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DELIVERY METHOD SELECTION FOR SUSTAINABLE PROJECTS

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Abstract: How to select the appropriate methods to deliver sustainable projects has gained growing concerns, especially when the demand for the sustainable projects has recently increased due to the accelerated depletion of natural resources and rising energy cost. The selection may not only affect the sustainable level that a project could achieve, but also the project final performance after being delivered. However, most current selection criteria were created for traditional projects, where sustainability was not fully considered. As a result, they cannot be directly used to select appropriate project delivery methods for sustainable projects. This paper proposes new selection criteria specific for sustainable projects. First, the characteristics of sustainable projects are identified. Then, all potential project delivery methods that can be used to deliver sustainable projects are reviewed and evaluated. Based on the characteristics of sustainable projects and the benefits/limitations of different project delivery methods, new selection criteria are proposed. The new selection criteria are expected to help owners, planners, and stakeholders decide which project delivery methods are more appropriate for their projects, when the sustainability requirements of the projects are required.

1 Introduction

It was estimated that there were over 13 million buildings in Canada; and these buildings accounted for almost 33% of Canada's energy production and 50% of extracted natural resources (Lucuik et al. 2005). Considering the current trend for the accelerated depletion of natural resources and rising energy cost, how to promote the sustainability of the built environments has gained the growing concerns in Canada. So far, more and more project owners, designers, and contractors have focused on the development of green buildings with the certification for the Leadership in Energy and Environmental Design (LEED). According to the statistics from the Canada Green Building Council (CaGBC), over 4000 Canadian projects have registered for the LEED® certification (CaGBC, 2013).

Despite the increasing demands for the sustainable development in Canada, there are limited comprehensive studies that investigated the selection of appropriate project delivery methods to achieve project sustainable design and construction. A project delivery method, by definition, equates to a procurement approach and defines the relationships, roles and responsibilities of project team members and sequences of activities required to complete a project (Walewski, 2001). The selection of an appropriate project delivery method may not only affect the sustainable level that a project could achieve, but also the project final performance on cost, schedule, and quality, after being delivered.

In order to address this knowledge gap, this paper proposes several project delivery method selection criteria that are specific for sustainable projects. First, the characteristics of sustainable projects are identified. These characteristics include LEED certificate level, project size, project cost, etc. Then, the

potential project delivery methods are reviewed and evaluated as long as they can be used to deliver sustainable projects. Based on the characteristics of sustainable projects, several new selection criteria are proposed considering the benefits/limitations of different project delivery methods. The new selection criteria help different parties involved in a project, such as project owners, planners, and stakeholders, decide which project delivery methods are more appropriate for their projects, when the sustainability requirements of the projects are required.

2 Background

There are several project delivery methods that are available for sustainable projects in Canada, including Public Private Partnership (PPP or P3), Construction Manager at Risk (CM@R), and Design-Build (D-B). Here are the details for these project delivery methods.

2.1 Public Private Partnership (PPP or P3)

The public-private partnership (PPP or P3) method has been widely considered by the government as a way to seek the financial and/or technical support in a public service or project from private sector companies (ACEC, 2009). Such partnership might bring several benefits (FTI, 2012). For example, more civil infrastructure projects could be initiated and developed through the involvement of the private finance (FTI, 2012). Also, governments could borrow the money at a low interest rate than the private companies, which may indirectly reduce the project cost. The collaboration between public authorities and private sector companies could help the integration and cross transfer of public and private sector skills, knowledge and expertise. Typically, in the PPP, the government is tied into a long-term contract with private companies, which may produce problems when it is necessary to make changes during the contract life (FTI, 2012).

The use of the PPP is now well established in Canada at the federal and provincial levels (CCPPP, 2013). It has played an important role when initiating and developing multiple building and capital projects in transportation, communications, power generation, energy delivery, water and wastewater facilities, waste disposal, and public service buildings. Recently, the PPP has been used frequently for small-scale development of schools, courthouses, and hospitals across Canada (ACEC, 2009).

