Dehghan et al. (2011), the Design-Bid-Build delivery system is a challenging arrangement for fast-tracking projects as it increases the risk of

coordination problems and that the proper channel of communication is not respected; resulting in project information being diffused in a non-uniform manner.

This thesis paper will examine several DBB fast-tracking projects, while emphasizing the fact that such projects require a high level of communication and coordination. For the purposes of this paper, projects were analyzed with the goal of identifying factors which cause schedule delays, while providing practical strategies and recommendations for project professionals on how to manage these types of projects.

1.1. Context of the Research

There are three types of college-level educational institutions in Quebec: public colleges; private colleges, which are divided into subsidized and under licence; and government operated colleges, which are not part of the public or private system. Colleges with narrow specialization like military college or conservatory are part of the government operated colleges. This research is focused on the public colleges, as their system, regulations and academic calendar differ from those of private and government-operated colleges. There are 48 public-funded colleges located in the province. All colleges have their rules and by-laws and are operated by individually structured administrative departments. Each college has facilities and procurement departments, and each college develops its own project management practices. However, there are standard procedures for procurement and laws regulating public bodies which applies to all the colleges. Considering all the constraints in the context of public colleges such as rigid academic calendars, as well as allocated budgets and regulations imposed by government bodies, project practitioners seek out techniques that can help them successfully deliver projects. Project practitioners using the DBB delivery model frequently apply schedule compression techniques like fast-tracking in order to shorten project duration. There are no legal obligations and requirements to use DBB as a default model. However, Société Québécoise des infrastructures (Quebec Infrastructure Society) and Public Works and Government Services Canada favoured the DBB as a standard delivery method for construction projects (SQI, 2018).

1.2 Issue Statement

As mentioned earlier, the state of college facilities demands significant investments for renovations and reconstruction, which means the number of construction projects should increase going forward. The construction industry in general often finds it challenging to complete projects within the shortest possible time frame. In the context of public colleges, time often is one of the main constraints; due to the requirements of the academic calendar, which impose a constraint of not interrupting academic activities. During the summer break, the execution is generally possible from the end of May up until mid-August. During the winter break, the projects can be executed in December and January in order to respect the condition outlined above. A schedule compression technique can be helpful in dealing with time-related constraints. Project practitioners from colleges most often tend to use an overlapping technique to shorten project duration in order to meet deadlines. On the other hand, construction and project management professionals are often not fully aware of all the implications of the fast-tracking method, since conventional tools and guidelines are not tailored to this method (Dey, 2000). Without proper tools, fast-tracking can mean the original project objectives are not achieved (Alhomadi, Dehghan, & Ruwanpura, 2011).

Nonetheless, several research pieces have shown that the fast-tracking technique considerably decreases project time when used in conjunction with the Design-Build delivery model. The Design-Build delivery system refers to a model where a single entity does the project's design and executes construction work. A detailed description of this delivery model is presented in section 3.2.3. Pena-Mora and Park (2001) suggested that fast-tracking in the DB model can decrease project delivery and save up to 30% of the project time. Meanwhile, Perkins (2009) and Alnuaimi, Taha, Al Mohsin, and Al-Harthi (2009) compared the DB and DBB delivery models. Statistically, a higher number of DB construction projects are executed within the initial schedule deadlines compared to DBB construction projects. According to the authors the number of changes due to design errors and reworks in Design-Build construction is lower than for Design-Bid-Build construction mode. As previously mentioned, the lack of appropriate data prevents researchers from being able to crystallize the fast-tracking effect on the DBB delivery mode. It remains a plausible hypothesis that the DBB method and the fast-tracking are not suitable for each other, that may result in poor resource management, budget and time overruns. In such a case, practitioners

might be interested in finding out which factors contribute to the incompatibility if the DBB is used in combination with fast-tracking. Is it possible to achieve the positive results and successfully deliver the project, while respecting the allocated budget and delivery schedules? Additionally, project professionals should address another question of whether it was intended during project initiation the use of the fast-tracking and, should that not be the case, at which point in the project, the decision was made to use the fast-track approach.

Answering these questions will contribute to the subject of fast-tracking and DBB delivery and will contribute to the advancement of the project management practices within the public colleges network.

1.3 Objectives

The objective of this research is to identify factors which have significant impacts on schedule variation when project phases are overlapped, during the Design-Bid-Build delivery system accounting for using a fast-tracking technique conducted at public colleges in the province of Quebec. More specifically, this study has the following sub-objectives:

SO1. Determine and categorize the context in which construction projects at public colleges are executed.

SO2. Identify the conditions under which the schedule compression technique is selected and implemented.

SO3. Identify and classify factors which have either negative or positive impacts on project schedules.

SO4. Recommend and develop strategies that can help project professionals mitigate negative impacts and maximize opportunities for positive impacts in relation to project schedules.

This research focuses on practical solutions; as it aims to help project professionals manage future DBB fast-track projects. Consequently, the intention of this work is to suggest practices which can be applied and tailored to the particular needs of Quebec public colleges.

CHAPTER 2 METHODOLOGY

In this chapter, the researcher will explain the approach used to search for, collect, and analyze the study's data, as well as the tools, and techniques that will help achieve the final results.

This research's objective and sub-objectives will be attained through literature review, interviews with project professionals from the college network, and a multiple case study. Exploratory interviews will provide the answer to SO1. A variety of perspectives obtained during exploratory interviews, and the multiple case study will provide answers to SO2. Identification and classification of the factors will be obtained by means of the interviews, multiple case analysis, and literature review, there by providing an answer to SO3. In chapter 4, the factors causing delays will be organized into 5 groups: external factors, design factors, client- and contractor- related factors and, miscellaneous. In his work, Fazio (1988) grouped factors that caused delays into two categories: delays that were directly caused by fast-tracking and those that have an indirect impact. Ahmed et al. (2003) classified the causes of delays as external and internal.

A detailed review of the existing literature and interviewees' suggestions will support the formation of a versatile understanding of the issue at hand and hence and a solution to SO4. Furthermore, it will aid in the development of practical recommendations which will help project professionals mitigate negative impacts and maximize the opportunities for positive impacts on the project schedule.

The methodology was categorized into the following three phases.

Literature Review

Literature search was conducted and relevant research papers were identified through Compendex, Web of Science, ProQuest and Google Scholar databases. The analysis of existing data helped group three main areas of the research. Therefore, the review of existing papers was carried out for fast-track projects, schedule delays in public construction projects, and the Design-Bid-Build delivery method.

Using the concept plan and research strategy as guidelines, existing articles and topics were sorted and non-relevant papers were eliminated from the pipeline. The following concepts and key words were used for research purposes in the research database of Compendex:

("fast track" OR "fast tracking" OR fast track* OR project*) AND ("design bid build" OR design* bid* OR "DBB") AND (factor* OR impac* OR schedul* OR "schedule variance") AND (construct* OR "public construction" OR "public constructions")

The outcome of this research strategy contained 605 records in the database, with articles dating from 1984 to 2020. Intentionally, the search results were set up to present the research papers starting as early as 1984, given the fact that since late 1980's techniques such as concurrent engineering and fast-tracking became a subject of promotion by researchers.

Upon browsing through the abstracts of 605 records, 56 articles were selected for more detailed analysis. They represent the works of the researches that partially or fully cover the topic of this study. A summary of these works will be discussed in detail in the next chapter.

The literature review will serve as a preparatory first step in identifying context implying execution of construction projects in public colleges. As well during articles analysis the existing strategies used to mitigate negative impacts on project schedule or maximize opportunities for positive impacts will be identified and further in discussion chapter theses strategies will be compared and grouped to represent some practical recommendations to project professionals.

Exploratory Interview

Exploratory field data collection was chosen as the second step of the research process, aiming to identify the factors that impact schedule in public construction projects. After analyzing the existing papers which intersect with the topic of the study and thoroughly describing the parameters that will help answer the research question, pertinent items of interest were compiled into a questionnaire. A questionnaire was developed to assess the perception of the project practitioners of various job levels.

A request was made to the Research Ethics Board of Polytechnique with a detailed description of the procedure of the recruitment process, along with the consent form and an example of the

questionnaire. After the ethic certificate CER-1920-27 was granted, the researcher's professional contacts were used to recruit 10 project practitioners from the public college community in the Montreal region. From the qualitative standpoint of the research, the objective was to understand various dimensions of the issue at hand. To begin with, 10 samples appeared satisfactory, given the study's objective and calendar constraints. Nonetheless, it also turned out at the end of the interview process that the sample of 10 people can be considered sufficient as a satisfactory level of data saturation was observed.

The questionnaire was divided into two parts. The first part of the questionnaire was related to general questions about the respondents, and the background information about the college. The second part of the questionnaire focused on causes and factors that will impact the schedule, as well practitioners' comments on their strategies and recommendations on how to mitigate negative impacts, while maximizing positive impacts of such factors and strategies on schedule variances.

To preserve the anonymity and convenience of the analysis, each participant was assigned a number from 1 to 10. The example of the questionnaire is enclosed in Appendix A.

Exploratory interview will shed light on all identified sub-objectives of this research work. The literature review findings will be combined with the information gathered from the project professionals to get a comprehensive answer to SO1. Specific conditions of project execution in public colleges together with the reasoning why there is a need to switch to fast-tracking technique and the factors causing schedule delay will be gathered and categorized answering to SO2 and SO3. In the second part of the questionnaire project practitioners will provide their suggestions of strategies which will serve as an answer to SO4.

Multiple Case Study

An exploratory case study was used to explore situations where the phenomenon had no clear or single set of outcomes (Yin, 2003). The research methodology employed a multiple case study to characterize and analyze information regarding the project schedule and support the data collected from exploratory interviews with project practitioners from public colleges. In a multiple case study, the main objective was to examine several cases to understand the similarities and differences between the cases and the factors causing the existence of the studied phenomenon.

The information was extracted from project documents made available by means of public request form “Access to the information”. An example of the filled form with the requested data is enclosed in Appendix B. The case studies covered seventeen construction projects from various public colleges of the Greater Montreal region.

All of the selected projects had the same input data, that was established during the submission of the access to the information form. Projects were only analyzed if they were executed between 2015 and 2019, and the original allocated budget was between 400 000$ and 2 000 000$, with the total planned duration between 6 months to 12 months. The following information was requested for the study:

1. Public tender package, with all the published Addenda, indicating the published dates.
2. Gantt Chart of preliminary project schedule before the start of construction
3. Gantt Chart of the final actual project schedule
4. Information about the results of the open tender
5. All change orders
6. Information and documents about preliminary design and final design.

Upon receipt of the data packages, the projects were verified to ensure that all of the requested information was available. For anonymity reasons and the accuracy of the research, the alphabet letter from A to Q will be assigned to each project.

Although, the basis of the responses to sub-objectives will be collected and combined during the literature review and an exploratory interview, the multiple case findings will enrich the answers with the results of the analysis.

CHAPTER 3 LITERATURE REVIEW

The scientific and professional literature relevant to the topic of the research will be reviewed in this chapter.

Literature review represents the backbone of this study. Taking into account the research question formulated in chapter 1, it proposes an overview of the main contributions related to the use of the fast-tracking technique, delivery methods, and public construction. The following search concept was used to gather the existing articles from the involved combination of fields: ("fast track" OR "fast tracking" OR fast track* OR project*) AND ("design bid build" OR design* bid* OR "DBB") AND (factor* OR impac* OR schedul* OR "schedule variance") AND (construct* OR "public construction" OR "public constructions").

The literature review supports the need for empirical research, as it shows that very few studies are currently available to answer the research question.

As depicted in Figure 3.1, the research focus of this study is located at the intersection of three topics. The data was extracted and analyzed, shaping a new area of research and a new category of its own. The literature reviewed can be classified into three main groups: fast-track projects, schedule delays in construction projects in the public sector, and project delivery methods. Due to the limited availability of information that addresses the factors causing schedule delays, it is important to review the three topics individually and identify potential factors, that can impact the project schedule and cause delays.

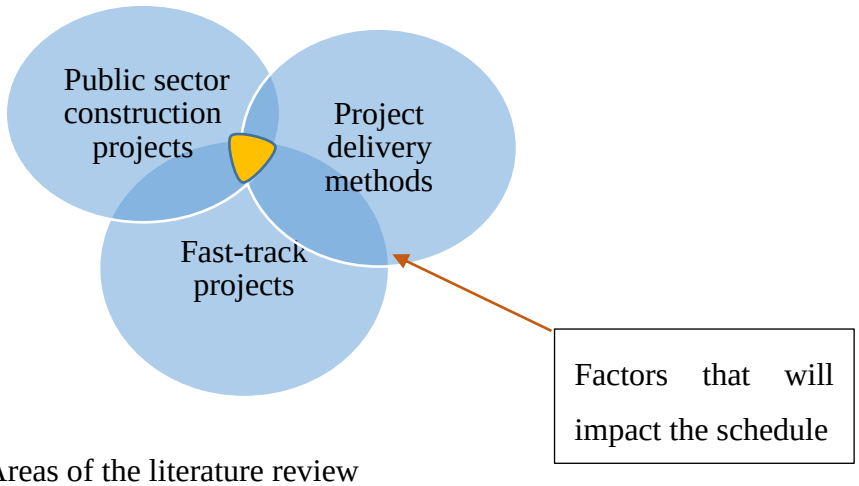

Figure 3.1 Areas of the literature review

3.1 Fast-tracking technique

There are several definitions of the fast-tracking technique, the summary of which is presented in Table 3.1. Ballesteros-Pérez (2017) identified fast-tracking as a technique which overrides the original order of upstream and downstream activities, while Sears, Clough, and Sears (2008) define it as overlapping of phases, commonly: design and construction. The notion of schedule compression technique is present in several industries related to product management, manufacturing, and industrial engineering.

Table 3.1 The definition of fast-tracking

Source	Definition
PMI(2017)	A schedule compression technique in which activities or phases normally done in sequence are performed in parallel for at least a portion of their duration.
Delaney (2016)	Fast tracking is often the most effective way to shorten the duration of a project, by allowing activities originally scheduled in sequence, such as design and construction, to overlap. And because time is money, fast tracking can result in significant cost savings as well.
Ottosson (2016)	Fast-tracking: looking for some activities that can be parallel instead of consecutive.
Ballesteros-Pérez (2017)	Fast-tracking a project involves carrying out sequential activities in parallel, partially overriding their original order of precedence, to reduce the overall project duration.
Sears et al. (2008)	‘‘Fast tracking’’ refers to the overlapping accomplishment of project design and construction. As the design of progressive phases of the work is finalized, these work packages are put under contract, a process also commonly referred to as phased construction. Early phases of the project are under construction while later stages are still on the drawing boards.

Reading through all of the definitions of the fast-tracking technique presented above, common points can be observed in the characterization of the technique and its main contribution to the project delivery. To summarize, the common definition of the fast-tracking technique comprises the intention to compress the project schedule by executing activities or phases in parallel, in contrast to sequential logic. Why is there a need for schedule compression techniques such as fast-tracking? There is no exact answer to this question, as different industries strive to achieve their own defined goals, missions, and objectives. Although due to the fact that Project Managers often face multiple time and budget constraints, they are forced to find ways to successfully deliver their projects in a more efficient manner.

One of the first mentions and investigations of the fast-tracking in construction started in 1983 when a study of the fast-track nuclear power plant construction was done by researchers Baker and Boyd (1983). They stated that significant cost savings were achieved as a result of the implementation of the fast-tracking technique. Nonetheless, Baker and Boyd (1983) found the processes should be well synchronized with the rigid management control and the implementation of innovative administrative procedures to achieve the time and cost savings. Williams made a substantial contribution to the fast-tracking technique development. Williams (1995) based on the example of the construction of the industrial facilities, formed a general framework of the fast-tracking technique, providing pros and cons of this method, describing strengths and weaknesses, obstacles and opportunities that a Project Manager and the project team can potentially face. Up until today, detailed processes and procedures are yet to be developed and various issues occurring during the project execution phase are to be investigated. Recent studies have been carried out undertaking an effort to unveil best practices of fast-track projects. Pena-Mora and Park (2001) designed a dynamic planning methodology, intended to improve the overall management and planning of fast-tracking construction projects, by providing strategies to overlap activities. Moazzami, Dehghan, and Ruwanpura (2011) contributed to the topic by developing a contractual framework, specific to fast-track projects. They provided an understanding of possible contractual risks while designing strategies to mitigate them. Garrido Martins et al. (2017) developed a conceptual model, using a simulation to assess risks during the fast-track construction project execution. In their work, researchers identified risks in developing various scenarios, thereby tracking the probability of attaining the planned fast-track project duration. Although for over 30

years, the technique of fast-tracking application was a topic of multiple pieces of research, there are various understudied areas, one of them being the application of fast-tracking with several project delivery models.

It is worth mentioning that in product management, manufacturing, and industrial engineering domains, different terminology is used to describe the schedule compression technique, such as concurrent engineering, parallel engineering, phased construction, and fast-tracking. However, these concepts are not interchangeable and often mistakenly considered to be the same. Concurrent engineering concepts found widespread use in product development when all design activities are integrated and executed in a parallel manner (Hambali, Sapuan, Ismail, Nukman, & Karim, 2009). In phased construction, a project is divided by either work category or by phases. The concept of fast-tracking uses the overlapping within each individual package. The concept of fast-tracking is widely used in construction and this study specifically targets the development of the fast-tracking concept.

3.2 Project delivery methods

The term "project delivery" is used to describe the process, which includes all of the procedures, actions, contractual relations, and obligations to complete the design and construction. The role of design and construction professionals' changes with each delivery method, as well as the procurement protocol and the role of the client. Although this research study concentrates on DBB project delivery, it will be beneficial to overview the differences, advantages, and disadvantages of other delivery models, which can also be used in public construction. In section 1.2 it was mentioned that several researchers determined that the schedule compression technique works well in the DB delivery model. It will be relevant to review the project delivery in detail and observe which factors may affect the positive outcome in the application of fast-tracking.

The following types of construction project delivery are used in public colleges:

- Design -Bid- Build;
- Design-Build;
- Construction Management.

3.2.1 Design-Bid-Build

A prominent feature of the Design-Bid-Build method is the level of the client, design professionals, and contractor's involvement. This method comprises three distinct phases. The client separately hires design professionals to develop the concept and detail design. In the next phase, the client nominates a contractor, through tendering process. In the last phase of this delivery method, a contractor completes the project following the prepared plans, while the design professionals monitor and review the execution.

Nevertheless, the client supervises and organizes the coordination between all parties involved. Parties are allowed to subcontract part of the work; however, they remain contractually responsible for it. Park and Kwak (2017) found that the DBB model is most-widely used within fixed-price contracts in public transportation projects. In the context of public colleges, this point is addressed in section 3.3.2. It is important to mention that this method is predominantly used in public colleges in Quebec. Figure 3.2 presents the Design-Bid-Build relations.

