TRANSFORMATIONAL LEADERSHIP FOR SUSTAINABILITY IN ARCHITECTURE ENGINEERING AND CONSTRUCTION PROJECT TEAMS

By

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ABSTRACT

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Green or sustainable Architecture Engineering and Construction (AEC) projects have become a global phenomenon. To deal with the unique nature of green projects, teams require improved design and construction processes. This demands teams to integrate and collaborate better. To achieve this, the literature highlights project delivery attributes such as delivery methods, contractual conditions, and owner's commitment. This study explores a new dimension in this regard: Leadership. Previous studies have pressed upon the need to explore the role of leadership in green AEC project teams. Proponents of leadership believe that it can help align team goals and create an encouraging atmosphere for improved performance.

Transformational leadership is currently one of the most highly regarded and researched theories in the literature. Transformational leaders inspire their followers by setting examples, give others individual attention, cater to their needs; and stimulate them intellectually by encouraging them to take part in discussions and bring in their ideas. There is a need to explore how transformational leadership emerges in green AEC project teams and can impact team performance. Some leadership experts believe that the concept of having a single leader for a team is not the true representation, and there can be multiple leaders in a team regardless of assignment, decision-making power, and position. This form of leadership is known as shared leadership.

To study this phenomenon in the AEC industry, this study collected data from nine near completion, new construction and major renovation projects aiming for a Leadership in Energy and Environmental Design (LEED) certification. LEED certification by the United States Green Building Council (USGBC) is the leading rating system for green buildings, both nationally and internationally. The researcher used the shortlist on the USGBC website to identify projects and invite team members to participate in this study via emails and phone calls.

This study uses mixed methods approach to achieve the study aims. A survey was used to collect individual-level data (n=103) and quantitatively test the relationship between perceptions of transformational leadership and team performance, mediated through team integration. The data was analyzed for validity using confirmatory factor analysis and reliability using Cronbach's alpha. The study employed structural equation modeling to test its hypotheses. At the project team level, case study methodology was adopted to qualitatively explore the structure and flow of transformational leadership in green AEC project teams using social networks. Case studies were analyzed using pattern matching, while t-test and Chi-square tests were also employed to assess additional leadership characteristics as a follow up to the network study.

The study provides significant theoretical contributions by developing a modified version of the Multifactor Leadership Questionnaire (MLQ) to measure transformational leadership specific to sustainability in AEC projects. It provides quantitative evidence in support of transformational leadership for team integration and team performance improvement. The study is first of its type to report leadership flow in AEC project teams and provides practical implications and directions for future research.

To my late Dada Abu,
"Who taught me that humility and empathy are the greatest virtues of all".
And my late Uncle Hanif,
"Who inspired me to believe in my abilities and never compromise on my values".
Both of them passed away in Lahore while I was away for my grad school.

ACKNOWLEDGEMENTS

It still feels unreal. I've finally accomplished the task that once looked overwhelmingly gigantic. The last few years have been a constant struggle. There were all sorts of challenges, ranging from the complexities of an alien education system to the nuances of the American society. But I was lucky to have so many wonderful people around, who helped and supported me in every way possible. They will always stay with me in my thoughts and prayers.

Dr. Sinem Mollaoglu is the best research advisor one can ask for. I couldn't have achieved this feat, had it not been for her extended guidance, inspiration, support and trust. She checks all the boxes for transformational leadership: Leads by example, never discourages her students, gives them the space to think on their own, and provides them with the individual attention they need. Her mentorship has not only transformed me into a confident researcher and presenter, but also has taught me the virtues of kindness, empathy, integrity, and courage. I've the highest of respect and gratitude for her and hope that one day I can make her proud.

I had a perfect doctoral committee, both in terms of expertise required for my work, as well as the level of support extended by each of the professors. Dr. Matt Syal, Dr. Mark Wilson, Dr. Rick DeShon and Dr. Zong Dhao pushed and guided me to incorporate diverse points of view. Their careful insights added great value to my work, for which I'm grateful.

I would like to especially mention Dr. Matt Syal, who has been a mentor for me since day one. He understood me very well, and always advised what was best for me. I thank him for the countless hours he spent in counseling and uplifting.

The SPDC staff was super helpful. Jill helped me figure things out on daily basis. So much work, but she always smiled. Janelle, Mary, Pat and Lauri, assisted me whenever I needed them. Jenn was a wonderful mentor when I volunteered for the writing center.

My SPDC friends, who were just like my family, were the reason I looked forward to going to school every day. Starting with Angelo, who was my academic babysitter for two years. He is perhaps the most selfless person I've ever met. He would go to any extent helping you, and I stand guilty of fully exploiting his kindness. Anthony, Leah, Mohsen and Mel, they were all very close to me. As we were all going through the same struggle, we had great empathy for each other. I wish them all the best in life. I will never forget our beautiful times together.

My friends in East Lansing have been the colors and tunes of my life these past few years. I wish I could name all of them here. Yasir and Azam, my Fulbright cohort mates from Pakistan, really helped me settle when I came, and remained a constant aid throughout. The whole Pakistani community provided me and Rabia with a support system that was close to home. My group of friends from around the world, with whom I shared the best of adventures and learned a great deal about different cultures. Florencia from Argentina, Laura from Finland, Sabawoon from Afghanistan, Karn from Thailand, Nouga from Egypt, Bihter from Turkey and Irene from USA. Every time we hanged out it was like meeting the world all together. I will always cherish our memories. Fulbright provided me with the opportunity to meet friends from over 50 countries; places I never knew existed; places I had so many misconceptions about. I thank all of them for sharing their stories.

I cannot miss mentioning the wonderful East Lansing community that welcomed us with arms wide open. Joan is like a mother to us. She was always there, celebrating the smallest of our

achievements, comforting us when we got sick, and feeding us whenever she got a chance. Mary and Connie from CVIP, who recognized my efforts for international student community and always highlighted them in front of university admin. It is not the place, but the people that I will miss the most.

Finally, I come to those who are dearest to me. My family. Especially my parents. I’m their product and I owe my life to them. I can’t forget the sacrifices they made in getting me where I’m today. My two brothers who are my strength. I’m sure they are super proud of me. My parents in law, who supported us throughout. My nephews and nieces, who are the source of joy for the whole family. And last, but certainly not the least, my beautiful wife Rabia. She has stood by me through thick and thin. Her love makes my life worth living. This is as much her achievement as mine. Perhaps more.

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KEY TO ABBREVIATIONS

AEC:	Architecture, Engineering and Construction
CFA:	Confirmatory Factor Analysis
LEED:	Leadership in Energy and Environmental Design
SEM:	Structural Equation Modeling
SNA:	Social Network Analysis
USGBC:	United States Green Building Council

Chapter 1 INTRODUCTION

1.1. Background

Green Architecture Engineering and Construction (AEC) projects, alternatively known as sustainable AEC and green building, aims at improving the environmental, health, economic, and productivity performance of buildings through innovative design, construction, and operation (USGBC, 2003). Green AEC projects have become a global phenomenon, and it is growing exponentially (Dodge Data & Analytics, 2016). LEED by USGBC is the leading rating system for green buildings, both nationally and globally (Ewing et al., 2013). Currently, there are more than 94,000 participating LEED projects, which account for 2.4 million square feet globally (USGBC, 2018).

Green AEC projects are unique because they are perceived as more complicated due to sustainability goals (Magent, 2009). High-tech equipment and components, like photovoltaics and smart building technology (Rohracher, 2001), require specialized professionals (Hoffman & Henn, 2008). Due to the broader scope of work and expensive equipment, sustainable AEC projects are thought to increase cost and time. These characteristics are seen on the LEED certification stats. Only a small proportion of projects succeed in achieving LEED Platinum, the top LEED certification for buildings. Moreover, the new version of LEED (LEED V4) has made earning LEED points more challenging (Melton & Andrews, 2016).

1.2. Problem Statement

Literature has frequently highlighted the unique nature of green AEC projects. The challenges of green projects require superior design and construction processes. Sustainability objectives of green AEC projects require teams to achieve maximum influence and avoid wasteful activities, and therefore the competencies from all relevant disciplines need to be mapped out together (Horman et al., 2006). This calls for the teams to integrate so that they can communicate and collaborate openly (Korkmaz et al., 2010). Researchers have mainly approached this through the lens of project delivery attributes, such as the owner's commitment, delivery system, contractual conditions, and construction processes (Olanipekun et al., 2017; Korkmaz et al., 2010; Mollaoglu et al., 2013). Leadership is another dimension to this, which is less explored so far.

Leadership skills have been highlighted as crucial for sustainable project performance, as they can inspire and direct the project teams towards sustainability goals (Ofori-Boadu et al., 2012). Traditionally, leadership has been conceptualized as the trait of a single person in the team, usually the functional manager. However, this is considered a misrepresentation of leadership (contractor et al., 2012). Recently, more and more researchers are adopting the new concept of shared or distributed leadership. It states that leadership is not the property of a single person in the team. There can be more than one leader, who may or may not have the positional authority (Mehra et al., 2006; Carson et al., 2007)

Transformational leadership is the most prominent and highly regarded approach for leadership in the current era (Ronald, 2014). The spirit of transformational leadership lies in inspiring the subordinates and aligning their vision with that of the project; giving them individual attention to cater to their needs; and encourage them to have an open discussion and share their ideas (Bass, 1985). Transformational leadership has been identified to positively impact team performance numerous times in the literature (Dionne et al., 2004; Braun et al., 2013). The characteristics of transformational leadership make it a perfect match for large, multi-disciplinary green AEC project teams. It is particularly useful for a shared leadership approach; however, the network studies of shared leadership have not yet tapped the potential of this theory. Thus, there is a need to explore how shared transformational leadership flows in green AEC project teams and what role it plays in improving team performance.

1.3. Research Goal and Objectives

The primary goal of this study was to "Explore the structure and role of transformational leadership in AEC project teams, providing a significant contribution to AEC literature." The objectives of the study are as follows:

1. Create a multi-level framework for study and measurement tools that:
    a. Guides the hypothesis development to relate transformational leadership and team performance mediated by team integration at the individual level, and
    b. Provides reasoning for research questions in order to explore the dynamics of transformational leadership using social networks at the team level.
2. Validate the framework and measurement tool via expert interviews.
3. Empirically test the study hypotheses at the individual level.

Answer the research questions at the team level, exploring the leadership networks in teams and assessing various characteristics of leaders.

1.4. Research Scope

The subject of this study is leadership in green AEC, which is very broad. To limit the scope, this research focused on LEED New Construction and Major Renovation projects in the USA. Moreover, only those projects were considered that were registered with the new LEED Version 4, as it is considered more complicated and hence improves the theoretical requirements of transformational leadership. Out of a population of 1512 projects, 152 were contacted for data collection, and 9 project owners agreed to participate. Individual responses were sought from all team members of owner, design, and construction organizations.

1.5. Methodological Approach

The study adopted a mixed-methods approach to test the study hypothesis at the individual level and answer the research questions at the project team level. The quantitative methods employed include confirmatory factor analysis, structural equation modeling, independent samples t-test, and chi-square test for distribution comparison. For qualitative analysis, pattern matching was used to interpret project-level analyses driven by social networks.

1.6. Deliverables/ Research Contributions

The primary deliverable of this research is the **"**Investigation of shared transformational leadership for large inert-organizational AEC project teams**."** Other deliverables include:

- Development of a measurement tool to record shared transformational leadership for sustainability in AEC project teams;
- Measurement of the effect size of shared transformational leadership on team performance;

- Assessment of characteristics for sustainability leaders in AEC project teams;
- Analysis of sustainability leadership flow in AEC project teams.
- Recommendations for:
    - Best practices in construction project management and management training;
    - Future research.

1.7. Reader's Guide

This dissertation is divided into seven chapters. Chapter 1 forms the ground by providing a quick overview of literature leading to the problem statement, followed by the research goals, objectives, and deliverables. Chapter 2 provides a detailed literature review regarding the various related areas. These include the detailed review of green AEC projects, their characteristics and performance; leadership theories, including transformational leadership and shared leadership; and transformational leadership in green AEC projects which link the two areas. Chapter 3 creates a framework to guide hypotheses and research questions development. Chapter 4 describes the methodology of research followed, including the study variables, data collection, and survey development. Chapter 5 presents the results for expert interviews, including the modification of study survey items and answers to questions regarding leadership in green AEC projects. Chapter 6 provides qualitative and quantitative analysis for the study framework. Hypotheses are tested, and research questions are answered. Chapter 7 lists the key findings and discusses the practical and theoretical implications of this research. Finally, Chapter 8 concludes the dissertation with the summary of findings, contributions of research, limitations, and future recommendation.

Chapter 2 LITERATURE REVIEW

This chapter begins with the introduction to green AEC and the unique nature of green AEC projects. After establishing the need for leadership in green teams, the chapter shifts gears to discuss leadership theories ending in transformational leadership. The merits of using Shared Social Network Analysis for leadership research come next along with basic SNA concepts. Finally, transformational leadership in the context of green AEC projects is explored, considering various scenarios and structures.

2.1. Sustainability in the AEC Industry

Green AEC is alternatively referred to as green building, green construction, sustainable building, and sustainable construction in the literature (Darko, 2016). There are many definitions available for green AEC in the literature. According to United States Green Building Council (USGBC), green AEC aims at improving the environmental, health, economic, and productivity performance of buildings through innovative design, construction, and operation (USGBC, 2003).

Buildings account for a large portion of global energy use and emissions. In the USA alone, residential and commercial buildings accounted for 39% of total energy and 72% of electricity consumption in 2017(EIA, 2018). Buildings are also a source for greenhouse gas emissions due to fossil fuel burning, handling of waste, and the use of certain products. In 2016, buildings accounted for producing 11% emissions (EPA, 2018). With the increased awareness of diminishing resources and climate change, the significance of green buildings has multiplied. Researchers have extensively compared the features of conventional construction with green

AEC. Green AEC is found to be superior in thermal comfort, health, productivity, indoor environmental quality, and economy in terms of life cycle costs (Zuo & Zhao, 2014).

Green AEC projects started gaining fame with both researchers and industry professionals in the early nineties (Kibert, 2012). In the current era, green AEC projects have already become a global phenomenon. A 2016 report predicts the global scale of green AEC projects to double by 2018 (Dodge Data & Analytics, 2016). LEED by USGBC is the leading rating system for green buildings, both nationally and globally (Ewing et al., 2013). Currently, there are more than 90,500 participating LEED projects with 2.2 million square feet covered area around the globe (USGBC, 2017). Thus, green AEC projects have already taken over a large portion of the construction industry and are estimated to grow significantly in the future.

2.1.1. Characteristics of Green AEC Projects

Green AEC projects are deemed to be more complicated in comparison to the traditional ones (Myers, 2008). Some of the unique characteristics of green AEC projects are as follows:

- In green AEC projects, the environment is given the status of a stakeholder. In comparison to the conventional projects, which set objectives based only on the owner/user requirements, green AEC projects have an added dimension to consider. Thus, the priorities on the project change. Activities such as life cycle cost analysis and energy modeling, which are otherwise ignored, become critical. The design requires a greater number of iterations, and construction requires new considerations, such as waste management (Horman et al., 2006).

- Due to broader scope/extra activities and expensive material/equipment, green AEC projects usually cost more and take longer to complete (Kim et al., 2014). However, the proponents of integrated design believe that it costs less to build green if sustainability is introduced at the schematic design and planning phase with a holistic approach (7 Group et al., 2009). Some case studies back this claim, where green buildings were built cheaper than their conventional counterparts (Dwaikat & Ali, 2016).
- Project sustainability goals increase the level of project complexity (Magent, 2009). They may require high-tech equipment and components such as photovoltaics, smart building technologies, and high-efficiency mechanical equipment, which are supplied by specialized vendors (Rohracher, 2001). The professionals capable of dealing with the new technology and techniques are scarce (Hoffmann & Henn, 2008). There is an added requirement for new and challenging documentation (France, 2007).
- In addition to the traditional participants in AEC projects such as owners, designers, and contractors, there are many new and specialized team members (or traditional members with additional roles and responsibilities) involved in green AEC projects. For example, sustainability /LEED consultant; Energy Modeler; Commissioning Agent; Energy Services Companies; specialized suppliers (like suppliers for FSC certified wood products and superior insulation materials); other specialized professionals (Widjaja, 2016).
- Policies to support and facilitate green buildings vary from state to state. For example, California requires LEED Silver certification for all state-funded significant projects (DuBose et al., 2007).

Sustainability objectives of green AEC projects require a systems approach to design and construction with input from a wide range of stakeholders as compared to the conventional member-based approach (Kibert, 2012). Multidisciplinary collaboration is critical for green buildings to produce innovative and effective solutions (Mollaoglu-Korkmaz et al., 2013).

2.1.2. Complexity in Green AEC Projects: LEED Versions and Certifications

LEED certification has four different levels based on the number of LEED points achieved. These include Certified (40-49 points), Silver (50-59 points), Gold (60-79 points), and Platinum (80+ points). A trend of certifications over the years can be seen in figure 2.1. It can be seen that despite LEED being around for almost two decades, not many projects have achieved platinum certification. On average, only 12 % of projects were able to achieve platinum certification since 2010.

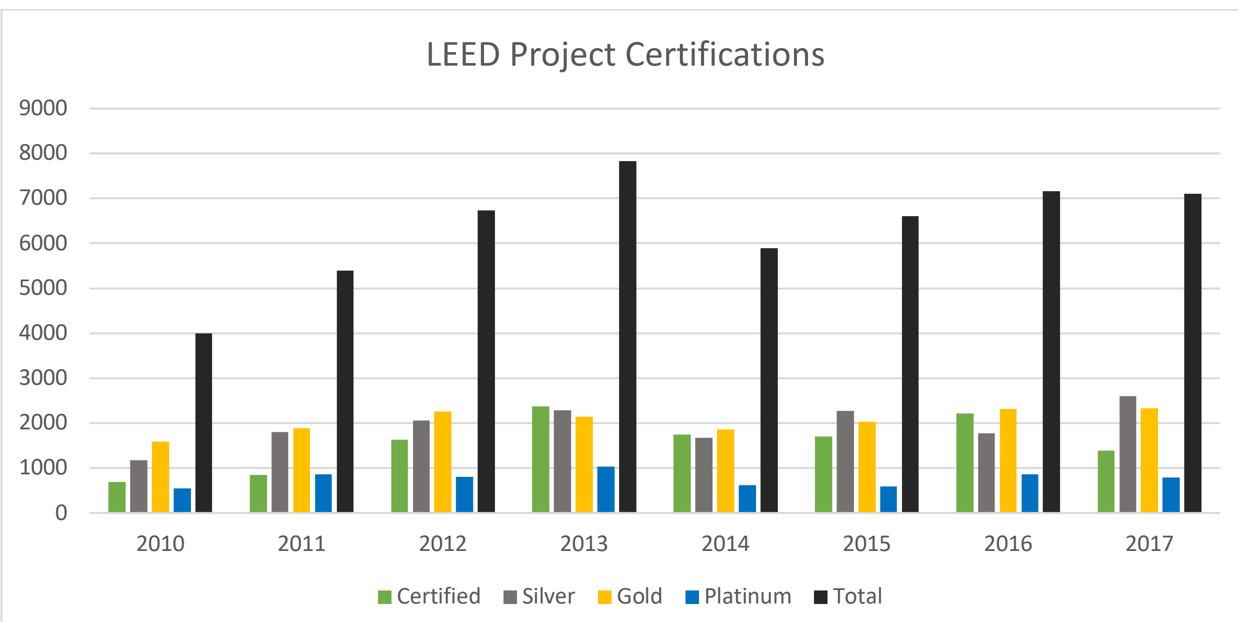

Figure 2-1 Number of LEED certified projects in the world (2010-2017)

In 2013, USGBC introduced version 4 of LEED. It is stricter and more demanding as compared to its predecessors. USGBC states the latest update (LEED V4.1) as the most rigorous green building rating system in the world. Due to the raised bar on sustainability for lower scores, the industry witnessed a strategy of risk aversion (Melton & Andrews Jr., 2016). It can be seen in Figure 2.2 that despite the launch, very few projects opted for LEED V4. USGBC announced the phase-out of LEED V3 in October 2016. More than 20,000 projects got registered in 2016, possibly because of this. In the following year (2017), the number of projects registered for LEED V4 spiked a little, but the total number went down tremendously.

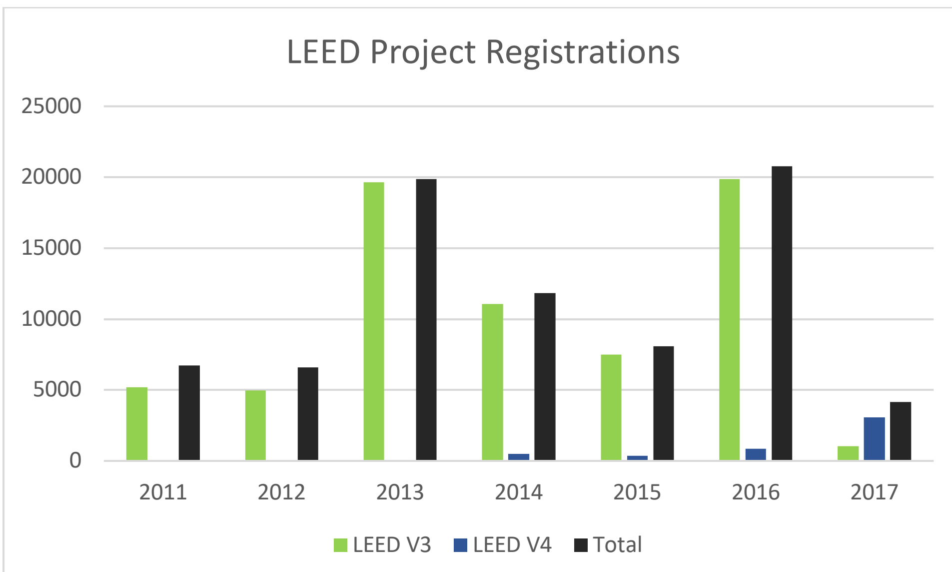

Figure 2-2 LEED Project Registrations over years

Green AEC projects are becoming more and more challenging and demanding with time. LEED projects always had vast scope for performance improvement, as a tiny proportion of projects could achieve top certifications. LEED V4, with its added complexity and requirements, has widened this scope further. Hence, there is a need to explore new means and methods in order to optimize the performance for LEED projects.

2.1.3. Leadership Requirements for Green AEC Projects

Optimal performance in green AEC projects demands interdisciplinary communication for optimized solutions and out of the box thinking for creative ideas. Therefore, team integration is highly regarded as the key to green AEC project performance (Widjaja, 2016; Magent et al., 2009; Korkmaz et al., 2010). Sustainability objectives of green AEC projects require teams to achieve maximum influence and avoid wasteful activities, and therefore the competencies from all relevant disciplines need to be mapped out together (Horman et al., 2006). The literature has advocated for a project delivery approach to achieve integration in green AEC project teams. However, it has been observed that the delivery method alone cannot achieve the aimed results (Mollaoglu-Korkmaz et al., 2013).