2.2 Construction Manager at Risk (CM@R)

In the project delivery of Construction Manager at Risk (CM@R), two contracts are involved. One is between the owner and the designer, and the other is between the owner and the construction manager. Typically, a professional construction management service provider is hired during the design phase of a project, and the added construction manager plays an important role in the project development. The construction manager may hold the trade contracts and take the project performance risks during the construction phase. Also, the construction manager could be responsible for a guaranteed maximum price for completing a project (AIA, 2005).

There are several benefits, if a project is delivered using the CM@R. First, the involvement of the construction manager at the project design phase may provide the owner and designer the expertise on the project constructability, cost, and schedule, even when the project is still at the design stage (Kwak and Bushey, 2000). In addition, the construction manager could facilitate the project coordination between different parties, which might reduce construction claims. The main limitation of using CM@R to deliver a project lies in the fact that the fee for the construction manager, which is often not through the competitive bidding, may add another layer of project cost (AIA, 2005). The additional cost may make small projects unable to afford (Touran, Ali, 2009). In addition, the lines of communication between the designer and the owner may become hampered because of the existence of the construction manager (Touran, Ali, 2009). Therefore, it is important to clearly define the roles and responsibilities of the designer and the construction manager in a project.

2.3 Design - Build (D-B)

In the Design-Build (D-B) project delivery method, the owner contracts with a single party, who provides both design and construction services for a project. Many owners prefer this kind of project delivery method simply because the D-B provider takes a single point of responsibility for both design and construction in a project. This way, the provider could provide the assistance in project budget and planning during the project design phase, and the delivery of a project could be fast.

Typically, the selection of the D-B provider is weighted towards qualifications and experience (Tim Mearig, 2004). Therefore, it is difficult for the owner to determine whether the optimum price has been achieved for the work. In addition, the project cost using the D-B project delivery is likely higher than the traditional project delivery methods due to the increased project risks, the reduced bidding competitions, etc. (Tim Mearig, 2004). Considering these characteristics, the D-B project delivery method is targeted for new construction projects that are highly time sensitive or the projects with small groups with the little needs for reviews and/or mid-course design changes (Touran, ali, 2009).

2.4 Lean Project Delivery (LPD)

The Lean Project Delivery (LPD) method focuses on the full use of the knowledge and skills of all participants involved in a project. It aims to delivering the project value, quality, and performance with less project cost and risk through the collaboration between different parties (Joseph A., 2007).The LPD method could maximize the effectiveness during the design, fabrication and construction phases. The recent studies indicated that up to 40 percent of the waste inherent to the traditional project delivery method could be eliminated with the LPD method (Joseph A., 2007). In addition to the maximization of the project effectiveness, the benefits of the LPD method for the owner includes the easiness to link design options to the owners' needs/objectives, and the great potential for reducing project cost. As for the designer and the contractor, the LPD method could minimize the amount of rework, and reduce design documentation time (UHS Project development team, 2011). This way, they could make more profits by building the facilities right at the first time. Currently, the LPD method requires the highly effective collaboration. Therefore, the owner initially needs to take the lead (Ballard, 2000).

3 Objective and Scope

There are several project delivery methods available, but how to select an appropriate one for delivering a project with the sustainable requirements has not been well investigated. Selecting an appropriate project deliver method means choosing a suitable way or system to organize the relationships of different parties in the design and construction processes. This is not always an easy or straightforward task, since the decision is typically made when the there is still the little information about the project scope and plans.

The objective of this paper is to propose several new criteria to facilitate the selection of an appropriate project delivery method for delivering a sustainable project. The delivery methods considered here include the Public Private Partnership (PPP or P3), the Construction Manager at Risk (CM@R), the Design-Build (D-B), and the Lean Project Delivery (LPD).