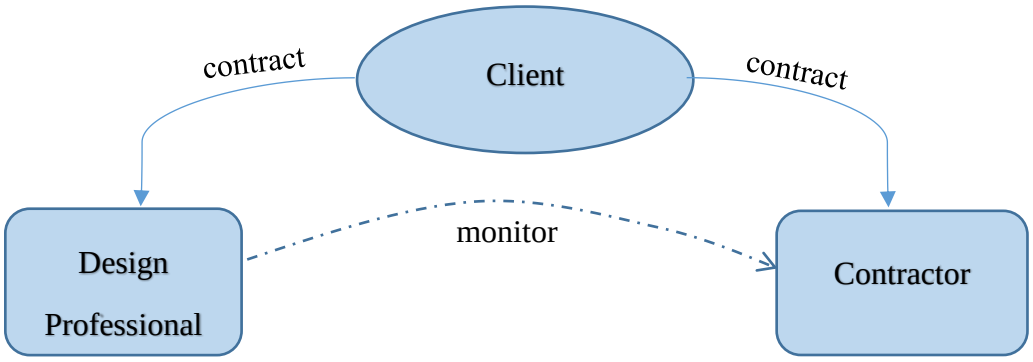

Figure 3.2 The Design-Bid-Build relations diagram

3.2.1.1 Advantages

One of the main characteristics and advantages of this approach is the client's direct control over project design and construction. Depending on the client's experience and the decision to be fully involved in the project's processes, design professionals can be engaged in the administration of

the execution of the work by the contractor to a greater extent. Despite that, the final decisions over the design, materials, documentation, and approval of the work remain under the control of the client.

Assigned roles are clear and transparent. Procedures and established management mechanisms exist to support the successful performance of this delivery method.

3.2.1.2 Disadvantages

A disadvantage of this approach is not receiving any input from the contractor during the design phase. Bajari, McMillan, and Tadelis (2009) analyzed the public procurement processes in DBB construction, and they identified that initial design in DBB projects is subject to change in almost all cases. Another disadvantage described by Perkins (2009) is that once the client, design professionals, and the contractor are bonded with a stringent contractual agreement, it blocks flexible communication and leads to inefficiency in dealing with unforeseen circumstances.

This method refers to the completion of each phase before the commencement of the next. The researchers like Fisher Jr (1990), Cho, Hyun, Koo, and Hong (2010) and Moazzami, Dehghan et al. (2011) concluded that the fast-tracking approach generally found its application in the Design-Build and the Construction Management delivery methods, which are described further. Coordination risks associated with the fast-tracking and the Design-Bid-Build delivery method can possibly impact the overall project execution.

Considering that the contractor is unknown during the elaboration of the design and construction documentation, it is hard to predict the total anticipated cost at the onset of the project. Most of the DBB projects use fixed-price contracts, which can negatively affect the project's total cost, since given many unknowns, the potential contractor will likely include a higher percentage of contingencies for them. Increased risk of cost overruns for public colleges translates into a need to compress project delivery and deal with a possible shortage of resources like qualified labour, materials, and equipment.

3.2.2 Construction Management

Construction management is a term covering a variety of project delivery scenarios, although it comprises two commonly used approaches: CM-as-Agent and CM-at-Risk. The Construction Manager and design professionals are employed at the same time. The CM will oversee the project budget and schedule from the early stages of the project. CM is commonly hired on large and complex public construction projects rather than small ones due to the associated consultant fees. However, if the client believes that internal resources are insufficient to supervise the project accordingly, a CM is hired to represent the client and assist in making decisions during the design and construction processes. Often a Construction Manager is an architect or an engineer hired independently from the design professionals. The CM-as-Agent model does not include design or construction services. However, it involves direction, monitoring and controlling over defined design and construction activities (Sears et al., 2008).

Touran et al. (2009) explain that the CM-as-Agent is an independent advisor, responsible for monitoring and controlling project execution, as well as contracts and payments on behalf of the client. CM-at-Risk is a combination between the Design-Bid-Build and the Construction Management project structures, as the CM takes responsibilities of the contractor together with construction management duties. Under this approach, the CM assumes the risk of cost overruns, performance deficiencies and schedule delays. The distinguishing point between the two structures is that the CM-as-Agent does not perform any construction work.

3.2.2.1 Advantages

A significant advantage of this approach is the expertise of the CM. He or she will assist the client in making necessary decisions required to support the quality of execution and overall performance of the project. The CM will help to keep the project budget in line and delivery schedule on track, and reduce the design errors and omissions. He will also provide construction and management advice to the client, sharing his expertise to the best of the client's interest. The CM is a part of the team from early on in the project, providing input from an experienced contractor point of view.

All in all, the tender process can be sequential, which permits the start of the construction phase before all the documentation is finalized, which will be advantageous for fast-tracking projects.

The CM-at-Risk advantages also include a maximum fixed price and a single point of responsibility.

3.2.2.2 Disadvantages

Due to the increase in participants in the project, communication is generally more complex, as it includes a third party consultant; therefore, the participants' roles can frequently be confused. In the case where the CM is undertaking part of construction work, there can be a conflict of interest related to cost control. Even though the budget can be strictly managed, the client's risk is directly related to the fact that the cost is not fully established until all of the components of the work are tendered, while construction usually commences before that.

3.2.3 Design –Build

In the Design-Build model, the client hires a single entity for the project's design and construction execution. The client has no legal responsibility, and all major obligations are transferred to the Design-Builder. Such obligations usually include design, construction, construction supervision, control, and commissioning of the project. There are two common variations in the Design-Build method. In the first one, the client will hire an independent consultant, who will be preparing the initial statement of requirements and procurement documentation, and providing advice throughout the project. In the second case, the client only engages a Design-Builder using the tender process. Table 3.2 below presents a comparison of the Design-Bid-Build and the Design-Build delivery models. Ibbs, Kwak, Ng, and Odabasi (2003) compared the performance of various Design-Build and Design-Bid-Build projects from the USA, Canada, and Latin America. In their study, researchers identified that the absolute change in schedule for DBB projects represented 8.4% compared to DB projects with 7.7%. Although the use of fast-tracking with Design-Bid-Build delivery is not uncommon in real life, given the fact that such projects are more at risk of falling short in terms of costs and timeline, the need to study them is critical.

Table 3.2 The Design-Build vs. The Design-Bid-Build

Design- Build	**Design-Bid-Build**
Client has one contract with Design-Builder.	Client manages multiple contracts including design professional and contractor.
Contractor participates in development of the design providing feedback and expertise.	Contractor is unknown during the design phase.
Usually using a fast-track technique to shorten the project duration for design and construction	Commonly, design and construction phases executed in sequential manner.

Three types of relations are typical for Design-Build delivery, and they are presented in Figure 3.3.

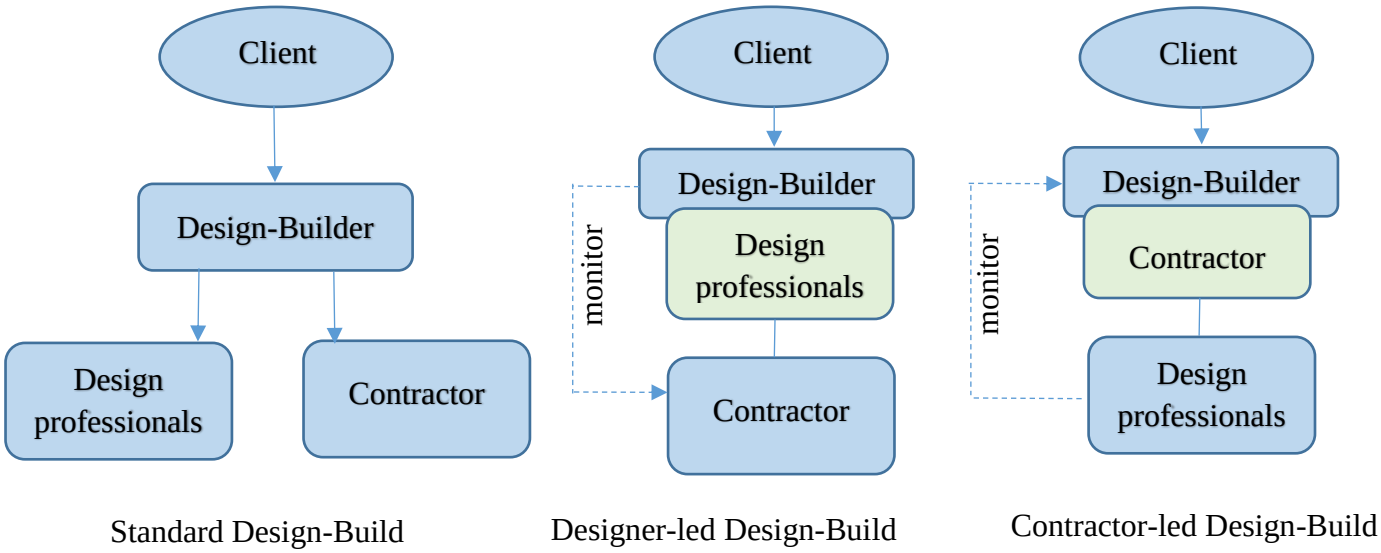

Figure 3.3 The Design-Build delivery relations

Contractor-led Design-Build delivery model often represented by General Contractor company, while Designer-led Design-Build commonly represented by Engineering or Architectural companies. Molenaar and Songer (1998) found that the success of the DB projects significantly depends on a scope and schedule definition, the owner, and the design-builder experience. Besides, Chan, Ho, and Tam (2001) discovered that client's and contractor's competencies, together with

the project's team commitment, correlated with the overall performance of the DB construction projects.

3.2.3.1 Advantages

On the client's part there is no legal responsibility for design and construction, which is a significant advantage. The Design-Builder is responsible for all of the work execution, deficiencies, and extras occurring during the project. The design professionals and contractors have an opportunity to work as a team, thereby increasing the team's performance efficiency. Such a structure of a project team is conducive for fast-tracking, since all arrangements can be made promptly, evaluating and weighing all the pros and cons. The client receives the design that was previously reviewed by the contractor, thereby reducing the risk of omissions and constructability issues. Besides that, the cost of the project is known early in the project.

3.2.3.2 Disadvantages

Although many clients need to know the cost of the project during its early stages, it can be disadvantageous for the client. Since the Design-Builder assumes all risks and responsibilities, they would quote a price which includes appropriate contingencies to cover all identified risks. Gransberg and Windel (2008) addressed the lack of quality control of the DB public construction projects. The study found that in order to ensure the quality of the work, the client will rely more on the qualification evaluation process and tend to be less proactive in resolving deficiencies.

The client has limited decision power in terms of design and approval during the project. Potential lack of communication between the designer and the client will increase the risk of the failure to deliver the final results to the client's satisfaction.

3.3 Construction projects' life cycle

An overview of existing literature about project life cycle is enough to appreciate that there exists at number of different concepts and terms describing phases within the "life cycle" context. A project life cycle can be described as a number of phases that the project will go through in order

to deliver the final result. PMI (2017) states that the life cycle provides the basic framework for managing the project and it divides project into 4 phases which are presented in Figure 3.4.

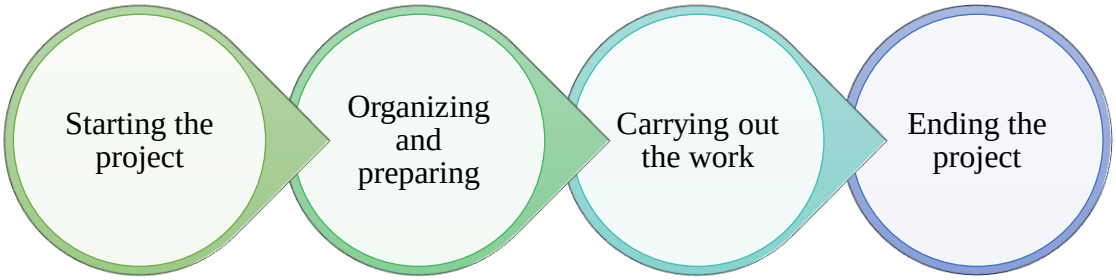

Figure 3.4 Project Life Cycle (PMI, 2017)

Based on the general principles of project life cycle the OIQ (2011) (Ordre des ingénieurs du Québec) developed the life cycle for construction projects outlining each phase in detail. The summary of construction project life cycle is presented in Figure 3.5.

Concept	Design	Implementation	Closure
• Customer requirements • Concept development • Feasibility study	• Functional design (preliminary pre-project design and final or detailed pre-project design)	• Procurement • Construction	• Transition • Operations

Figure 3.5 Construction project life cycle

In order to better understand the requirements of each phase, as well as make inferences regarding the best practices to achieve the stated objectives of the project, the researcher will review each phase individually.

3.3.1 Concept

The first phase of construction project life cycle is the concept. During the concept phase a preliminary risk analysis is completed to establish the needs for the project's existence. The output of this phase is a development of the project charter, which serves as a record of both purpose and methodology.

3.3.1.1 Customer requirements

First of all, before proceeding with the needs' analysis, the stakeholders should be identified and categorized. After that, during the customer requirements phase, the project objective should be introduced. The expectations of the project outcome must be clearly defined before moving to the concept development phase. The authors of PMI (2017) guide suggest to meticulously determine and document all the requirements in order to be able to manage the stakeholders' needs to meet the project's objectives.

3.3.1.2 Concept development

This process is often performed in parallel with the feasibility study. After the customers' needs and requirements were determined the basic parameters, functionality, attributes and specifications of the project should be established.

Buede and Miller (2016) suggested to include a broad range of ideas in the process, from inexpensive to very expensive, and then narrow them down to a subset of most favourable concepts, out of which the ultimate selection will be made.

3.3.1.3 Feasibility study

The feasibility study helps defining the scope, in order to establish a few possible scenarios for the project. During this process the analysis and evaluation should be done to assess the constructability and potential of the proposed project to support the decision making during the concept phase.

The feasibility is study conducted to investigate whether the project is based on an achievable concept and within the budget constraints, in which case the engineering and architectural

professionals can proceed to the design phase. Despite the fact that the feasibility study is an important process of the concept phase it is often skipped due to time and budget constraints.

3.3.2 Design

The second phase of a construction project life cycle is design. In order to integrate the concepts into a functional design and to resolve all design obstacles, the phase can be sub-divided into preliminary pre-project design and detailed pre-project design.

3.3.2.1 Preliminary pre-project design

Preliminary pre-project design is basic design which often serves as a liaison between concept development and detailed pre-project design. The main focus of this process is to create a general framework used to establish the execution of the project.

Blanchard, Fabrycky, and Fabrycky (2006) described preliminary pre-project design as a process of addressing the questions of “what” and “how” from the concept development. The allocated requirements from the concept development process drive the preliminary pre-project planning into addressing these questions on a lower level.

A preliminary pre-project design report is prepared includes basic drawings outlining engineering and architectural components of the project, as well as early stage construction cost estimates.

3.3.2.2 Detailed pre-project design

During the detailed pre-project design process all of the design problems which were unsolved during the preliminary pre-project design must be resolved. One of the most important activities of this process is to verify that the final design of the project remains economically viable. If it turns out, that by any means it is not, then the decision must be made to either revise the original concept together with design solutions, or even terminate the project.

A detailed pre-project design report will include the final design concept with engineering and architectural plans and specification. Also, it should include a detailed construction cost estimate

and schedule, documenting quality and acceptance plan, listing the acceptance criteria required to meet the customer's expectations.

3.3.3 Implementation

The third phase of construction project life cycle is implementation. PWGSC (2019) views the purpose of implementation phase in converting the approved detailed design into procurement / contractual documentation to deliver the final result which will meet the project objectives. At the end of implementation phase the final result of the project is evaluated according to a list of requirements and if stakeholders' quality expectations were met, the project is deemed to be completed. Otherwise, corrective actions will be prescribed to finish the phase.

3.3.3.1 Procurement

Once all the decisions on "what" and "how" of the project are made, the next step is to identify the procurement strategy. PMI (2017) suggests that the purpose of the procurement process is to establish the project delivery method, the type of contractual agreements and payment types, as well as how the procurement will advance during the project execution.

For each procurement purchase the statement of work should be developed, which includes quality requirements, specifications, period of execution or acquisition, location and other important information that will help a potential seller determine the capability of delivering services or materials.

The output of this process is the acquisition of services and materials that are required to achieve the project's objectives.

3.3.3.2 Construction

Following the procurement process, the construction process includes the physical activities necessary to achieve the project's objectives. Throughout this process all the key stakeholders should be kept informed and updated of project's status. During this process all plans are updated on a regular basis, following the physical execution.

Once all of the project deliverables have been executed and accepted by the customer, the project is ready to transition to the last phase, which is closure.

3.3.4 Closure

The fourth phase of construction project life cycle is closure. The output of the closure phase is the official sign-off document and a lesson learned examination on what went well and what didn't, which will help future project teams of the organization.

3.3.4.1 Transition

The purpose of this process is to release final deliverables to the customer. The Project Manager will handle over all project documentation to the final user. Suppliers will produce the technical manuals along with the necessary trainings. At the same time the Project Manager will communicate the project closure to all of the stakeholders releasing the project resources and terminating all procurement contracts.

3.3.4.2 Operations

In this process the operations team of the client resumes the day-to-day regular activities. New minor construction activities and upgrades are completed by operational maintenance team.

3.4 Schedule delays in construction

Over 1,500 articles focus on causes of schedule delays in construction projects in different countries and industries. A schedule delay can be defined as a situation, when a construction project is not completed within the planned period of time (Ahmed, Azhar, Castillo, & Kappagantula, 2002). It is considered to be one of the most frequent issues in public and private construction projects worldwide. KPMG International interviewed executives from 165 engineering and construction companies around the world and found that 77% of the respondents reported project underperformance due to delays, poor estimating processes, and failed risk-management processes (Bagaya & Song, 2016). In his work, Memon (2004) categorized causes of schedule delay into

excusable delays and non-excusable delays. While excusable delays are unforeseeable and are caused by third parties beyond the control of the project team or a contractor, the non-excusable delays are usually foreseeable and related directly to the contractor. Thus, the significant distinction between these two is the determination of which party is liable for the delay.

3.4.1.1 Factors causing schedule delays in international construction projects

In the past decade, many researchers studied the causes of schedule delays in public and private construction. Most of these studies were carried out in developing countries. The summary of the factors impacting the schedule is shown in Table 3.3. Bagaya and Song (2016), Bekr (2015) and Alsuliman (2019) focused on analyzing public construction projects, while the rest of the researchers studied private construction projects.

Table 3.3 Factors causing schedule delays in construction

Researchers	**Country of the research**	**Top 7 Factors causing schedule delays**
Bagaya and Song (2016)	Burkina Faso	Financial capability of contractor; Financial difficulties of owner; Equipment availability; Slow payments of completed work; Poor subcontractor performance; Inadequate planning and scheduling; Weather conditions (heavy rains and floods).
Alsuliman (2019)	Saudi Arabia	Focus on financial analysis and awarding the lowest bidder; Awarding contractors' projects beyond their financial and technical potential; Selection of contractors who have other faltering projects; Ministries are not interested in the development of the engineering sector; Government entities are late in giving financial rights to contractors; Weakness of the financial and technical capabilities of some contractors; Government entities do not withdraw the delayed projects from the faltering contractor.
Ahmed et al., (2003)	USA	Change orders; Changes in drawings; Incomplete documentation; Changes in specifications; Building permits approval; Decisions during development stage; Design development.
Bekr (2015)	Iraq	Low performance of the lowest bidder contractors; Design changes by the owner; Delay in progress payments by the owner; Owners' lack of experience in construction; Poor qualification of supervision staff of the owner's engineer; Uncooperative owner with the contractor or consultant; Lack of coordination with contractors.
Makulsawatudom et al. (2004)	Thailand	Lack of material; Incomplete drawings; Incompetent supervisors; Lack of tools and equipment; Absenteeism; Poor communication; Instruction time.
Sambasivan and Soon (2007)	Malaysia	Improper planning; Site management; Inadequate contractor experience; Finance and payments of completed work; Subcontractors; Shortage in material; Labour supply.
Aibinu and Odeyinka (2006)	Nigeria	Contractors' financial difficulties; Clients' cash flow problem; Architects' incomplete drawing; Subcontractor's slow mobilization; Equipment breakdown and maintenance problem; Suppliers late delivery of ordered materials.
Lo, Fung, and Tung (2006)	Hong Kong	Inadequate resources due to contractor/lack of capital; Unforeseen conditions; Exceptionally low bids; Inexperienced contractor; Works in conflict with existing utilities; Poor site management & supervision by consultant; Unrealistic contract duration imposed by client.