Ofori-Boadu et al. (2012) highlighted the requirements of leadership in green AEC projects. After a thorough review of the dynamic nature of green AEC projects, they advocated for improved leadership skills in order to inspire and direct teams towards the sustainability goals (Ofori-Boadu et al., 2012). Leadership skills are known to positively impact integration and create a climate of creativity and innovation in teams (Zaccaro, 2001; Sarros et al., 2008). Effective leadership is one of the top factors of success in cross-functional teams like those in green building projects (Olopade & Franz, 2018).

2.2. Leadership in Theory

There are many definitions of leadership in literature. According to Rost (1993), there are over two hundred ideas and concepts regarding leadership. Prominent leadership researchers like Bernard M. Bass (2008) are of the view that it is pointless to arrive at a single universal definition, as it varies according to the context and the requirements of the individuals applying it. There have been attempts, however. Winston & Patterson (2006) published an article exclusively for this purpose. Their basic definition of leadership is as follows:

> "A leader is one or more people who select, equip, train, and influence one or more follower(s) who have diverse gifts, abilities, and skills and focuses the follower(s) to the organization's mission and objectives causing the follower(s) to willingly and enthusiastically expend spiritual, emotional, and physical energy in a concerted, coordinated effort to achieve the organizational mission and objectives." (Winston & Patterson, 2006, pg. 7)

It is crucial to differentiate between leadership and management, as both are often confused. Firstly, managers can be leaders, but it is not required for leaders to be managers. They can be any member of the group/team (Rost, 1993). Some significant differences between leaders and managers have been pointed out by Nahavandi (2003).

Table 2-1 Leaders versus Managers (adopted from Nahavandi, 2003)

LEADERS	MANAGERS
Focus on the future	Focus on the present
Create change	Maintain status quo and stability
Create a culture based on shared values	Implement policies and procedures
Establish an emotional link with followers	Remain aloof to maintain objectivity
Use personal power	Use position power

2.2.1. Leadership Theories in the Literature

One of the first theories regarding leadership, known as the great-man theory, was promoted by a Scottish philosopher, Thomas Carlyle, in the 1840's (Hook, 1950). The concept has evolved a great deal since then. In a recent publication, Lord et al. (2017) reviewed the articles from the Journal of Applied Psychology since 1948 and identified three waves of advancement in leadership research. Initially, leadership was limited to personal behavior or style, but gradually the discussion of gender, social cognition, situation, team, and transformation made the literature very rich and broad.

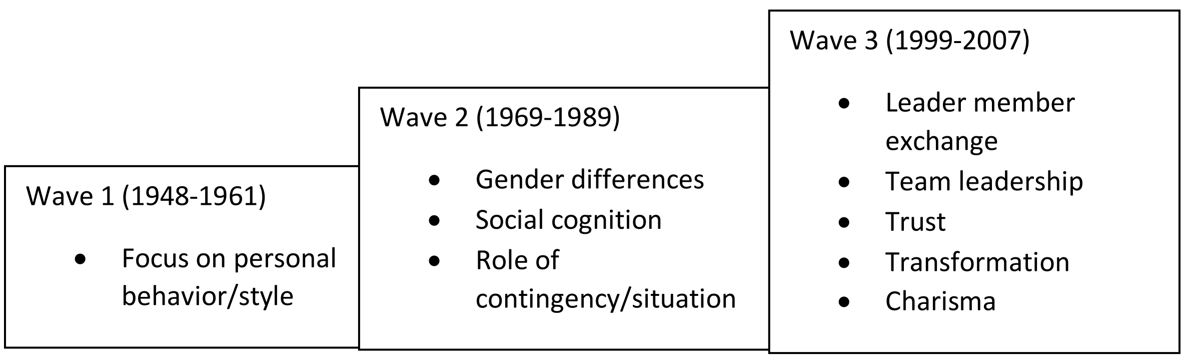

Figure 2-3 Three Waves of Leadership Research in the Journal of Applied Psychology

As discussed by Rost (1993), there are hundreds of different views and concepts. It is impossible to cover every point of view. However, there is a handful of widely known and cited leadership theories in the literature (Ronald, 2014; McCleskey, 2014), which are presented in chronological order below.

i) *<u>Trait Theories</u>*

The advent of trait theories can be traced back to the great-man theory, which stated that great men or leaders are simply born with certain traits that enable them to achieve greatness (Hook, 1950). One of the biggest proponents of this idea was perhaps Sir Francis Galton. In his book "Hereditary Genius", he presented his studies on high performing judges to even wrestlers in the 19th century England, trying to prove that extra-ordinary abilities were hereditary, and ran in the family (Galton, 1869). Although the great man theory kept on intriguing researchers for at least a century (Borgotta et al., 1954), and personal traits still show up in literature with relevance to leadership now and then (Kirkpatrick & Locke, 1991), the new theories gradually replaced the trait theories because they seemed to be too simplistic with little analytical use and practical application (Van & Field, 1990).

ii) *Behavioral theories*

The behavioral theories introduced a new focus on behaviors of men carrying out leadership roles, against the mental or physical attributes. Ronald (2014) lists seven important works in this regard.

a) Lewin et al. (1939) at Iowa State University studied three leadership styles, namely: Authoritarian (all decisions to be made independently by the leader), Democratic (all decisions to be taken together through group discussions) and Laissez-faire (Complete independence to all group members. No leadership involvement in individual decisions).
b) Fleishman (1953) proposed a two-dimensional model of leadership with independent and simultaneous consideration for both task and leadership. A leader can have any combination of high or low task orientation and high or low relationship orientation for his group.

High relationship orientation Low task orientation	High relationship orientation High task orientation
Low relationship orientation Low task orientation	Low relationship orientation High task orientation

Figure 2-4 The leadership quadrants inspired by Flieshman (1953)

c) The famous University of Michigan scholar Rensis Likert created a similar model with production centric behavior, with clear goal attaining attitude, and employee-centric behavior, with strong interpersonal relationships (Likert, 1967). The major difference from Fleishman's model was that Likert's model was unidirectional, which means that one could not have the best of both behaviors at the same time.

d) Douglas McGregor, a social psychologist, introduced Theory X and Theory Y in his book "The human side of enterprise" (McGregor, 1960). In simple words, theory X assumes that all employees are lazy and insecure. On the contrary, theory Y assumes the employees look at their work as a source of satisfaction. Both concepts can also co-exist in a leader's mind and define the leadership strategy to be used. Theory X supports a more authoritarian approach, while theory Y leans towards democratic style.

e) In continuation of the initial work by Lewin et al. (1939), Tannenbaum and Schmidt (1958) developed a continuum of the leader-behavior model, with one end as completely authoritarian, while the other end being delegation of power. The leader's behavior, according to them, could fall anywhere on the line.

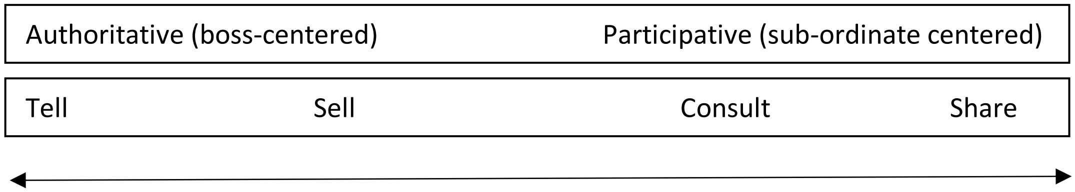

Figure 2-5 The continuum of leadership behavior (adopted from Tannenbaum and Schmidt, 1958)

f) Building upon Fleishman's two-dimensional theory of task and relationship orientation, Blake and Mouton (1964) came up with the famous Managerial Grid featuring five different leadership styles.

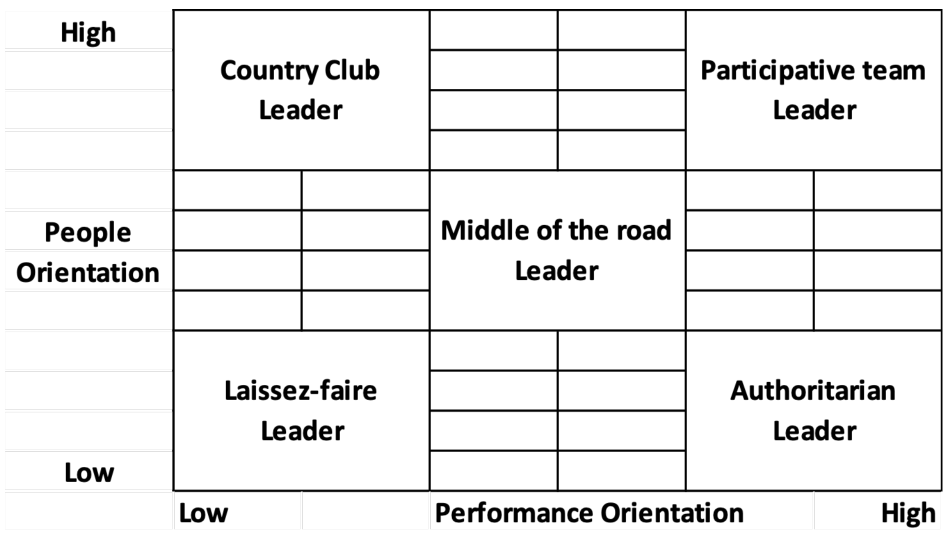

Figure 2-6 The managerial grid (adopted from Blake and Mouton, 1964)

g) The final behavioral theory can also be considered as a situational theory, according to Ronald (2014). Reddin (1970) presented a modified version of the managerial grid, called the three-dimensional theory. He defined four leadership styles in the grid, as follows:

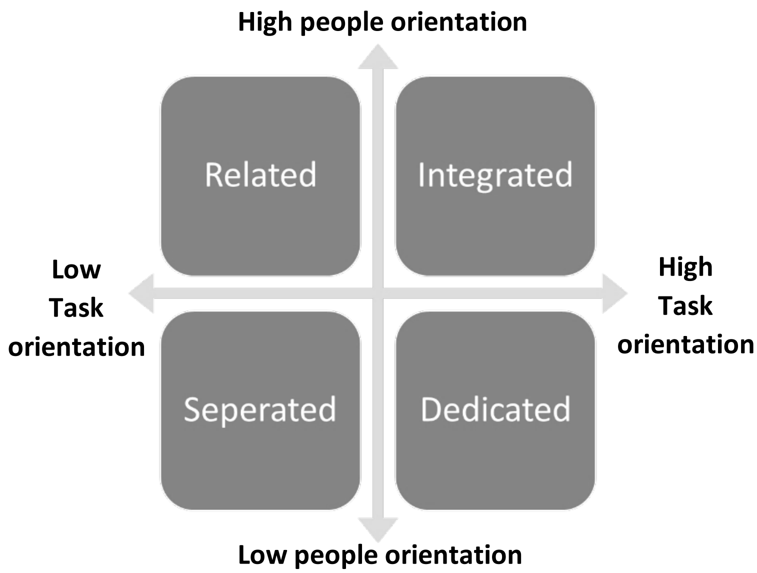

Figure 2-7 Grid for neutral leadership styles. (adopted from Reddin, 1970)

Reddin (1970) further argued that there is a third dimension to this, and that is appropriateness. The same leadership style can be highly effective if used appropriately and can be counter-productive if misused. Taking an example of the separated style with low on both task and people orientation, if it is used in the form of the missionary, it is ineffective. However, if the same is given the shape of bureaucracy, it can be very impactful.

iii) *Contingency theories*

Contingency or situational theories began with the management psychologist, Fred Fiedler's Contingency model (Fiedler, 1967). He came up with an unusual and exciting idea that leaders who focus more on task orientation perform better in situations of either high or very low levels of control. One the other hand, the leaders with high people orientation perform better in moderate conditions.

Situational theory by Hersey and Blanchard (1977) followed Fiedler's model. They took the two-dimensional Fleishman model and added a third dimension of the situation regarding the sub-ordinate level of maturity. They defined four levels of maturity as follows

M1 = subordinates are neither capable, nor willing

M2 = subordinates are willing, but not capable

M3 = subordinates are capable, but not willing

M4 = subordinates are both willing and capable

The authors argued that the level of maturity that sub-ordinates posses decides the task and people focus for leadership style. This can be visualized in the following figure 2-8.

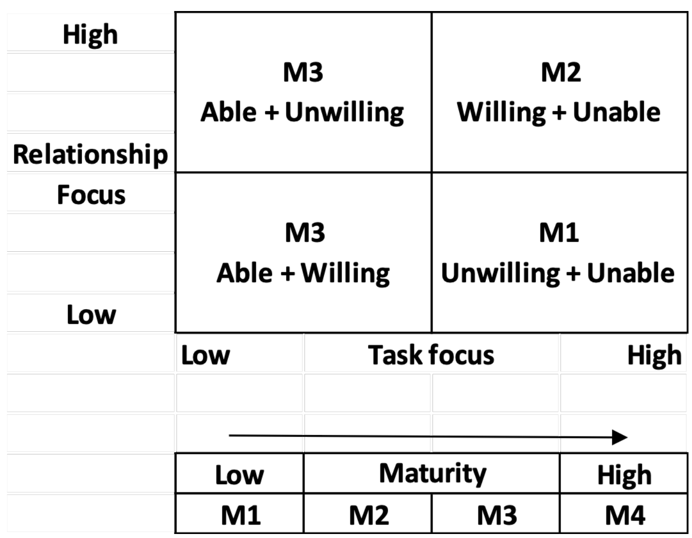

Figure 2-8 The situational theory grid (adopted from Hersey and Blanchard, 1977)

Another theory of more abstract nature, known as the path-goal theory, was presented by House (1971). According to House, the leadership style is a function of the leader's behavior, subordinates' needs, and organizational situation. The primary role of a leader is to pave the path for sub-ordinates and organizations to achieve their goals. For the purpose, the leader directs, supports, and participates accordingly.

Finally, the normative decision model by Vroom and Jago (1988) based their theory upon the continuum like Lewin et al. (1939) and created a decision-making tool to decide what level of leadership (from autocratic to democratic) the situation requires.

iv) *Transactional/Relational theories*

The transactional theories, also known as the exchange theories of leadership, are based upon the mutually beneficial relationship between the leader and followers. The most famous theory in this regard is the LMX (Leader-Member-Exchange) theory. Built upon the vertical dyad linkage (VDL) model by Dansereau et al. (1975), the theory proposes a model where leaders form close relationships with some sub-ordinates (also known as in-group) and a distant relationship with others (out-group).

2.2.2. Transformational Leadership

Identified by the famous historian and political scientist James MacGregor Burns (Burns, 1978), the transformational leadership theory was majorly developed by Bernard M. Bass (Bass, 1985). The spirit of transformational leadership lies in inspiring the subordinates through charisma and transforming them. Bass identified 4 I's in relation to transformational leadership:

Idealized influence refers to the leader becoming a full-fledged role model, acting out and displaying ideal traits of honesty, trust, enthusiasm, and pride, among others. It is further divided into idealized influence attributed and idealized influence behavior.

Inspirational Motivation by a leader refers to providing the meaning of tasks to followers. It usually involves providing a vision or goal. The group is given a reason or purpose to do a task or even be in the organization. The leader will resort to charismatic approaches in exhorting the group to go forward.

Leadership behaviors related to idealized influence and inspirational motivation include creating pride in the followers for being linked with the leader or team, encouraging the followers to go beyond their personal interests in favor of the group cause, assuring that the problems will be solved, expressing optimism regarding the future, and sharing the vision in a compelling manner.

Intellectual stimulation is provided by a leader in terms of challenge to the prevailing order, task, and individual. S/he seeks ideas from the group and encourages them to contribute, learn, and be independent. The leader often becomes a teacher. Some of the behaviors related to intellectual stimulation include asking for input from followers while making decisions, making the followers comfortable to disagree, and encouraging them to think critically.

Individualized consideration emphasizes on catering to the needs of team members. The leader acts as a role model, mentor, facilitator, or teacher to bring a follower into the group and be motivated to do tasks. Some of the behaviors related to individualized consideration include Spending time and effort in coaching/training, listening attentively to the followers, and taking care of their concerns/requirements.

Significance: Transformational leadership is the most prominent and highly regarded approach for leadership in the current era (Ronald, 2014). It is empirically proven to help teams share knowledge, vision, commitment, and mental models (Braun et al., 2013; Dionne et al., 2004;

Ayoko et al., 2014). Transformational leadership has also been found to impact individual and team performance positively many times in the literature (Dvir et al., 2002; Dionne et al., 2004; Braun et al., 2013).

As compared to other leadership styles which are very task-oriented, transformational leadership aims to enhance team development, create cohesion, and promote integration in teams (Zaccaro et al., 2001). The fact that transformational leadership acknowledges and caters to the social context makes is very suitable for temporary organizations like project teams (Tyssen et al., 2013).

2.2.3. Shared Leadership

Recently, the literature has seen a surge of studies on shared leadership, advocating it as a better approach as compared to the traditional concept of a single team leader (Contractor et al., 2012). The traditional leadership focusses on the individuality of the leader, which is not the accurate representation of leadership in teams. Thus, an expanded unit of analysis is more suitable for both researchers and practitioners (Gronn, 2002). Thus, new leadership forms have emerged, which recognize leadership as a shared process in the team. These forms are referred to as “Shared”, “Collective”, or “Distributed” leadership interchangeably (Avolio et al., 2009).

There are different approaches researchers have used for shared leadership in teams. D'Innocenzo et al. (2016) in their meta-analysis listed down three theoretically distinct forms: aggregation (Collective leadership of the complete team as a unit), density (dyadic networks of links between team members), and centralization (Distributed form, in which there can be many formally appointed and emergent leaders). These forms depend on the type of referent in the studies. If the team members respond to team leadership as a whole or rate themselves as leaders, it is aggregated. However, if the team members rate their peers for the leadership they provide, then SNA approaches (density and centrality) are used. Chinowsky (2008) has defined the two terms as follow:

- *Network density*: This measure indicates the level of interaction that exists between the network actors. Conceptually, network density is the number of links that exist between the actors in a network in comparison to the total number of links possible between all the actors. Thus, a larger number of network density would mean that more members in the organization are regularly interacting.
- *Centrality*: The measure of centrality that reflects the distribution of links in the overall network. A high value of centrality for a network shows that a small percentage of actors have high percentage of links with other actors. On the other hand, a low value of centrality shows a relatively uniform distribution of links throughout the network. For instance, if a project manager controls most of the communication with the team, it is a highly centralized network.

Shared leadership studies have linked team performance and other relevant constructs with higher network densities and lower centralities (or higher leadership distributions). The network-based approaches (density and centralization) have received better evaluations in terms of effect sizes as compared to aggregation (wang et al., 2014). Density is more widely used, as centrality is more susceptible to errors. For example, low centralization scores can also be a result of the absence of leadership (D'Innocenzo et al., 2016).

In addition to the density and centrality measures, network analysis also provides rich data for the study of sources and patterns of leadership in teams (Carson et al., 2007). A hypothetical example of leadership network is presented in Figure 2-9 below.

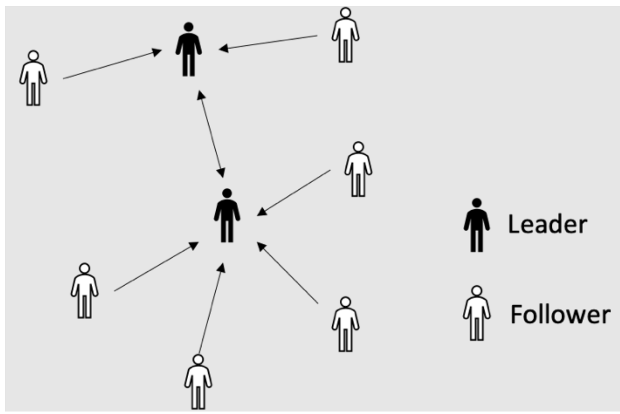

Figure 2-9 Example of a leadership network created as a result of peer nominations

2.2.4. Using Transformational Leadership Theory in Shared Leadership context

Transformational leadership is extensively studied for shared leadership models. In fact, the new genre leadership theories – such as transformational and charismatic leadership – are found to have a stronger relationship with team performance as compared to the traditional leadership theories – such as participative and transactional leadership – when used in the context of shared leadership (Wang et al., 2014). However, one category of shared leadership studies has not yet specified the form or type of leadership shared in teams. For this, we will have to understand the concept of the referent.

Approaches to shared leadership can be divided into three categories based on the type of referent used: i) Team as referent: In these studies, respondents are asked to rate perceived leadership experienced in teams; ii) Self-assessment: In these studies, respondents rate themselves as leaders; and iii) Other team members as referents: In these studies, respondents rate their team members individually for their leadership qualities. In the first two categories, leadership is calculated through aggregation. This means that all responses are added up to make one value for the whole team. The third category, in which each respondent rates other team members, enables researchers to create social networks and evaluate measures such as density and centrality (Wang et al., 2014). This approach not only helps to evaluate individual team members more objectively as compared to self-assessment but also provides the opportunity for an in-depth analysis of teams.

Network studies of leadership, that fall in the third referent category, use cumulative overall leadership (e.g., Carson et al., 2007; Mehra et al., 2006). This means that they simply ask the respondents to give one leadership value for each of their team members. So far, they have not taken advantage of leadership theory (or content of leadership), possibly due to the cumbersome and time-intensive data collection process it brings to evaluating large teams (Conger & Pearce, 2003). The more recent commentaries have, however, stressed the need to explore multiple dimensions within the broad theoretical positions (D'Innocenzo, 2016). As argued by Schröpfer et al. (2017), having the links alone in networks is not sufficient to evaluate leadership in teams; quality and strength of ties are also important. Recommending a future framework for shared leadership studies, Sweeney et al. (2019) highlighted the importance of specifying the type of leadership in distributed leadership frameworks. Moreover, in the prevalent centrality and density studies miss the opportunity of qualitatively studying the roles of leaders and followers in teams (Wang et al., 2014).

In summary, while transformational leadership is one of the most effective forms in the shared leadership context, it is yet to be utilized by network studies in the form where peers in teams are used as referents.

2.3. Leadership in Green AEC Projects

The requirement of leadership in green AEC projects is established in section 2.1. This section investigates leadership in the context of the construction industry in general and tries to identify the key leadership roles in green AEC project teams.

2.3.1. Background

Management skills have always been the focus of construction literature (Skipper & Bell, 2006). Management consists of hard skills, like planning, costing, monitoring, and reporting. Leadership, on the other hand, includes soft skills, like vision, motivation, trust-building, and ethics (Rubin et al., 2002). Leadership skills are not given much importance in construction as compared to technical skills (Skipper & Bell, 2006). This is because of the culture and mentality prevailing in the industry. The focus is only on the day to day transactions to achieve the cost, schedule, and quality results. Thus, the managers end up managing the workforce every day to hit the targets, rather than leading the teams in continuous improvement towards long term goals (Toor & Ofori, 2008).