In order to develop the new selection criteria, the information of 40 projects has been first collected and compiled. These projects were developed from 2002 to 2011 with a wide range of public and private facilities construction. Then, a comprehensive list of the factors that can affect the project delivery decision make are investigated from the information of 20 projects. Based on the analysis of the project data with the factors, a Weighted-Matrix Delivery Decision schema has been developed. The schema has been validated with another 20 projects. The test results show the accuracy of the proposed schema.

4 Proposed Methodology

4.1 Project Data Collection

The information of 40 sustainable public or private projects have been collected and compiled. The projects were developed in Canada during the last 10 years, including the construction of different types of facilities. They all received the LEED certificates issued from the Canada Green Building Council. In order to effectively organize this information, the following coding table has been adopted, and the numerical scores are assigned correspondingly.

Table 1: Data Coding Table

PROJECT FACTORS		CODES VALUES			
LEED Certification Level	Description	Certified	Silver	Gold	Platinum
	Score	1	2	3	4
Project Quality Performance	Description	Low	Moderate	High	
	Score	1	2	3	
Project Design Complexity	Description	Low	Moderate	High	
	Score	1	2	3	
Project Size	Description sq. ft	Small < 100 k	Medium 100 K - 200 k	Large > 200 k	
	Score	1	2	3	
Project Cost	Description $C	Low < 50 M	Moderate 50 M - 250 M	High > 250 M	
	Score	1	2	3	
Project Schedule	Description	Short < 1.5 years	Moderate 1.5 – 2.5 years	Long > 2.5 years	
	Score	1	2	3	
Project Target	Description	Renovation	New		
	Score	1	2		

4.2 Project Data Analysis

According to the Data Coding Table, the collected data have been analyzed from the aspects of LEED Certification Level, Project Quality Performance, Project Design Complexity, Project Size, Project Cost, Project Schedule, and Project Target. Here is a brief summary of these 40 projects.