Three of the factors perceived common among all the presented studies are: (a) incomplete design or design changes; (b) incompetent supervisors or contractors; (c) lack of material or equipment. To offer the solution to the problem at hand, it is vital to understand the root cause of schedule delays.

Incomplete design/ Design changes

Incomplete drawings or multiple design changes have a significant impact on productivity, often causing delays due to the necessity of revisions, reworks to complete the drawings and new corrected design. Makulsawatudom et al. (2004) indicated that the sole factor causing design changes is limited time and budget set up by a client. Design professionals frequently lack time and budget to complete all drawings before the procurement process starts. Chances are that design will have conflicts, omissions, and will require verification for constructability. Besides that, should the client not take time to determine the entire scope of the project, there eventually will be disappointment and dissatisfaction with the final design, causing requests for design changes.

Incompetent supervisors/contractors

According Sambasivan and Soon (2007), the reason for inadequate contractor experience is linked to the fact that public tender contracts are frequently awarded to the lowest bidder. In some cases, the selected contractor lacks the required experience and knowledge to manage the project in question. At the same time, Makulsawatudom et al. (2004) found that the reason for hiring an incompetent supervisor for the project is rooted poor human resource management, allowing the promotion of workers lacking competencies and knowledge. Both of these factors can cause schedule delays due to inadequate planning of the execution, defective work, and inappropriate application of tools and equipment.

Lack of material or equipment

Aibinu and Odeyinka (2006) found that the lack of materials and equipment is generally linked to incompetent project management. As a result, either the equipment required to execute the project is inaccurately determined, or the machine's capacity is overestimated, in both cases leading to a shortage.

However, the shortages of certain basic materials will negatively impact the schedule as well. In some countries, the demand for raw materials exceeds the supply, causing an inevitable price

increase. For instance, according to Sambasivan and Soon (2007) would wait for the price to decrease prior to purchasing materials or equipment. However, such waiting times will interfere with the established project schedule.

3.4.1.2 Contractual risks as a cause of schedule delay

Main causes of schedule delays in construction were described in the previous section. Although all of the reviewed projects were executed internationally, it is a starting point for further examination of such causes in the developed world. Considering the lack of such data in Quebec, the review of existing research papers is the primary source providing an overview of the situation. In this section, the elements associated with procurement regulations in Quebec will be reviewed, since they can be directly linked to the schedule delays.

In 2019 specific changes were introduced, affecting public colleges' procurement and budgeting processes. The main changes that affected the timeline are addressed in C-65.1, r. 5 Regulation regarding construction contracts of public bodies (EOQ, 2018). The public body is obliged to publish the tender notice at least for 15 days, and in case the addendum will be published affecting prices, the 7-day deferral of the closing date should be granted. The introduction of new timelines also affected the changes in the internal by-laws of colleges, increasing the duration of coordination, budget approvals, and contractual documentation preparation. Such context creates additional pressure for Project Managers in terms of schedule compression planning. Some activities can not be either superseded or compressed, and in some cases, the sequence of activities must be respected in a very strict way.

It is worth mentioning that an incomplete design package and an inadequate procurement process may lead to inaccurate cost estimates, causing cost overruns. It will lead to numerous change orders which eventually cause construction rework and multiple modifications. It can also lead to overlooked work during the tender, which was not assigned to any party.

3.5 Summary

SO3 was partially accomplished through the literature review process. To formulate a comprehensive answer to SO3, information from chapters 4 and 5 will be assorted to identify and classify factors, which have either a negative or positive impact on project schedules.

Factors causing schedule delays were identified and classified. In the absence of such studies in Quebec, eight international projects were analyzed to determine relevant factors' similarities. Additionally, Quebec's new and existing regulations were explained.

With regards to SO4, suggested recommendations and strategies will be described in Chapter 6 of this research paper. In order to obtain a complete answer to SO4, recommendations provided by project professionals during exploratory interviews will be added and analyzed. The description and the outcome of the interactions with project professionals are outlined in the next chapter. The interviews were analyzed to present the results in an organized form and provide a general understanding of public college projects.

CHAPTER 4 EXPLORATORY INTERVIEW AND ANALYSIS

In this chapter, the interview process will be reviewed in detail and provide more context regarding the creation of the questionnaire used for the purposes of collecting relevant data from the practitioners. The researcher will be covering the following 3 important steps with regards to data gathering and interpretation: 1) preparation, 2) overview of the participants' profile and, 3) summary of the analysis and results obtained. The exploratory interview's main contribution to this work is to develop a general understanding of the public college project practitioners perspective on fast-track DBB projects and, consequently, to identify the most salient factors which have a direct impact on the schedule delays, as well as strategies used by practitioners to manage fast-track projects.

4.1 Interview presentation

Shrestha and Fernane (2016) suggested dividing questionnaires into several parts in order to simplify their structure and as it makes it easier for the participants to follow the direction of the interview process. Based on best practices described in available literature, the questions compiled have been subdivided into 2 parts: 1) general questions and, 2) open-ended questions, in order to obtain a broader picture of the practitioners' experience with DBB fast-track projects within the public college environment, as well as specific examples of challenges and potential solutions.

In their research, Mpofu, Ochieng, Moobela, and Pretorius (2017) have developed a set of steps to follow regarding the development of questionnaire, in order to assist interview participants to provide maximum useful information without being restricted to a predefined answer. The authors recommended to design the questionnaire while paying particular attention to its focus, phraseology, question sequence and overall presentation, and also suggested starting with the piloting process. During the first interview the researcher received general feedback with regards to the overall interview experience. Based on the feedback received, the researcher produced small altercations to the questionnaire adjusting question phrasing, sequencing of questions and terminology used. The researched ahs equally added 10 extra minutes to the interview duration.

Several preparatory steps were undertaken in order to complete the exploratory interview stage of this research, determining the size of the sample group, designing the questionnaire, following the Ethics Committee's approval process, facilitating the interview with respondents, and, finally, interpreting the results obtained. As it was previously mentioned in Chapter 2, the exploratory interviews' primary goal was to provide the answers to SO2 and SO3. The interviewees' sample group comprised project practitioners from different job rank levels, currently employed by public colleges located in the Montreal region. Potential participants were selected from the researcher's personal professional network, as well from the publicly available contact information of several public colleges. Of the total number of the 22 potential participants solicited, ten professionals agreed to participate in the study. The questionnaire was designed to provide insight into the projects executed, conditions, and rationale as to why there was a need to use fast-tracking, while fully accounting for the composition of the participant's sample. The researcher only approached project practitioners upon the receipt of the corresponding approval letter. All interviewees agreed to meet in person on premises, either in their offices or board rooms, in cases when the interviewee shared the office with another colleague. On average, every interview lasted approximately 1 hour, however 4 participants out of 10 have expressed genuine interest in the subject matter, shared more of their personal experiences and provided valuable information in order to help enrich the research and enhance future analysis. Such interviews lasted approximately 2 hours.

With participants' full consent, the interviews have been recorded, and each respondent's answers were transferred into the questionnaire. Data collection and recording has been performed under the condition of the participant's anonymity, whereby each participant has been assigned an identification number from 1 to 10. In order to prevent potential data loss, all recorded materials have been saved on 2 separate USB drives. One of the drives has been provided to the Research Director, while the second drive has been retained by the researcher for further processing and analysis. During the processing stage, the audio files have been compared to the responses recorded in the physical questionnaire. The processing of each individual questionnaire has taken approximately 3 business days, which included the transfer of the full answer to a separate document and combining responses on a question by question basis.

The subsequent analysis stage included calculating the average and median values for quantitative general questions, as well summing up and ranking qualitative open-ended questions, primarily

based on corresponding response frequency. Such responses have been presented in the descending frequency order, in order to emphasize the importance of the most relevant factors mentioned by the practitioners. Detailed results of the questionnaire processing are presented in the “Results” section of this paper, while the “Analysis” section contains the results breakdown, along with an overview of potential outcomes.

As a first exploratory step, the interview process presented a plausible option for the initial collection of raw data. The questionnaire was designed to obtain project professionals' opinions on the level of importance of and potential challenges stemming from the schedule variations, as well as the client’s perspective on the possible factors which can cause significant schedule delays in fast-track DBB projects.

As previously mentioned, the questionnaire was subdivided into two parts. Part 1 of the questionnaire covered the general information on the respondents and the relevant educational institution. The questions contained in Part 1 included, but were not limited to, the years of experience, the number of projects executed per year, the projects’ budgets, as well as others, which can be reviewed by consulting the sample questionnaire included in Appendix A. In the second part of the questionnaire, the respondents were asked to identify the relevant factors which may potentially impact the delivery schedule in either positive or negative ways. The participants had an opportunity to share their experiences, strategies and recommendations on how to mitigate negative impacts, while simultaneously maximizing the potential of positive impacts on schedule variance.

Based on the interview analysis conducted by the researcher, the following issues were addressed further in this chapter: i) which factors commonly cause schedule delays in the DBB fast-tracking projects across public colleges in Quebec and; ii) how can this study help project management practitioners minimize the impact of schedule delays in future projects. The information gathered from the study was used to conduct qualitative analysis for further results interpretation and discussion.

4.1.1 Profile of participants

Table 4.1 presents the general profile of the participants and the colleges they are employed by. For anonymity reasons, names have been excluded from the table below.

Public colleges use their own job titles system, which is slightly different from the system used by the project management industry. In order to avoid ambiguity, the general description of various posts used for the purposes of this paper is included below.

Facilities Director is responsible for overseeing multiple projects at the same time, with a strategic approach to the overall project portfolio. However, it should be noted that he or she only executes a few projects per year directly as a PM.

An Associate Director supervises small size projects with an overall expenditure of approximately 500 000$ to 800 000$.

Coordinators in the publicly funded college network are responsible for managing project portfolios along with managing project execution as PMs.

Project Managers supervise assigned projects, as well as perform a number of operational day-to-day tasks.

Table 4.1 Summary profile of the participants

Sample Number	**Job level**	**Years employed**	**Average capital budget per year**	**College profile**	
				Number of buildings	**Number of students**
1	Director	9	1 million	Over 15	6000
2	Associate director	18	500 000$	Over 15	6000
3	Coordinator	6	1.5 million	Over 5	10000
4	Coordinator	8	800 000$ to 1 million	Over 10	8000
5	Coordinator	5	5 to 6 million	Over 10	7000
6	Project Manager	15	2.5 to 3 million	Over 10	8000
7	Project Manager	7	600 000$	Over 10	7000
8	Project Manager	6	2 million	Over 10	7000
9	Project Manager	4	2 million	Over 15	6000
10	Project Manager	11	5 to 6 million	Over 15	6000

Results obtained by the means of the interview / questionnaire are presented in the following section. Interestingly, some of the respondents expressed contradictory opinions vis-a-vis their peers. The dispersion of opinion is welcomed by the researcher as it presents an opportunity to evaluate the complexity of each individual situation and provide deeper insight into the bigger

picture. While conducting the analysis, the researcher took into consideration the particulars and details pertaining to such factors as college, job level and years of experience. The participants acknowledged that there was a lack of clear practical project management guidelines, which can be applied during the implementation of fast-tracking in DBB projects. All of the participants have requested a copy of the final research results.

4.2 Results

Based on the existing literature on the subject matter, timely delivery of the project according to the agreed upon schedule is one of the most critical requirements of the client, and coincidentally one of the most significant constraints faced by project management professionals. The schedule / timeline can play a vital role in making the decision between executing and abandoning the project, which, in turn, is quite often related to the nature of the industry in question. The projected timeline is the most sensitive aspect of time-driven and time-constrained public projects, which is closely monitored by all stakeholders.

It is important to acknowledge and emphasize the fact that the interviews conducted by the researcher represent only a small sample of the population (~5%), given the infeasibility of interviewing 200 project specialists employed by public colleges in Quebec. Overall data satisfaction was attained as professionals interviewed represented different institutions and varying job levels, possess considerable work experience within the public college system, and have previously used the fast-tracking technique in construction projects.

4.2.1 General questions

For the purposes of the interviews, the researcher has relied on the definition of fast tracking, as presented in the PMBoK guide, in order to clearly define the subject in question. One of the objectives of the interview was to establish the practitioners' perception of fast tracking, including their "real life" definition of it, and to compare it to the traditional one. Interestingly, all the respondents provided descriptions which were very similar to the one provided in the PMBoK.

Additionally, respondents mentioned that in the modern day working environment it has become a norm to carry out projects using fast-tracking as a technique to speed up the project execution and meet respective deadlines.

After having grouped all the answers, the general real-life definition of fast-tracking crystallized to a parallel performance of tasks and activities where possible, in order to speed up the project and shorten the delivery timeline. Examples of such activities include working on design finalization, while at the same time working on the construction part. Traditionally, these tasks and activities would be performed in a sequential manner.

According to one of the participants, fast-tracking is a useful tool "For the capital projects that should be done at a certain time and if the timeline is not met it affects the financial viability and it creates a lot of outside pressure" (Respondent #104331).

According to six out of ten respondents, timeline constraints and resource limitations were identified as top factors contributing to the choice of fast-tracking.

Furthermore, in order to grasp a better understanding of the respondents' profile, as well as the specifics of CEGEP projects, the researcher has asked a series of questions which revealed the broader picture regarding the number of projects executed per year and number of projects executed using fast-tracking technique. Additionally, in order to better understand the general scope of the projects carried out by respective colleges, the respondents were asked to identify the overall allocated budget for capital construction projects, the average budget and duration of such projects.

Figure 4.1 below shows the total number of DBB projects executed per year versus fast-track projects. Vertical numbers represent respondents' sample assigned IDs from 1 to 10, see Table 4.1 for more details.

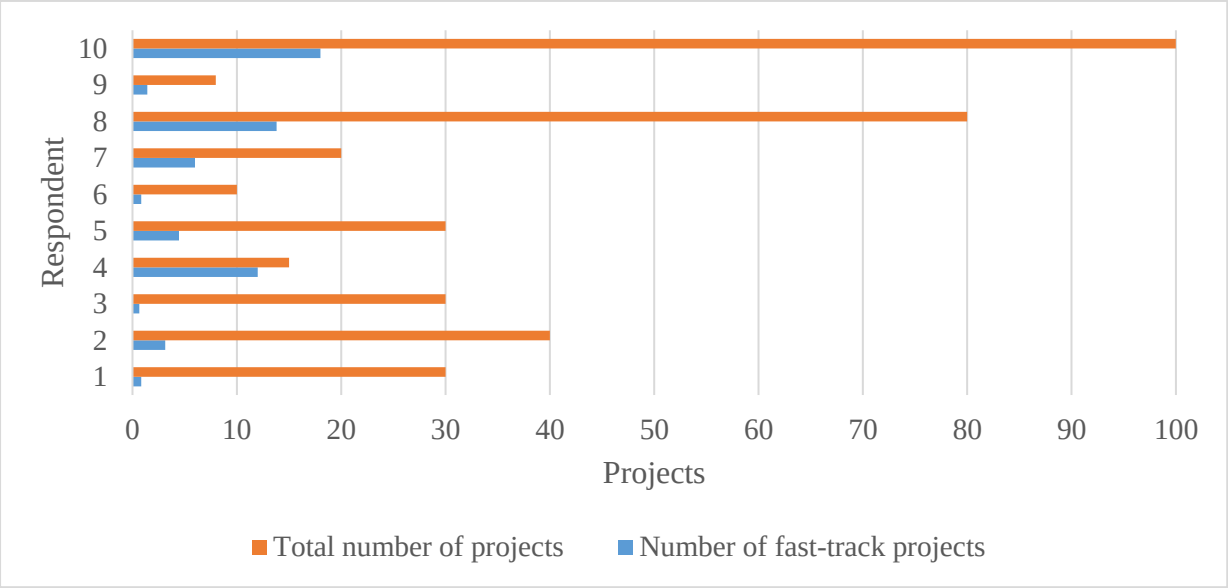

Figure 4.1 The distribution of the DBB projects and the DBB fast-track projects per year

In Table 4.2. below shows the percentage distribution of the fast-track projects per year for each participant.

Table 4.2 Percentage distribution of the fast-track projects per year versus traditional projects

Sample number	**Fast-track projects executed per year**
1	2.8%
2	7.8%
3	2.2%
4	80%
5	14.8%
6	8.3%
7	30%
8	17.3%
9	17.9%
10	18%
Median distribution	16.05%

On average, 16.05% of the total annual number of projects are executed using the overlapping of different phases and activities. Although this number can be considered somewhat insignificant, it should be noted that given the overall budget of fast-track projects and the importance of timely delivery, these projects are considered of high priority. Data collected from the questionnaires revealed that the total number of projects executed per year varies depending on the job level and the college in question. Consequently, it has been established that senior-level managers participate in a larger number of projects, while project managers oversee considerably fewer projects on an annual basis. Interestingly, the percentage of fast-track projects out of the total was found to be approximately the same for all of the ten respondents. The maximum number of executed projects stood at 100 per year, and the maximum number of projects using overlapping techniques stood at 18 per year.

Participants identified fast-track project duration range from 2 months up to several years, with the average duration of 8.5 months. For the purposes of this paper, total duration includes all stages of project development from the initiation to the commissioning. The average execution phase of the project lasted from 2 to 4 months and was performed during the time of a school break whenever possible.

On average, approximately 2.05 million dollars was allocated from the college's budget for fast-track projects. Figure 4.2 shows the distribution of the proportion of the allocated budget for fast-track projects on a per project and per year bases.