In a literature review, Toor & Ofori (2008) found that leadership related endeavors date back to as early as the 1980s, but progress has been plodding. The reason lies in the distance of industry from social science. Neither social scientists understand the dynamics of construction, and nor the construction professionals realize the importance of social science (Langford et al., 1995).

The majority of studies done for leadership in construction has focused on behaviors and traits of project managers and supervisors quantitatively. Moreover, almost all studies focus on theories based on task versus relationship orientation of leaders. Only a few studies use transformational leadership as their basis for research. No study was found that used shared transformational as the leading form.

Leadership research for green AEC projects is further scarce. Substantial efforts in improving management frameworks for sustainable construction exist, such as green project management practices (Robichaud and Anantatmula, 2011) and green project management framework (Rumaithi & Beheiry, 2016). Despite the immense value of these studies, they do not fulfill the requirements of leadership. Leadership for sustainability is the weakest in construction, which is a significant gap, given the importance of sustainability in current times (CIOB, 2008). Recently, Tabassi et al. (2016) studied the relationship of leadership competencies of project managers and the performance of sustainable building projects in Malaysia. The authors found a strong relationship for intellectual competencies of project managers and impressed upon the need to further the research with moderating and mediating variables to explore in-depth.

2.3.2. Roles

A construction project focusing on sustainability can have many additional roles and responsibilities. This section begins by discussing the leadership requirements of core stakeholders: Owner, Architect, and Contractor in a traditional setup. This is followed by a discussion on how leadership is facilitated differently in various project delivery systems.

a. Owner

The owner or client has been categorized as the single most important stakeholder to determine a green AEC approach for the project (Pitt et al., 2009). Owners are the driving force behind the success of green AEC projects. Their commitment, or dedication to implementing the sustainability features, is translated into the achievement of green project goals (Korkmaz et al., 2010; Beheiry, 2006). The type of owners and their motivation behind going green is essential in this regard (Korkmaz et al., 2011). The owners can be looking for energy efficiency for long term savings, better indoor air and light quality for improved productivities, passion for the environment, and marketing. Highly committed owners try to introduce sustainability early in the process (Korkmaz et al., 2011).

The indicators of owner's commitment leading to the success of green AEC projects include (i) Educating project team members (ii) Selecting Project Participants based on their expertise (iii) Integrating the team members (iv) Empowering project team participants to develop innovative solutions (v) Commissioning of separate experts to guide the project delivery process (vi) Support from top management (vii) Encouraging improved performance of project participants (viii) Developing and sharing a vision & (ix) Early introduction of sustainability in the project (Olanipekun et al., 2017). All of these indicators can be related to one of the dimensions presented in the transformational leadership theory. The relationships are presented in Table 2-2.

Table 2-2 Relationship Between Transformational Leadership and Owner's commitment

Transformational Leadership dimensions (Bass, 1985)	**Related Indicators of Owner's Commitment (Olanipekun et al., 2017)**
Individual Consideration *(Showing empathy; Paying attention to development needs and growth)*	Educating Project Team Members
	Selecting Project Participants based on their expertise
	Support from top management
Intellectual Stimulation *(Soliciting followers' new ideas; stimulating intellectual creativity to solve complex problems)*	Integrating the team members
	Empowering project team participants to develop innovative solutions
	Commissioning of separate experts to guide the project delivery process
Inspirational motivation *(Show determination and confidence; articulate an inspiring vision)*	Developing and sharing a vision
	Encouraging improved performance of project participants
Idealized influence *(Setting an example as a role model for followers)*	Early introduction of sustainability in the project

b. Architect/ Designer

Architects are considered the second most important stakeholders after owners for the implementation of sustainability in construction projects (Pitt et al., 2009). The realization of the need for leadership skills in architects is very old.

> "The way people work together is the most primary form of communication. Architects should be leaders in this capacity and not just presenters of final results." (Straus & Doyle, 1958)

Architects were once master builders, but over time their role has been reduced to designing only. The construction industry today is more fragmented than ever. This calls for architects to be proactive and expand their scope of work to include collaboration and integration (Burr & Jones, 2010). Architects of today are required to help devise a vision with the owner (idealized influence), communicate extensively with the contractor (individual consideration), and include his skills during the design process (intellectual stimulation) (Burr & Jones, 2010). In addition to the owner and contractor, it is critical for architects to lead miscellaneous designers involved in the process as well. According to a study, structural engineers feel that the design team fails to integrate when architects do not fulfill their leadership role (Uihlein, 2016).

c. Contractor

The contractor's input is highlighted as not only valuable but critical in the green building literature (Riley et al., 2003). Amongst the traits of highly successful construction project managers are sharing values (idealized influence), imaging exciting possibilities and inspiring (inspirational motivation), and seeking out innovative ways to change and grow (intellectual stimulation). Chad Dorgan of McCarthy construction states that they do not rely on mandating sustainability on their workforce and try to inspire them (inspirational motivation) so that they do it with passion and desire (Slowey, 2017). Notably, the field supervision personnel, who are responsible for grass root implementation and play one of the most critical roles in the success of the project, should be kept in the communication loop from the very beginning. Kim et al. (2017) discovered that the field supervisors on green AEC projects feel that their abilities have not been utilized. The authors have advocated for sharing the vision of the project with them, and also including their feedback on early design phases of the project, if possible.

Superintendents are responsible for on-site execution of work. Therefore, they are responsible for both the in-house workforce and subcontractor personnel in action. Hagberg (2006) has listed key attributes for successful superintendents, and the first of them is leadership. Also included in the list are motivational skills and having a vision.

d. LEED/Sustainability Consultants

Many green building projects teams have one or more specialized team members known as Sustainability/LEED consultants to help them through the LEED process. There is not much literature available on these consultants. They, however, have been identified as one of the main stakeholders and leaders in green building teams (Opoku, 2015). They are considered very important for the LEED certification process to be smooth and effective (Frattari et al., 2012).

2.3.3. Project Delivery Methods

As project delivery methods change, so do the responsibilities and consequently, the leadership requirements. The design-build (DB) system makes the design-build contractor in charge of both design and construction (Widjaja, 2016). The advantages of DB are more integration between design and construction professionals. The design-build contractor has excellent potential to share the vision, inspire the complete project team, and stimulate the team intellectually. The negative aspect is that owner has less control over the design. As the owner is the source of the project's sustainability vision, a single point of contact might make it difficult for the owner to practice transformational leadership.

Integrated Project Delivery (IPD) seems to have the most potential for transformational leadership. In this highly collaborative delivery system, all major participants (owner, contractor, architect/designer, and subcontractors) enter in a contract together with financial risk-sharing (Widjaja, 2016). In other delivery systems, the owner creates the project vision majorly with input from the architect/design-build contractor. In IPD, all major stakeholders, including at least the architect/designer and contractor, are actively involved in assisting the owner in vision building. Due to a common, contract the organizational boundaries are faded, and there is free communication. Also, more stakeholders are included in communication and decision-making processes (like suppliers, future building users, and subcontractors). This allows more motivation, individualized consideration, and intellectual stimulation. Thus, IPD creates an excellent environment for transformational leadership to not only exist at more levels but also to thrive unopposed.

Chapter 3 STUDY FRAMEWORK

The previous chapter gives an insight into green AEC projects and transformational leadership with elaborative details. By reflecting upon the learnings, this chapter develops a multilevel framework of transformational leadership and individual/team outcomes. The framework provides the basis of the study hypothesis and research questions.

The framework proposes investigations at the following levels:

- Individual Level: The framework argues that the perceptions of transformational leadership are directly related to team performance. Further, this relationship is mediated through perceived team integration.
- Project Team Level: The framework takes an exploratory approach to observe the dynamics of transformational leadership in green AEC project teams.

The framework (shown in Figure 3-1) is based on the narrative that leadership by its very nature is a multilevel phenomenon, and it is necessary to broaden the investigations accordingly (Chun et al., 2009).

3.1. Individual Level Framework

Transformational leadership is positively related to team performance (Braun, 2013; Wang & Howell, 2010; Dionne, 2004). Also, integration is a significant trait required by the green AEC project teams for optimum performance (Widjaja, 2016; Magent et al., 2009; Korkmaz et al., 2010). Transformational leadership has the potential to be the source of integration in work teams, as shown in previous studies (Zaccaro, 2001; Sarros et al., 2008). Therefore, the following hypotheses are proposed at the individual level.

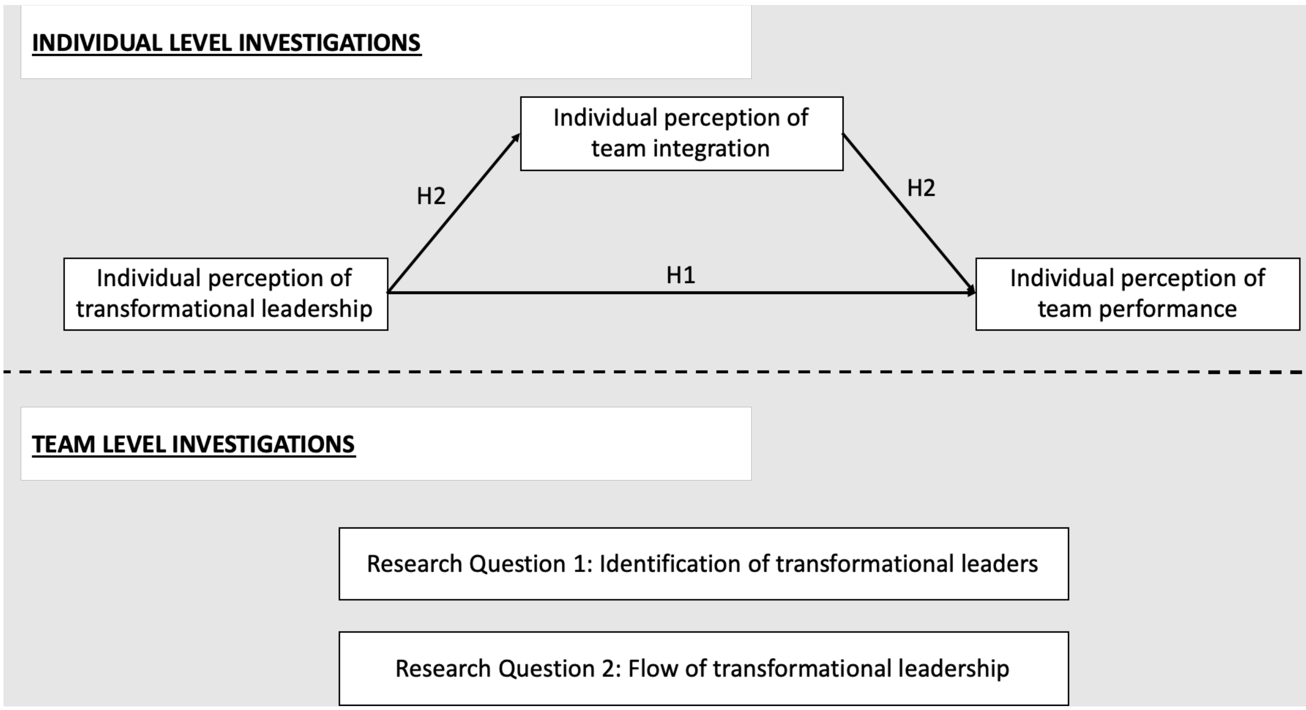

Figure 3-1 Multilevel Framework for the Study in green AEC projects

3.1.1. Hypothesis 1: Transformational leadership and team performance

Transformational leadership uses inspiration, individualized consideration, and intellectual stimulation to create cohesion and communication in teams leading to improved performance in teams (Dionne, 2004). The charisma of transformational leaders inspires the followers to transcend above their personal agendas and work wholeheartedly for the team goals (Shamir et al., 1993). It also creates a climate of trust amongst the team members, which is a significant indicator of team performance (Braun et al., 2013). Thus, the following hypothesis is posed:

Hypothesis 1. The individual perception of transformational leadership for sustainability in a team is positively related to the individual perception of team performance in sustainability.

3.1.2. Hypothesis 2: Mediating role of team integration

Regarding individual perceptions, a team is defined as well-integrated when its members understand their roles and are comfortable with them, when they freely contribute to the team discussions and decision-making, and when they feel positive about the team's overall functioning (Litchtenstein et al., 1997). Leaders are required not only to influence the followers collectively but also to encourage and facilitate them to interact and integrate. Improvement in the team process is ignored in earlier leadership theories. Transformational leadership has the unique strength of aligning the individual goals with team goals and creating an environment of interaction and collaboration (Zaccaro et al., 2001). Team integration is highlighted as the primary requirement for optimum performance in green AEC project teams (Mollaoglu-Korkmaz et al., 2011). Thus, the following hypothesis is posed:

Hypothesis 2. The individual perception of team integration mediates the relationship between the individual perception of transformational leadership for sustainability in the team and the individual perception of team performance in sustainability.

3.2. Team Level Framework

As discussed in the previous chapter, shared leadership/team leadership studies have used both aggregation and social network techniques for analysis. Aggregation, whether it is in the form of collective leadership (such as in Friedrich et al., 2009) or team leadership (such as in Braun et al., 2013), is unable to incorporate the dynamics of large inter-organizational work teams such as in construction. Social Network Analysis (SNA) is the most suitable approach to study the dynamics of shared leadership. Shared leadership is based on relationships, and SNA is relational by its very nature. Tie between actors (typically people) is the unit of analysis in SNA. Building upon this unit, SNA has developed various network structure and analysis techniques. Therefore, shared leadership can not only be visualized but also be better analyzed and explained through SNA (Meindl et al., 2002). The current study proposes to use the perceptions of individual team members regarding the transformational leadership of one or more leaders to form social network ties. These ties are used to create leadership networks for team-level analysis. Figure 3-2 represents this SNA approach.

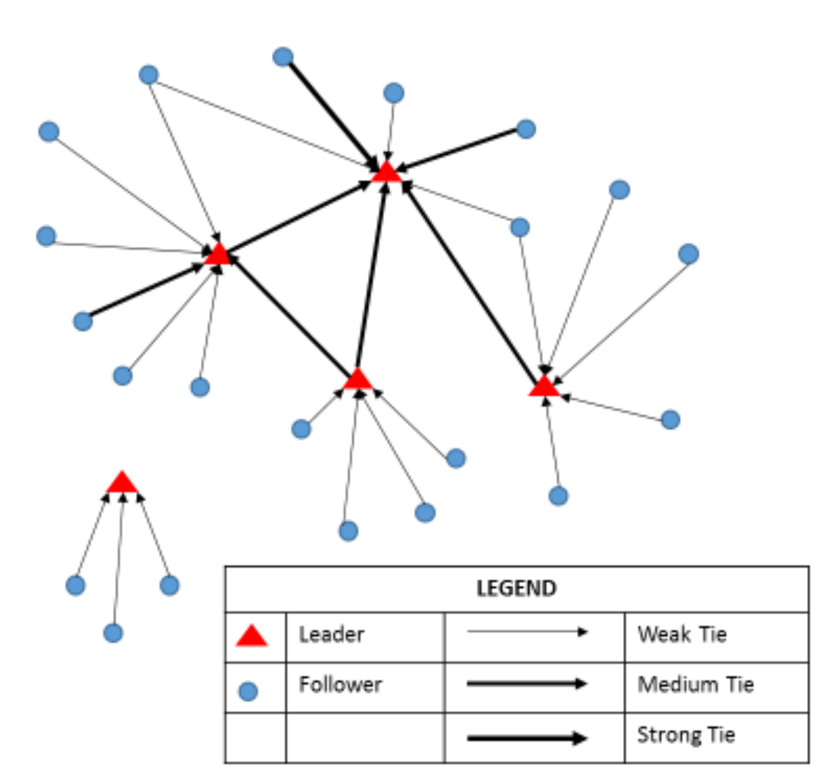

Figure 3-2 Conceptual network diagram for transformational leadership in construction project team

The SNA based shared leadership studies to date have focused on relatively smaller teams. Moreover, almost all of them belong to the same functional unit. For example, Mehra et al. (2006), in their highly cited distributed leadership paper, used 28 sales teams with an average size of 13 members. Similarly, the shared leadership study by Carson et al. (2007) used 59 consulting teams with member sizes ranging from 4 to 7. The samples of these studies are in high contrast with green AEC project teams, which are not only cross-functional but are also much larger. For example, a recent study by Garcia-Cortes (2017) on an educational building aiming for LEED certification. This study reported a project team size of more than 160 members from over 12 functions creating several multi-disciplinary sub-teams.

Feng et al. (2017) suggested that distributed leadership should be assessed in the context of leader attributes, the nature of the task, and the context of occurrence. Traditional methods for shared leadership in teams consider a single measure like centrality or density of social networks as representative of team leadership. Expanding on the traditional approach, this study proposes an exploratory approach for an in-depth understanding of how transformational leadership emerges in green AEC project teams and the factors that influence it. The next sections review key concepts in the literature to help shape the research questions in this pursuit.

3.2.1. Research Question 1: Identification of Transformational Leaders

The first concept is of tiers in construction project teams, as discussed by Mollaoglu et al. (2014). It states that the construction project teams are distributed into three tiers: (1) A core tier consisting representatives of the owner, contractor, and designer/architect; (2) an intermediate tier consisting of organizational colleagues of core tier members; and (3) a peripheral tier, which includes sub-contractors, suppliers, and various consultants. This tiered structure is shown in Figure 3-3.

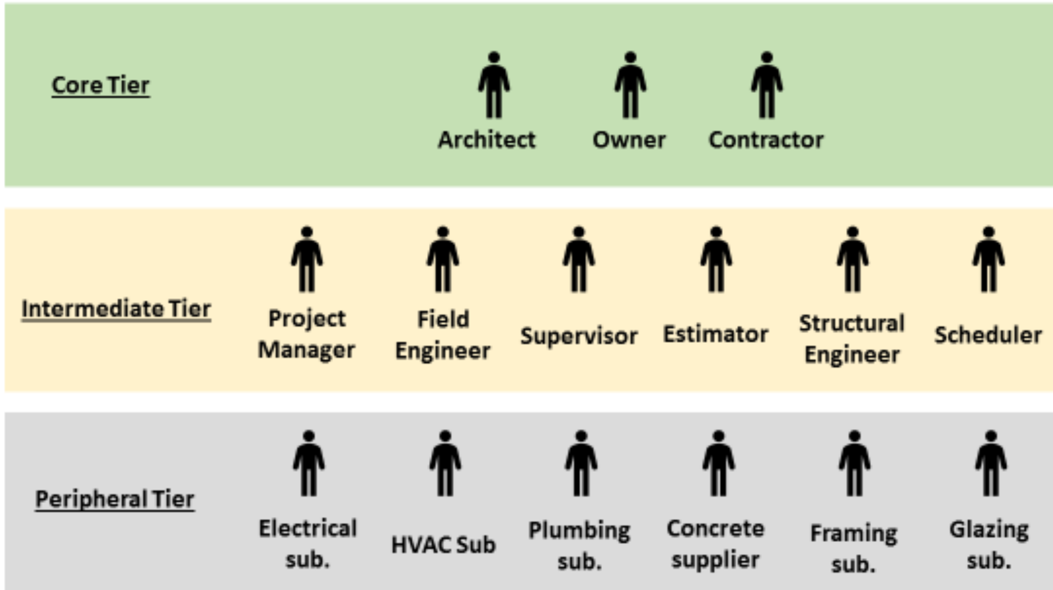

Figure 3-3 Construction project team tiers (adopted from Mollaoglu et al., 2014)

Literature provides a rationale for leadership requirements in the core team members. Sustainability in construction is an owner-driven pursuit. The type of owner and the reason for pursuing green AEC projects are, therefore, of prime importance (Korkmaz et al., 2011). For example, an owner might be interested in a minimum level of LEED certification because of legal obligations (such as state or city laws), or to add marketing value (such as real estate developers), or maybe an owner is dedicated to the cause of environmental protection and wants to go for the top certification level. This background shapes the owner's commitment, one of the most highlighted metrics for the green AEC team and project success (Korkmaz et al., 2010; Olanipekun, 2017). The owner's commitment is related closely to transformational leadership, as discussed in section 2-2.

One of the prime features of transformational leadership is sharing vision through inspiration. The project vision is created by the owner with the help of the designer(s) (Burr & Jones, 2010).

The architect, therefore, is considered the second most important stakeholder in green AEC projects, after the owner (Pitt et al., 2009). This vision is later conveyed to the contractor, which is the party to lead the construction of a facility. Therefore, as prime carriers of project vision, the core team members are expected to demonstrate transformational leadership behaviors. Other members that have been indicated in the literature to practice leadership in construction teams include the project managers. The project managers have the responsibility of inspiring, sharing the vision, and promoting innovation amongst the team (Tabbasi et al., 2016; Slowey, 2017). Also, the field supervisors are expected to practice leadership behaviors within their functional spheres (Hagberg, 2006).

The literature has identified the team members mentioned above as leaders in AEC project teams. However, there is a need to explore their transformational leadership behaviors in the context of green AEC projects. Also, there is a possibility of other team members from lower tiers of AEC project teams to emerge as transformational leaders. Emergent leaders have been identified in other studies like Mehra et al. (2006). Thus, the following research question is formed:

Research Question 1. Who are the transformational leaders for sustainability in green AEC project teams and how are they distributed in the project networks?

3.2.2. Research Question 2: Flow of Transformational Leadership

The second concept is trickle-down leadership, as discussed by Mayer et al. (2009). The findings of this study suggest that there is a trickledown or top-down effect of leadership from top leaders to supervisors and, finally, the employees. However, the proponents of shared leadership disagree with this conceptualization. They believe that it is a much more complicated phenomenon, and formal authority is not the only source for leadership in teams (D'Innocenzo et al., 2016).

Moreover, as the team member categorization in the tiers proposes, the intermediate tier team members are the functional subordinates of core tier team members. It can be assumed that the leaders of the core tier will have followers in their respective functions. However, this fragmentation has been observed to fade away in the integrated type of contracts like Design-Build and Integrated Project Delivery (IPD) (such as in Garcia-Cortes, 2017). Therefore, we cannot confidently predict the followers of any leader. Thus, the following research question is posed:

Research Question 2. How does transformational leadership for sustainability flow in green AEC project teams? Who are the followers of transformational leaders?

3.3. Summary

Chapter 3 presented a multilevel framework of transformational leadership in green AEC project teams at individual and team levels. The individual-level hypotheses and the team level research questions developed in the framework are listed again in the table 3-1.

Table 3-1 Study hypotheses and research questions

Individual Level Investigations
<u>Hypothesis 1</u>. The Individual perception of transformational leadership for sustainability in a team is positively related to the individual perception of team performance in sustainability.
<u>Hypothesis 2</u>. The Individual perception of team integration mediates the relationship between the individual perception of transformational leadership for sustainability in a team and individual perception of team performance in sustainability.
Team Level Investigations
<u>Research Question 1</u>. Who are the transformational leaders for sustainability in green AEC project teams and how are they distributed in the leadership network?
<u>Research Question 2</u>. How does transformational leadership for sustainability flow in green AEC project teams? Who are the followers of transformational leaders?

