ASSESSING THE IMPACT OF EXPERIENCED PROJECT TEAM MEMBERS IN GREEN BUILDING PROJECTS

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ABSTRACT

Project experience is generally regarded as highly valuable in the architecture, engineering and construction industry. This is also true for green building projects, which often need to deal with new building technologies and processes. This paper attempts to study the importance of experienced project team members for successful planning and executing of green building projects. Certified LEED green building projects in Canada were studied in this research. Project information, project team information, green building certification grade, and certification year were collected and analyzed using a link analysis technique. Organisations that have been involved in multiple green building projects and their inter-organisational interactions were identified. The results show that projects certified with higher green building certification grades often involve more experienced project team members, and that working with experienced team members can reinforce mutual experience as compared with working with less experienced member.

Keywords: *Green Building; Organisational Ranking; Page Rank; Project Team.*

1. INTRODUCTION

The design, construction and management of a green building project are different from a traditional construction project. When stakeholders approach a green building project, more emphasis is given to (i) considering the whole life cycle of the building and its components, (ii) consuming less energy and water, and (iii) providing better user satisfaction (Glavinich, 2008). Owners and investors are willing to invest more upfront for operational savings. Energy conserving technologies and equipment are installed to achieve these goals. This requires design and construction practices that are different from traditional construction practices. The complexity in its design and construction requires a green building project to have specialized role players in their project team with little or more green building experience (Kibert, 2007). A traditional construction project has a design and construction team working together or separately to execute the design and construction activities. In addition to the design and construction team, a green building project team has participants including (i) a green building consultant, who advises on the green building technologies and green building grade; (ii) a commissioning agent, who ensures that a building or facility is designed, constructed and operated to meet the requirements; (iii) green building material suppliers, and so on. While some traditional construction projects also have specialized design consultants, their roles and involvement are different from those in green building projects. A green building project team consists of participants from various disciplines and often requires frequent collaboration during design and construction. The diversity in the project team poses a serious challenge for collaboration which is a key factor in determining the success of a green building project (Robichaud and Anantatmula, 2010). Therefore, to successfully execute a green building project, the project team needs to be experienced and collaborative in nature. This paper aims to analyse project team combinations and rank organisation based on their green building experience. Organisational rank is determined based on the organisations' green building experience (no of green building projects involved) and their collaboration with experienced organisations.

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The construction industry has limited practice storing organisational/project team information; therefore, it becomes tedious to collect project team information. In this study, the Canadian green building database was used as the data source because it is an official database that is trustworthy and provides credible project/team information for analysis. All the collected projects from the database are LEED certified buildings by the Canadian Green Building Council (CaGBC). Projects in different locations may have different construction practices, or involve regional green building organisations. Hence, instead of considering the entire project data as a whole, projects were categorized based on their location to get more accurate results. Collected data include project name, location, grade obtained and team information. The page rank algorithm, a link analysis technique, is then used on the project team data to rank the organisations and examine how the rank affects the outcome of the project. The impact of an organisations' rank in a project team was then compared with the green building certification to identify any relations between them.

2. LITERATURE REVIEW

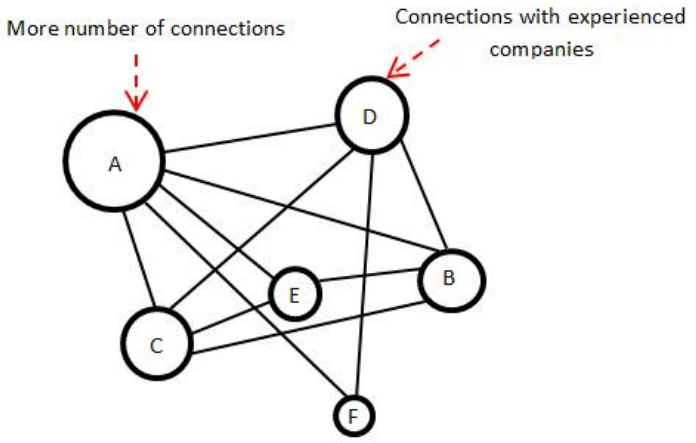
The Literature on organisational analysis has proven that project participants have a certain impact on the outcome of the project. For example, Wang and Huang (2006) suggested that the stakeholders' project performance positively correlates with each other and the owner plays a key role in project success. It also discussed the importance of the effect of project managers as the single point of responsibility and the coordinator for successful projects. Organisational analysis in construction not only stops with analysing the collaboration among participants and their inter-organisational relations, it also extends to analysing individual organisation's metrics and the project team combination. Shokri-Ghasabeh *et al.* (2010) proposed a model based on a company's previous experience in selected projects during its project selection. Reed and Gordon (2000) concluded that the integrated design process encompasses cross-disciplinary teamwork thus enabling improved and effective sustainable design. The importance of key players like owners, designers and contractors to the success of the construction project is well documented by (Chan and Chan 2004; Albanese 1994). The relevant literature provides sufficient evidence about the importance of the project participants and their collaboration in construction projects. It has also established the existing differences between a green building and a traditional construction project. However, there have not been any studies carried out to find the impact of project teams on the outcome of a green building project. Since previous studies have shown the importance of project participants and project team to project success, this study attempts to determine the influence of the project team in green building projects.