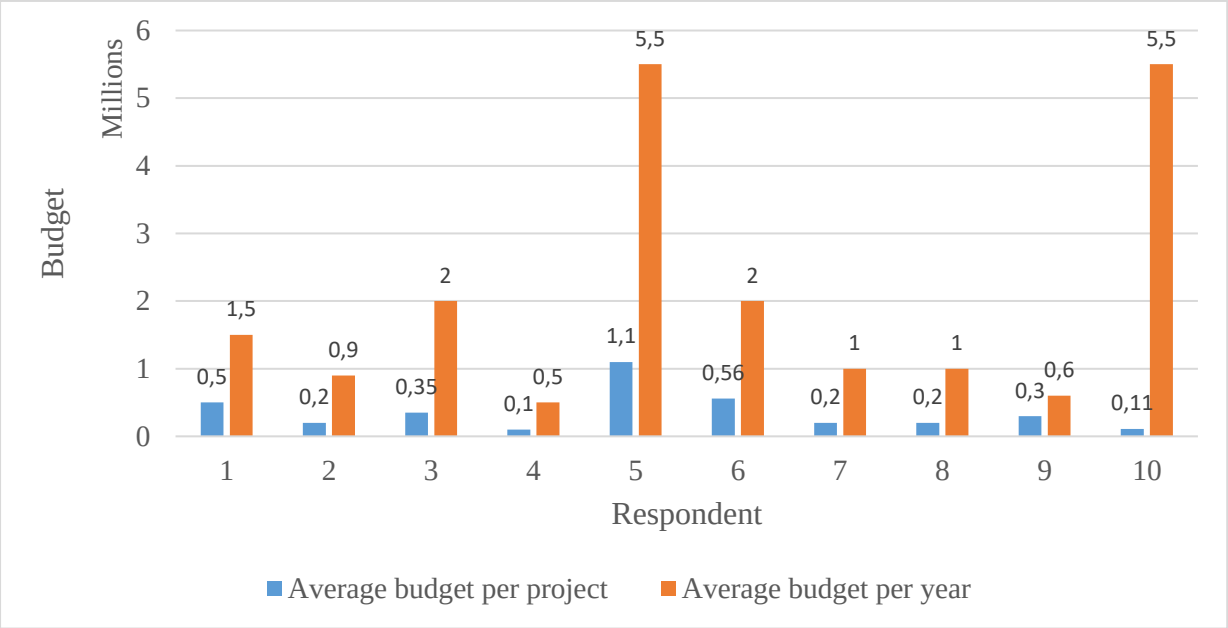

Figure 4.2 Average budget of DBB fast-track projects distributed per project and per year

4.2.2 The reasons of fast-tracking technique application

During the second part of the interview process, project practitioners were asked semi-structured questions and they were requested to elaborate in more detail on the application of fast-tracking techniques in DBB public projects. When asked to name three main reasons as to why one would execute a project using a fast-tracking technique, 3 out of 10 interviewees responded that they would rather execute the project performing activities in a sequential order, completely avoiding fast-tracking and any potential overlapping of activities and phases. However, it should be emphasized that all respondents agreed that fast-tracking is inevitable in certain situations, and that the need to overlap phases or activities occurs quite often.

Based on the results obtained, top reasons for using fast-tracking can be separated into internal and external. Internal reasons include the following: Academic Calendar, Process of Budget Approvals and Limitations, Stakeholder Impact and Lack of Global Project Planning. Nine out of ten project management professionals named the Academic Calendar as the most important reason to execute the project using schedule compression techniques. External reasons mentioned by the project participants include Grant Deadlines set up by the Governmental Authorities, Resource

Availability, Securing the Price of Material and Resources. Figure 4.3 below provides a visualization of the above ranking distribution.

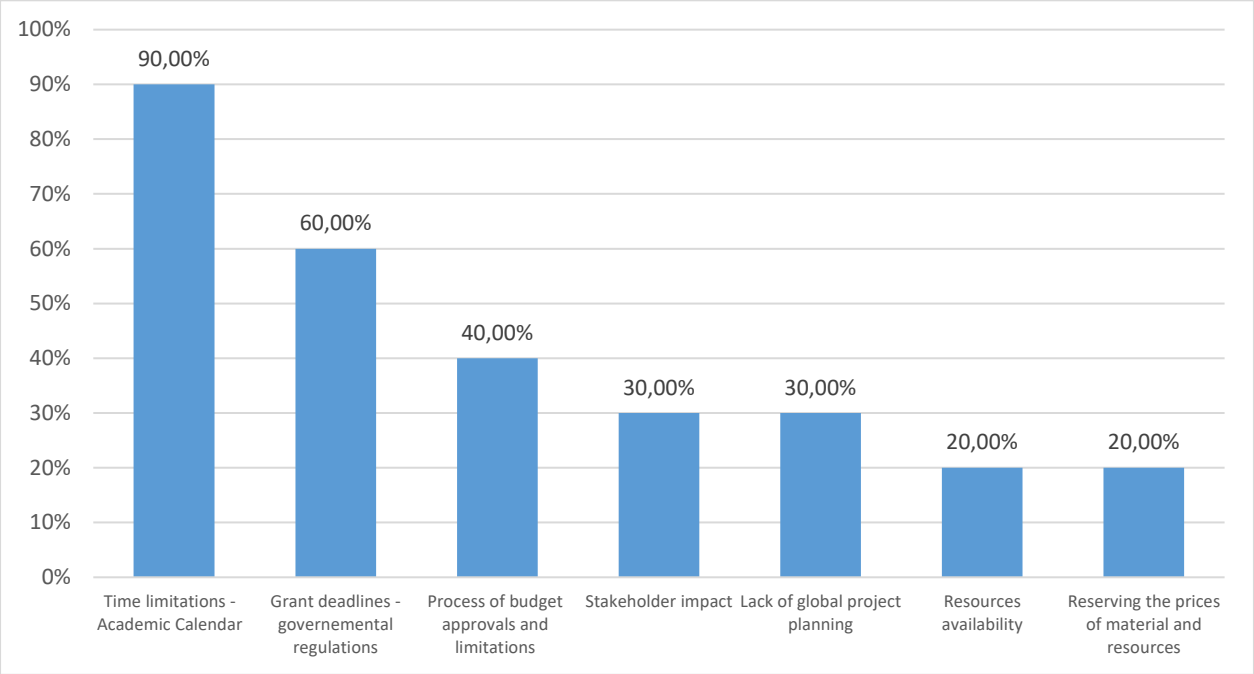

Figure 4.3 Reasons for using fast-tracking in project execution (percentage of respondents who identify each reason)

4.2.3 Overlapping of project phases

The next question practitioners were asked was to identify the stage or phase of the project during which the decision to execute a project using the fast-tracking technique was made. The answers to the question were evenly split, as five participants out of ten identified the Design phase and five other participants identified the Bid phase as being the crucial one. Such choices were later supported by arguments in favor of one or the other, which will be further discussed in the Analysis section of this paper.

Participants were then asked to reflect on most impactful factors, both positive or negative affecting project execution and delivery schedule. Upon identification of such factors (listed and discussed below), the interviewees highlighted the fact that their level of impact was more pronounced when using fast-track delivery. Figure 4.4 provides a summary of factors identified, categorized by the

researcher into the following 5 groups: external factors, design and construction, client-related factors, subcontractors/contractors, and miscellaneous factors. It is worth mentioning, that more specific factors such as budget availability, team expertise, meteorological conditions, site conditions, equipment and resource availability, and coordination between the client, contractor, and design professionals can also impact the project outcome in a positive or negative way.

The top 5 factors identified by the practitioners are as follows:

1. Design omissions and errors;
2. Equipment and resource availability;
3. Labour shortage;
4. Inadequate scope definition;
5. Lack of contractor expertise.

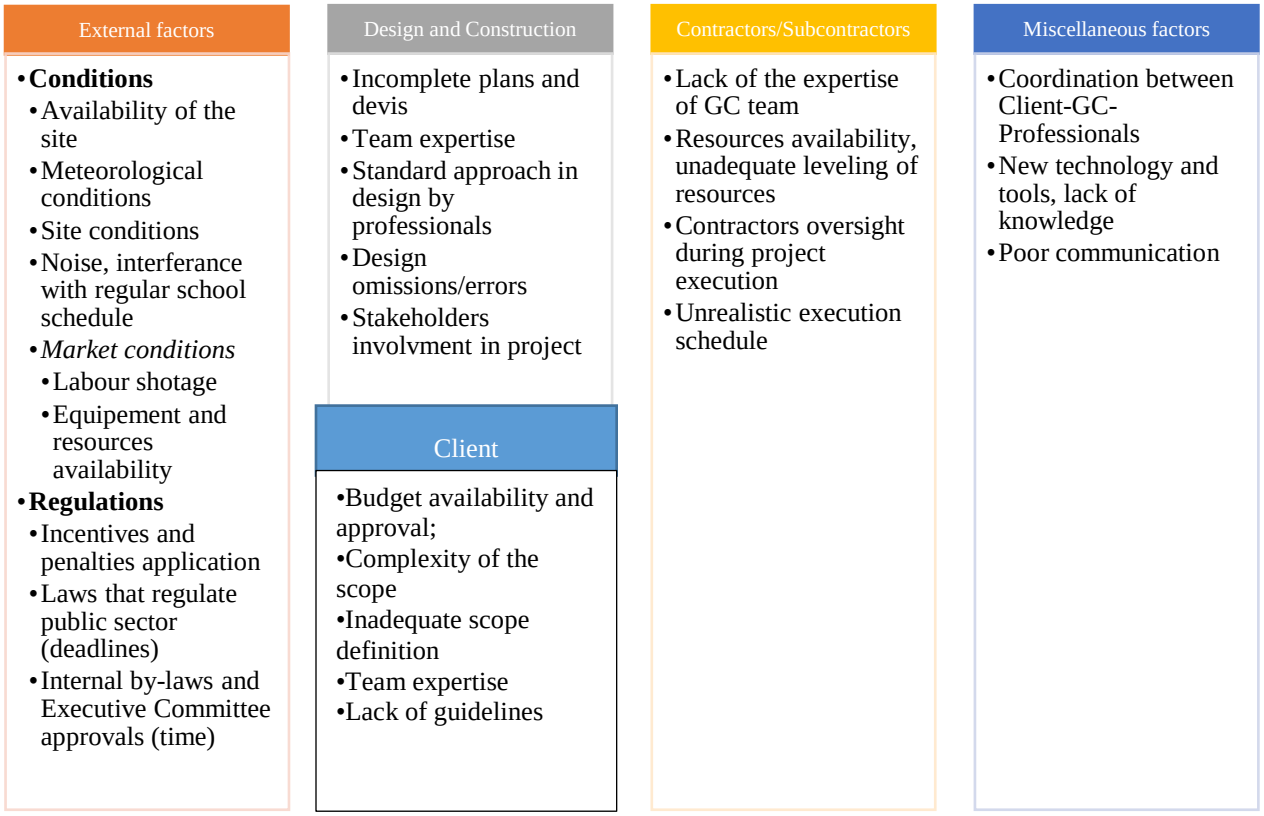

Figure 4.4 Factors causing delays in DBB fast-track public projects

Design omissions and errors ranked first, with 60% of respondents identifying this factor. Respondents noted that minor omissions found at the early stages of the project wouldn't generally have a major impact on the project execution and delivery, however, if such omissions and errors were to be found during the construction phase, it is highly likely that such a development would entail cost overruns and schedule delays. Equipment and resource availability ranked second with 50% of respondents backing it, as well as a labour shortage, followed by inadequate scope definition and the lack of contractor team expertise with 40%, respectively. Other factors mentioned above are uniformly distributed. Factors such as team expertise, lack of guidelines, communication between parties, budget availability, imposed deadlines, and unrealistic execution schedule were named by 30% of respondents only.

4.2.4 Strategies

The last question of the interview covered the strategies used by participants to address fast-tracking projects. Most of the respondents mentioned that certain strategies could potentially be used as good practice for all of the projects, however the same strategies are crucial when conducting a project in a fast-track manner. The strategies discussed were separated into two groups: (a) strategies that can be used to mitigate the impact of the schedule delays and, (b) strategies that can maximize the positive effect of fast-tracking on the project's schedule. Strategies discussed will be presented in chapter 6, along with other strategies suggested by the existing literature on the subject matter. A detailed analysis of their impact on the most important project factors will be provided as well.

4.2.4.1 Strategies to mitigate schedule delays

Delays are costly and frequently result in re-working, disputes and, ultimately, unsatisfied clients. The findings uncovered during the interview process can potentially be used as a foundation, which can help shape the understanding of improvement areas, modifications to existing practices and overall process improvement. The below strategies are based on the information provided by the participants viewed through the prism of existing research publications. The strategies are presented in order of prevalence, therefore strategies 1, 2 and 3 were named by 60% of project

practitioners; strategies 4 and 5 were proposed by 30% of respondents and strategy 6 was named by 1 participant only.

1. Plan the project far in advance. Identify potential risks and prepare a risk management strategy / response plan.
2. Weekly follow up meetings with all project stakeholders. Strict budget and schedule control.
3. Timely monitoring and controlling of established deadlines and explicit commitment of the general contractor.
4. Use of various schedule breakdown techniques.
5. Verification of the design by the means of engineering peer review.
6. For the mid-size and large-scale projects, hiring a Construction Manager, who will act as the client's representative and supervise construction works. This strategy will be beneficial for clients, which usually lack resources.

4.2.4.2 Strategies to maximize the opportunities of the positive impact on the project's schedule

The critical elements of the project are cost, time and quality. The success of the project is determined based on these factors. The following strategies are aimed to facilitate successful project execution. These strategies are mostly focused on the project's schedule and how to maximize the potential positive events that can help execute projects on time or even ahead of schedule. These strategies are presented in order of prevalence. Hence strategies 1 and 2, each named by 70% of participants, strategy 3 was selected by 40% of respondents and strategies 4 and 5 chosen by 30% of respondents during the interviews.

1. Build a trustworthy relationship with professionals and general contractors. It is an excellent way to motivate people to make them feel in a supportive team environment.
2. Using incentives rather than penalties.

3. Adopting a new approach of procurement documents package preparation, which will include the detailed description of the expected quality of the final result; important aspects as resources and equipment availability.
4. During the design, the phase proceeds with the two-step verification of the plans and devis. The first step, engineering peer review and the second step is verified by the college's maintenance specialist.
5. Use the resource levelling or resources crashing technique to maximize the project execution—Reserve funds for the night shift or the weekend shift work.

4.3 Analysis

While seeking to successfully complete the project within a compressed time frame, project practitioners resort to various techniques within the framework of the fast-tracking delivery method. One of the most common ways to reduce overall project delivery time (from design through construction) is to minimize design delivery time by overlapping sequential activities (Bogus, Molenaar, & Diekmann, 2005). Project practitioners identified the average duration of projects and compared it to the standard college schedule. Interviewees emphasized that they have to face the fact that there are two weeks of construction holidays during the summer school break and winter school break. Furthermore, during the summer season, the contractors are usually in high demand due to the general labour shortage. As contractor labor demand exceeds available supply, the project costs can potentially exceed the budgeted expenses by an average of 15%. Given such conditions, the PM has to plan ahead, and, often as the last resort, make the decision to execute the project using fast-tracking, thus mitigating the gravity of schedule constraints.

Based on the answers collected during the interview process, approximately 16.5% of projects carried out by the interviewees are executed using fast-tracking. Even though the percentage might seem to be on the lower end, practitioners interviewed mentioned that these projects are usually of high priority. For instance, several colleges allocated over 5 million dollars on a per project basis for the fast-track projects, which is quite significant as per the distribution presented in Figure 4.2 earlier.

When comparing existing literature rationale for using fast-tracking in general and phase overlapping specifically versus the practitioners' reasoning for the same, it came as somewhat unexpected as the two did not completely coincide. It was an unexpected result considering that a large number of articles covers the overlapping of construction phase as a most common in the industry. However, the reality of the public college industry significantly differs from the private sector. Taking a closer look into Figure 4.3, it should be noted that 90% of respondents named "Time Limitations - Academic Calendar" as a main reason as to why the project can potentially be carried out using fast-tracking techniques. Academic guidelines generally impose major schedule constraints on the delivery of construction projects throughout public colleges. Colleges are operating during three study semesters, leaving a relatively small window of opportunity for project execution.

Grant deadlines / Government Regulations ranked second, with 60% of the votes. A possible explanation for that would be the fact that public colleges often apply for grants to improve existing facilities, with such grants being available from different provincial and federal programs. However, all programs have strict deadlines and different approval timelines. Most likely such projects are planned with the project hard completion date in mind. In this case, PM can decide to use fast-tracking during project initiation.

40% of respondents ranked third, the Budget Approval Process. The process of budget approval across public colleges is usually quite lengthy. An average construction project budget should be requested 6 to 9 months before the project initiation phase, in order to go through the verification process of the college's Executive Committee to receive the final approval. On top of all the constraints described above, the changes in procurement regulations which entered into effect in 2019, introduced hard logic dependencies that project practitioners have to consider when establishing project schedules. In such cases, the project practitioners are obliged to initiate the project one year prior to executing construction work or using schedule compression techniques (See section 3.4.1.1). These steps may cause additional delays in the project execution, since the Executive Committee meeting schedule is established far in advance, and such meetings only occur 6 to 8 times a year.

When project practitioners were asked to name the stage or phase during which the decision was made to execute a project using the fast-tracking technique, the answers were evenly split

between the Design phase and the Bid phase. It is possible that such an outcome is due to the fact that each project is unique, and it is worth looking at the overall picture and review projects case-by-case, taking into consideration all major, minor and tertiary factors which can have an impact on the decision. Based on Russell and Ranasinghe (1991) suggestions and best practices outlined in their work, the decision to use fast-tracking techniques should be made at the beginning of the project. In other words, for successful achievement of project objectives an adequate pre-project planning is crucial, defining the detailed scope along with overall project execution directions. During the interview process project practitioners revealed that most of the executed projects are of small and small to medium size. In rare cases a budget allocation was made to perform a feasibility study or detailed pre-project design. This is an important point, which should be extensively explored and analyzed. Perhaps, if the pre-project planning work was to be performed in a more diligent manner, it would help save the PM's time during project execution, as most of the project risks would be uncovered during that stage. On the other hand, this additional step would add time to project execution, and, ultimately, result in additional costs incurred.

According to Afshari, Khosravi, Ghorbanali, Borzabadi, and Valipour (2010) identifying possible delays early provides a better chance to manage and control possible causes through the project's life cycle. The researcher decided to compare the top 5 factors named by respondents with factors described by authors in existing literature on the subject in question and identified several matches. As per the research articles by Makulsawatudom et al. (2004) in Thailand and Ahmed, Azhar, Kappagntula, and Gollapudil (2003) in the USA, it appears that respondents named several common factors described below, across different geographies. In Thailand, the factor that was ranked number one causing schedule delay was the lack of material, and only the second factor mentioned was incomplete design. The same is true for the research conducted in the USA. Equipment and resource availability together with labour shortage and incomplete plans and devis were identified by respondents during the interview process. Design omissions / errors was ranked as the major contributing factor by the project professionals, however it was not identified as such in the existing literature on the subject matter. This can potentially mean that the application of fast-tracking influenced certain aspects of project execution, which consequently resulted in design omissions and errors. The same can be true for inadequate scope definition and lack of the

contractors' expertise, as these factors can potentially cause schedule delays and were identified as such by project professionals who participated in the study.

Equipment and resource availability, together with the labour shortage, also appear as contributing factors in the research done by Sambasivan and Soon (2007) in Malaysia. This may mean that these factors can possibly have an impact on construction projects and it is therefore important to identify the extent of such impact.

4.4 Summary

In this chapter, the first step was made to achieve the SO1, SO2, as well add more data to the SO3 and SO4 results. Through a series of interviews sampled project professionals shared their opinions on strategies, which can be used to mitigate the impact of schedule delays and maximize opportunities of positive actions. Besides that, participants provided overall information regarding construction projects executed in public colleges and explained conditions under which a decision to complete a construction project using a fast-tracking technique was made. In this chapter, the factors were narrowed down to the context of construction projects in public colleges in Quebec. In the following chapter, multiple public colleges' projects will be analyzed, providing the supplementary data aiming to bring an answer to the sub-objectives of the research.

CHAPTER 5 MULTIPLE CASE STUDY

A multiple case study appears to be the most appropriate approach, when taking into consideration the fact that the topic in question has not been sufficiently studied, and currently there is no practical guide for the implementation of fast-track public projects in the Design-Bid-Build delivery system. Case studies were selected as an additional source of data, complementing the information presented in Chapter 4. Existing research confirms that case studies can help explore the topic in question through a variety of perspectives, while taking into consideration each individual projects' context. In Chapter 4 several factors were identified during the exploratory interview stage, however, the specifics of project team composition and project type (new construction, renovation, remodeling) were not taken into consideration.