Chapter 4 METHODOLOGY

4.1. Summary of Goals and Objectives

The primary goal of this study was to "Explore the structure and role of transformational leadership in AEC project teams, providing a significant contribution to AEC literature." The objectives of the study are as follows:

1. Create a multi-level framework for study and measurement tools that:
    a. Guides the hypothesis development to relate transformational leadership and team performance mediated by team integration at the individual level, and
    b. Provides reasoning for research questions in order to explore the dynamics of transformational leadership using social networks at the team level.
2. Validate the framework and measurement tool via expert interviews.
3. Empirically test the study hypotheses at the individual level.
4. Answer the research questions at the team level, exploring the leadership networks in teams and assessing various characteristics of leaders.

4.2. Overview of Study Phases

Phase 1. Framework Development: This phase includes the development of a multi-level framework that guided the study hypothesis and proposition development, as described in Chapter 3. The study variables considered for measurement are further explained in section 4.3.

<u>Phase 2. Expert Interviews:</u> The primary purpose of conducting expert interviews is to seek guidance on the topic in general, and the data collection approach in specific. The findings from these interviews are presented in Chapter 5. The feedback of experts on measurement tools and sampling strategy are discussed in section 4.4.

<u>Phase 3. Study of Project and Team Members:</u> This phase includes the planning and execution of main data collection from projects and individuals that are team members in those projects. Section 4.5 includes the characteristics of the study population, sampling strategy, project selection criteria, data collection procedure, data analysis techniques and procedures to maintain data quality.

4.3. Phase 1: Framework Development

A multilevel framework was developed in Chapter 3. This section presents study hypotheses and research questions, study variables, and development of the measurement tool.

4.3.1. Study Hypotheses and Research Questions

Individual Level Hypotheses:

> **<u>Hypothesis 1</u>.** Individuals' perceptions of transformational leadership for sustainability in a team is positively related to individuals' perceptions of team performance in sustainability.

> **<u>Hypothesis 2</u>**. Individuals' perception of team integration mediates the relationship between individual perceptions of transformational leadership for sustainability in team and individual perception of team performance in sustainability.

Team Level Research Questions

<u>Research Question 1</u>. Who are the transformational leaders for sustainability in green AEC project teams and how are they distributed in the projectnetwork?

<u>Research Question 2</u>. How does transformational leadership for sustainability flow in green AEC project teams? Who are the followers of transformational leaders?

4.3.2. Study Variables

There are three individual level variables in the research model. Perceived transformational leadership is independent in nature, perceived team integration is the mediating variable, while perceived team performance is a dependent variable. Additionally, there is project performance, which was evaluated through both traditional (cost, schedule and quality) and sustainability measures.

Perceived Transformational Leadership

This study used a distributed leadership approach as proposed by Mehra et al. (2006) for Transformational Leadership. Thus, a team can have more than one leader including officially designated and emergent leaders. Each team member was asked to nominate one or more fellow team members (maximum 3) as LEED/sustainability leaders. The nominator was then investigated further regarding transformational leadership skills of each nominee. The total perceived transformational leadership for each nominator was calculated by aggregating the weight of each nominee leader, as depicted in Fig. 3-2.

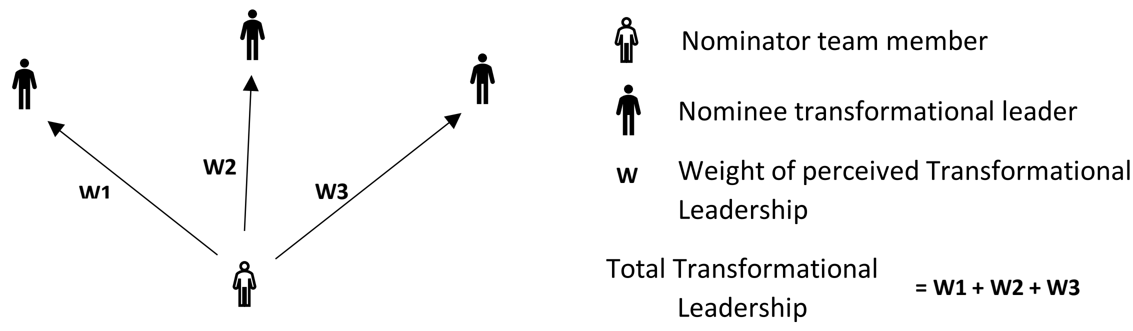

Figure 4-1 Transformational Leadership Exposure

The measures for Transformational leadership are inspired from the adapted version of the Multifactor Leadership Questionnaire - MLQ 5X (Xirasagar et al., 2005). A total of 10 items - 2 for each dimension - are adapted. All responses were collected on a Likert type scale: 1 (Not at all); 2 (Once in a while); 3 (Sometimes); 4 (Fairly Often); 5 (Always). The metrics are listed in table 4-1., and the survey questions are given in Appendix C.

Perceived Team integration

Green AEC project delivery literature has heavily argued team integration phenomenon, which is a construct based on delivery attributes such as early involvement of participants, design charrettes, and communication methods used (Mollaoglu-Korkmaz, 2014; Franz et al., 2017). This study particularly focuses on the individuals' perceptions of team integration. In this regard, this study followed the approach used by Lichtenstein et al. (1997). According to them, perception of team integration has three dimensions: individual participation, role clarity, and assessment of team functioning (Lichtenstein et al., 1997). The metrics are listed in table 4-1., and the survey questions are given in Appendix C.

Perceived Team Performance

Team performance is a very common terminology in literature, yet there is no agreement on a single standard way to measure it (Guzzo & Dickson, 1996). Many studies base it on the project outcomes, some use effectiveness of communications within the team as the ground, while others claim team functioning should be the dimension to approach this (Yeung, et al., 2007; Hsu et al., 2012; Hoegl & Gemuenden, 2001). This study adopts the team performance metrics as given in Tabassi et al. (2014), as they are created specifically in the context of construction projects. The metrics are listed in table 4-1., and the survey questions are given in Appendix C.

Table 4-1 Individual Level Study Metrics

Construct	Dimensions	Measures
Perceived Transformational Leadership *Xirasagar et al. (2005)*	**Idealized Influence: Attributes**	Inspires pride in me for being associated to a LEED project.
		Gives respect and regard.
	Idealized Influence: behaviors	Communicates the sustainability vision and goals for the project.
		Effectively communicates a collective sense of mission regarding LEED certification.
	Inspirational Motivation	Generates optimism about project's success in achieving LEED certification goals.
		Passionate to work on project's LEED certification goals.
	Intellectual Stimulation	Discusses different perspectives on problems related to LEED certification.
		Helps evaluate the benefits and liabilities of each potential solution related to LEED certification.
	Individualized Consideration	Helps think differently about sustainability.
		Helps in developing strengths related to LEED certification.
Perceived Team Integration Lichtenstein *et al. (1997)*	**Individual participation with team**	Contributing information about sustainability.
		Interpreting information about sustainability
		Comfort in disagreement
		Contribute in decision making about sustainability.
	Role clarity in team	Awareness of expectations on sustainability related tasks.
		Awareness of team roles and responsibilities for execution of sustainability related tasks.
	Individual assessment of team functioning	Interdependence of team members on sustainability related tasks.
		Fitness of sustainability related activities together

Table 4-1 (Cont'd)

		Team collectiveness vs fragmentation on sustainability related tasks.
Perceived Team Performance *Tabassi et al. (2014)*		Sound technical decisions about sustainability on project
		Meeting project sustainability expectations.
		Appropriate courses of action to meet project sustainability requirements.
		Choosing the best available strategies for meeting project sustainability goals.
		Fewer reworks on sustainability related tasks
		Innovative solutions to the problems related to sustainability.

Project Performance

Project performance was measured for both traditional and sustainability dimensions.

- Traditional Project performance was measured in terms of triple constraints (Time, cost and quality). Completion in time, within budget, and as per the required quality has been widely recognized as the major criteria of project success (Meng, 2012). Time and cost performance were measured using the schedule and cost growth metrics (given below) developed by Konchar & Sanvido (1998).

  Schedule growth = (Total Time/Total As-Planned Time)/Total As-Planned Time * 100

  Cost growth = (Final Project Cost – Contract Project Cost)/Contract Project Cost * 100

  For quality, the owner's satisfaction regarding product is considered the major measure as encouraged by Kagioglou et al. (2001). Satisfaction level was measured for the whole building, as well as for each building system separately for detailed analysis.

- Sustainability Performance was measured based on the LEED performance of the project. Performance was measured by comparing the initial and current LEED scorecard/checklist of the project. LEED scorecards have been used previously to measure the performance of LEED buildings, such as by Mollaoglu-Korkmaz et al. (2013).

4.3.3. Development of the Measurement Tool

In light of the study variables described in section 4.3.2. three data collection and measurement tools were developed. Open ended interview questions (Appendix C) were designed for Industry experts. A survey (Appendix C) was developed for data collection from all team members. Ans structured interview questions (Appendix D) were designed for Owner's representative to elicit information about the project characteristics and performance.

Institutional Review Board Requirement: As the study uses human subjects, it was subjected to a review and approval from the Institutional Review Board (IRB) at Michigan State University (MSU). A data collection protocol was therefore submitted for approval before the start of data collection. The data was collected through online surveys. (Approval letter in Appendix A)

4.4. Phase 2: Expert interviews

Expert judgement is recommended to improve the content validity of data collection instruments (Korb, 2012). Three industry experts – one from owner, contractor, and designer organizations each – with extensive experience in the field of green AEC were interviewed via video calling. In addition to feedback on data collection tools, the structured questions (given in Appendix B) also gathered experts' views on: complexity and challenges of green AEC; origin of sustainability in projects; and presence, emergence, and role of transformational leaders. Results from these interviews were used to modify data collection tool and inform sampling strategy for stage 3, survey of project team members. The detailed findings from these interviews are presented in Chapter 5. Here, we present the modifications suggested by experts for measurement tool.

4.4.1. Measurement Tool Revisions

The experts had a number of concerns over the clarity of questions in the initial tools. With these changes, the new Questionnaire tool for all team members and structured interview questions for owner's representative are given in Appendix C and Appendix D respectively. The questions in initial tools which were recommended to be changed/modified/removed are listed in table 4.1. below.

Table 4-2 Changes in the Measurement tools based on Expert Interviews

Initial Statement	Recommended change
Questions for Team Integration	
I frequently interpret information	Replace with: I'm frequently encouraged to think outside my job responsibility.
I can comfortably disagree with others on my team.	Modify into I can comfortably talk about my opinions/ideas.
I'm certain about what other members of my team expect of me. and I'm certain of what other members of my team are supposed to do.	Both statements rejected. Replaced with the following: Members of my team value the roles and contributions of all team members.
	New Question: I'm aware of the overall LEED goals of the team.
We function as a team working for shared goals, as compared to fragmented individuals focused on their personal agendas.	I feel like I'm an integral part of the collective team effort pursuing shared LEED and green building goals.
Questions for Team Performance	
The team has made sound technical decisions.	The team has made sound decisions based on project's sustainability principles.
The output of the team has met project expectations.	The output of the team has exceeded the initial project performance goals
The team has chosen the best available strategies for meeting project goals.	The team has explored a wide array of options to choose the best available strategies.
The team has succeeded in achieving fewer reworks.	The team has succeeded in achieving fewer reworks/change orders.
The team has developed innovative solutions to the problems.	The team has developed innovative solutions in pursuit of project goals.
Questions for Transformational Leadership	

Table 4-2 (Cont'd)

This person gives me respect and regard.	This person builds respect and regard among all team members.
This person communicates the sustainability vision and goals for the project.	This person facilitates clarity regarding sustainability vision and goals for the project.
This person discusses different perspectives on problems.	This person helps us explore different perspectives on potential solutions related to LEED certification.

4.4.2. Data Collection Strategies

The findings of expert interviews identified factors that impact the performance of sustainability projects. These factors included owner and/or tenant types (e.g., private, public, government, higher education), and regulations by city/state government. The data collection was designed keeping all these factors in mind. An attempt was made through systematic sampling to incorporate a variety of owner types and project locations in the sample.

4.5. Phase 3: Study of Projects and Team Members

4.5.1. Study Population and Sample

The study population was limited to ongoing sustainable projects in the United States aiming for one of the four LEED certifications under LEED Version 4. Certification for sustainability provides a standard measure for evaluating and comparing performance. LEED being the most common certification globally (Ewing et al., 2013) was therefore considered the most suitable option. To control the variability based on facility types, only commercial projects were considered. Commercial projects generally larger and more complex as compared to residential projects (Senescu et al., 2012), they are expected to have larger and more inter-disciplinary teams. The findings of expert interviews (Phase 2) revealed that location (e.g., climate, topography, the stringency of local codes and regulations, sensitivity of the public towards sustainability issues) and owner and/or tenant types (e.g., private, public, government, higher education) affect the performance of green AEC projects. Therefore, the population was not limited in these factors to overcome sampling error and improve the generalizability of study results for all population.

As discussed in section 2.3.2, delivery systems can impact transformational leadership in teams. Therefore, an attempt was made to select the projects from three common types of systems, namely: Design-Build, Design-Bid-Build, Integrated Project Delivery, and Construction Management at Risk. Also, the level of LEED building certification defines the level of service/complexity for projects, that can impact transformational leadership in teams. It is observed that Gold and Platinum certifications require more optimization as compared to certified and Silver certifications (Kats et al., 2003). Therefore, an attempt was also made to select projects from each of the 4 certification levels. 9 near completion projects with similar characteristics with reference to specifications and size were targeted for consistency while the researcher aimed for variety in location, owner type, aimed LEED certification level, and project delivery methods variables as described above. Multiple case studies provide flexibility for cross-case comparison and synthesis. Moreover, twelve projects generated a cumulative sample size of more than 1000 individuals for objective 1, which ensured the quality of quantitative analysis.

4.5.2. Case Study Selection

USGBC's online database (www.usgbc.org/projects) was used for selection of case studies. New construction commercial projects aiming for a LEED certification using LEED V4 were filtered for United States, and all the projects already having a finish date were neglected as the study required ongoing construction. Systematic sampling process was used, and every 10th project on the list was send an invitation to participate in the study, until the required sample size and characteristics were achieved.

4.5.3. Data Collection

An online survey questionnaire (Survey given in Appendix C) was used to collect data from the sample teams. It was distributed amongst all the team members to extract their responses on distributed transformational leadership, sustainability vision, and task mental models. A semi-structured interview was used to elicit information about the project delivery attributes and project performance from project managers. The interview (provided in Appendix D) consists of both close ended and open-ended questions for a broader exposure to each case study.

4.5.4. Data Analysis and Quality

As discussed earlier, the study uses mixed methods to answer the research questions. The individual level model uses quantitative approach to the hypotheses, while the project level model uses propositions that require qualitative exploration and reasoning. Therefore, this section of data analysis is divided into the quantitative and qualitative parts respectively.

Quantitative Data Analysis and Quality

The quantitative analysis for the model will begin with quality checks for survey variables (Appendix C). These checks include tests for reliability and validity. The statistical analysis follows.

Reliability**:** mainly depends upon the consistency of a measure. It means that a person providing with responses for an instrument should have the same responses each time he/she fills that survey. Although an exact value of reliability cannot possibility be calculated, various measures can give us an estimate. The attributes of reliability include homogeneity (also known as internal consistency), stability and equivalence. The description of these attributes, along with their tests are provided in the table 3-1.

Table 4-3 Attributes of reliability (adopted from Heale & Twycross, 2015)

Attribute	Description	Tests
Homogeneity	The extent to which all items on a scale measure one construct	• Item-to-total correlation • Split-half reliability • Kuder-Richardson coefficient • Cronbach's α
Stability	The consistency of results for an instrument with test repetitions.	• Test-retest • Parallel-form reliability testing
Equivalence	The consistency of responses with multiple-users or alternative forms of an instrument	• Inter-rater reliability

Validity: Validity means that the instrument is measuring what it was intended to measure. There are different forms of validity. The three main types are construct, content and criterion. Their descriptions along with tests are given in table 3-2.

Table 4-4 Types of Validity (adopted from Korb, 2012 & APA, 1974)

Validity Type	Description	Tests
Construct	The tool accurately measures the construct under investigation	• Multi-trait Multi-method (MTMM) matrix • Factor Analysis
Content	The tool covers all the aspects related to the construct	• Expert judgement
Criterion	The measures in the tool are related to the outcome	• Concurrent validity test • Predictive validity test

Although the constructs used in the study are adopted from validated constructs but modified to some extent, therefore CFA was employed to validate the constructs before using them for statistical analysis in hypotheses testing.

***Statistical Analysis*:** The study used Structural Equation Modeling (SEM) to test the study hypotheses. Independent samples t-test and chi-square tests were also employed to test the characteristics of identified leaders.

Qualitative Data Analysis and Quality

The second part of the study will assess various propositions at the project level qualitatively. As the proposed research will use case studies, the relevant quality considerations and analysis techniques will be used. The reliability, and various forms of validity for case study research, along with their descriptions and techniques as presented by Yin (2003) are given in table 3-3.

Table 4-5 Case Study research quality tests

Quality Test	Description	Technique for case study
Reliability	Depicts that the operations of the research can be repeated achieving the same results	• Use case study protocol • Develop case study data base
Construct Validity	Depicts accurate operational measures for the for the areas being studied	• Use multiple sources of evidence • Establish chain of evidence
Internal Validity	Establishes a causal link (For Explanatory case studies only)	• Pattern-matching • Explanation-building • Rival explanations • Logic models
External Validity	Depicts the generalizability of research findings	• Theory in single case studies • Replication logic in multiple case studies

Case study data analysis: The proposed study uses the theory to form propositions in order to direct the case study towards a specific data. The case study analysis was done using pattern-matching, explanation-building, and cross-case synthesis techniques (Yin, 2003).

Explanation Building

Explanation building is an iterative technique used to demonstrate causal links. First the theoretical statements are laid down, and the findings of case study are compared. The statements are then revised, if needed, and compared with the findings again. The revisions are further carried out until the causal link is identified. This technique needs case as the analysis may turn away from the real topic of study.

Cross Case Synthesis

Cross Case Synthesis is used in multiple case study researches to find pattern between data. This adds to the internal validity of the study. An objective scoring or comparison criteria is established to facilitate comparisons across multiple case studies. Objective data is used to find similarities and differences in the features of each case study.

Chapter 5 RESULTS FOR EXPERT INTERVIEWS

This chapter covers the results from initial Expert interviews. As mentioned in previous chapter, three experts - belonging to contractor, client and consultant organizations - were interviewed in phase 2 of this study. The major objective was to validate the subject and content of this study. The structured interview questions (Appendix B) were designed to 1) record the perceptions of industry experts regarding green AEC projects and the role of transformational leadership, and 2) receive the feedback of industry experts on the structure and content of questionnaire. In this chapter we begin with the introduction of experts, and then present the findings of part 1 in structured interviews. The findings of part 2 and revisions for measurement tools are already presented in section 4.4.

5.1. Introduction of Experts

As mentioned earlier, three experts were interviewed from designer, contractor and owner teams. A brief introduction of each expert is presented in Table 5-1.

Table 5-1 Expert Introductions

Expert	Team	Experience	Highlights
1	Designer	21 Years	• Participated as a team member for over 60 LEED certified and 80 LEED registered projects. • Co-chaired USGBC’s international task force. • Served as LEED faculty. • Served on LEED steering committee. • Chaired the LEED curriculum committee. • Co-authored a book on integrative design.

Table 5-1 (Cont'd)

2	Contractor	15 Years	• Directly involved in more than 100 LEED projects of various nature. • Served as corporate director of sustainability for two large construction companies. • Author of two books on sustainability. • Teaching sustainability at USGBC and other renowned platforms.
3	Owner	18 Years	• Working as the director of development for a major developer since 2012. • Managed 14 LEED projects. • Also worked in the capacity of project manager for 3 years and delivered one of the first LEED project in Virginia.

5.2. Structured Interview Results

Structured interview questions were designed to elicit expert views on green AEC and role of transformational leadership in it. The findings are presented for each question one by one.

Question: Can you please shed some light on the complexities of green AEC projects? How are they more challenging as compared to their traditional counterparts?

Experts were unanimous that the complexity of sustainable projects cannot be generalized. It depends on many factors including the intention behind going green, the learning curve maintained by the team and the level of certification. A lower level LEED certification is not much different, and the only added complexity is additional requirements.

Expert 1 believed that the aim behind going green is really what differentiates in the context of this question. If the aim is just to gain points and earn certification alone, a LEED project is not much different from traditional project. When the team aims higher, the individual point categories start depending on each other and the inclusion of innovation and integration becomes critical. This is where a traditional team and a LEED team become different. ". . . *the point categories now need to speak to each other. Each of the team members now need to think outside their normal area.*"

Expert 3 echoed with this idea, and specified Platinum level certification with LEED Version 4 more complicated. *". . . for example, we executed a LEED Platinum project and it was very challenging. Version V4 has made it even more difficult. You actually look for innovative solutions at a higher certification level or Platinum."*

Expert 2 believed that LEED or green projects are not more complicated; they are just different. *" . . . . It just needs more patience and out of the box thinking sometimes. You need the right people for the right roles. Construction projects are very fast paced and green projects bring in the requirement of additional learning. Therefore, the important thing is to learn as you go. There is no time to stop and wait."*

Question: How do these projects come alive? In other words, who initiates the idea of going green on a project in your experience? Why?

All experts agreed that it is mostly the owner that initiates sustainability in such projects, however the underlying reasons for the owner to take this initiative varies from case to case.

Expert 1 was of the view that owner is the key, and owner's aim behind going green plays an important role *". . . if the mission of owner or owner organization comes in line with green transformational thinking, that really helps in achieving the best results."*

Expert 2 also believed that the owners mostly initiate sustainability projects because of reasons ranging from government requirements and marketability to sometimes even self-motivation. It is also possible for the architect to convince the owner, especially when it is possible without spending a lot of money. But normally it is always a business decision, one way or other. *". . . there are some owners, architects and contractors out there that truly care, but at the end of the day it is always a business decision. Interestingly, building green is often times financially profitable too. Also, when it is financially feasible it becomes an easy decision."*

Expert 3 also suggested that Owner is the major initiator, with many possible reasons behind the decision of building green *". . . Nowadays it is mostly local requirement, which is strong motivator for basic level sustainability incorporation. Motivation behind going for higher certification levels is energy savings and return on investments, branding, and creating a more unique product in the marketplace."*

Question: Is there generally a transformational leader involved in green AEC projects?

The experts believed that such leaders exist in green AEC project teams, but they are rare.

Expert 1 responded that there are generally a few team members who facilitate the procedure and take the lead for sustainability. There are normally from architect's or designer's side. Some owner's do realize the importance of sustainable leadership in green projects and hire a third-party consultant for this role.