Construction researchers have previously adopted various methods to conduct organisational analysis. Gransberg *et al.*, (1999) proposed a quantitative method to identify the success of partnering in construction projects. Shokri-Ghasabeh *et al.*, (2010) proposed a multi criteria selection model on a company's previous experience in selected projects during its project selection. Since this paper focuses on analysing project teams' collaboration, a link analysis technique was selected. In network theory, link analysis is a data-analysis technique used to evaluate relationships (connections) between nodes (objects). Relationships may be identified among various types of nodes, including organisations, people and transactions Chakrabarti *et al.*, (1999). Application of link analysis includes; Investigation of criminal activity, Computer security analysis, Search engine optimization, Market research and Medical research (Neville and Jensen 2000; Xu and Chen 2004; Lu and Getoor 2003). It can be seen that link analysis techniques have been applied to different areas of research but they are seldom applied in the construction industry. Link analysis techniques can offer valuable insights on issues relating to nodal relationships and nodal rankings. Potential construction applications include analysing organisational relationships, communication and information exchanges, organisational ranking in a project team, innovative applications in construction scheduling, task allocation, etc. This paper focuses on analysing the collaboration of organisations involved in green building projects and ranks them based on their strength of collaboration and green building project experience. It is then compared with the final green building certification of the project to identify any relationships between project team combination and green building certification. To achieve these purposes, the page rank algorithm was chosen for this study. The page rank algorithm and the methodology to analyse collaboration patterns in project teams are discussed in detail in the following section

3. METHODOLOGY

3.1. PAGE RANK ALGORITHM

After exploring various link analysis algorithms, the page rank algorithm was selected for this study. The page rank algorithm is based on the concepts that if a page contains important links towards it, then the links of this page towards the other pages are also considered to be important (Page *et al.*, 1999). Since the page rank algorithm ranks its objects based on its connections and the strengths of those connections, it was found appropriate to use it in this study. An example is illustrated in Figure 1. The illustrated network contains six nodes and each node has a link with the other nodes, as illustrated. In this network, nodes are treated as organisations and the connections between them are treated as collaboration. As shown in Figure 1, node A (i) has more connections than the other nodes and (ii) has connections with nodes that have a higher number of connections. Therefore, node A is highly ranked. In another case, nodes B, C and D have connections with four other nodes but node D is rated higher than nodes B and C because node D has connections with nodes that have more connections.



Node	Rank
Org A	1
Org B	3
Org C	3
Org D	2
Org E	5
Org F	6

Figure 1: Page Rank Example

The same principle has been applied to green building projects and, in this case, organisations were ranked based on their experience and their collaboration with experienced participants. The equation used to calculate the page rank score for each organisation is shown below. Equation 1 calculates the rank of an organisation A.

$$R(A)_i = \sum_{x \in B_A} \frac{R(X)}{N(X)} \qquad \text{(Eq:01)}$$

where, R(A) refers to the rank value of organisation A, which is dependent on the rank values for each organisation X, denoted by R(X); N(X) represents the number of organisations collaborated with A; and B_A represents the set that contains all the organisations collaborated with A.