During the exploratory interview, project practitioners were asked to provide general information about the fast-track projects and share their opinions on factors causing the variance between planned and actual schedule execution. In addition to the previous set of data, the researcher analyzed each project, with a particular emphasis placed on examining the potential dependency between the context and the phenomenon of schedule delays. The impact of the above mentioned factors and reasons for inevitable delays can potentially be uncovered by decomposing specific project events. Taking into account the fact that only seventeen projects have been evaluated for the purposes of this research paper, it remains somewhat challenging to unambiguously determine the dependency or correlation of obtained variables. Nevertheless, an attempt to establish such relationships will be made further in this chapter.

Fazio et al. (1988) stated that there are two ways to measure the overall performance of a fast-tracking project. The first method will use the hypothetical sequential schedule and perform a comparison with the fast-track schedule. The second method shows a comparison of the actual project and its as-planned initial and as-built schedules. The first method uses forecasted hypothetical information, while the second method relies on the existing projects' data. Information received from public colleges will help perform the multiple case study using the second method mentioned by Fazio et al. (1988) comparing actual and planned results.

A complete summary of analysis' plan is presented further in section 5.2.

5.1 Data Collection

In order to analyze multiple cases, the method of comparing the planned versus as-built results was selected. All things considered, this method seems most beneficial for the purposes of this research, as the comparison is based on actual data. The rationale for choosing this method was based on two main reasons: 1) the ability to analyze the real-life data for each case and across cases using multiple sources of evidence (Yin 2003,2009) [45] [44] [44] [44] [44]; and, 2) the ability of the method to capture structural changes within Quebec's public college system. Although public colleges in Quebec province are regulated and governed by the same policies, the administrative structure differs from one another. Between the years 2010 to 2015 several administration units underwent significant internal changes. The organizational structure has changed, which, in turn, affects the implementation of projects and their execution. Thus, by analyzing multiple projects from various colleges, more comprehensive data will be obtained.

A public information request form sent out to fourteen public colleges in the Montreal region to obtain all the necessary information about actual completed fast-track projects. In addition to the access to information request form, data from the Système électronique d'appel d'offres (SEAO or Electronic tendering system) webpage was used to consult tendering documentation. SEAO is a public tendering system which groups most of the tenders in the province of Quebec, with information easily accessible by the general public. With regards to the fast-track projects data, requested information was received within a month from six colleges. Remaining eight colleges confirmed they have not carried out fast-track projects which fell under defined criteria. Seventeen projects from six colleges were examined across several categories and grouped, in order to obtain the final sample project case.

Extensive literature review and exploratory interviews served as inputs to set parameters used in the access to the information requests, with an example of the information request form presented in Appendix B. Sample inclusion was based on the following criteria: (a) construction fast-track projects; (b) dates of execution between 2015 and 2019; (c) planned project duration between 6 and 12 months; (d) planned project budgets between 400 000$ to 2 million.

The documentation obtained by means of the public request included the following:

1. Tendering information including all published Addenda;

2. Gantt charts of planned execution schedule and Gantt chart of actual as-built schedule;
3. Tender results;
4. Project documentation with change orders, technical devis, and plans for construction and as-built.

The information obtained will complement the general context of the research and build an understanding of the schedule variation causes in public DBB fast-track projects.

Figure 5.1 and Figure 5.2 present the sample project cases grouped by duration and costs. For anonymity reasons and the research's accuracy, each project was assigned an identification letter from A to Q.

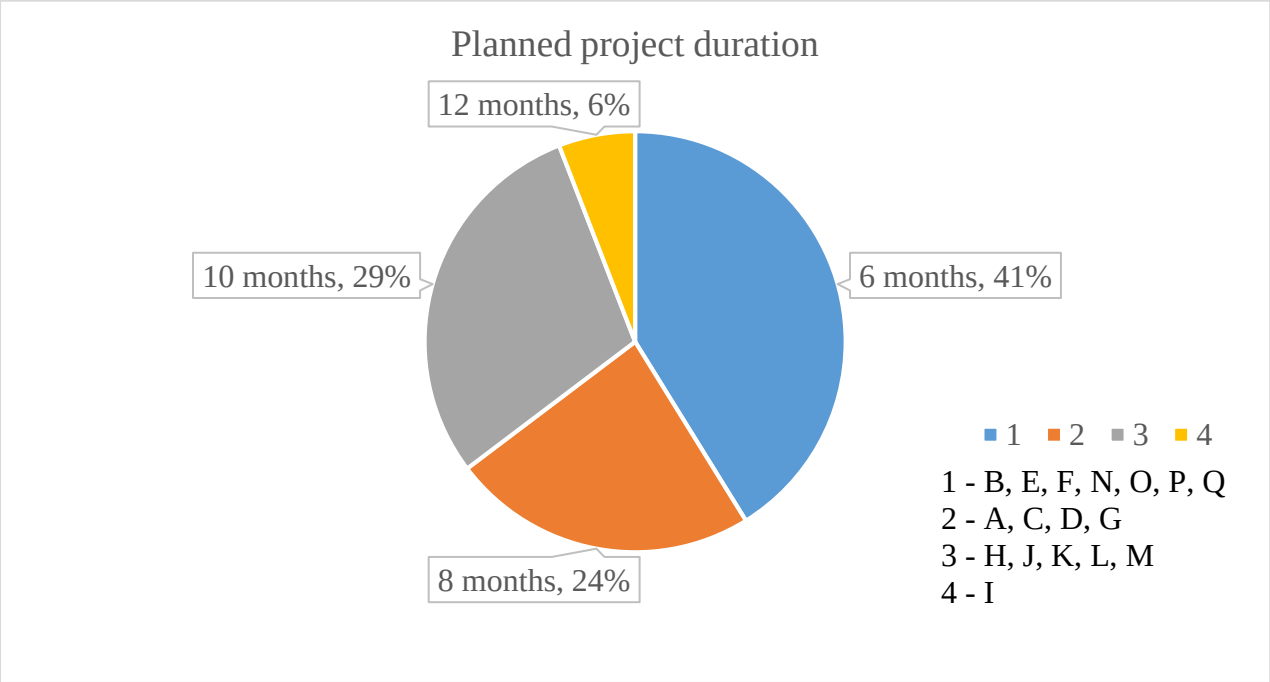

Figure 5.1 Planned Projects Duration

The minimum planned project duration of sample cases was established to be 6 months. Projects “B”, “E”, “F”, “N”, “O”, “P”, and “Q” fared on the lower end of the sample’s planned project duration range, project “I” was the only one that fared on the higher end with an established duration of 12 months.

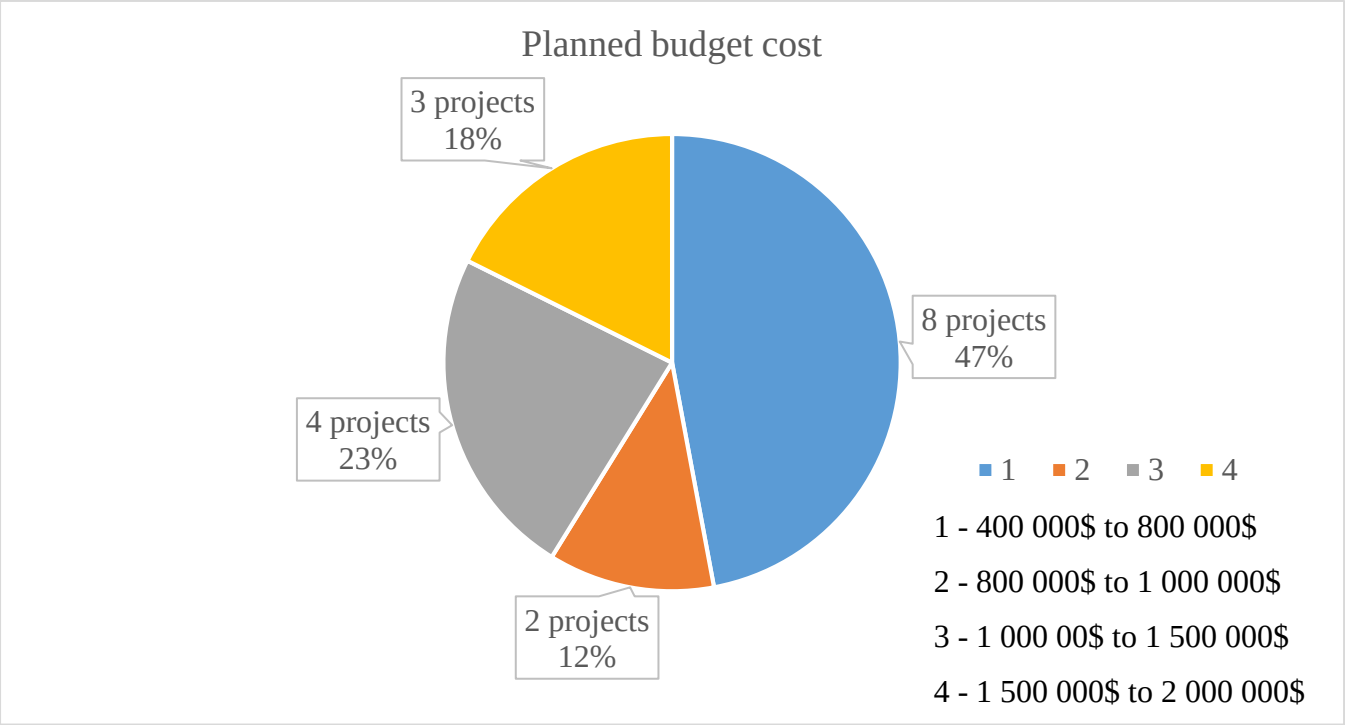

Figure 5.2 Planned Projects' Budget Cost

Projects planned budget expenditures were grouped into 4 categories: (1) 400 000$ to 800 000$; (2) 800 000$ to 1 000 000$; (3) 1 000 000$ to 1 500 000$ and (4) 1 500 000$ to 2 000 000$. Within each category, several projects represented a fairly similar picture with regards to planned project costs, such an approach will help to perform the comparison of projects with similar scope.

5.2 Analysis

This multiple case study aims to explore and delve into the understanding of the schedule delay causes, while accounting for each individual project's specifics.

After the researcher received and examined all the information requested from colleges, it became evident that there was a need to conduct a more comprehensive in-depth analysis. For instance, for the purposes of an exploratory interview the researcher included potential factors which could affect the project's schedule in an indirect manner. The complete analysis path is as follows:

1. Evaluation of the potential contractors. An assessment whether there is a potential link between the lowest bidder/ bids variation and the project's actual cost. Determine if the bidder can indirectly impact the schedule variation.
2. Evaluation of the factors which can impact the project's actual budget and can potentially affect the actual schedule.
3. The next focal point is cost variation and its association with schedule variation. Performing an in-depth analysis of the impact of the project's planned and actual costs as well as trying to establish a link with potential schedule delays.
4. As a next step, the researcher set to evaluate the design professionals-related factors and their impact on schedule, through the rework and change orders and whether the number of design consulting companies has a potential direct link to a high number of change orders per project. A high number of change orders may eventually translate into additional time, initially not accounted for in the schedule. Therefore, the researcher will attempt to assess the indirect association of the design consultants with the schedule delay.
5. The next step would be to identify a possible link between schedule delays with the percentage of the Design and Bid phases' overlap.
6. The client administrative delays interpretation and its effect on the schedule variation.

Based on the above, the possible impacts of different factors were divided into three categories: client-related, design professionals-related, and contractor-related.

As a general note, for the purposes of the analysis the term "planned schedule” means an initial schedule that was designed using fast-tracking before the start of the construction phase. The term "schedule variation" means the difference between the planned schedule and "actual schedule". "Actual schedule" is defined as the project execution calendar, finalized when the project was delivered and adjusted based on real-time data.

The analysis was started with the evaluation of the bidders. Table 5.1 shows the number of bids received during an open tender, as well as the lowest and highest bids. Construction companies can easily access the public tender's documentation and participate in the bids, however, no matter the number of participants, the client will typically nominate the lowest bidder. Overall, bidders receive

an identical tender package. Construction union, CCQ, fixes market prices for the labour, meaning that the labour hourly rates are defined and fluctuate only slightly, depending on the region. The materials needed are identified in the devis and should be within the same price range for all the bidders. Last but not least, administration costs and ultimate profit generally average 10-15% for construction companies working within the public sector industry. Based on the above, it is quite logical that all bids received will exhibit a slight variation in prices. However, as can be seen in Table 5.1, several projects have a significant percentage of variation between the lowest and highest bidder. A potential topic which can be explored in future research could examine the reasons for the significant variation between the lowest and highest bid and what factors trigger such variation. For the purposes of this paper the analysis aims to identify how such significant variation can affect the schedule delay, whether directly or indirectly.

Table 5.1 Results of an open tenders

Project	**Number of bids received**	**Lowest bidder**	**Highest bidder**	**Percentage of variation**
A	10	$1 169 306	$1 378 900	18%
B	7	$868 380	$1 083 680	25%
C	6	$1 208 971	$1 669 000	38%
D	3	$1 373 544	$2 416 492	76%
E	7	$623 000	$966 000	55%
F	3	$719 500	$769 880	7%
G	5	$1 593 200	$1 768 000	11%
H	3	$1 596 180	$1 683 200	5%
I	2	$888 200	$939 468	6%
J	4	$413 000	$541 698	31%
K	5	$430 430	$529 485	23%
L	2	$598 000	$609 000	2%
M	9	$963 000	$1 418 550	47%
N	2	$1 916 000	$1 942 226	1%
O	13	$448 000	$537 300	20%
P	9	$700 814	$817 400	17%
Q	2	$526 900	$667 813	27%

The next step in the analysis process is to assess how the actual project cost is affected by the variation in bids' received. Figure 5.3 depicts a graph of the potential relationship between the above mentioned two variables. Results obtained do not exhibit an explicit dependency of project costs on the bid variation, however certain trends can be distinguished for several projects. For instance, However, samples do not move in a uniform manner, which makes it more challenging to quantify the impact of the variables unambiguously. To trace and prove the interdependency of two variables in question, an additional examination should be performed, including expanding the sample size to at least 100.

The next step in the analysis process is comparing the lowest bids to the actual cost of the project upon completion, as well as the schedule variation. A detailed comparison is presented in Figure 5.4. Generally, the impact of low project quotes is a very broad topic with some unclear implications. For example, the project quote may be deliberately underestimated and substantially more capital is spent throughout the duration of the project. It remains challenging to state with a high level of precision as to why low bids enter the marketplace, with 2 potential explanations being (a) low contractors' qualifications and experience, and (b) contractors deliberately attempting to lower the bid in order to win the tender and subsequently increasing the cost of the work through several change requests.

Figure 5.3 Bids' variation impact on Actual project cost

Figure 5.4 Lowest bids' impact on the schedule variation and on actual project cost

Results presented in Figure 5.4 show that the three factors are moving together in the same trajectory, as there are three clearly visible peaks for the sample projects D, G, H and N. Aside from the clear impact of the factor in question on the project cost and delivery schedule, it should be noted that these results can also be interpreted within the scope of the project budget's size, i.e the bigger the project budget is, the higher the risk of schedule and cost overruns.

Studying this aspect in more detail, we will take a look as to how the bids' variation affects the schedule and the project's cost, i.e whether a significant discrepancy between bids received can potentially translates into cost overruns and schedule delays. The comparison in question is shown in Figure 5.5.

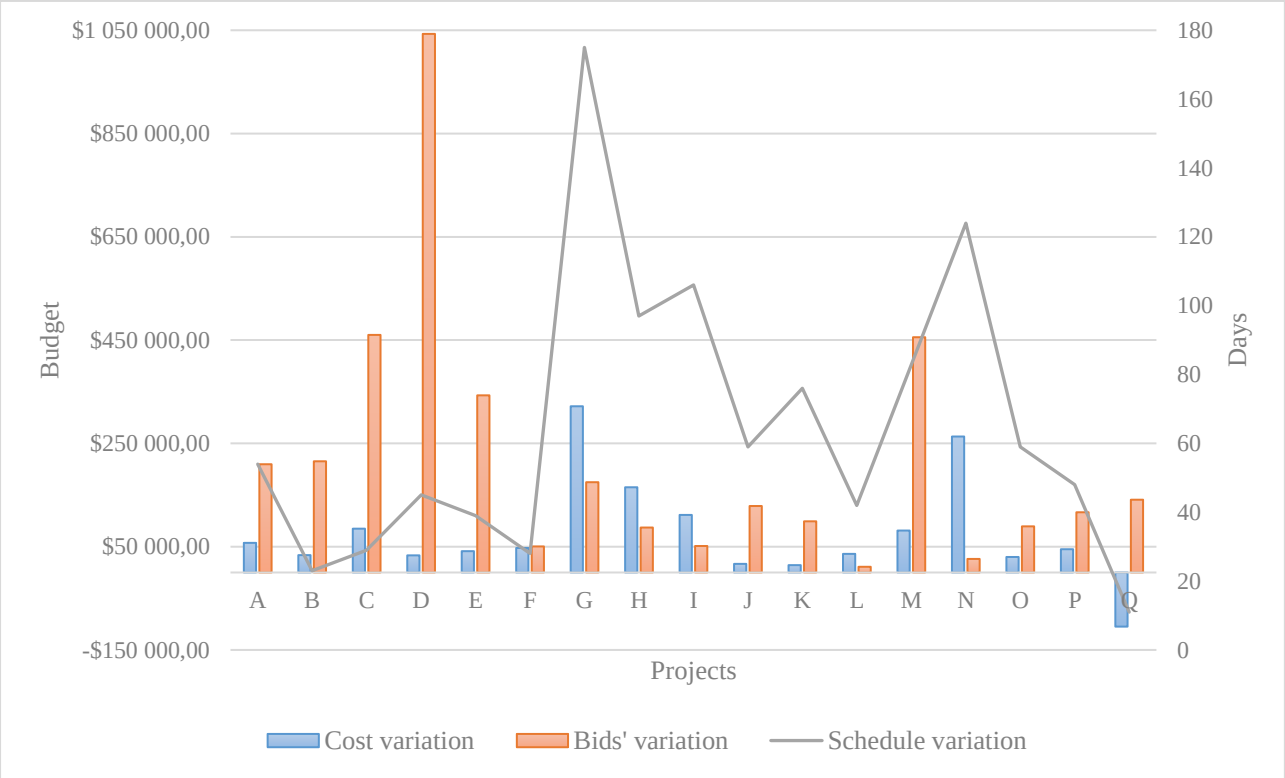

Figure 5.5 Bids' variation effect on cost and schedule variations

There are no visual signs of dependency on bids variation with schedule and cost variation from this point. However, there are signs of a potential relationship between schedule and cost variation. This can indicate that factors impacting the project's schedule, causing delays in the project execution timeline, will also cause an increase in discrepancy between the planned and actual cost of the project. Vice versa, factors impacting the project budget will affect the project schedule.