Expert 2 also agreed that such leaders exist in teams, sometimes even at lower tier levels. But they are very few *". . . I met superintendents. People who managed logistics. Who were very passionate about the environmental cause and the spirit of building green?"*

Expert 3 also had a similar understanding. *". . . Usually just one or two people. There is a person from the architect's side normally that leads. But in better case scenarios, there is one person each from owner and architect teams who take up this role."*

Question: Do you think transformational leaders of green AEC project team can positively impact the outcomes?

Responses of industry experts varied to some extent for this question. Expert 1 strongly agreed to the impact and consequently the need of transformational leadership in teams. Expert 2 and 3, on the other hand, suggested that it happens sometimes.

Chapter 6 RESULTS FOR HYPOTHESES AND RESEARCH QUESTIONS

6.1. Sample Characteristics and Data Demographics

The following sections introduce the study sample. All case studies included in this study are educational institute projects. Therefore, first the data collection process is explained that led to this unique and unexpected set of projects. Afterwards, the characteristics of case studies are discussed one by one. Finally, demographics for data consisting of individual responses is presented.

6.1.1. Selection of Case Studies

As per the guidelines laid out in section 4.5, systematic sampling was used to contact every 10th project on the list obtained from USGBC website and filtered for respective criteria (see section 4.5.2). A total of 1512 projects were shortlisted, out of which 152 projects were contacted and 9 projects eventually participated. Table 6-1 lists the owner categories with respective numbers.

Table 6-1 Projects and their owner types – Available Vs Contacted Vs Participated

Owner Type	Number of projects available	Number of Projects contacted	Number of Participants
Business Improvement District	5	0	
Community Development Corporation	9	1	
Corporate: Privately Held	267	30	
Corporate: Publicly Traded	88	9	
Educational: College, Private	51	8	1
Educational: College, Public	121	15	4
Educational: Community College, Private	5	0	1
Educational: Community College, Public	39	6	1
Educational: K-12 School, Private	19	0	
Educational: University, Private	50	4	
Educational: University, Public	115	16	2

Table 6-1 (Cont'd)

Government Use: Federal	100	12	
Government Use: Local, City	181	13	
Government Use: Local, County	83	10	
Government Use: Local, Public Housing	3	0	
Government Use: Other	33	2	
Government Use: State	51	5	
Investor: Bank	5	0	
Investor: Equity Fund	4	0	
Investor: Individual/Family	7	3	
Investor: Investment Manager	8	0	
Investor: Real Estate Investment, publicly traded	9	0	
Investor: Real Estate Investment, Non-traded	7	1	
Main Street Organization	1	0	
Non-Profit (that do not fit into others)	75	7	
Religious	5	2	
No category	171	8	
Total	1512	152	9

It can be seen in Table 6-1 that all individuals that agreed to participate in this study were involved in educational institution projects. This can be supported by the fact that 26.4% projects in the list belong to educational institutions – more than any other owner category. According to a McGraw-Hill report Schools and Universities are highly motivated to build green as compared to other owners (McGraw-Hill, 2014). Some reasons mentioned in literature for this phenomenon are sustainability perceptions and educational needs (Richardson & Lynes, 2007). According to the researcher's experience, another main factor for this uniform sample is the organizational structure of universities and easy to reach personnel. Finally, the presence of researcher bias can also not be ruled out completely. There is a possibility of researcher to be more supportive to educational institutions based on initial success in collecting data (Lüttin, 2012).

6.1.2. Summary of Case Study Projects

Basic characteristics of case study projects that participated in this research are summarized one by one in the following sections. A structured interview was conducted with the owner's and designer's representatives in this regard. All projects were pursuing a LEED New Construction/Major Renovation certification under version V4 and were in their late construction phases. The geographical distribution of all case studies is demonstrated in figure 6-1 below.

Figure 6-1 Geographical Locations of Case Study Projects

Case Study 1 is a new construction project for an indoor sports facility located in the Midwest region. The budget of the project was $40 million. The building consists of 2 floors and the total area is 11, 401 sq. ft. The project used Design Build method of project delivery. *Case Study 2* is a major renovation and new addition project of a STEM building in the Midwest region. The total budget for the project is $32 million. The building consists of 3 floors with total area of 89,000 sq. ft. The project used design-build delivery method. *Case Study 3* is a new construction project for student health center located in the Southeast region. The budget of the project is $14.5 million. The building consists of 2 floors with the total area of 4,500 sq. ft. Delivery method used is Design Bid Build. The project used Design-Bid-Build method of project delivery*. Case Study 4* is a major renovation and new addition project for a technology center located in the Midwest region. The budget of the project is $13.78 million. The work covers a total area of 187,822 sq. ft. for 2 floors of a 4-story building. *Case Study 5* is a new construction project of a performing arts center located in the Southeast region. The budget if the project is 69.6 million. The total covered area is 80,300 sq. ft. The building has 2 floors for most of the area. *Case Study 6* is new construction project of an academic building located in the Midwest region. The budget of the building is $13 million. The total covered area is 30,000 sq. ft. for a 3-story building. *Case Study 7* is a new construction project of student residential complex located in the West region. The budget of the building is $101 million. The total covered area is 197,000 sq. ft. *Case Study 8* is a major renovation and addition project of an academic building located in the West region. The budget of the project is 16.5 million. The covered area of the project is 54,050 sq. ft. The building has two floors. *Case Study 9* is a new construction project of a sports facility in the Southeast region. Total budget of the project is $50 million. The covered area of the project is 88000 sq. ft. The building has 4 stories. These characteristics of case study projects are summarized in table 6-2 below.

Table 6-2 Basic characteristics of Case Study Projects

Case Study	Region	*Building Use	Budget ($)	Area (sq. ft.)	Project Delivery Method
1	Midwest	Sports Facility	40 M	11,401	Design-Build
2	Midwest	STEM Building	32 M	89,000	Design-Build
3	Southeast	Health Center	14.5 M	4,500	Design-Bid-Build
4	Midwest	Technology Center	13.78 M	187,822	CM at Risk
5	Southeast	Performing Arts Center	69.6 M	80,300	Design-Bid-Build
6	Midwest	Academic Building	13 M	30,000	Design-Bid-Build
7	West	Residential Complex	101 M	197,000	Design-Bid-Build
8	West	Academic Building	16.5 M	54,050	Design-Build
9	Southeast	Sports Facility	50 M	88,000	CM at Risk

**All projects belong to educational institutes and are located within college campuses*

6.1.3. Individual Level Data Demographics

An online questionnaire was used to collect data from individuals as explained in section 4.5.3. Owner representatives were requested to send out online survey link to team members from owner, designer, contractor and main representatives of subcontractor organizations. A total of 103 responses were received from 9 case studies. The summary of response rates is presented in the table 6-3.

These responses were further categorized according to the project role – owner, designer, contractor and subcontractor. LEED consultants and commissioning agents were considered separately in the category 'Others', unless they identified themselves as a part of one of the other categories. Descriptive statistics of data according to project role is presented in table 6-4.

Table 6-3 Individual survey response rate

Case Study	No. of team members	No of responses received	Response Rate (%)
1	24	14	58.3
2	18	13	72.2
3	30	10	33.3
4	38	8	21.1
5	22	12	54.5
6	25	9	36
7	35	14	40
8	27	16	59.3
9	28	7	25
Total	247	103	41.7

**These numbers include only one representative from subcontractor organizations working at that time of the project.*

Table 6-4 Respondent roles in case study projects

Roles	**Case Study**									**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Owner	2	2	1	1	4	2	4	1	2	19
Designer	4	4	6	3	4	4	5	13	3	46
Contractor	5	1	3	2	3	3	0	2	1	20
Subcontractor	3	4	0	2	0	0	3	0	0	12
Other	0	2	0	0	1	0	2	0	1	6
Total	14	13	10	8	12	9	14	16	7	103

The respondents were also asked to mention if they have a LEED certification (LEED AP BD+C, LEED Green Associate or others). The number of certifications with each project role is presented in table 6-5 below. Moreover, 80% respondents were male while 20% were female.

Table 6-5 LEED accreditation status for the respondents

Roles	Certification				Total
	None	LEED AP (BD+C)	LEED Green Associate	LEED Neighborhood	
Owner	7	9	3	0	19
Designer	17	24	4	0	45
Contractor	12	6	1	1	20
Subcontractor	11	0	1	0	12
Other	1	6	0	0	7
Total	48	45	9	1	103

6.2. Individual Level Analysis

This section presents the results for hypothesis testing for the two study hypotheses developed in chapter 3 – study framework. These hypotheses are as follows:

Hypothesis 1 Individuals' perceptions of transformational leadership for sustainability in a team is positively related to individuals' perceptions of team performance in sustainability.

Hypothesis 2 Individuals' perception of team integration mediates the relationship between individuals' perceptions of transformational leadership for sustainability in team and individuals' perception of team performance in sustainability.

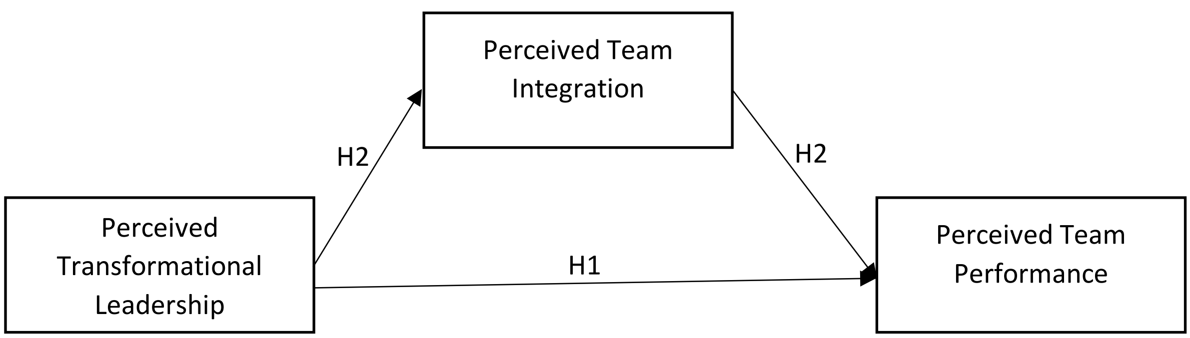

Figure 6-2 Study Hypotheses

The section begins with testing the data for reliability. Also, the data is checked for normality as it defines the methods used in CFA and SEM. Afterwards, CFA is performed for construct validity. Finally, the two hypotheses are tested one by one and results are presented using SEM.

6.2.1. Reliability- Cronbach's Alpha

Cronbach's alpha is the most widely used measure of internal consistency. It is particularly preferred when you have a questionnaire with multiple Likert questions forming a scale. A value of 0.7 or greater is recommended (Cronbach, 1990). A test was performed for the scale of each latent variable. The alpha values for transformational leadership, team performance and team integration came out to be 0.999, 0.911 and 0.888 respectively. Therefore, the data is reliable for analysis. No item showed an improvement in alpha value for any of the scales if deleted. The summary of results is presented in table 6-6.

Table 6-6 Cronbach's Alpha values for variable scales

Latent Variable	No. of items in scale	Cronbach's alpha	Cronbach's alpha based on standardized items
Perceived transformational leadership	10	0.999	0.999
Perceived team performance	6	0.911	0.916
Perceived team integration	9	0.888	0.900

6.2.2. Normality of data

When using CFA and SEM in analysis, checking for normality of data is very important. For statistical models Maximum Likelihood (ML) estimation method is most commonly used. However, ML assumes normality of data. If the data is not approximately normal, ML will tend to produce biased results in terms of both models fit and parameter estimates (Finney & DiStefano, 2006).

There are three methods available to test the normality of data: graphical, numerical and formal normality tests (Razali & Wah, 2011). In this study histograms were used to visually assess normality of data, reinforcing the findings with skewness and Kurtosis measures, and the formal Shapiro-Wilk test. A z-test is used to test normality for skewness and kurtosis. Z-scores are obtained by dividing the skewness and excess kurtosis values (provided by SPSS) by their standard errors. For a medium sample size ($50<n<300$), a z value of above 3.29 shows the data is not normal (Kim, 2013). Regarding normality tests, Shapiro-Wilk test is the most powerful test available for all sample sizes (Razali & Wah, 2011), and therefore selected for this study. A significance value of 0.05 or greater is needed to pass data for normality.

It was concluded by visually observing histograms for all items that the data is not normal. This deduction was further verified through skewness and Kurtosis z-scores as well as Shapiro-Wilk normality test. Results for these tests are listed in table 6-7. It can be seen that all items fail the normality testing.

Table 6-7 Results for normality tests

Item	Skewness			Kurtosis			Shapiro-Wilk	
	Value	SE	Z	Value	SE	Z	Statistic	Sig.
Perceived transformational leadership								
L1	1.157	0.238	4.861	0.531	0.472	1.125	0.833	0.000
L2	1.114	0.238	4.681	0.424	0.472	0.898	0.836	0.000
L3	1.106	0.238	4.647	0.414	0.472	0.877	0.837	0.000
L4	1.12	0.238	4.706	0.349	0.472	0.739	0.831	0.000
L5	1.113	0.238	4.676	0.423	0.472	0.896	0.838	0.000
L6	1.07	0.238	4.496	0.302	0.472	0.640	0.839	0.000
L7	1.109	0.238	4.660	0.422	0.472	0.894	0.837	0.000
L8	1.134	0.238	4.765	0.485	0.472	1.028	0.835	0.000
L9	1.102	0.238	4.630	0.344	0.472	0.729	0.837	0.000
L10	1.108	0.238	4.655	0.311	0.472	0.659	0.834	0.000
L11	1.134	0.238	4.765	0.502	0.472	1.064	0.834	0.000
L12	1.115	0.238	4.685	0.397	0.472	0.841	0.836	0.000
L13	1.219	0.238	5.122	0.727	0.472	1.540	0.826	0.000
L14	1.234	0.238	5.185	0.786	0.472	1.665	0.822	0.000
L15	1.266	0.238	5.319	1.005	0.472	2.129	0.82	0.000
L16	1.171	0.238	4.920	0.779	0.472	1.650	0.835	0.000
Perceived team performance								
P1	-1.613	0.238	-6.777	3.575	0.472	7.574	0.775	0.000
P2	-0.627	0.238	-2.634	-0.143	0.472	-0.303	0.871	0.000
P3	-1.28	0.238	-5.378	1.86	0.472	3.941	0.811	0.000
P4	-1.408	0.238	-5.916	2.235	0.472	4.735	0.817	0.000
P5	-0.539	0.238	-2.265	-0.135	0.472	-0.286	0.887	0.000
P6	-0.808	0.238	-3.395	-0.035	0.472	-0.074	0.873	0.000
Perceived team integration								
I1	-1.069	0.238	-4.492	1.054	0.472	2.233	0.796	0.000

Table 6-7 (Cont'd)

I2	-0.981	0.238	-4.122	0.573	0.472	1.214	0.854	0.000
I3	-0.761	0.238	-3.197	-0.188	0.472	-0.398	0.777	0.000
I4	-1.275	0.238	-5.357	1.101	0.472	2.333	0.804	0.000
I5	-1.128	0.238	-4.739	1.632	0.472	3.458	0.793	0.000
I6	-1.727	0.238	-7.256	3.029	0.472	6.417	0.672	0.000
I7	-0.572	0.238	-2.403	-0.777	0.472	-1.646	0.767	0.000
I8	-0.696	0.238	-2.924	-0.17	0.472	-0.360	0.82	0.000
I9	-1.404	0.238	-5.899	2.633	0.472	5.578	0.789	0.000

6.2.3. Validity - Confirmatory Factor Analysis

CFA assess how well the model fits the data. Since the data was found to be non-normal, Maximum Likelihood (ML) estimation that is the default for CFA and assumes normality of data cannot be used. Out of all the solutions available for moderate to severe non-normality of data in SEM, the most recommended one is using Satorra-Bentler scaling that gives robust estimates (Finney & DiStefano, 2006). MLM estimator in lavaan package of R uses this scaling method and thus was employed for CFA and SEM in this study. All items had very strong loadings on the latent variables, except I6 (0.4), which also showed negative variance. Therefore, I6 was removed from the scale. The resulting CFA is shown in figure below.

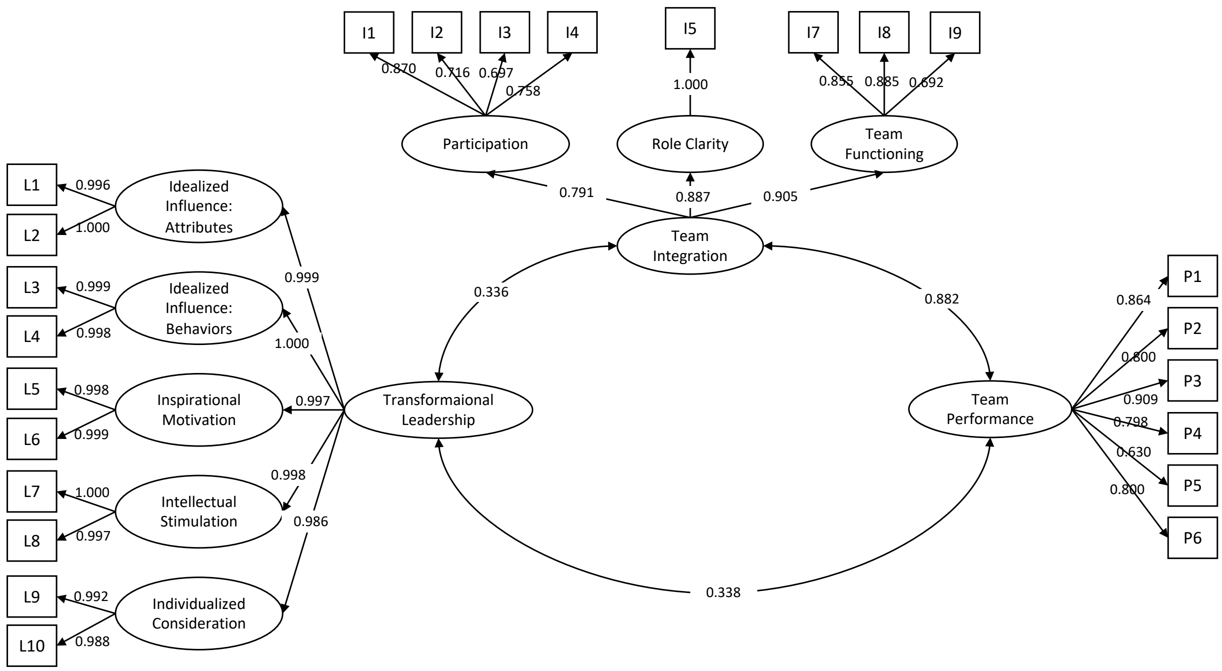

Figure 6-3 Confirmatory factor analysis for study model

Fit indices measures: CMIN/df = 1.42, CFI = 0.974,
TLI = 0.971, RMSEA = 0.064, SRMR = 0.070

CFA results are based upon 103 responses. Hu and Bentler (1999) cut-off criteria are employed to assess the model fit (0.95 for CFI, 0.8 for TLI, 0.08 for SRMR, and close to 0.06 for RMSEA). The Comparative Fit Index (CFI=0.97) is greater than 0.95 and close to 1.00, suggesting that the model fits the data well (Hu & Bentler 1999). The Tucker-Lewis Index (TLI=0.97) is greater than 0.8 and close to 1.00, indicating a good fit as well (Hu and Bentler, 1999). The Root Mean Square Error of Approximation (RMSEA) is 0.064 that is close to 0.06 (Hu and Bentler, 1999) and equal or lower than 0.8 (Browne and Cudeck, 1993). Overall, the fit indices suggest that the model in Figure 6-3 is plausible for the data.

6.2.4. Hypothesis 1: Transformational leadership and Team performance

Hypothesis 1 states that individuals' perceptions of transformational leadership for sustainability in a team is positively related to individuals' perceptions of team performance in sustainability. To incorporate the fixed effects of nine project teams from different projects, dummy variables were introduced in the model to control for their effect. The results for SEM are shown in Fig 6-4 below.

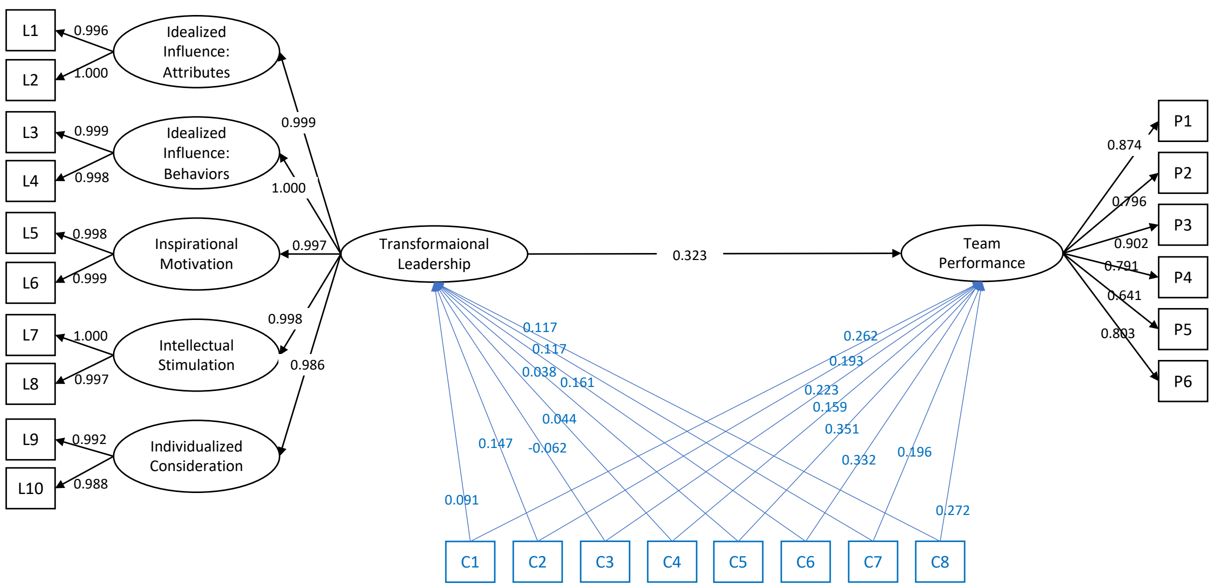

Figure 6-4 Hypothesis 1 - transformational leadership and team performance

Fit indices measures: CMIN/df = 1.56, CFI = 0.971,
TLI = 0.967, RMSEA = 0.074, SRMR = 0.038

The results show a positive relationship with a path coefficient of 0.326 and a p value less than 0.001 indicating strong relationship.

6.2.5. Hypothesis 2: Transformational leadership and Team performance mediated by Team integration

Hypothesis 2 states that individuals' perception of team integration mediates the relationship between individual perceptions of transformational leadership for sustainability in team and individual perception of team performance in sustainability. Again, SEM was used to test the hypothesis and results are shown in Figure 6-5.