3.2. CANADIAN GREEN BUILDING DATABASE

Green buildings projects are increasing in numbers in developed countries thus making the market very mature. Canada adopted the LEED standard in 2003 and has certified over 4000 projects so far. CaGBC has introduced a variety of assessment standards including new construction, existing buildings, schools, interior designs, commercial interiors, neighbourhood development and homes. This longevity and evolution of the standard has raised the growth of green buildings in Canada and made the market more mature. Many organisations are involved in green building projects and possess valuable green building experience. The Canadian green building database contains rich information about all the LEED certified projects in Canada. The database contains information like, project name, location, certification level, registration year, certification year, green building technologies, scorecard, project team information, etc. This is why the Canadian green building database was used in this study for collecting project team

information. The collected information includes project name, location, certification level, registration year, certification year, and project team information. Out of the 4531 available project profiles in the database, only 229 projects provided project team information. The 229 projects were distributed into 10 provinces. In construction, the location of a project can have an impact on the construction practices, cost and team selection (Kaming *et al.*, 1997). Considering the scope of the study, we extracted project team information by location. The data was first classified according to different provinces before conducting the analysis. This location-based classification helps identify regional collaboration and makes the analysis more meaningful. Provinces with at least 25 projects were chosen for the analysis, as fewer projects will not provide enough collaboration details for a strong analysis. With that criterion, projects from Alberta province and British Columbia province were chosen for the analysis. The CaGBC introduced a new green building standard in 2009 and since changes in green building standard brings changes in design priorities and construction tasks, projects registered up to 2008 was chosen in this study. This helps to maintain standardization among the selected projects and treats them all equally. Project team data from all of the projects in Alberta and British Columbia provinces were collected. Firstly, involvement of organisations in all green building projects was found. A collaboration matrix between organisations was then formed based on their involvement in green building projects. The page rank algorithm was later applied to the collaboration matrix to identify the rank of each organisation. Organisational ranks were then matched with each project team to understand their impact on the project's green building certification. The organisational rank and their impact on projects are discussed in the following section.

4. RESULTS

In this study, Alberta had 19 projects in total and a total of 103 unique organisations participated in those projects. British Columbia had 31 projects in total with 178 organisations involved in the 31 projects. Table 1 represents the organisations with the top 10 page rank scores (PR Score) from both the provinces. The PR Score was calculated to identify the highly ranked organisations in each province. A higher PR Score indicates that the organisation has more number of green building project experience and/or collaboration with experienced organisations. Anonymity of organisations was maintained to preserve the confidentiality of the organisations involved. The calculated page rank score of the organisations was then mapped with the project team of all the collected projects to identify the relationships between the organisational rank and green building certification.

Table 1: Organisational Ranking Results Using Page Rank Algorithm

Alberta		**British Columbia**	
Company	**PR Score (till 2008)**	**Company**	**PR Score (till 2008)**
Total No. of Companies	103	Total No. of Companies	178
Company A10	6.13	Company B7	9.40
Company A23	4.84	Company B8	4.76
Company A22	2.69	Company B36	3.33
Company A27	2.55	Company B53	2.60
Company A3	2.14	Company B24	2.43
Company A21	1.91	Company B39	2.41
Company A33	1.61	Company B16	2.40
Company A83	1.60	Company B61	2.09
Company A50	1.52	Company B54	2.07
Company A41	1.48	Company B42	2.07

4.1. FULL PROJECT TEAM ANALYSIS

This section analyses the rank of the full project team of all the projects from both provinces. Organisational rank of every organisation was matched with the project team to identify the relationships between project team rank and the final green building grade of the project. The analysis does not simply consider the sum of the PR score for the whole project team and compare the sum score with green building grade. Instead, a more detailed study on the collaboration patterns of the organisations was examined to investigate the impact on the final green building grade. To understand the impact of collaboration patterns, the project team composition of the highest (Platinum) and lowest (Certified) certified projects were examined. 'Platinum' is the highest and 'Certified' is the lowest available green building grades in the LEED Canada certification system. Table 2 lists all the Platinum projects from both the provinces and identifies the presence of the top 25 and top 10 organisations. The total number of organisations in almost all the Platinum projects was more than 10. Only two projects had total participants of less than 10, one with 9 and the other with 5. From the organisational rank, we matched the values to the whole project team to find the presence of the highly ranked organisations in the platinum case study projects. Among the 7 Platinum projects, all the projects had a top 25 member and top 10 members. In all the 7 projects, at least one to four top 10 organisations were involved. This shows the importance of collaboration among top organisations in a green building project team. It also iterates the fact that the experience of the organisation is a huge factor and can have a positive effect in determining the final green building grade of the project.