In Table 5.1 it was established that the variation between lowest and highest bidder can be drastic with a maximum of 76%. Table 5.2 presents the bids of the lowest and a second lowest bidder. The researcher will further present a visual comparison of the variation of time, cost and bids in Table 5.3

Table 5.2 Comparison of the lowest bids

Project	Lowest bidder	Second Lowest bidder	Bids variation of lowest and second lowest (%)
A	$1 169 306	$1 211 460	4%
B	$868 380	$902 723	4%
C	$1 208 971	$1 255 000	4%
D	$1 373 544	$1 383 333	1%
E	$623 000	$686 000	10%
F	$719 500	$768 500	7%
G	$1 593 200	$1 612 851	1%
H	$1 596 180	$1 644 000	3%
I	$888 200	$939 468	6%
J	$413 000	$434 700	5%
K	$430 430	$448 888	4%
L	$598 000	$609 000	2%
M	$963 000	$985 354	2%
N	$1 916 000	$1 942 226	1%
O	$448 000	$464 519	4%
P	$700 814	$715 000	2%
Q	$526 900	$667 813	27%

As per the above data, the average bids' variation for 17 analyzed sample projects is 5%; cost variation stands at an average of 6%; and, finally, the time parameter exhibits the highest variation

between the planned and actual schedule with a 17 sample projects' average of 32%. For certain projects, such as "G", "H", "M", N and "O", two out of three parameters (time and cost) exceed the average variation of the sample. Notably, for the project "I" all three parameters bids (lowest and second lowest bids), time and cost exceed the average variation of the sample.

Table 5.3 Percentage representation of average and actual time, cost and bids variation

Project	**Bids Variation (%)**	**Actual Cost Variation (%)**	**Actual Time Variation (%)**	**Bids Variation Average (%)**	**Cost Variation Average (%)**	**Time Variation Average (%)**
A	4%	5%	28%	5%	6%	32%
B	4%	4%	16%	5%	6%	32%
C	4%	7%	15%	5%	6%	32%
D	1%	2%	23%	5%	6%	32%
E	10%	7%	27%	5%	6%	32%
F	7%	7%	19%	5%	6%	32%
G	1%	20%	91%	5%	6%	32%
H	3%	10%	40%	5%	6%	32%
I	6%	13%	37%	5%	6%	32%
J	5%	4%	25%	5%	6%	32%
K	4%	3%	32%	5%	6%	32%
L	2%	6%	18%	5%	6%	32%
M	2%	8%	35%	5%	6%	32%
N	1%	14%	52%	5%	6%	32%
O	4%	7%	41%	5%	6%	32%
P	2%	6%	33%	5%	6%	32%
Q	27%	-20%	8%	5%	6%	32%

At this point, it remains challenging to assess as to why there is such a significant difference in cost and schedule variation is observed for some projects compared to the others, given that the analysis was carried out evaluating the same indicators. As a plausible hypothesis, the researcher assumed that during these projects, certain decisions were made and consequently actions were undertaken, which directly or indirectly influenced the indicators in question. Analysing factors that can be potentially directly or indirectly associated with a schedule delay, the researcher will continue following up on projects which will continue exhibiting significant deviations in results and analyze such projects for potential factors causing schedule delays and will present the summary of analysis in Table 5.6.

Figure 5.6 presents a potential relationship between the schedule and the cost of the project. As it can be seen from the figure, both variables are moving in a uniform manner. The data for projects "G" and "Q" do not follow the same trend as for the other projects sampled. For sample project "Q", the budget variation is negative, because the client decided to remove a part of the planned work from the original scope and decrease the project budget in order to meet the deadlines. The initial scope included a renovation of three designated areas, and after a change in scope; the mechanical, electrical and architectural work in one area was cancelled in its entirety. By changing the scope, the client made an effort to shorten the project duration and reduce the schedule delay, which consequently translated into project budget decrease of 104 807$.

Sample project "G" exhibits an astounding 91% of the schedule variation due to additional work that wasn't identified during the planning phase. This extra work had a detrimental impact on the project cost as well. More specifically, structural and civil engineering work was added, which significantly increased both the time and the price. In this case, the design omissions and incomplete drawings were the leading factors causing both schedule delays and an increase in price.

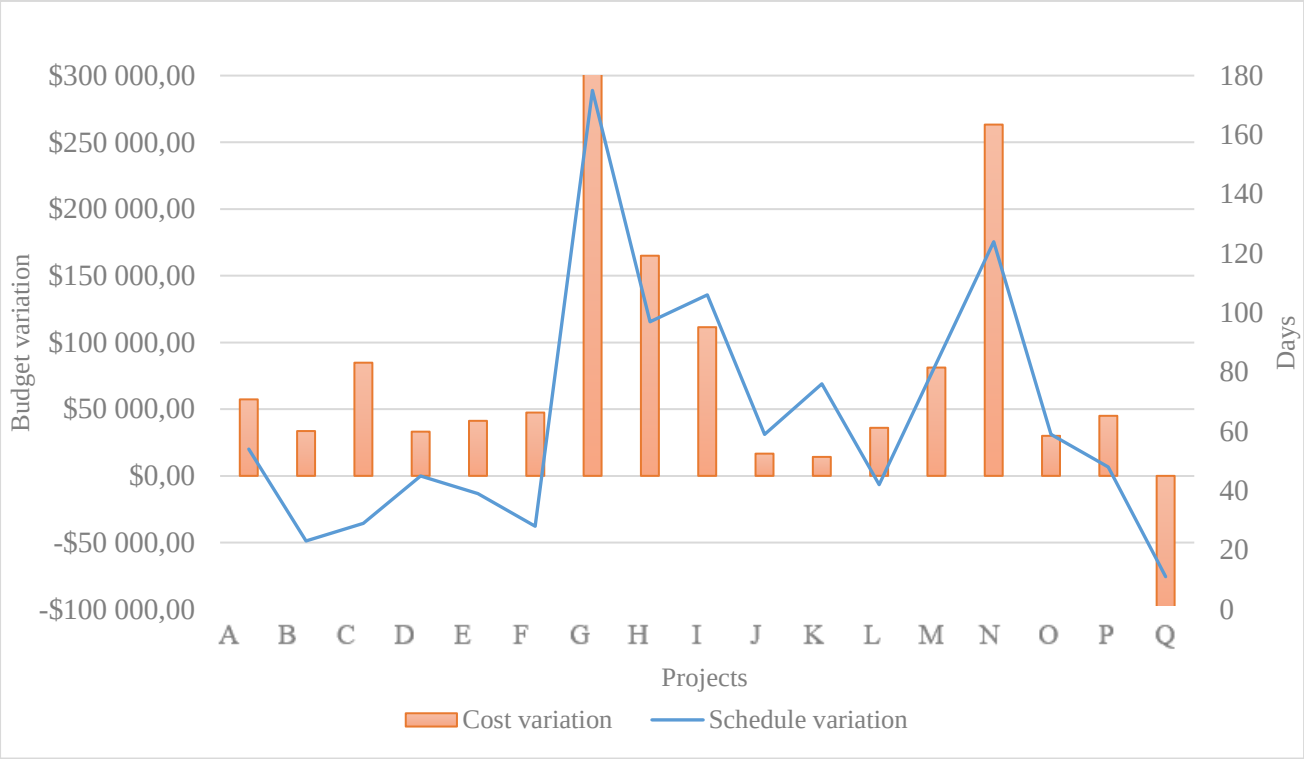

Figure 5.6 Project schedule and cost dependency

The next area of focus of the analysis was cost. Table 5.4 and Figure 5.7 depict the planned project budget versus actual project budget, as well as the percentage of difference.

Information extracted from the table below shows that projects “G”, “H”, “I” and “N” were executed with budget overruns of 10% or more. Essentially, these projects had to undergo additional rounds of approvals of the extras and eventually received the required budget to complete the project. Quite frequently it takes several weeks to get such an approval and the needed allocation of an extra budget. Since a Project Manager has to obtain approvals from both the Treasury Board and Executive Committees, these extra steps significantly increase the project’s duration and expands the project's schedule.

Table 5.4 Sample's planned and actual budget

Project	Planned budget	Actual cost	Percentage of variation
A	$1 169 306	$1 226 633	5%
B	$868 380	$901 969	4%
C	$1 208 971	$1 293 798	7%
D	$1 373 544	$1 406 675	2%
E	$623 000	$664 249	7%
F	$719 500	$766 950	7%
G	$1 593 200	$1 915 042	20%
H	$1 596 180	$1 761 180	10%
I	$888 200	$999 634	13%
J	$413 000	$429 657	4%
K	$430 430	$444 635	3%
L	$598 000	$634 008	6%
M	$963 000	$1 044 180	8%
N	$1 916 000	$2 179 273	14%
O	$448 000	$478 000	7%
P	$700 814	$745 814	6%
Q	$526 900	$422 093	-20%

Sample projects “C”, “E”, “F”, “M” and “O”, are in the gray zone since the extras do not exceed 10% of the total budget, but they have attained a relatively high mark of 7-8%. Depending on each project's context and its initial planning, contingency and management reserves may represent only 5% of the total budget. Therefore, these sample projects will require an approval on the college

level for a budget allocation to cover the extra costs. Such requests usually take at least a week before they receive authorization and the funding necessary to cover additional costs. Similarly, the project's budget projection and execution are discussed during the approval process. The client has to evaluate how much money will be needed to complete the project. Sometimes it may be worthwhile to suspend the project in order to find the necessary funds or reduce the scope in some cases.

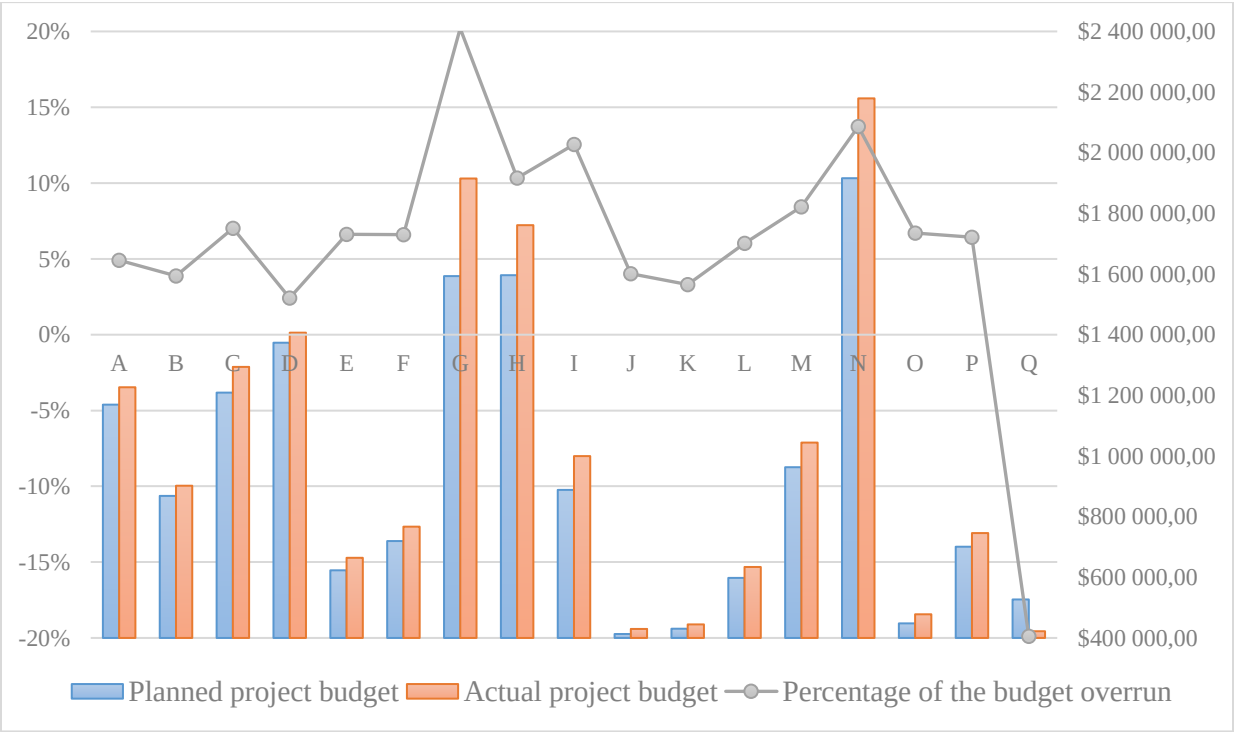

Figure 5.7 Planned Project Budget Versus Actual Project Budget

Based on the information presented in Table 5.4 and Figure 5.7, the next step in the analysis process is to evaluate the possible link between the planned project budget and the percentage of variation between planned and actual budgets. Figure 5.8 shows the trendline of the potential dependency between the variables, with the higher values of the planned project budget are associated with the higher percentage of the budget overruns. For the sample project “Q” the scope was changed during the project execution, so the percentage of change shows a negative value.

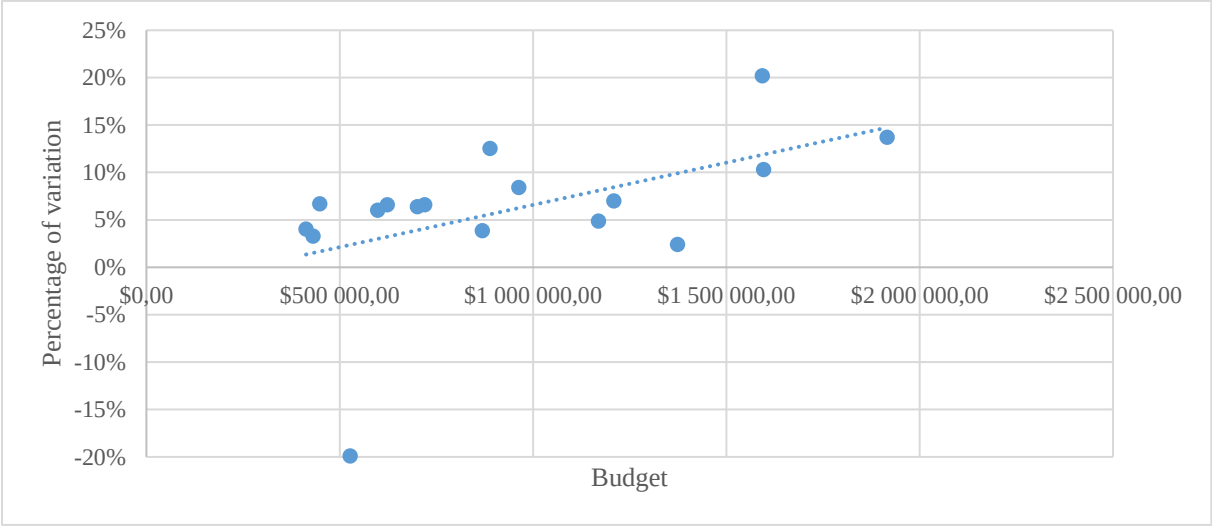

Figure 5.8 Potential dependency of the planned project budget and the budget overruns

Following the analysis and evaluation of potential contractors and their impact on the project's schedule, the next step of the study is to analyze the impact of the design professionals. Such professionals represent the client and provide engineering and architectural design, as well as leading the technical part of the project. Based on the documentation received multiple consulting companies participated in the project for certain samples. Of particular interest is to learn how the design companies will impact the project schedule, more specifically, if the factor of engaging multiple consultants on one project causes the schedule delay. The researcher considered that the consequences of incomplete tender packages and omissions in the design are Addenda and Change Orders. For each sample, the number of issued Addenda, along with a number of Change Orders were totalled. Addenda is a tool frequently used in public tenders, which serves as the first application of fast-tracking. Design professionals use Addenda to publish the final design for a tender when the Bid phase has already started. Hence, they are overlapping the Design and Bid phases and, at least hypothetically, reducing the duration of the project.

In contrast, Change Orders used during the Construction phase and indicate any changes from the original construction plans. Figure 5.9 depicts the information on the number of Change Orders and the number of design consulting companies used. The maximum number of Change Orders of 34 and 32 correspond to sample projects “N” and “M”, respectively. Projects “A”, “G”, “H”, “I”, “K” and “O” had over 10 Change Orders throughout the project execution.

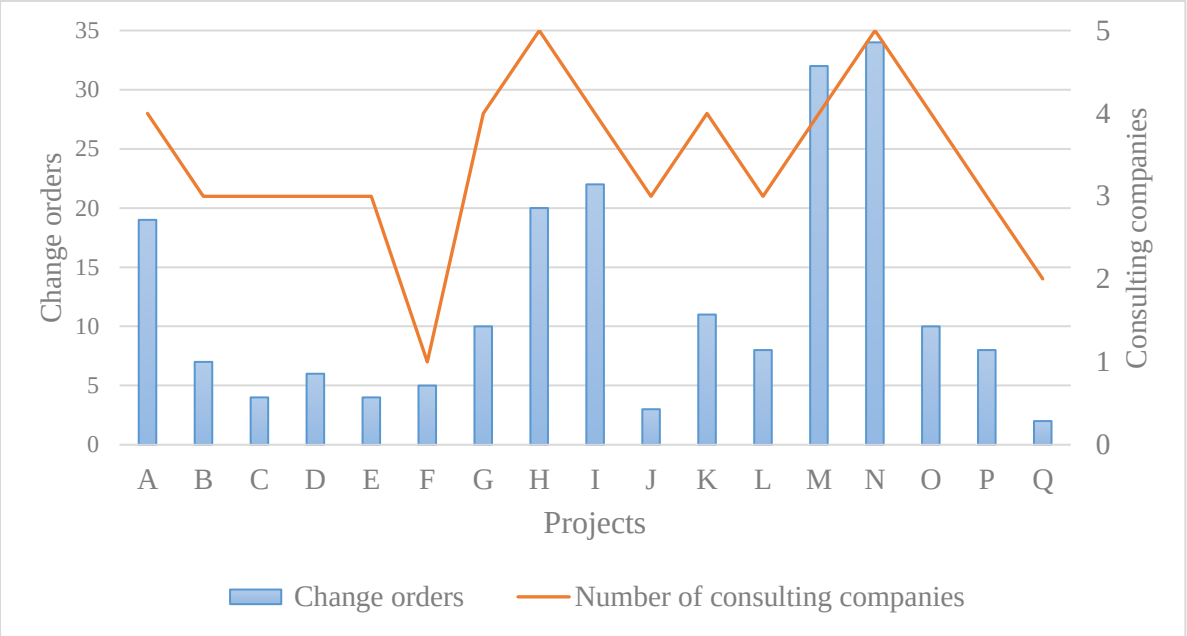

Figure 5.9 Change Orders Versus Design Professionals

For samples “H” and “N”, five consulting companies were working on the project design. Therefore, the client had to engage in more complex communications, in order to ensure that the coordination of all parts of the design was done without any contradictions. There is no clear tendency at this point. For several projects, a higher number of companies involved in the project's design potentially corresponded to a higher number of Change Orders during the project execution. However, at this point, it should be noted that other factors are possibly causing additional work and rework, which directly translated into Change Orders.

Similar findings were examined by other researches. Alnuaimi et al. (2009) found a link between the qualification of the consultant and the Change Orders caused by the client. According to the authors, the fact that the client may not receive proper information and suggestions from the design professionals during the design phase, will inevitably lead further to changes during execution. However, Larsen, Shen, Lindhard, and Brunoe (2015) found that other factors which impact an increase in the number of Change Orders are client-related, as the client will request modifications to design or require additional work to be added to the scope. Depending on the team's qualification, such requests can result in increased omissions, changes, and rework, leading to time overruns.