- LEED Certification Level

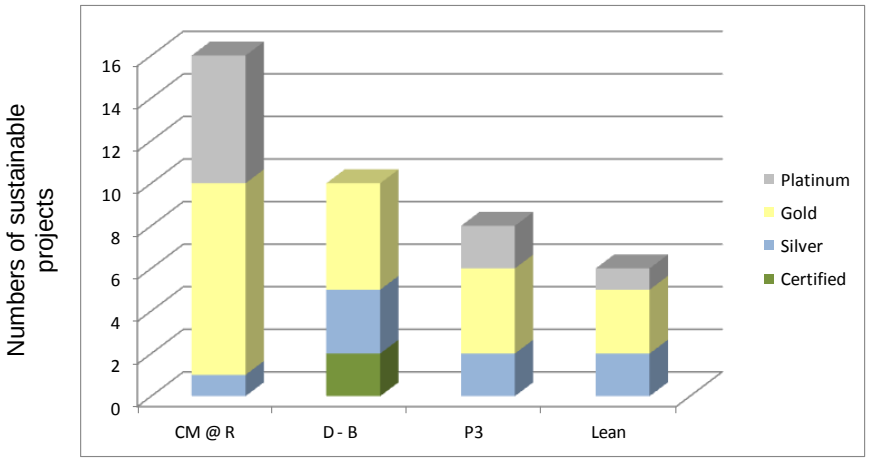

Figure 1: Relation between PDM and LEED Certification Level

- Project Quality Performance

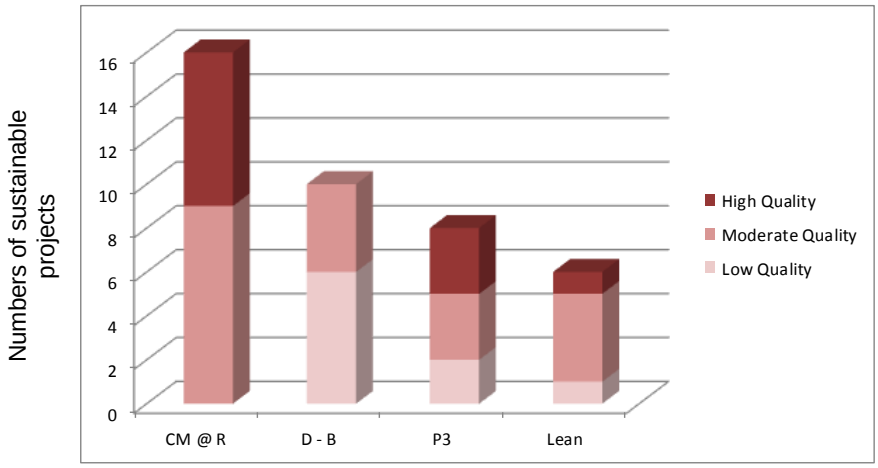

Figure 2: Relation between PDM and Project Quality Performance

- Project Design Complexity

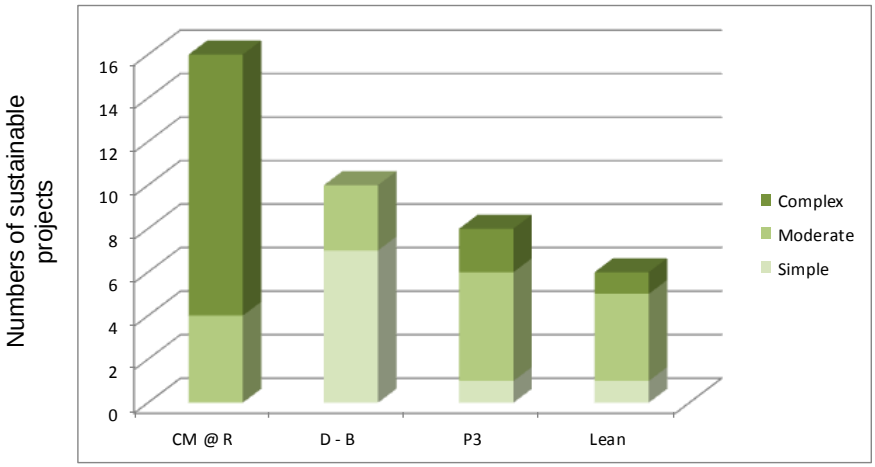

Figure 3: Relation between PDM and Project Design Complexity

- Project Size

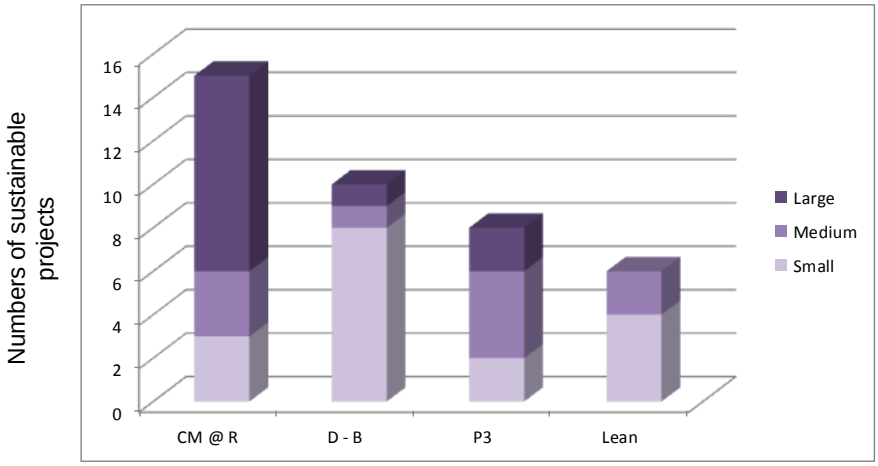

Figure 4: Relation between PDM and Project Size

- Project Cost

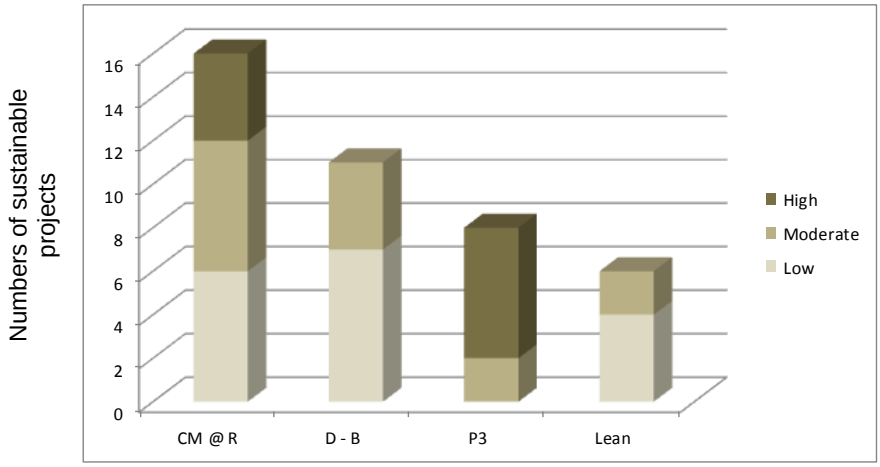

Figure 5: Relation between PDM and Project Cost

- Project Schedule

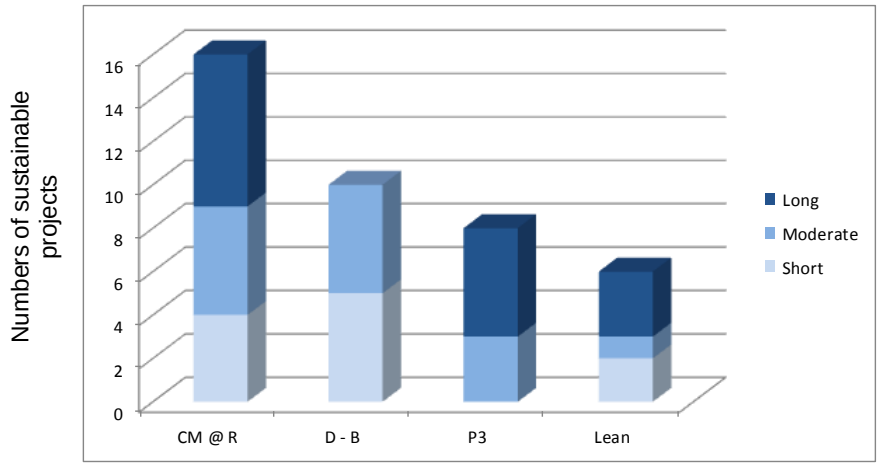