Table 2: Platinum Case Study Analysis

Project	Province	Total Organisations	Top 25 Organisations	Top 10 Organisations
Vento Residences	Alberta	10	6	3
Child Development Centre (University of Calgary)	Alberta	12	7	3
Energy Environment Experiential Learning Building, University of Calgary	Alberta	11	4	2
Operations Centre, Gulf Islands National Park Reserve	British Columbia	12	4	3
Dockside Phase 1 - Synergy	British Columbia	11	5	4
Centre for Interactive Research on Sustainability	British Columbia	9	3	3
Creekside Community Recreation Centre	British Columbia	5	1	1

Table 3 lists all the certified projects from both provinces and identifies the presence of top 25 and top 10 organisations. Certified is the lowest rating available in the LEED green building certification standard. Among the 7 certified case studies from both provinces, only two had a total organisation of more than 10. The involvement of top 25 organisations in all the certified projects was very few, ranging from a minimum of 0 to a maximum of 2 organisations. 6 projects have only 1 organisation in the top 10 list and 1 project has no organisations in the top 25 and top 10 list. This shows the lack of collaboration among top companies in the certified projects and this could be one of the reasons for achieving a lower grade.

The results from the two tables show the importance of collaboration among the top organisations in green building projects. While collaboration can be found in the top organisations in Platinum projects, certified projects have weak to no collaboration of top organisations in their project team. The numbers of top organisations involved in the certified projects were substantially lower than the Platinum projects paper despite not having a major difference in the total number of organisations involved in the project team. From a numbers perspective, the average number of organisations involved in Platinum and

Certified projects was 10 and 8, respectively. The Platinum projects have an average of 40% of participants from the top 25 organisations and 27% of participants from the top 10 organisations. On the other hand, certified projects have an average of only 17% and 12% in their top 25 and top 10 organisations, respectively. This shows the impact of experienced project participants in green building projects. Green building projects involves execution of green building tasks that are complex and different from a traditional construction project. Organisations with more experience in green building projects are well prepared to meet the challenges of a green building project, whereas organisations with less green building experience are less prepared to tackle the challenges faced in green building projects. Therefore, collaboration between top organisations can have a positive effect on the final green building grade and a lack of collaboration between top organisations might yield a lower green building grade.

Table 3: Certified Case Study Analysis

Project	Province	Total Organisations	Top 25 Organisations	Top 10 Organisations
Glenmore Filtered Water Pump Station Renovation	Alberta	8	1	1
Spruce Grove City Hall	Alberta	5	2	1
Livingston Place 8th floor	Alberta	6	2	1
Czorny Alzheimer Centre	British Columbia	10	1	1
Phase 2 Studio Building (Electronic Arts Inc.)	British Columbia	9	1	1
Faculty of Management Centre	British Columbia	8	1	1
Time Marketplace - 180 West Esplanade	British Columbia	9	0	0

5. CONCLUSIONS

The impact of the project team on the outcome of a green building project has been given limited attention in green building research. This study attempts to fill the gap by investigating the impacts of experienced project participants in green building projects. This pilot study proposes the use of the page rank algorithm, which is a link analysis technique, to measure organisational rank in green building projects. The impact of the organisational rank in green building project teams and the final green building grade was then studied. Key findings of this study show that projects with a higher green building certification grade often involve more experienced project team members, and that working with experienced team members could reinforce mutual experience as compared with working with less experienced members.

This study has proposed an innovative method to analyse organisations for project team selection and helps identify the strategies to form an efficient project team. Owners and managers in the green building industry can adopt this technique and strategies during project team formation to get improved performance. The authors used a mathematical technique to rank organisations in green building project teams, but the lack of completeness in organisational data of certain green building projects means that the calculated rank is not directly correlated with the reputation of the organisation or the project. The lack of project team data limited the sample size of projects in this study. The impact of the results also highlights the importance of preserving organisational data in the construction industry. Future study can focus on analysing the key role players in a project team and developing an improved algorithm to study multiple parameters of the project team characteristics. Projects with different owner types, building types and certification types (Gold and Silver certification) will be studied to find similar or different trends in project team combinations. Discussions with project team members can be conducted to support the results and relationships with different performance metrics like cost, schedule, quality, etc. can also be studied.

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