Dehghan and Ruwnapura (2013) found that overlapping has a maximum duration beyond which further overlapping is impossible and will cause significant rework. When the researcher was perusing the projects' documentation, it was established that Project Managers overlapped the Design and Bid phases in all cases. Although this decision was part of the approach to shorten the project duration, it remains to be seen whether the duration was in fact shortened. It is unclear weather the percent of overlap will have an impact on the project when fast-tracking technique is applied. The column "variation in overlap" shows the percentage for each project, therefore it will be possible to make a comparison with the schedule variation.

The information about schedule delays, the project's total duration, and the duration of the Design and Bid phases overlapping were selected and grouped in Table 5.5. Highlighted in red are the samples representing over 35% in variance between the project's planned versus total duration and over 45% in variance overlap of the Design and Bid phases.

Table 5.5 The summary of the sample's schedule

Project	Schedule delay, days	Total project duration, days	Percentage of variation	Overlap of Design & Bid, days	Variation in overlap, %
A	54	192	28%	12	55%
B	23	144	16%	6	30%
C	29	192	15%	7	47%
D	45	192	23%	7	35%
E	39	144	27%	7	35%
F	28	144	19%	9	45%
G	175	192	91%	12	46%
H	97	240	40%	14	64%
I	106	288	37%	18	62%
J	59	240	25%	6	40%
K	76	240	32%	7	37%
L	42	240	18%	6	30%
M	83	240	35%	9	50%
N	124	240	52%	15	68%
O	59	144	41%	7	47%
P	48	144	33%	4	20%
Q	11	144	8%	6	33%

- over

35% in variance the project's planned vs total duration

45% overlap of the Design and Bid phases

Interestingly, all of the seventeen fast-track projects selected for multiple case study were delayed to some extent. The schedule lags vary, with the minimum delay of 15% and the maximum as high as 91% of the planned duration. Sample project “Q” shows a figure of 8%, albeit the fact that the scope of the project was modified in an attempt to meet the deadline. Eventually, the project was commissioned 11 days later than planned. Project “G” was commissioned 175 days later than planned, which represents a schedule variance of 91%. Such a variation can be explained by the fact that during project execution additional work was identified, which was not a part of the initial design: a problematic area and the necessity of correcting part of the site were omitted during the design phase.

Figure 5.10 shows the potential connection of two factors: the percentage of the overlap and schedule variance. Signs of a potential relationship between the indicators is noticeable, as each value moves closer together in a similar trajectory. Hence, the higher the percentage of the overlap, the higher the chances that the project will have a more significant schedule variance. Sample projects “A”, “G”, “H”, “I”, “K”, “M”, “N” and “O” show over 35% overlap of two phases, which considerably influences the total duration of the project and the variance between planned and actual schedule. The use of the fast-tracking amid the Design and Bid phases appears to bring a negative result.

Figure 5.10 Association of the schedule variation and the Design and Bid phases overlap

Earlier in this chapter, the analysis aimed to identify whether Design Professionals- and Contractor-related factors will have an impact on the schedule delay. Last but not least are the client-related factors, which are represented by administrative procedures and mostly associated with approval processes. Figure 5.11 exhibits Client-related delays and schedule variance.

An unusual development was discovered during the review of the data collected. Results are published after the public tender opening has taken place, but the actual contract is awarded with a significant leg in some cases. For example, sample projects “H”, “M” and “N” have over 30 days of delay between the Bid phase and the start of Construction. Based on the samples' preliminary schedules, this delay was not forecasted by a Project Manager and was not included in the schedule. Sample projects “G”,”I”, “K” and “O” have over 15 days of delay between two phases.

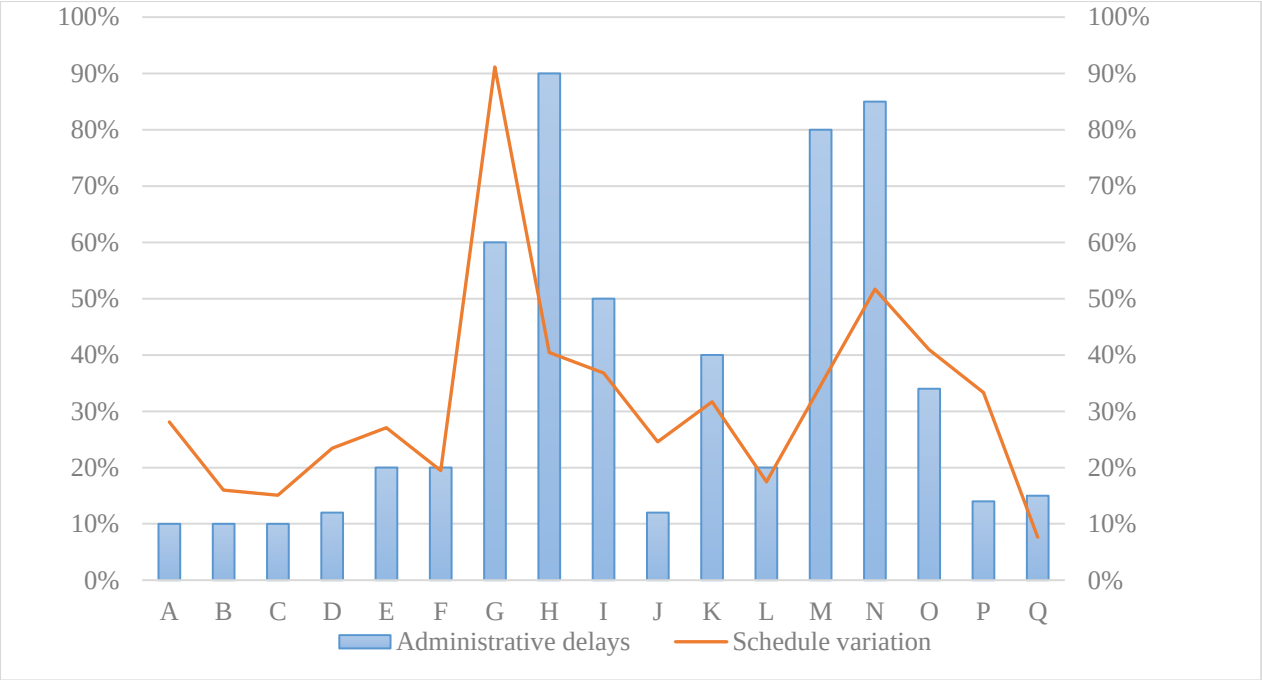

Figure 5.11 Potential relation of the Client Administrative Delays and Schedule Variation

Both variables appear to move uniformly, showing the signs of a potential relationship. The context of the Client-related delays for each sample may be different. However, the overall tendency exposes a possible link between administrative client-related processes and their impact on the project's timely execution.

After breaking multiple indicators down, the researcher chose projects “G”,”H”, “N”, “M” and “I” which exhibited significant deviations from the rest of the sample. Table 5.6 presents possible reasons related to schedule and cost variation combined together with the type of the project. The factors obtained will be compared with data in Table 4.4 gathered during the exploratory interview.

Table 5.6 Potential association of factors causing delays and type of projects with schedule and cost variations

Project	Schedule delay, days	Schedule delay, %	Cost variation, $	Cost variation, %	Type of project	Factors causing delays
G	175	91%	$321 841	20%	DBB fast-track Renovation project divided into 2 phases Est. duration 8 months. Est budget 1.5 mil dollars.	Stakeholders involvement in the project; Inadequate scope definition; Incomplete plans and devis; Design omissions/errors; Site conditions
H	97	40%	$165 000	10%	DBB fast-track Replacement of HVAC system Est. duration 10 months. Est. budget 1.5 mil dollars.	Incomplete plan et devis; Design omissions/ errors; Complexity of the scope; Internal by-law approval process; Lack of guidelines; Lack of the expertise of the GC
I	106	37%	$111 434	13%	DBB fast-track Remodeling project Est. duration 12 months. Est. budget 1 mil dollars	Incomplete plans and devis; Inadequate scope definition; Lack of the expertise of the GC; Equipment and resources availability; Coordination between Client-GC-Professionals
M	83	35%	$81 180	8%	DBB fast-track Remodeling project Est. duration 10 months. Est. budget 1 mil dollars	Internal by-law approval process; Design omissions/ errors; Availability of the site; Lack of guidelines; Coordination between Client-GC-Professionals
N	124	52%	$263 273	14%	DBB fast-track Remodeling project Est. duration 6 months. Est.budget 2 mil dollars	Unrealistic execution schedule; Internal by-law approval process; Inadequate scope definition; Lack of the expertise of the GC; Coordination between Client-GC-Professionals; Design omissions/ errors; Labour shortage

In the above cases, the term “renovation project” refers to restoring the original space using new design, while the term “remodeling project” means a structural alteration of a space, creating a new layout and a new design.

For project “G”, it remains highly likely that one of the main factors causing such a drastic schedule and cost variation is associated with an inadequate scope definition, which entailed that the stakeholders were not satisfied with the outcome and requested additional changes. Over 15 requests in Change Orders are marked as modifications or additions, demanded by a Client. However, the colossal change came from the incomplete plans and devis, as well as design omissions. As mentioned earlier in this chapter, the oversight in the structural design caused a major modification to the plans, which required an addition of a new concrete slab, adding demolition work under the conditions of mold and asbestos. Such site conditions were not accounted for in the original design and ended up costing the PM a week of delay, as the site was closed due to the health and safety concerns.

Project “H” had over 30 days of delay, which was not originally included in the project schedule and caused by the internal approval processes. Additionally, a high number of Change Orders required on-the-go changes due to the modifications and additions to the original concept. Finally, some work was not defined in the mandate of the project and was added during the construction phase, as scope of the project was reevaluated several times.

With regards to project “I”, the challenges stemmed from poorly defined scope and incomplete plans and devis, which led to a delay at the beginning of the construction phase, when instead of starting the work, the contractor had to wait for modifications in design and final decisions from the client on how the space was to be used. Additionally, certain activities were delayed due to inadequate resource distribution and equipment availability, possibly indicating the lack of expertise of the GC in managing fast-track projects.

Project “M” was delayed for over 30 days due to the clients’ approval processes, as well as over 15 days due to the internal schedule of the college, as some areas were not available until a certain time. The lack of guidelines in approaching fast-track projects and a lack of possible risk assessment was the prevailing factor in decisions made by project stakeholders. Also, worth mentioning is the poor communication between GC, Client and Design Professionals. Over 18 days

of delay due to directives changes were indicated in the final project schedule. They were sent for approval to different stakeholders and were not efficiently communicated, in order to reduce the timeline of this process. Last but not least, 32 Change Orders were issued throughout the duration of the project, mostly with modifications to the original design caused by initial design omissions.

Project "N" was equally impacted by a number of factors which caused a schedule delay and budget overruns. First of all, it took 34 days to get a contract approval and confirm budget allocation for a client. Poor coordination between the GC, Client and Design Professionals created a lag in communication and approval processes, adding 20 days extra to workshop drawings and Change Orders approvals. With regards to the Change Orders, a maximum sample number of 34 Orders was issued, when compared to the rest of 17 analyzed projects. 34 of Change Orders are indicative of multiple corrections and modifications in design due to errors and omissions. Finally, the GC provided an unrealistic schedule at the beginning of the construction phase and probably showed the lack of the expertise throughout the project, as resources were not available as needed during certain periods. However, the same might also be associated with the fact that GC subcontractors experienced a labour shortage.

After analyzing the 5 projects selected, potential factors associated with schedule delays and cost overruns were identified. The top 5 factors are as follows:

1. Design omissions/ errors;
2. Incomplete plans and devis;
3. Internal by-laws and Executive Committee approvals (time) and Coordination of GC-Client-Professional
4. Lack of the expertise of GC team
5. Inadequate scope definition

During exploratory interview and during multiple case studies Design Omissions / Errors ranked as a number one factor, while a total of 3 out of 5 factors were named by project practitioners during the exploratory interview process. This can potentially signify that should these factors occur during the fast-track projects, they are most likely to cause a schedule delay. Additionally, they can potentially influence the occurrence of other factors, whether directly or indirectly.

Equipment and resource availability, as well as labour shortage were ranked number 2 and 3 contributing factors during the interview. During the project evaluation stage, the researcher found signs that such factors may cause a significant delay for projects “I” and “N”. However, for projects “G”, “H” and “M” these signs were minimal and may not largely impact the project delivery schedule, based on the documents analyzed.

5.3 Propositions of multiple case study

The summary of the propositions that emerged from the qualitative multiple case analysis is presented further in this section. Baxter and Jack (2008) stated that during an exploratory study, propositions equated with hypotheses which are essentially educated guesses as to the study's possible outcomes. Propositions suggested are related to the client, design professionals and the contractor.

During the analysis stage, the impact of bids on the actual project budget was evaluated. In several samples, the variance between the lowest and the highest bidder is drastic. It is difficult to state without a shadow of a doubt whether results obtained are a coincidence and to some degree a consequence of market fluctuations and labour shortage. Perhaps, the lowest bidder could have inadequately estimated the required work and provided poor scheduling. In this case, samples with a higher percentage of change between the lowest and highest bidder may exhibit a higher actual project cost. The first proposition is that the bid variation can potentially cause cost overruns. Several sample projects show a potential link between both variables; however, an additional study of a larger sample is required to ascertain this proposition.

The second proposition that the cost overruns can cause a schedule delay. Due to the need for additional budget approval and allocation, the process might require several weeks and therefore delay work execution. If budget overspending exceeds 10%, further approval from the Treasury Board and Executive Committee will be required along with supporting documentation as proof and a detailed explanation of the situation. Until documentation is in full compliance and necessary funding is received, the project will remain "frozen." Certainly, this will have a detrimental impact on the overall duration of the project.

The third proposition is that the number of design professionals involved in the project will negatively affect the project's schedule and inevitably cause delays. As both DBB delivery and fast-track methods require a high level of clear communication and coordination between the project team and a large number of consulting companies will potentially expose the project to miscommunication risks and design errors. A higher number of consultants will also drastically increase the number of communication channels, which will lead to increased time for design approvals and a higher probability of omissions when drawings are put together. These assumptions were formed as potential sample projects with a higher number of consulting companies exhibited a higher percentage of Change Orders and issued Addenda. Although Addenda are used as a tool to overlap two phases in order to shorten project duration, Change Orders are undesirable as they are often associated with errors and omissions in the design.

The fast-tracking method is used when there is a need to perform the project within a shorter period. In order to adapt this method to the public college system and deadlines some Project Managers use the schedule compression technique to overlap the Design and Bid phases, despite ample evidence that in many cases the resulting effect is contrary to the desired one, leading to multiple schedule delays. This proposition is based on the analysis of each sample project’s schedule variance and the phase overlap percentage.

Another proposition that design omissions/errors are one of the main factors causing schedule delays in DBB fast-track construction projects in public colleges. Together with incomplete plans and devis, and inadequate scope definition, these factors could potentially be eliminated or avoided, if the pre-project detailed planning or feasibility study would have been conducted.

Another factor that was identified during the qualitative multiple case study is client administrative delays. In public colleges, the approval process sometimes takes longer than originally planned. All sample projects analyzed have exhibited at least a ten-day gap between opening/publishing of the bids' results and awarding the contract. The contract had to pass the Executive Board approval and since the dates were established for the full year in advance, the Project Manager had to manoeuvre and plan the project accordingly, while taking into account such dates as fixed time constraints.

5.4 Summary

The multiple case study's findings show that schedule delays can be impacted in both direct and indirect manner. In addition to the pertinent factors identified during the interview stage, certain unexpected findings were uncovered during the analysis stage. For all the seventeen sample projects, the main overlap fell on the Design and Bid phases. Additionally, the client- related administrative delays were uncovered, which, if present, can significantly affect the schedule timeline variation.

The path of analysis was outlined, offering 6 main angles to the research. Projects have been evaluated through the prism of such factors as the evaluation of the bidders and their potential impact on schedule and cost variation, potential impact of design professionals' factors and, finally, the impact of multiple Change Orders.

The above research and analysis represented the second step in identifying factors and their potential interrelationships and their combined impact on the project's timeline. During the evaluation of multiple indicators, 5 projects were selected for a more detailed examination. Finally, the findings were compared to the interpretations outlined in Chapter 4.

The results of the multiple case study will be discussed in chapter 6.

CHAPTER 6 DISCUSSION

The focus of this chapter is the interpretation of the results obtained in the previous chapters. The researcher will provide a broader overview of the proposals, recommendations for implementation, as well as various strategies on approaching challenges arising during implementation of fast-tracking techniques in DBB projects. The relevance of different factors will be equally addressed and compared to the existing research on the subject matter.

In previous chapters, various sources of information and data were presented in order to come to meaningful conclusions with regards to stated research objectives. Most recent information about fast-tracking projects, public construction processes, and Design-Bid-Build delivery model were extracted and analyzed by means of a comprehensive literature review, exploratory interviews and a qualitative multiple case study aimed at identifying factors causing schedule delays.

6.1 Results versus literature

The results of the qualitative multiple case study, as well as the exploratory interview, will be compared with the existing literature in this section.

In their work Bagaya and Song (2016) discussed results of the study conducted by KPMG International (2013), in which 77% of participants reported project underperformance caused by imperfect estimation process and failed risk-management processes. According to Moazzami, Dehghan et al. (2011), the most significant risks causing delays are cost overruns caused by inaccurate cost estimates, design errors and omissions, and change orders. One of the first aspects analyzed in the case study is the impact of the contractor’s bids on the cost overruns. Cost overruns will subsequently impact the performance of the project, causing a schedule delay. The topic remains open to interpretation with regards to the reasons causing such a colossal (in some cases over 70%) variance between highest and lowest bid estimates. The proposition is that there are two main factors contributing to such variation: inaccurate cost estimates and poor scheduling. In the case of public colleges, cost overruns were identified as a factor which will eventually lead to a schedule delay. Requests for additional budget and budget reallocation's lengthy approval processes contribute to a more significant variance between planned and actual schedules. The

study results envisage that usually fixed-price contracts are not suitable for fast-tracking, both for complex or non-complex projects (Moazzami et al., 2011). Perhaps, a lump sum contract structure is a root cause of the budget over-expenditure due to incomplete plans and omissions in the design during the Bid phase. It remains challenging to predict changes which can be brought on during the project execution. As a matter of fact, cost overruns and schedule delays are both parts of the same vicious circle. Given a limited budget, Project Managers generally agree to extend the schedule, often performing the work during irregular work hours and weekends, leading to higher costs. Conversely, for time-driven projects, the client can consent to add extra resources to finish projects on time, leading to an increase in the project's actual cost.

Goudreau (2001) reported five key elements that burden projects: payments, authority, change order, schedule of the work, and contract documents (Alnuaimi et al., 2009). A multitude of research papers exists, in which change orders were named as one of the factors that cause schedule delay, for example Larsen, Shen et al. (2015) named it as one of the top five factors for public construction projects. In this study, the factor that causes a higher percentage of Change Orders is the number of consultants. A higher number of consulting companies working on the same project will substantially increase the chances of errors and omissions in design and contribute to a higher percentage of Addenda and Change Orders. Change Orders will eventually cause a delay, as the extra work or rework in question was not planned initially. Both Fazio et al. (1988) and Williams (1995) named a number of risks associated with fast-track construction projects, including lack of design optimization and coordination on behalf of consultants, along with insufficient design information. This study supports the above statements, as during the interview and case study consultant-related factors were found to have a significant impact on the project's performance. According to Ahmed et al. (2003), consultant-related factors are directly linked to design-related delays.