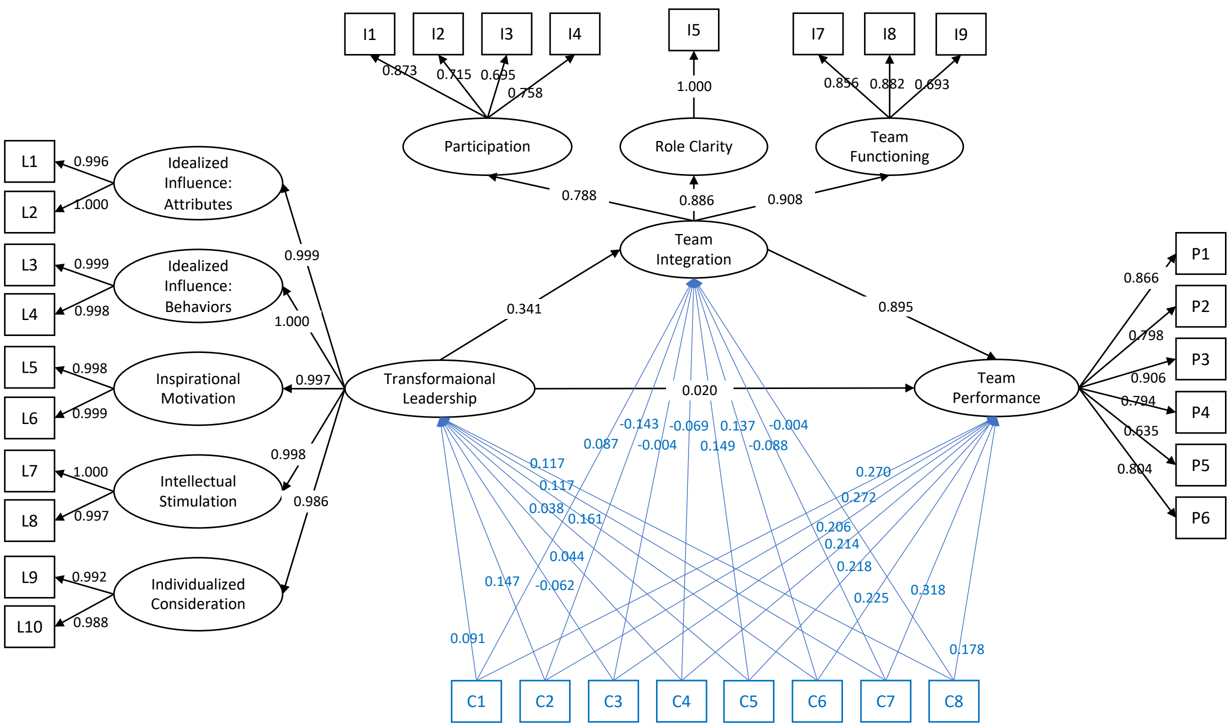

Figure 6-5 Hypothesis H2 - Mediating Effect of Team Integration

Indirect = 0.305, Direct = 0.020, Total = 0.325
Fit indices measures: CMIN/df = 1.47, CFI = 0.959,
TLI = 0.954, RMSEA = 0.068, SRMR = 0.062

The results show a positive relationship between leadership and integration, and between integration and performance (coefficients 0.341 and 0.895 respectively). The p value for both these relationships is less than 0.001. The direct relationship between leadership and performance is weak coefficient (0.02) and p value is greater than 0.05. The results clearly indicate a mediation of relationship between transformational leadership and team performance through team integration.

6.3. Team Level Analysis

This chapter presents the results for team level research questions which are as follows:

- Research Question 1. Who are the transformational leaders for sustainability in green AEC project teams and how are they distributed in the leadership networks?
- Research Question 2. How does transformational leadership for sustainability flow in green AEC project teams? Who are the followers of transformational leaders?

In all 9 case studies, team members were asked to identify transformational leaders and also provide with a weightage for each. The chapter begins with a brief description and leadership network of each case study. Then, each research question is addressed one by one in the following sections.

6.3.1. Leadership Networks in Case Study Projects

In this section a leadership network is drawn for each case study followed by a list of discovered leaders and their characteristics. The network diagrams developed with the help of UCINET and NETDRAW use color coding for associations of actors. Moreover, the strength of ties is translated with the help of tie thickness. For the list of leaders, the following information is provided for each:

- Indegree Centrality: Aggregating all leadership scores received from all followers in the team.

- Stage at which got involved in the project: The options provided were, Conceptual design (0-15% design complete), Schematic design (15-30% design complete), Design Development (30-60% design complete), Construction documents (60-99% design complete) and Construction.
- Experience: Total professional experience in Construction Industry
- LEED Projects: Number of LEED projects worked on before the project under discussion.
- LEED Accreditation: Any of the accreditations offered by USEFP, if acquired.

Moreover, a few identified leaders did not respond to our request for data collection, and thus their information is missing. They have been pointed out by an asterisk (*) at the end of their names both in the networks and tables.

Case Study 1

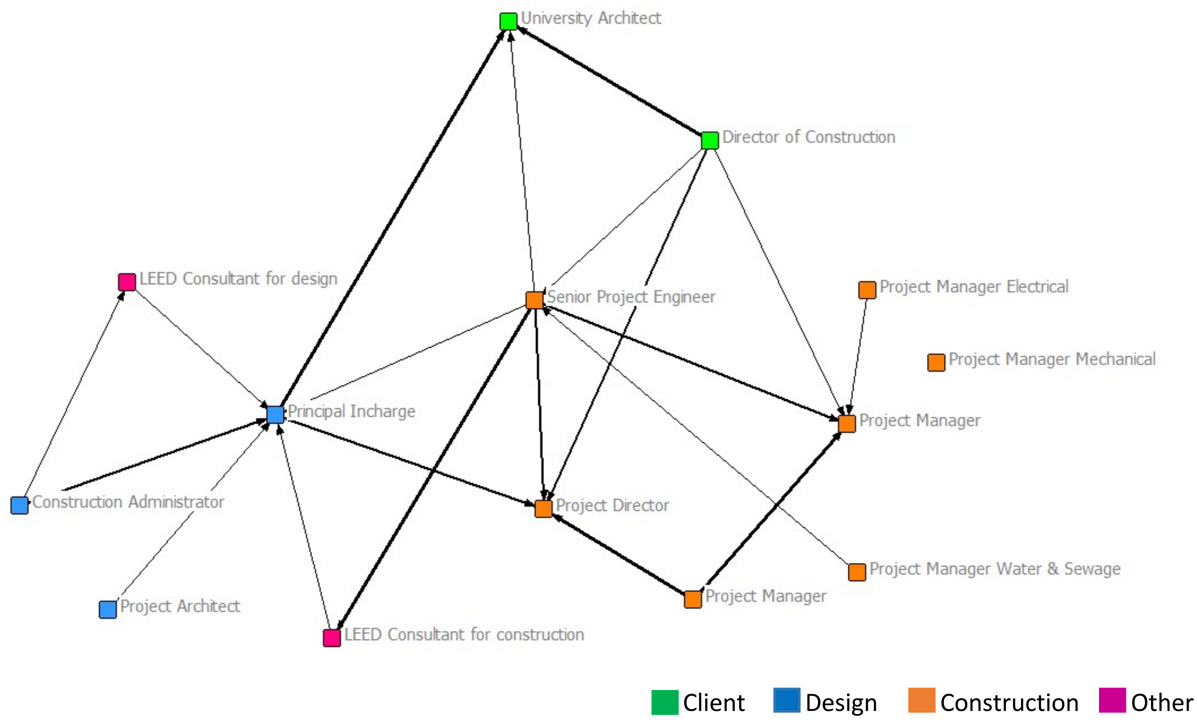

Figure 6-6 Leadership Network for Case Study 1

Table 6-8 Identified Leaders for Case Study 1

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
Principal In-charge (Designer)	24.1	Conceptual design	42	7	None
Project Director (Construction)	22.025	Conceptual design	37	10	LEED AP (ND)
Project Manager (Construction)	19.7	Construction documents	10	1	None
University Architect (Owner)	16.8	Conceptual design	29	8	LEED AP (BD+C)
Senior Project Engineer (Construction)	8.1	Conceptual design	9	1	LEED Green Associate
LEED Consultant (Construction)	5.7	Construction	17	60	LEED AP (BD+C)
LEED Contact (Design)	4.9	Construction documents	20	6	LEED AP (BD+C)

Case Study 2

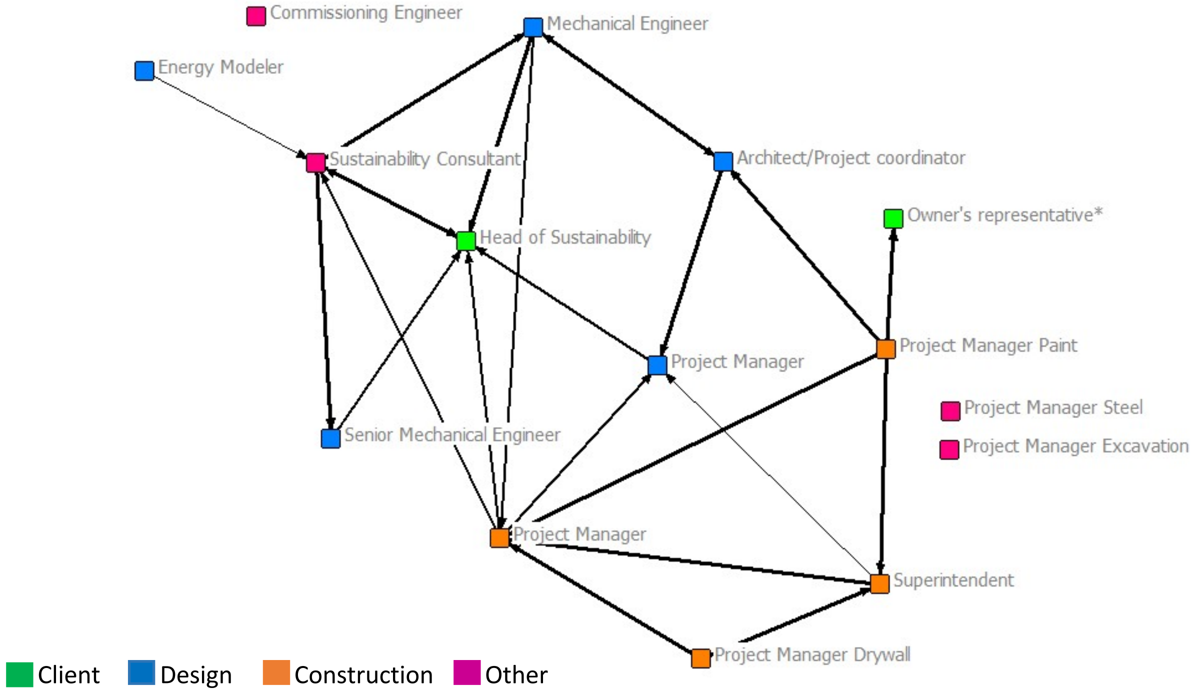

Figure 6-7 Leadership Network for Case Study 2

Table 6-9 Identified Leaders for Case Study 2

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
Head of Sustainability (Owner)	25.3	Conceptual design	40	1	LEED Green Associate
Project Manager (Construction)	22.4	Schematic design	15	18	LEED AP (BD+C)
Project Manager (Design)	14.8	Conceptual design	21	6	LEED AP (BD+C)
Sustainability Consultant	13.5	Schematic design	16	60	LEED AP (BD+C)
Superintendent (Construction)	11.3	Construction documents	40	0	None
Mechanical Engineer (Design)	11.3	Schematic design	6	8	LEED AP (BD+C)
Architect/Project coordinator (Design)	11.2	Schematic design	20	0	None
Owner's representative (Owner)*	5.6				
Senior Mechanical Engineer (Design)	5.3	Conceptual design	14	8	LEED AP (BD+C)

Case Study 3

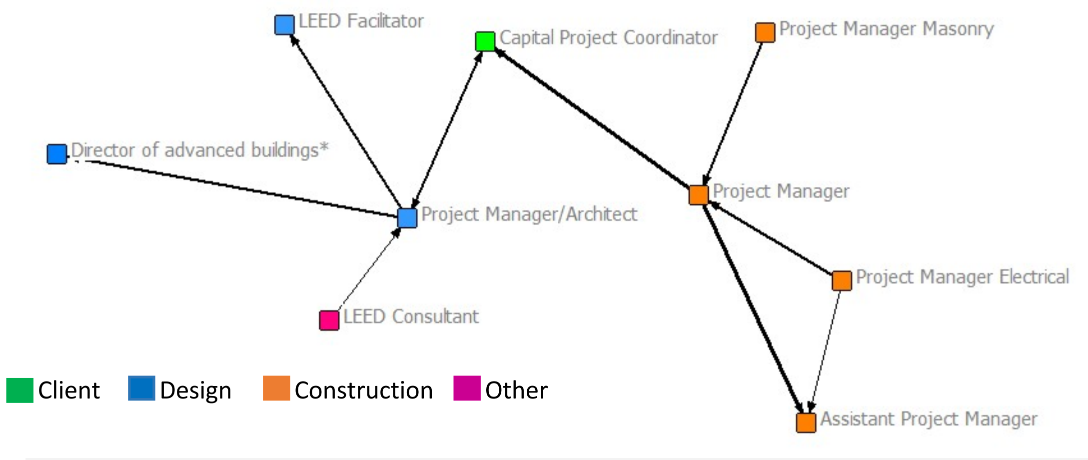

Figure 6-8 Leadership Network for Case Study 3

Table 6-10 Identified Leaders for Case Study 3

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
Capital Project Coordinator (Owner)	10.8	Conceptual design	25	1	None
Assistant Project Manager (Construction)	10.4	Construction	4.5	0	None
Project Manager (Construction)	9.5	Construction	20	2	None
Project Manager/Architect (Design)	8.15	Conceptual design	28	4	LEED AP (BD+C)
Director of advanced buildings (Design)*	4.8				
LEED Facilitator (Design)	4.6	Schematic design	5	30	LEED AP (BD+C)

Case Study 4

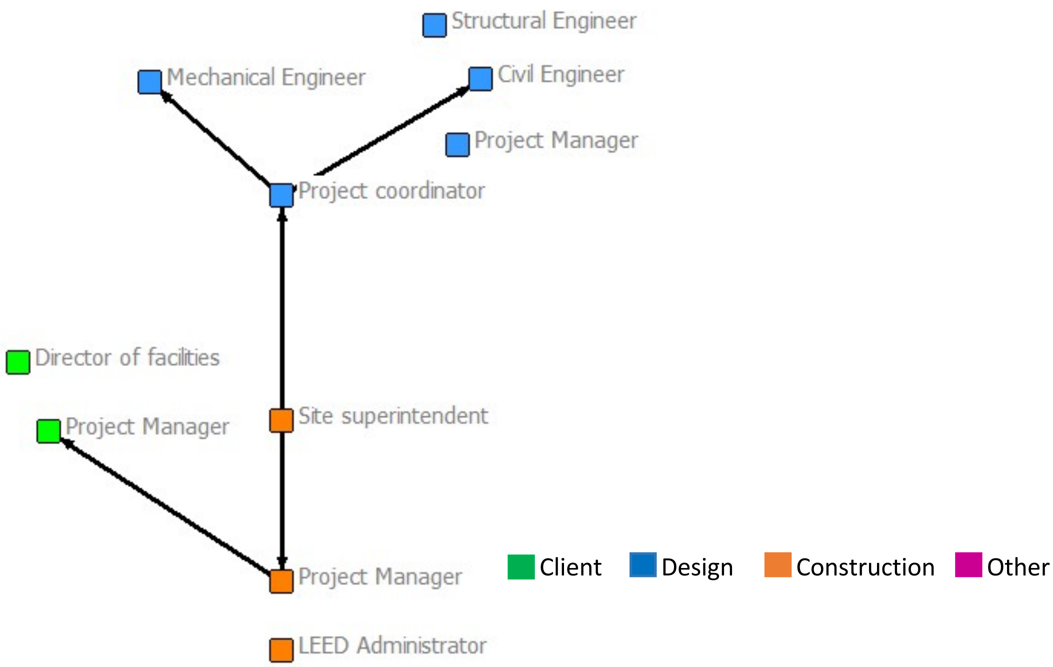

Figure 6-9 Leadership Network for Case Study 4

Table 6-11 Identified Leaders for Case Study 4

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
Project Manager (Construction)	5.9	Design development	28	2	LEED AP (BD+C)
Project coordinator (Design)	5.9	Design development	15	0	None
Project Manager (Owner)	5.2	Conceptual design	16	1	None
Civil Engineer (Design)	5	Design development	9	9	LEED AP (BD+C)
Mechanical Engineer (Design)	4.8	Conceptual design	35	47	LEED AP (BD+C)

Case Study 5

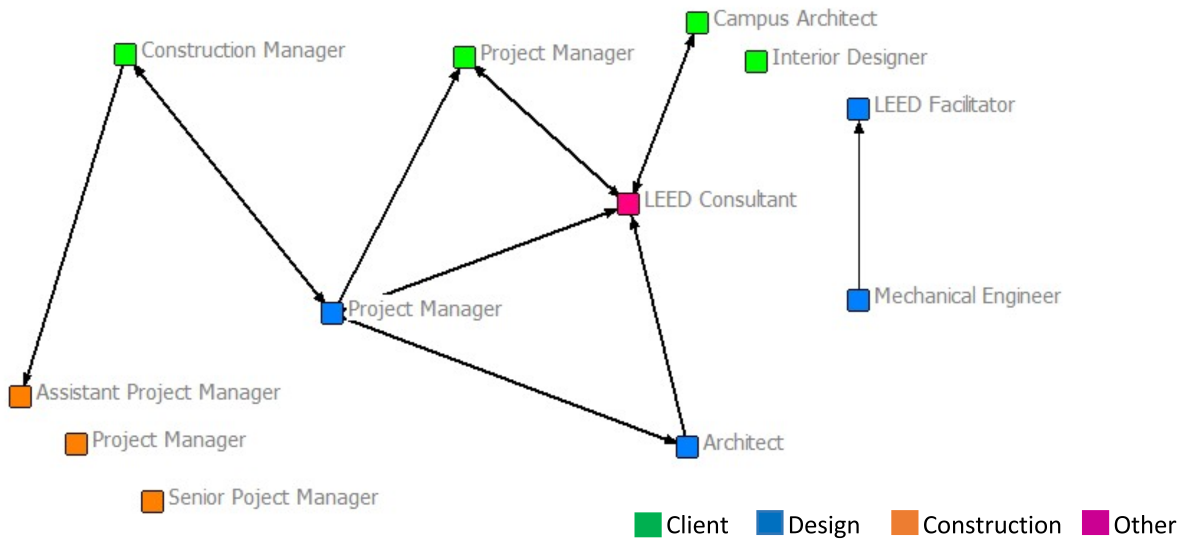

Figure 6-10 Leadership Network for Case Study 5

Table 6-12 Identified Leaders for Case Study 5

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
LEED Consultant	20.7	Design development	15	20	LEED AP (BD+C)
Project Manager (Owner)	11.4	Conceptual design	4	3	None
Construction Manager (Owner)	6	Construction documents	10	0	None
Project Manager (Design)	5.9	Conceptual design	8	1	None
Architect (Design)	5.9	Conceptual design	35	3	LEED AP (BD+C)
Assistant Project Manager (Construction)	5.9	Construction documents	5	1	LEED AP (BD+C)
Campus Architect (Owner)	5.5	Conceptual design	33	30	LEED AP (BD+C)
LEED Facilitator (Design)	4.8	Schematic design	10	60	LEED AP (BD+C)

Case Study 6

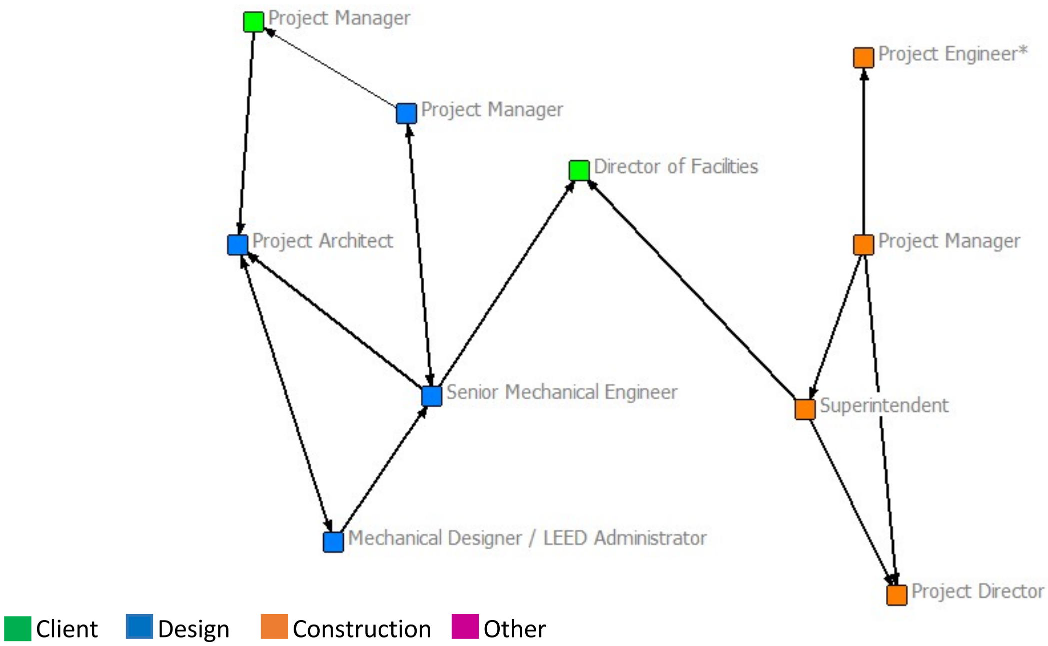

Figure 6-11 Leadership Network for Case Study 6

Table 6-13 Identified Leaders for Case Study 6

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
Project Architect (Design)	17.9	Schematic design	10	1	LEED Green Associate
Senior Mechanical Engineer (Design)	16.1	Conceptual design	12	20	LEED AP (BD+C)
Director of Facilities (Owner)	12	Conceptual design	16	2	None
Project Director (Construction)	11.9	Schematic design	13	7	LEED AP (BD+C)
Project Manager (Construction)	6	Conceptual design	26	2	LEED AP (BD+C)
Mechanical Designer / LEED Administrator (Design)	6	Conceptual design	2	7	LEED AP (BD+C)
Superintendent (Construction)	6	Construction	32	3	None
Project Engineer (Construction)*	6				
Project Manager (Design)	4.2	Conceptual design	22	6	LEED AP (BD+C)