Figure 6: Relation between PDM and Project Schedule

- Project Target

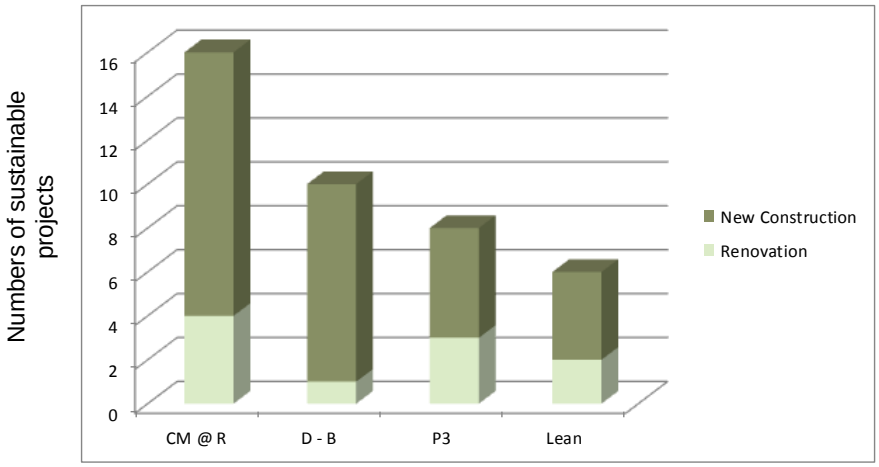

Figure 7: Relation between PDM and Project Target

4.3 Weighted-Matrix Delivery Decision Approach

A Weighted-Matrix Delivery Decision method has been developed to provide a means for the owner to examine and document a project delivery decision for an individual project. It provides owners with a process to select a delivery method by prioritizing project objectives and selecting the delivery method that best aligns with these objectives. This method is comprised of four distinct steps: 1) Define and Rank Selection Factors; 2) Weight Selection Factors; and 3) Score Project Delivery Methods.