Furthermore, design, construction, and labour-related factors will substantially impact the schedule delay than payment-related factors. It is worth mentioning that during the interview stage, the top external factors named were equipment and resource availability and a labour shortage. These factors will not only have a direct impact on the schedule and budget, but can potentially jeopardize overall project delivery. Failure to provide sufficient labour is a red flag, which points to the contractor having trouble paying its subcontractors or is in dispute with them (Conley, 2015).

One of the most important case study findings was the impact of phase overlapping on the project's delivery timeline. Overlapping has a maximum duration beyond which further overlapping is impossible, as no preliminary information is available (Dehghan & Ruwnapura, 2013). Using the multiple case study samples, the Design and Bid phase had 47% of average overlap, causing 32% of the change in schedule. It remains quite significant and representative that none of the seventeen sample projects were delivered on time and within the allocated budget. Dehghan and Ruwnapura (2013) stated that project duration reduction has to have a positive effect on activities that form a critical path; otherwise, non-critical activities do not reduce the duration. Besides, such overlapping will eventually cause an increase in budget costs. Therefore, to overlap phases, the client and project professionals should plan such an undertaking in advance, taking into consideration the positive and negative effects of the schedule's compression.

Lastly, during exploratory interview and multiple case study the top factors causing schedule delay were design omissions / errors, inadequate scope definition and incomplete plans and devis. Scope definition and preliminary design selection are usually established during pre-project planning. Wang and Gibson Jr (2006) emphasised that significant decisions are made during the early pre-project planning phase. They equally mentioned that it is a crucial stage of the project and can not be neglected, as it constitutes a comprehensive framework for detailed project planning and scope definition. By analysing the 17 projects and interviewing project practitioners, the researcher came to conclusion that insufficient time is allocated to properly defining the base parameters of the project. The feasibility study or pre-project design are often underestimated, however, they can potentially reduce risks of design errors and omissions and reworks.

6.2 Theoretical contributions

The objective of the research was accomplished by identifying a set of factors which can have a significant direct or indirect impact on the project and potentially cause schedule delays. The factors were discussed in the previous sections of this research paper and recorded accordingly.

The following list of sub-objectives were equally explored and accomplished during the research, providing both theoretical and practical contributions to the construction industry in Quebec public colleges.

1. The context and the description of construction projects within public colleges were gathered from pieces of existing public data and literature, interviews and the multiple case study. Such a comprehensive assessment helped obtain a more accurate understanding of the environment in which the fast-track DBB public construction projects were executed.

2. Furthermore, the researcher recognized that there are multiple series of events and circumstances shaping the conditions under which the schedule compression technique is eventually selected and implemented. The most salient ones are timeline restrictions of the academic calendar, followed by the grant deadlines and recently accepted laws and regulations imposed by the government authorities.

3. Factors which had either negative or positive impacts on project schedules were identified based on the multiple case study results and the interviews. The factors explored were compared and in certain cases matched to existing research papers from related domains. However, taking into consideration a relatively small sample size of projects examined, it remains challenging to unambiguously confirm obtained results within a meaningful level of statistical significance. Thus, it would be beneficial to conduct similar analysis on a sample of a larger size, by means of a variety of statistical tools, such as factor analysis, regression analysis or an extended case study.

4. Based on the existing research papers and the exploratory interview, necessary measures and recommendations were suggested to outline the study's practical applications.

To summarize the above, the contribution of this research paper was delivered through a thorough examination of a topic, which has not yet been studied to a great extent. Preliminary conclusions of this report can serve as the first step towards defining and formulating a new theoretical and practical knowledge base within the construction project management segment. Practical recommendations on the subject matter are outlined in the following section.

6.3 Contributions and practical recommendations

The primary objective of this section is to synthesize the interview and multiple case findings and discuss the results obtained within the framework of the research question.

To the dislike of clients, contractors and consultants, many projects experience extensive delays and thereby exceed initial time and cost estimates(Odeh & Battaineh, 2002). The main disadvantages of the DBB delivery model are high risks of miscommunication and lack of coordination between the parties involved. At the same time, the fast-tracking method is exposed to similar types of risks and the successful delivery of the project requires conscientious and scrupulous planning and managing of the communication channels between the project team and multiple stakeholders. Odeh and Battaineh (2002) suggested adopting new approaches to delivery systems, such as Design-Build and Construction Management in order to reduce the risk of schedule delays.

Strategies proposed by project practitioners and recommendations found in the existing literature are summarized below, along with practical recommendations for their implementation.

6.3.1 Recommendations for schedule delay mitigation

The recommendations linked to the multiple case study, exploratory interviews, and existing literature are the following:

1. Develop and adopt a new framework. The way to achieve sustainable reductions in design delivery time is to develop a framework based on concurrent engineering principles, which can be used to evaluate information dependencies in the design process (Bogus et al., 2005). It is a very important aspect as design omissions, and consultant related factors are on the top of the list of causes related to projects underperformance.
2. It is important to plan the project far in advance, while identifying potential risks and preparing a risk response plan to the best of one’s ability. The results of the case study done by Pena-Mora and Park (2001) showed that project schedules overlapping of phases over 50% may not be efficient and can negatively impact the project's vital indicators. Therefore,

it is crucial to thoroughly plan for the implementation of the fast-tracking method applied to the project, rather than making critical decisions without planning and preparation. Alnuaimi et al. (2009) also suggested preparing a well-defined brief scope definition with the help of a feasibility study or end-user interview. The client should have a good understanding of the project's objectives and expected results.

This strategy can minimize the impact of external factors, such as equipment and resource availability, inadequate scope definition and incomplete plans and design, as well as potential design omissions / errors which may be encountered along the way. Therefore, during the pre-project planning stage, the Project Manager and the team will have time to work on a detailed scope definition and engage the design professionals earlier in the timeline to work on the project's design. To emphasize this point, the 3 out of 5 main factors were potentially associated with inadequate pre-project planning based on the analysis of results of 5 projects from the 17 sample projects.

3. Timely monitoring and control of the established deadlines and commitment of the general contractor. It is worthwhile to monitor project execution on a daily basis for small projects and weekly basis for medium-sized projects. This form of control will allow project practitioners to detect schedule baseline deviations during the early stages of their occurrence and prepare an immediate response plan. Reducing the response time and allowing the Project Manager to align all execution work with the schedule will help prevent activity and resource slippage. In addition, weekly follow-up meetings with all project stakeholders are essential in order to keep budget and timeline under control. By taking the above measures the PM will be able to directly influence the stakeholder involvement factor.

4. Use various schedule breakdown techniques, such as milestone scheduling or rolling wave planning technique. When the project is performed with an overlap of two phases, it is hard to develop a detailed sequential execution schedule. It would be more appropriate to use techniques which provide for ongoing schedule development as new information becomes available. This approach can save the client's time and remove unnecessary pressure on designers, potentially reducing the number of design omissions. Considering that the designers are often under pressure to minimize plan development time in order to speed up

the construction phase, removing such undue pressure should reduce overall project delivery time (Bogus et al., 2005).

5. Verify the design by the means of an engineering peer review. It can be highly beneficial for a client to hire external consulting firms to cross-check existing design for potential omissions and constructability. As such, this action should minimize the risk of change orders, reworks and extras during the construction stage. Additionally, it might be useful to periodically review the design professionals selected to ensure their satisfactory technical capabilities, as suggested by Alnuaimi et al. (2009).
6. For the mid-size and large-scale projects, hire a Construction Manager who will act as a representative of the client and supervise the construction work. Fisher Jr (1990) proposed using the Construction Management model as it will minimize fast-tracking coordination problems and reduce the overall delivery timeframe. Songer, Diekmann, Hendrickson, and Flushing (2000), Cho et al. (2010) stated in their respective works that the optimal delivery method for schedule compression is the Design-Build. Nevertheless, one of the mentioned above methods can be tested and adapted for application in public colleges. Potentially decreasing the impact of the factor of stakeholder involvement and interference, design omissions and unrealistic execution schedule.

6.3.2 Recommendations to maximize positive impact opportunities on the project's schedule

The recommendations suggested below are directly linked to the factors identified during the exploratory interview, the multiple case study, and the existing literature.

1. Build a trustworthy and transparent relationship with design professionals and the general contractor. Building such relationships is an efficient manner to increase the level of motivation of employees and partners, as well as to build a supportive team environment. At the same time, PMs can clearly address budget and payment-related delays which have a drastic impact on the project performance, by clearly defining payment milestones and establishing a crucial liaison between the client, design professionals and the contractor. A

sufficient portion of the total payment should be tied to later contract milestones, in order to incentivize the contractor to complete those work items on time (Conley, 2015).

2. Using incentives rather than penalties. Public institutions are often hesitant to use incentives and consider such type of remuneration as a waste of money and extras. This perception is incorrect to a degree, as failure to complete the project on time may result in additional costs, loss of potential opportunities and increased risks, all of which can result in total costs which are multiples of the amount of incentive. Despite the existence of the penalties in the contractual documentation, it remains challenging to apply such penalties and fees in real life situations. It is a long and time-consuming process, which requires a considerable amount of time from project professionals, procurement, and legal teams. Generally speaking, instead of shortening the project duration, penalties might increase the gap between planned and actual schedules. Odeh and Battaineh (2002) suggested that the liquidated damages clause should be enforced and adapted to all the contracts, along with offering incentives for the early completion.

3. Adopt a new approach of procurement documents package preparation, which will include the detailed description of the expecting quality of the final result; important aspects as resources and equipment availability. For instance, if specific equipment or material has a long lead delivery time, it is imperative to prepare a pre-purchase procurement request.

4. During the Design phase, proceed with a two-step verification process of plans and devis. The first step will be an engineering peer review and the second one should encompass an audit by the college's maintenance specialist. Generally, operational maintenance staff should be very familiar with the facility and can be a valuable resource used to verify the proposed design and confirm whether its implementation is feasible and compatible with existing systems.

5. Use the technique of resource levelling or resources crashing to maximize the project execution. In certain situations, it can be quite prudent to reserve funds for night or weekend shift’s work. As Pena-Mora and Park (2001) suggested, labour control should be flexible, and the hiring process should be reduced to the highest extent possible, in order to reduce its negative impact on fast-tracking.

6.4 Research limitations

This research has delivered some valid practical conclusions and contributed to further development of public college's practices regarding the application of fast-tracking methodology for DBB projects. The limitations of the research conducted are as follows:

1. Research data was collected only from Design-Bid-Build fast-track projects executed between 2015 and 2019 from public colleges in the Greater Montreal region, since the primary research objective was to study the case of public colleges and identify factors that cause schedule delays. For the purposes of this research, no data was collected from other regions of Quebec. This limitation reveals the opportunity for geographic extension of the research.

2. The number of sample projects used for the qualitative case study is meaningful enough to develop preliminary conclusions, yet still somewhat limited. The goal of the study was to explore the phenomenon which hasn't been examined in-depth in any other research papers. The results should be validated further by means of a more extensive study based on a larger sample size.

3. The exploratory interview process included project practitioners representing the client. Expanding the research across the stakeholder dimension and including the data from contractors and design professionals will add substantial insights and increase the value of the propositions presented.

4. The case studies' interpretations might not be as valid for other public institutions, given the exclusive focus of this research paper on public colleges of Quebec. However, key insights might still be useful for other institutions and can be adapted to other organizations' needs.

Addressing these limitations will create an opportunity for further research, which is discussed in the next section.

6.5 Further research suggestions

There are plenty of opportunities for future research on the subject matter. Data collected for the purposes of this research can be used as a foundation for more extensive quantitative study using a sample of over 100 projects to either confirm or oppose the propositions developed. The next step would be conducting a Delphi survey, preferably including over 50 project practitioners from the public colleges in Quebec, as well as experienced design professionals and contractors. This approach will provide substantially more unbiased results.

Another direction of the future research could be confirming the validity of the factors identified in this paper, which can potentially cause schedule delays. Such factors can be further looked at under the lens of their frequency of occurrence, severity and their overall importance.

Finally, most prior research on the subject matter has focused on the fast-tracking technique application and optimization within the framework of the Design-Build delivery method. However, this is not the case in real life in real life situations, as such a framework was designed based on the principles of concurrent engineering to address fast-track projects for Design-Build delivery mode only. So far, there is no specific framework regarding the application of similar principles for the Design-Bid-Build delivery system. This lag should definitely be filled in the future, when considering the fact that DBB is being used as a default delivery system for various public institutions.

CHAPTER 7 CONCLUSION

The fast-tracking technique can be a successful tool when there is a need to deliver projects faster and reduce execution time. Considering the lack of guidelines and the fact that general project management practices are not tailored to address fast-tracking, there exists a strong demand for improvement. This study's findings show that the project schedule is affected by the client-, design professionals-, and contractor-related factors in different ways. As a result, the project manager has to focus not only on the schedule, but also on budget-related issues and quality all at the same time. Cost and quality factors will impact the schedule delays and vice versa. The client must also manage and maintain clear and concise communication with design professionals and contractors, since the top factors causing schedule variation were identified as the lack of proper planning and management, and design-related issues. As it was noted by Williams (1995), well- managed and experienced teams have a significant impact on the successful application of fast-tracking when executing a project. This study aimed to provide practical suggestions within the context of the public college system in Quebec.

This study's possible implications are directly related to the challenges faced by the DBB fast-track public construction projects managers, specifically with regards to the schedule timelines. Based on the results of this study, it is now possible to counter the impact of negative factors and adjust the delivery model so that fast-tracking projects will be more beneficial to execute. The researchers' primary goal was to convey the significant insights provided by this study with regards to multiple challenges faced by project management practitioners, as well as potential strategies to remedy such challenges, in hope of their potential application within the public college system.

This paper made a practical contribution to the industry practices, however there always are opportunities for continuous improvement and future research. It might be beneficial if this study will be followed by additional expanded research, which will demonstrate the effect of the factors on a broader level.

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APPENDIX A EXPLORATORY INTERVIEW QUESTIONNAIRE

POLYTECHNIQUE MONTRÉAL
TECHNOLOGICAL UNIVERSITY

Entretien exploratoire

(English message will follow)

Pour les besoins de la recherche, nous utiliserons la définition suivante du «fast-tracking » : *« Le « Fast-tracking » est une technique de compression de l'échéancier qui prévoit que des activités, ou des phases, normalement exécutées en séquence, sont exécutées en parallèle, tout au moins sur une partie de leur durée »*. (PMBOK, 6ème édition).

Considérant cette définition:

1. Combien d'années d'expérience avez-vous dans la gestion de projets dans un collège public?
2. Quelle est votre définition de la méthode accélérée dans la vie réelle et quels facteurs qualifieront un projet de fast-track?
3. Combien de projets utilisant la technique de «fast-tracking » que vous avez exécutés dans un collège public?
4. Pouvez-vous estimer le nombre de projets réalisés chaque année avec une ou plusieurs phases qui se chevauchent au cours de son exécution?
5. Combien de projets exécutez-vous par un an?
6. Quelle est la durée habituelle des projets dans les collèges publics où vous travaillez?
7. Quel est le budget moyen des projets accélérés?

a) par projet ; b) par un an

8. Pouvez-vous identifier les 3 (trois) raisons pour lesquelles le projet est exécuté de manière accélérée?
9. À quel stade / étape du projet la décision est-elle prise de passer à une méthode accélérée?
10. Quels sont les principaux facteurs qui ont une incidence sur l'échéancier d'un projet lorsque les phases de conception et de construction se chevauchent?

- Veuillez classer les facteurs positifs

- Veuillez classer les facteurs négatifs

11. Ces facteurs se produisent-ils également lorsque les projets sont exécutés de manière traditionnelle (séquentielle)?
12. Avez-vous des stratégies que vous utilisez pour atténuer tout impact négatif sur l'échéancier lorsque vous appliquez une méthode accélérée (fast-track) sur un projet?
13. Avez-vous des stratégies que vous utilisez pour maximiser les opportunités d'impact positif sur l'échéancier lorsque vous appliquez une méthode accélérée (fast-track) sur un projet?

Merci de votre participation et de votre intérêt pour cette recherche. Votre contribution est très importante et le résultat vous sera envoyé et dans les 14 prochains jours, puis si nous aurons besoin de quelques éclaircissements, nous communiquerons avec vous.

Exploratory Interview

(English message)

For the research purposes, we use the following description of fast-tracking: "Fast-tracking is a schedule compression technique in which activities or phases normally done in sequence are performed in parallel for at least a portion of their duration". (PMBOK, 6th edition).

Considering this definition:

1. How many years of experience you have managing projects in public college?
2. What is your real-life experience definition of fast-tracking and what factors will qualify the project as a fast-track project?
3. How many projects using fast-tracking technique you executed in public college?
4. Can you estimate the amount of projects per year that are performed with overlapping one or more phases during it's execution?
5. How many projects you execute per year?
6. What is the usual duration of the projects in public college where you work?
7. What is the average budget of the fast-track projects?
   a) per project; b) per one year
8. Can you identify the 3 (three) reasons why a project is performed in fast-track manner?
9.
10. What are the main factors that impact the schedule of a project when design and construction phases are overlapped?
    - Please classify the positive factors

- Please classify the negative factors

11. Do these factors also occur when the projects are performed in traditional (sequential) manner?
12. Do you have any strategies that you use to mitigate any negative impact on the schedule when you perform fast-track projects?
13. Do you have any strategies that you use to maximize the opportunities of positive impact on the schedule when you perform fast-track projects?

Thank you for your participation and interest in this research. Your input is very important and the result will be sent to you within 14 days, then if we will need some clarifications we will contact you.

APPENDIX B ACCESS TO THE INFORMATION FORM

Institution

Précisions sur l'information demandée (p.ex., le domaine, la période, le genre de documents)

Sujet de la recherche: projets de construction d'immobilisations (rénovation)
Période: 2015 à 2019
Portée du projet: 400 000 $ à 2 000000 $
Durée préliminaire du projet (estimée): 6 à 12 mois
Nombre de projets: 3 ou plus
S'il vous plaît fournir les documents suivants:
-Appel d'offres public, avec tous les addendas publiés, indiquant les dates publiées.
-Diagramme de Gantt du calendrier préliminaire du projet avant le début de la construction
-Diagramme de Gantt du calendrier définitif du projet
-Informations sur les résultats de l'ouverture de l'appel d'offres
- Toutes les ordres de changement
-Informations et documents sur la conception préliminaire et la conception finale. Si l'était un des changements majeurs dans la conception, veuillez préciser le motif et le demandeur de ces modifications
-Si le projet n'a pas été achevé à temps, veuillez préciser la raison et le (s) facteur (s) qui ont influencé l'échéancier d'exécution du projet
- Précisez s'il y a eu des retards ou des temps de traitement longs de la part des autorités pour obtenir l'approbation du projet

Méthode d'accès préférée : ☐ Recevoir une copie papier des documents ☐ Recevoir une copie électronique des documents.

Nom du demandeur

Adresse — Numéro, rue, appartement | Ville ou village

Province | Code postal | Numéro de téléphone

Cette demande est présentée en vertu de la *Loi sur l'accès à l'information* par

☐ un citoyen canadien, un résident permanent ou une personne présente au Canada, qui fait partie de :

☐ médias ☐ organisation ☐ membre du public
☐ entreprise ☐ secteur universitaire
☐ refuse de s'identifier

OU

☐ une société présente au Canada

Date

Les renseignements personnels du présent formulaire sont protégés par la *Loi sur l'accès à l'information* et de la *Loi sur la protection des renseignements* personnels.