Case Study 7

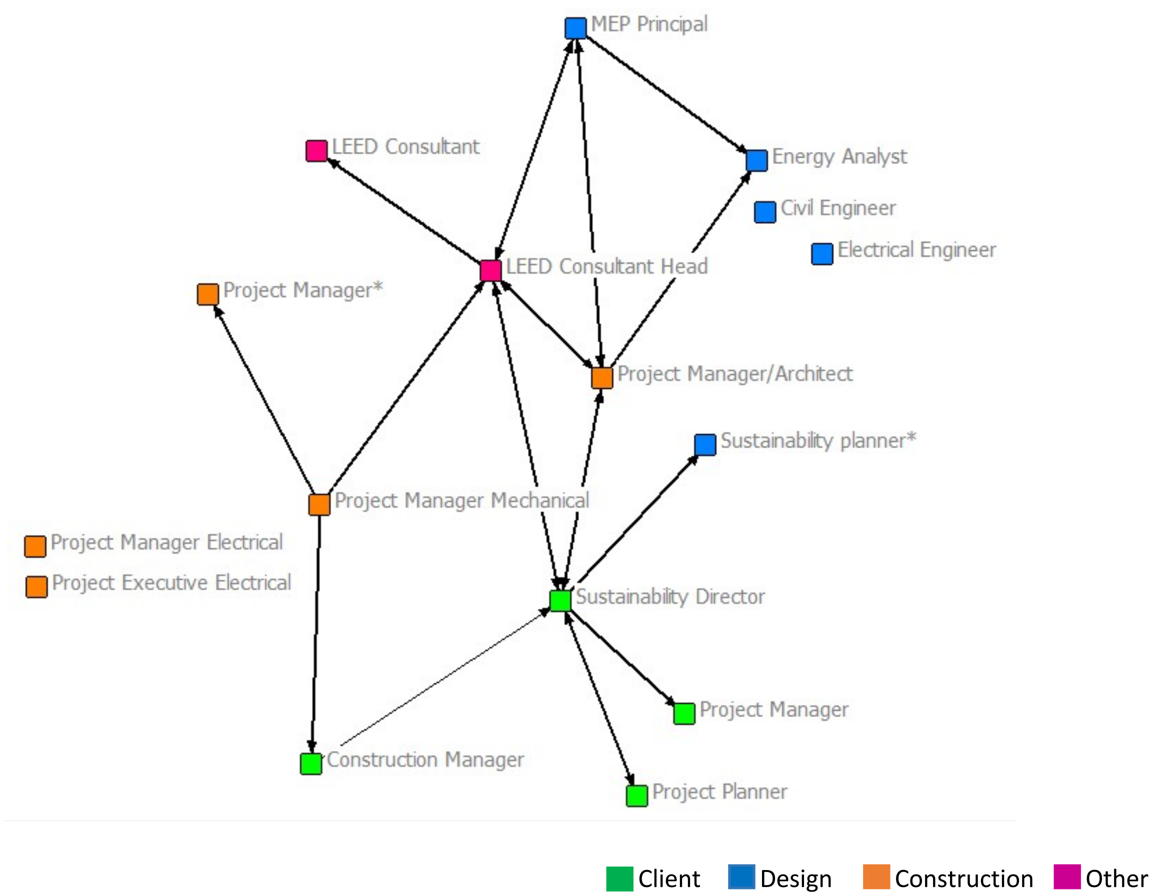

Figure 6-12 Leadership Network for Case Study 7

Table 6-14 Identified Leaders for Case Study 7

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
LEED Consultant Head	21.5	Schematic design	14	100	LEED AP (BD+C)
Sustainability Director (Owner)	18.5	Conceptual design	26	67	LEED AP (BD+C)
Project Manager/Architect (Design)	15.5	Conceptual design	16	7	None
Mechanical Engineer (Design)	11	Conceptual design	9	30	LEED AP (BD+C)
Sustainability planner (Design)*	5.6				

Table 6-14 (cont'd)

Project Manager (Owner)	5.4	Design development	27	12	LEED AP (BD+C)
LEED Consultant	5.3	Construction	2	15	LEED AP (BD+C)
Energy Analyst (Design)	5.2	Conceptual design	5	20	LEED AP (BD+C)
Project Planner (Owner)	5.2	Conceptual design	26	10	LEED AP (BD+C)
Project Manager (Construction)*	5				
Construction Manager (Owner)	4.9	Schematic design	20	8	None

Case Study 8

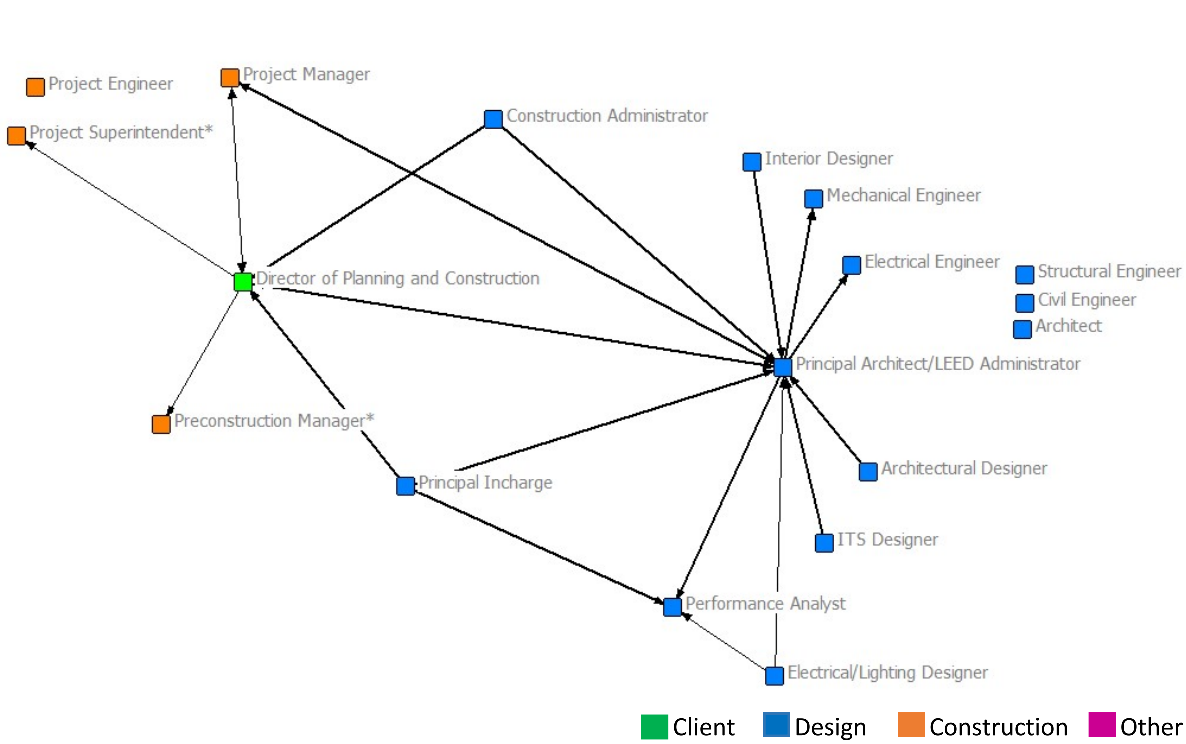

Figure 6-13 Leadership Network for Case Study 8

Table 6-15 Identified Leaders for Case Study 8

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
Principal Architect/LEED Administrator (Design)	36.65	Conceptual design	14	11	LEED AP (BD+C)
Director of Planning and Construction (Owner)	22.25	Conceptual design	37	4	LEED AP (BD+C)
Performance Analyst (Design)	15.35	Schematic design	15	30	LEED AP (BD+C)
Project Manager (Construction)	9	Design development	29	5	None
Electrical Engineer (Designer)	6	Schematic design	2	2	None
Mechanical Engineer (Design)	6	Conceptual design	13	11	None
Project Superintendent (Construction)*	4				
Preconstruction Manager (Construction)*	2				

Case Study 9

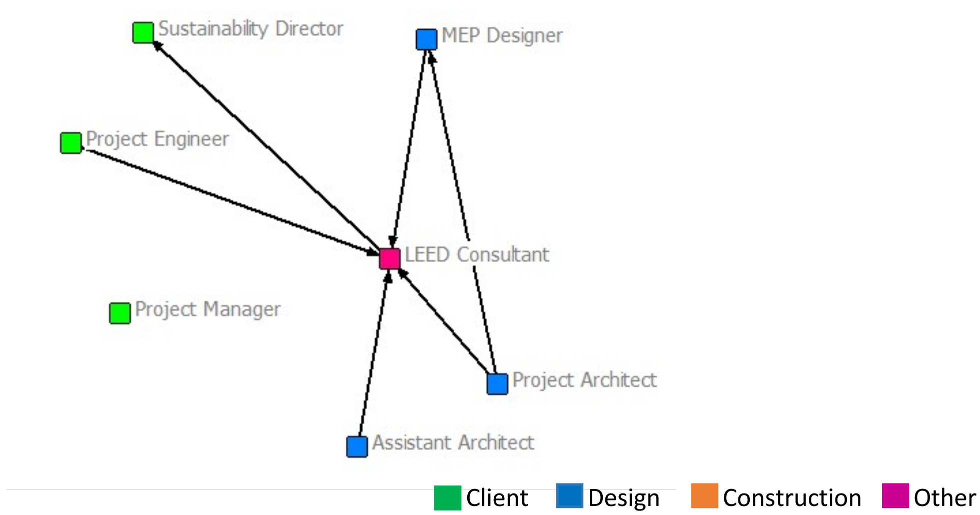

Figure 6-14 Leadership Network for Case Study 9

Table 6-16 Identified Leaders for Case Study 9

Leader Role	Indegree centrality	Stage at which involved in project	Experience (Yrs)	LEED Projects	LEED Accreditation
LEED Consultant	20.4	Schematic design	35	115	LEED AP (BD+C)
MEP Designer	6	Conceptual design	19	20	LEED AP (BD+C)
Sustainability Director (Owner)	5.9	Design development	20	3	None

6.3.2. Research Question 1: Identification of Transformational Leaders

This section presents the characteristics of sustainability leaders in LEED project teams. A total of 65 team members were identified as transformational leaders across 9 case studies. 7 of these identified leaders did not respond to our request for data collection, and therefore their information is missing. The tier distribution, professional experience and competencies are listed below

<u>Theoretical Versus Identified Leaders</u>

As introduced in section 3.2, literature guides us about the potential leaders in AEC teams. These leaders include project representatives for owner, contractor and designer organizations, project managers and supervisors. A descriptive analysis of the identified leaders inthis study informs us that 41 leaders out of 58 belonged to the managerial roles discussed in theory. 17 leaders however belonged to roles not associated with leadership in AEC literature. The frequencies of various roles for both theoretical and identified leaders are given in table 6-17.

Table 6-17 Theoretical versus identified Leaders in the Case study Projects

Theoretical Leaders		Newly Identified Leaders	
Role	Frequency	Role	Frequency
Owner's representatives/Directors	4	Project Planner (Owner)	1
Project Manager (Owner)	6	Project coordinator (Owner)	1
Project Manager (Design)/Design head	10	MEP Engineer (Design)	9
Project Director (Construction)	2	Civil Engineer (Design)	1
Project Manager/Assistant Project Manager (Construction)	7	Project coordinator (Design)	2
Superintendent (Construction)	2	Energy Analyst (Design)	2
LEED Consultant/ Coordinator/Administrator	10	Project Engineer (Construction)	1
TOTAL	41	TOTAL	17

It can be seen that designer team members are most frequently nominated as leaders for sustainability in teams amongst the newly identified roles (14 out of 17). This was also tested with the help of crosstabs chi-square value for design team members and newly identified leaders and the difference of distribution was found to be significant.

Table 6-18 Crosstabs for newly identified leaders and design team members

Newly_Identified_Leaders * Design_Team_Members Crosstabulation

Count

		Design_Team_Members		
		0	1	Total
Newly_Identified_Leaders	0	56	30	86
	1	4	13	17
Total		60	43	103

Table 6-19 Test for difference of distribution for design team members

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.094[a]	1	.001		
Continuity Correction[b]	8.457	1	.004		
Likelihood Ratio	10.183	1	.001		
Fisher's Exact Test				.002	.002
Linear-by-Linear Association	9.996	1	.002		
N of Valid Cases	103				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.10.

b. Computed only for a 2x2 table

Moreover, it is observed that transformational leaders can be serving at a variety of roles in teams such as coordination, energy analysis and construction engineering.

Professional Experience

The total professional experience of leaders varied from 2 years to 42 years. An independent samples t-test shows that the mean of total professional experience for leaders is not significantly different from the mean of rest of team members. Therefore, total professional experience was not found to be a significant predictor of transformational leadership. The group statistics and t-test results for experience are presented in tables 6-20 and 6-21 respectively.

Table 6-20 Group statistics for Total Professional Experience

Group Statistics

		N	Mean	Std. Deviation	Std. Error Mean
Experience	Rest of the team members	45	19.72	12.081	1.801
	Transformational Leaders	58	19.28	10.916	1.433

Table 6-21 Comparison of means for total professional experience

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Experience	Equal variances assumed	.970	.327	.193	101	.848	.438	2.272	-4.070	4.945
	Equal variances not assumed			.190	89.637	.850	.438	2.302	-4.135	5.011

The number of LEED projects worked on (LEED experience) for leaders ranged from 0 projects to 115 projects. Interestingly, the difference of means independent samples t-test showed that the LEED experience for transformational leaders is significantly greater than rest of the team members. The group statistics and t-test results for LEED experience are presented in tables 6-22 and 6-23 respectively.

Table 6-22 Group statistics for LEED Experience

Group Statistics

		N	Mean	Std. Deviation	Std. Error Mean
LEED Projects	Rest of the team members	45	7.42	9.760	1.455
	Transformational Leaders	58	16.16	24.017	3.154

Table 6-23 Comparison of means for LEED experience

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
LEED _Proj	Equal variances assumed	11.702	.001	-2.295	101	.024	-8.733	3.806	-16.283	-1.183
	Equal variances not assumed			-2.515	79.198	.014	-8.733	3.473	-15.645	-1.820

LEED Accreditation

Majority of transformational leaders were found to have a LEED accreditation of some sort by USGBC. On the other hand, majority of rest of the team members were found to have no accreditation. The frequencies of various accreditations are given in table 6-24 below.

Table 6-24 Frequencies of LEED Accreditation

		Accreditation				
		None	LEED AP (BD+C)	LEED Green Associate	LEED Neighborhood Design	Total
	Rest of the team members	29	10	6	0	45
	Transformational Leaders	19	35	3	1	58
Total		48	45	9	1	103

Chi-square values for these cross tabs show that the two groups are have significantly different distributions for accreditations. Therefore, the accreditation rate for transformational leaders is greater than rest of the team members. Please refer to table 6-25.

Table 6-25 Test for difference of distribution for LEED Accreditation

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.596[a]	3	.001
Likelihood Ratio	17.569	3	.001
Linear-by-Linear Association	3.942	1	.047
N of Valid Cases	103		

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is .44.

6.3.3. Research Question 2: Flow of Transformational Leadership

This section explores the trends of leadership flows in teams through leadership networks. First, the cases are checked for trickle-down effect mentioned in literature. Afterwards, the role of delivery system is assessed with the help of pattern-matching.

Trickle-down Flow

As presented in section 3.2, the trickle-down leadership literature suggests that leadership follows the top down route. It means that for an organization, the top managerial role will act as a leader for its immediate subordinates. These subordinates will then transfer it to further lower level and so on.

A close look at leadership networks (Fig 6-6 to Fig 6-14) reveal that leadership does not necessarily follow the organizational trickle-down route. Team members of owner, design and construction organizations can be exchange leadership at multiple levels. For instance, in Fig 6-7 for case study 2, the immediate superior for construction superintendent is project manager (construction). But he also nominates the project manager (design) as a transformational leader. Another interesting observation is that it is possible for a team member in a sub-ordinate role to act as a leader for its superior. For instance, In Fig 6-8 for case 3, the Project Manager for General Contractor nominated his subordinate as a transformational leader. There may be many organizational and phycological factors that may cause these patterns.

Role of Project Delivery Methods

The potential impact of delivery methods used for case study projects on the flow of transformational leadership was introduced in section 3.2 in light of the literature. Essentially, a single contract for both design and construction is expected to have more inter-organizational links.

Looking at patterns of leadership flow across the cases and comparing them with the respective delivery system provides us with interesting findings. It was observed that the leadership links between design and construction team members appear in the design build and CM at Risk type of contract, but they are majorly absent in design-bid-build type of contracts. Case 9 is the only exception in this regard.

Table 6-26 Links between design and construction phases in case study projects

Case Study	Delivery method	Links between design and construction
Case 1	Design-Build	Yes (multiple)
Case 2	Design-Build	Yes (multiple)
Case 3	Design-Bid-Build	No
Case 4	CM at Risk	Yes (single)
Case 5	Design-Bid-Build	No
Case 6	Design-Bid-Build	No
Case 7	Design-Bid-Build	No
Case 8	Design-Build	Yes (multiple)
Case 9	CM at Risk	No

There is a clear pattern of design-construction links, in comparison to delivery system, where design-build teams show more tendency for leadership flow between design and construction personnel.

<u>Network Density of Leadership Ties and Project Performance</u>

Studies to date have repeatedly used network density as a measure of shared leadership (Carson et al., 2007). Density is preferred over centrality in social network analysis to approach leadership (Wang et al., 2014). Density of leadership networks is calculated by aggregating the weights of all links present in a network and dividing the sum by number of possible links between team members. To compare, we used the level of LEED certification achieved by the case study projects and perceived sustainability performance as the measure of performance. Table 6-27 below lists the network densities of case studies and those performance measures.

Table 6-27 Network densities and project performance measures in the case studies

Network density	LEED Certification Level	Perceived sustainability performance	Case study
1.71	Silver	Satisfied	6
1.55	Gold	Satisfied	3
1.37	Silver	Strongly satisfied	9
1.15	Gold	Strongly satisfied	2
1.11	Silver	Satisfied	1
1.08	Gold	Strongly satisfied	7
1	Silver	Satisfied	5
0.59	Silver	Neutral	4
0.53	*Certified*	*Satisfied*	*8*

Range of performance measures from lowest to highest:
Network density (0.53 – 1.71), LEED Certification Level (Certified, Silver, Gold, Platinum), Perceived Sustainability Performance (Strongly dissatisfied, Dissatisfied, Neutral, Satisfied, Strongly Satisfied)

Comparing the levels of certification and the density values side by side, we observe a pattern where higher densities are observed for higher levels of certification case studies. This trend is shown in Figure 6-15. Network density for the only certified case study project was lowest amongst all (i-e, 0.53). Five Silver level projects showed the most variation in terms of density values. The values ranged from 0.59 all the way up to 1.71, with a mean value of 1.156. There are 3 Gold certification level projects. Mean of their network densities came out to be 1.26, which is slightly greater than silver certified projects.

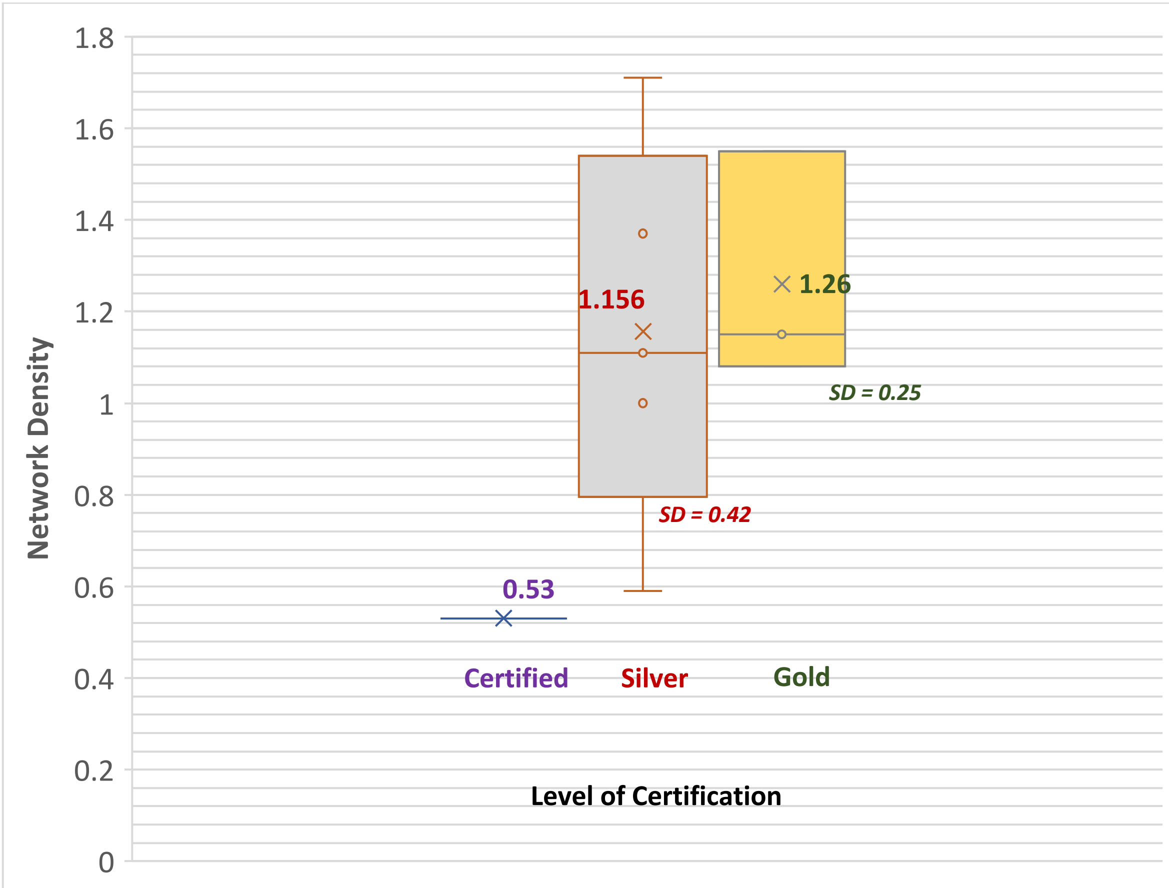

Figure 6-15 Network Densities vs levels of LEED Certifications

A similar trend is observed when network densities are compared with the project's sustainability performance perceived by the owner's representatives (Figure 6-16). Network density for the only neutral performance was one of the lowest (i-e, 0.59). Mean network density for case studies with "strongly satisfied" performance perception (1.2) was just a little bit higher than the mean density for case studies with "Satisfied" performance perception (1.18).