- **Define the Selection Factors**

This step begins by defining a set of selection factors. The selection factors consist of the characteristics of the sustainable projects. In this step, the owner needs to establish the project goals at the beginning of the project delivery selection process. These goals include: 1) LEED Certificate Level; 2) Project Quality Performance; 3) Project Design complexity; 4) Project Size; 5) Project Cost; 5) Project Schedule; and 6) Project Status.

- **Weight Selection Factors**

In this step, the owner weights the selection factors. Here, the Rank Order Centroid (ROC) Method is adopted. The ROC method provides a simple way of giving weight to a number of items ranked based on their importance. This method takes those ranks as inputs and converts them to weights for each of the items. The conversion is based on the following formula, where M is the number of the selection factors and W_i is the weight for the ith item (Touran et al. 2009).

$$Wi = (1/M)\sum\ (1/n)^M \qquad (1)$$

- **Project Delivery Method Decision/Selection Matrix**

In this step, the owner scores each delivery method in terms of the selection factors. Then, the scores are multiplied by the weights of the selection factors. The sum of the results could help the owner make a decision on which project delivery method should be selected. One example of the selection matrix has been listed in Table 2. In the Table, the PPP has not been included, considering the fact that the PPP is mainly for the governmental projects with the need of a huge project budget.

Table 2: PDM Selection Matrix

PDMS		**CM @ R**		**D-B**		**LEAN**	
Selection Factors	Weight	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
LEED Certification	0.37	3	1.11	2	0.74	3	1.11
Project Quality Performance	0.23	3	0.69	1	0.23	2	0.46
Project Design & Complex	0.15	3	0.45	1	0.15	2	0.30
Project Size	0.10	2	0.20	3	0.30	1	0.10
Project Cost	0.07	2	0.14	3	0.21	1	0.07
Project Schedule	0.05	2	0.10	3	0.15	2	0.10
Project Status	0.02	1	0.02	2	0.04	1	0.02
Total Score			2.71		1.82		2.18

5 Validation

20 projects have been used and tested for validating the proposed method. Table 3 illustrated the test results. The selections made from the selection matrix have been compared with the actual selections made to indicate the accuracy. In those 20 projects, 7 projects were delivered with CM@R, another 7 projects were delivered with D-B, and the remaining 6 projects were delivered with LPD. According to the results from the decision matrix, the accuracy for the selection of CM@R, D-B, and Lean could reach 100%, 85.7%, and 83.3%.

Table 3: Accuracy of PDM Selection Matrix

PMD	SCORE	CASE STUDIES				
		Total Number of checking the case studies	Correct selection		Number of the incorrect selection	
			Number	Percent.	Number	Percent.
CM@R	2.71	7	7	100%	-	-
D-B	1.82	7	6	85.7%	1	14.3%
Lean	2.18	6	5	83.3%	1	16.6%

6 Conclusion

There are several project delivery methods; however, no single project delivery method is suitable for delivering all sustainable projects. It is necessary for the owner to carefully analyze the characteristics of a given project and seek to find an appropriate project delivery method, so that its benefits could be closely satisfied with the project requirements. This paper focused on the investigation of the selection of appropriate project delivery methods specifically for the projects with the sustainable requirements. The project delivery methods considered in the paper include the PPP, CM@R, D-B, and LPD. The selection matrix has been created based on the data collected from the sustainable projects in Canada. The proposed selection matrix has been tested with 20 project data. The preliminary results show the effectiveness of the matrix.

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