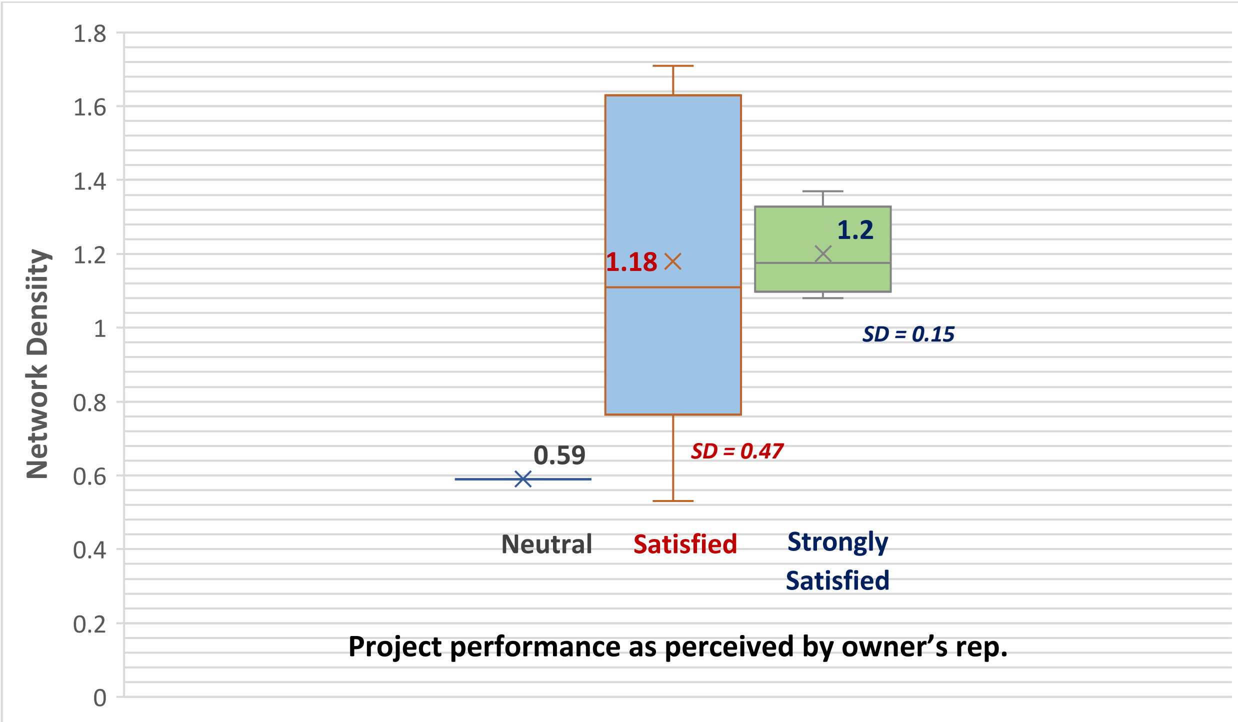

Figure 6-16 Network Densities vs owner's perception of project performance

These results lead to the acceptance of research proposition that the density of leadership network is positively related to a team performance (Carson et al., 2007). Also, they ensure that the non-response bias concern at project level is eliminated as variety of certification levels and team performance perceptions were observed.

6.3.4. Summary of Key Findings

The results chapter is concluded by listing the key findings, presented in table 6-27.

Table 6-28 List of Key Findings

Research Questions/Study Hypothesis	Key Findings
Individual level study hypotheses	
Hypothesis 1: Individuals' perceptions of transformational leadership for sustainability in a team is positively related to individuals' perceptions of team performance in sustainability. *Not Rejected*	Key Finding 1: Individuals' perceptions of transformational leadership for sustainability in a team is positively related to individuals' perceptions of team performance in sustainability.
Hypothesis 2: Individuals' perception of team integration mediates the relationship between individual perceptions of transformational leadership for sustainability in team and individual perception of team performance in sustainability. *Not Rejected*	Key Finding 2: Individuals' perception of team integration mediates the relationship between individual perceptions of transformational leadership for sustainability in team and individual perception of team performance in sustainability.
Team level research questions	
Research Question 1: Who are the transformational leaders for sustainability in green AEC project teams?	Key Finding 3: There can be multiple transformational leaders for sustainability in AEC project teams serving at a variety of roles. Key Finding 4: Designers are likely to emerge as transformational leaders for sustainability in AEC project teams even if they may not be assigned to leadership roles. Key Finding 5: Transformational leaders for sustainability are more likely to have past experience of working on green AEC projects. Key Finding 6: Transformational leaders for sustainability are more likely to have a green credentials such as LEED accreditation offered by USGBC.
Research Question 2. How does transformational leadership for sustainability flow in green AEC project teams? Who are the followers of transformational leaders?	Key Finding 7: Transformational leadership does not necessarily flow from top to bottom in the organizational hierarchy. Key Finding 8: Project delivery systems play a role in molding the flow of transformational leadership in green AEC projects. Key Finding 9: Overall network density for shared leadership is positively related to the project's sustainability performance.

Chapter 7 DISCUSSIONS

Chapter 7 provides the theoretical contributions and practical implications for the findings of this research. The major themes from the findings are discussed one by one, and all the discussions are summarized at the end.

7.1. Flow of Leadership in AEC Projects

The cascading effect of leadership, as proposed by Bass et al. (1987), and later adopted by many authors such as Mayer et al. (2009) as the trickle-down effect of leadership suggests that leadership follows a top-down flow in organizations with superiors transferring it to subordinates. The findings of this study for AEC teams show otherwise; there is evidence for bottom-up flow as well as parallel flow between organizational affiliations. This finding goes in line with the proponents of shared leadership, who believe that leaders can emerge at any level regardless of their role and position (D'Innocenzo et al., 2016).

The patterns of cross-organization leadership flow between design and construction team members is an interesting observation and can be explained in light of AEC delivery systems literature. Because of the early involvement of construction personnel and the same organizational affiliation of design and construction team members, design-build teams are expected to facilitate higher levels of team integration (Mollaoglu-Korkmaz et al., 2013), where, members from different organizations are expected to share improved task and team mental models. This means that they have a similar understanding of tasks, roles, responsibilities, and personality traits of team members (Shafique & Mollaoglu, 2020). Shared mental models in teams develop trust, which is required for leadership growth (Dirks, 2000).

7.2. Multi-level Study Framework

This study employed an approach that enabled it to examine transformational leadership quantitatively at the individual level through SEM, and qualitatively at the team level through social networks. Both micro and macro findings help draw a more holistic picture of organizational behavior (Kozlowski & Klein, 2000). Past researches on leadership in AEC focus on leader characteristics (Grill et al., 2017; Tabassi et al., 2016; Rumaithi & Beheiry, 2016). These researches are unable to present the team level dynamics of leadership. This study not only records the impact of transformational leadership perceived by individual team members but also help visualize the distributed structures of leader-follower links that are indicators of team outcomes (Mehra et al., 2006).

7.3. Team integration through shared transformational leadership

With team members coming from various organizations and expertise areas, AEC project teams can be fragmented. For this reason, team integration is extensively studied for AEC project teams and found to have a strong impact on team outcomes (Franz et al., 2017; Baiden & Price, 2011). Team integration has special importance in green AEC projects. The complex processes require input from all parties of the project, and therefore it is critical for them to freely contribute to team discussions and decision making (Mollaoglu-Korkmaz et al., 2013).

AEC literature has multiple investigations on how project delivery methods (such as contract type) and practices (such as partnering) influence team integration (Franz et al., 2017; Eriksson, 2015; Mollaoglu-Korkmaz et al., 2013). This study explores a new means of integrating teams in AEC: transformational leadership. We find many comprehensive investigations on transformational leadership in fields as diverse as computing (Carreiro & Oliveira, 2019), manufacturing (Kalsoon et al., 2018), healthcare (Giddens, 2018; Sow, 2017), hotel management (Mohamed, 2016) and supply chain (Wang & Cruz, 2018). In AEC, there are only a few studies like Tabassi et al. (2016), which focus on the traits of project managers. This research is the first of its kind to use shared transformational leadership in the AEC industry.

7.4. Role of emergent leaders

Using shared leadership helped this study to explore sustainability leaders in AEC for the first time. Many of these leaders are emergent: those not with roles associated with leadership in AEC literature. Emergent leaders enhance team effectiveness. Teams that create emergent leaders are known to outperform teams in which new leaders fail to emerge (Souza & Klein, 1995). However, the leadership style plays a big role in deciding their impact. Emergent leaders positively influence team performance when they practice open communication, care for others and optimism (traits similar to modern theories like transformational leadership). In comparison, they negatively impact team performance when they practice directive, task-oriented leadership style (Druskat & Pescosolido, 2016). Therefore, it is very important to investigate the content of leadership in teams. Role of Emergent leadership also depends on its positioning in the team leadership network. According to Mehra et al. (2006), teams perform better when emergent and designated indicate each other as leaders in teams, and work in coordination. Hence, to optimize the role of emergent leadership in teams, we also need to optimize the team structures that facilitate maximum coordination.

7.5. Designers as emergent leaders

It is interesting to observe that most emergent leaders are design team members. This finding goes in line with the theory, as designers are the pioneers of green AEC. The green building revolution began when a group of passionate architects took the initiative and formed a committee on the environment within the American Institute of Architects (AIA). Designers have since been leading the movement as the biggest proponents of sustainable design and construction (Yudelson, J., 2010). Designers (architects and engineers) are trained to consider climate change in their practice (Anderson, 2020); hence they take more responsibility. It is also observed that MEP design engineers have the most numbers in these emergent leaders. Energy efficiency is a major portion of LEED design and construction. Mechanical engineers are the head of design development (Orsi & Armiñana, 2018) and therefore take the lead. Energy design and modeling not only require a technical effort but also input from various team members (Swarup et al., 2011). Their requirement for higher collaboration might be the reason they develop and practice transformational leadership.

7.6. Role of relevant experience and qualification

Relevant experience and knowledge have long been associated with leadership development. (Brungardt, 1996; Whitaker et al., 1991). The relationship is best expressed in the articles associated with leadership development. Individuals begin their leadership journey based on essential personality traits such as self-confidence and adaptability (Judge et al., 2002). Then gradually, through experience, education, and training, they gain the confidence and knowledge to take leadership initiatives (Day & Dragoni, 2015). In the context of findings regarding the LEED accreditation, AEC team members have reported feeling more knowledgeable and accomplished to perform their tasks after receiving an accreditation (Bruce et al., 2009). The findings add to the AEC literature by informing the importance of specific traits in context of leadership development and can find valuable application in the industrial trainings.

7.7. Role of Network Density on Project performance

Social Network approach to study shared leadership is considered the best in terms of effect size and detail of findings. Density is the most widely used network measure associated with shared leadership (Carson et al., 2007). This study showed patterns indicating that network density was related to project sustainability performance in terms of both the level of certification expected to achieve, as well as the owner's perception. The finding has significant implications for the AEC industry, where formal leadership and transitional hierarchical structures are prevalent. A change of mindset where all team members are empowered, trained, and encouraged to lead can reap significant benefits in terms of team and project outcomes.

7.8. Generalizability of Findings

As described in the methodology section, the population for this study consisted of new construction and major renovation projects in the US, aiming for a LEED certification under version 4. Systematic random sampling was used to contact the project teams. The sample of nine project teams varies in location, LEED certification level, team performance perception, and leadership network densities, eliminating the possibility of non-response bias that only high performing teams participated in the study. However, all projects were owned by educational institutions, which can impact the generalizability of findings to the original population.

Also, LEED projects outside the US might have different patterns of leadership. Effective leadership varies widely from culture to culture. In developing countries, for example, leaders are more task oriented. Their goal is to get things done quickly and effectively. They are less focused on communication, innovation, and human development (Bersin, 2012). Therefore, we can hypothesize the transformational leadership networks for sustainability in developing country teams are less dense and strongly hierarchical.

8. CONCLUSIONS AND FUTURE RECOMMENDATIONS

This chapter briefly summarizes the goals and objectives of this research as well as the contributions. The chapter finishes with limitations and some recommendations for future research.

8.1. Summary of Research Goals and Objectives

The primary goal of this study was to "Explore the structure and role of transformational leadership in AEC project teams, providing significant contribution to AEC literature". The objectives of the study are as follows:

1. Create a multi-level framework for study and measurement tools that:
    a. Guides the hypothesis development to relate transformational leadership and team performance mediated by team integration at the individual level, and
    b. Provides reasoning for research questions in order to explore the dynamics of transformational leadership using social networks at the team level.
2. Validate the framework and measurement tool via expert interviews.
3. Empirically test the study hypotheses at the individual level.
4. Answer the research questions at the team level, exploring the leadership networks in teams and assessing various characteristics of leaders.

8.2. Summary of Study Methods

As mixed-methods research, this study employed several methods for data collection and analysis. For the individual-level data, an online survey was used. Project characteristics for each case study were collected through a telephone interview with the owner's representative. For the analysis of study hypotheses at the individual level, CFA was first employed for model validation. Afterward, the model was tested using structural equation modeling. The team-level analysis included pattern matching for leadership networks created through SNA.

8.3. Summary of findings

There are several findings of this study emanating from individual and team level analysis results. These findings are listed in order below.

1. Transformational leadership is positively related to team performance.
2. Team integration mediates the relationship between transformational leadership and team performance.
3. There can be multiple transformational leaders for sustainability in project teams serving at a variety of roles.
4. Designers are expected to emerge as new leaders for sustainability in AEC project teams.
5. Transformational leaders for sustainability more likely have past experience of working on green AEC projects.
6. Transformational leaders for sustainability are more likely to have a green AEC accreditation such as LEED offered by USGBC.
7. Transformational leadership does not necessarily flow from top to bottom in the organizational hierarchy. Many organizational and psychological factors may play a role in defining it.

8. Delivery methods (such as Design-Build and Design-Bid-Build) employed for projects may play a role in defining the leadership links across organizational boundaries.
9. Overall network density for shared leadership in case studies was found to be positively related to the project's sustainability performance in terms of certification level and owner's performance perception.

8.4. Deliverables and Contributions to the Body of Knowledge

The study's main contribution to the body of knowledge is to investigate shared leadership for large inert-organizational AEC project teams for the first time. The individual and team level analysis resulted in some novel contributions, which are listed below

1. Multifactor Leadership Questionnaire (MLQ) is a heavily utilized tool for transformational leadership (Bass & Avolio, 1996). To employ this tool for sustainability leadership in AEC project teams, this study developed a modified version of the tool with the help of industry experts.
2. The effect of leadership on team performance mediated through team integration is investigated in literature for other types of leadership – such as servant leadership in Sousa & Van Dierendonck (2016). This study uses shared transformational leadership for the first time in this relation. Also, it is the pioneer study that uses any kind of leadership to predict integration and performance in AEC teams.
3. This study adds to the theory of leadership development by contributing reflections from green AEC project teams. LEED project experience and LEED accreditations are found to be predictors of leaders for sustainability, which goes in line with Day & Dragoni's conclusions (Dragoni, 2015).

4. This study contributes to the shared leadership literature by adopting transformational leadership measurement scales utilizing social network rating approach and examining actor attributes for a detailed qualitative analysis. Earlier studies have used the overall leadership of peers and thus were limited to only the density and centrality of networks. Acting upon the recommendations of leadership researchers, the new approach not only added more value in terms of tie content but also provided more context by including the leader and follower characteristics.
5. The study provides support to emergent leader theory (D'Innocenzo et al., 2016) against trickle-down theory (Mayer et al., 2009) for leadership in AEC project teams. It informs that the flow of transformational leadership for sustainability depends on many factors in addition to the hierarchical dependency of roles. One of these factors is project delivery, which is discussed in this study.

8.5. Limitations

Despite all its findings and contribution, the study has some limitations, which are listed below:

1. All case studies belong to educational institutions as owners despite the author's efforts to collect a random sample. This affects the generalizability of study results.
2. The response rate from team members from each case study ranged from 21.1% to 72.2%. The missing data from social networks reduces the quality of team-level analysis results as there may be more leaders in the team. Also, this casts away the possibility of cross-case comparison of SNA properties such as density and centrality.
3. Most of the case study projects were not comfortable sharing objective data on project performance metrics, such as LEED checklist, cost over-runs, and schedule. This

prevented the author from investigating relationships, such as between team and project performance.

8.6. Recommendations for Future Research

Future researchers can use the methods employed by this study to investigate shared transformational leadership in various contexts for AEC or other inter-organizational project teams. Some of the themes are presented below:

Multilevel model: This study failed at creating quantitative or qualitative links between the team, sub-team, and individual-level variables. To completely understand organizational behavior, both individual and group level investigations are required to relate empirically. Future researchers can develop such multilevel models to add further value to their findings.

Longitudinal studies: This study used cross-sectional data from near completion project teams. However, it is imperative to understand the evolution of leadership from the beginning of the project cycle to the end. It can be hypothesized that as Mechanical engineers emerged as leaders in this study, there might be different professionals filling in the roles of transformational leaders at different phases of the project. Therefore, researchers are advised to consider using longitudinal data in future studies.

The response rate: Collecting data from all team members is essential to add more validity to the leading networks. This study suffered in terms of response rate, and thus the leadership networks might have missed important individuals as leaders or followers. Future researchers are advised to make efforts in order to collect responses from all members of the teams.

The criterion for leader identification: The findings of this study are in line with the previous studies (such as Carson et al., 2007 and Mehra et al., 2006), where most of the team members were identified as leaders. However, as we move to more individual-focused studies with this research, it is recommended for future investigators to develop a criterion which can differentiate between various leaders of a team based on multiple factors, such as the number of followers, weightage of leadership, role in the team and position in the social network.

APPENDICES

Appendix A: Internal Review Board (IRB) Approval Letter

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EXEMPT DETERMINATION

October 29, 2018

To: Sinem Mollaoglu

Re: **MSU Study ID:** STUDY00001459
Principal Investigator: Sinem Mollaoglu
Category: Exempt 2
Exempt Determination Date: 10/29/2018

Title: Transformational Leadership in Green Construction Project Teams

This study has been determined to be exempt under 45 CFR 46.101(b) 2.

Principal Investigator (PI) Responsibilities: The PI assumes the responsibilities for the protection of human subjects in this study as outlined in Human Research Protection Program (HRPP) Manual Section 8-1, Exemptions.

Continuing Review: Exempt studies do not need to be renewed.

Modifications: In general, investigators are not required to submit changes to the Michigan State University (MSU) Institutional Review Board (IRB) once a research study is designated as exempt as long as those changes do not affect the exempt category or criteria for exempt determination (changing from exempt status to expedited or full review, changing exempt category) or that may substantially change the focus of the research study such as a change in hypothesis or study design. See HRPP Manual Section 8-1, Exemptions, for examples. If the study is modified to add additional sites for the research, please note that you may not begin the research at those sites until you receive the appropriate approvals/permissions from the sites.

Change in Funding: If new external funding is obtained for an active study that had been determined exempt, a new initial IRB submission will be required, with limited exceptions.

Reportable Events: If issues should arise during the conduct of the research, such as unanticipated problems that may involve risks to subjects or others, or any problem that may increase the risk to the human subjects and change the category of review, notify the IRB office promptly. Any complaints from participants that may change the level of review from exempt to expedited or full review must be reported to the IRB. Please report new information through the study's workspace and contact the IRB office with any urgent events. Please visit the Human Research Protection Program (HRPP) website to obtain more information, including reporting timelines.

Office of Regulatory Affairs
Human Research Protection Program

4000 Collins Road
Suite 136
Lansing, MI 48910

517-355-2180
Fax: 517-432-4503
Email: irb@msu.edu
www.hrpp.msu.edu

Personnel Changes: After determination of the exempt status, the PI is responsible for maintaining records of personnel changes and appropriate training. The PI is not required to notify the IRB of personnel changes on exempt research. However, he or she may wish to submit personnel changes to the IRB for recordkeeping purposes (e.g. communication with the Graduate School) and may submit such requests by submitting a Modification request. If there is a change in PI, the new PI must confirm acceptance of the PI Assurance form and the previous PI must submit the Supplemental Form to Change the Principal Investigator with the Modification request (available at hrpp.msu.edu).

Closure: Investigators are not required to notify the IRB when the research study can be closed. However, the PI can choose to notify the IRB when the study can be closed and is especially recommended when the PI leaves the university. Closure indicates that research activities with human subjects are no longer ongoing and have stopped. This means there is no further interaction or intervention with human subjects and/or no further analysis of identifiable private information.

For More Information: See HRPP Manual, including Section 8-1, Exemptions (available at hrpp.msu.edu).

Contact Information: If we can be of further assistance or if you have questions, please contact us at 517-355-2180 or via email at IRB@msu.edu. Please visit hrpp.msu.edu to access the HRPP Manual, templates, etc.

Exemption Category. Please see the appropriate research category below from 45 CFR 46.101(b) for full regulatory text. [123]

Exempt 1. Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Exempt 2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Exempt 3. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if:
(i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

Exempt 4. Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

Exempt 5. Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

Exempt 6. Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

[1]Exempt categories (1), (2), (3), (4), and (5) cannot be applied to activities that are FDA-regulated.
[2] Exemptions do not apply to research involving prisoners.
[3] Exempt 2 for research involving survey or interview procedures or observation of public behavior does not apply to research with children, except for research involving observations of public behavior when the investigator(s) do not participate in the activities being observed.

Appendix B: Structured Interview Questions for Industry Experts

1. Can you please briefly describe your personal history of being involved in sustainable AEC projects?
   - How long have you been working in sustainable projects?
   - How about LEED projects?
   - Can you please describe your leadership activities/ efforts in the industry, you can talk about the books you wrote, workshops conducted or major events that you spoke at. Or do you have a bio that you can share with me if it is easier?

2. Can you please shed some light on the complexities of AEC projects? How are they more challenging as compared to their traditional counterparts?

3. How do these projects come alive? In other words, who initiates the idea of going green on a project in your experience? Why?

4. Is there generally a transformational leader involved?

5. Do you think transformational leaders of green AEC project team can positively impact the outcomes? Please explain.

   <u>Part 2: Feedback on survey questionnaire</u>

6. Please review the survey instrument in the attached that we will use to collect data from project case studies an provide us your feedback.

Appendix C: Survey

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Thank you for accepting our invitation to take this survey.

Purpose of research

The purpose of this research study is to explore the role of transformational leadership in sustainable construction project teams. The study will quantitatively test the impact of shared transformational leadership in teams on perceptions of team integration and team performance. Additionally, the study will also examine the leadership structures through social network analysis. This is a first of its kind effort for Architecture Engineering and Construction (AEC) industry.

What will you do

You will be asked to complete this web-based survey based on your experience and perceptions regarding the LEED goals of "Indoor Practice Facility Project" for research purposes. Completing the survey at each time point will take approximately 10 min. In the survey questions you will rate transformational leadership of your fellow team members, team integration and team performance.

Potential benefits to green construction industry

Your participation will contribute to a greater understanding of how transformational leadership emerges in green construction project teams, and what role it plays in improving the team integration and team performance.

Potential risks
There are no foreseeable risks associated with participation in this study.

Privacy and confidentiality
Your responses to survey items will be confidential. For research purposes, the researchers will be able to identify your responses. No one outside the research team will know how you responded to any particular question. The researchers will not disclose any specific information about case studies or study participants to the maximum extent allowable by law. The MSU Human Research Protection Program may have access to the data. Publications coming out from this study will present the data in aggregate form, so no participant will be identifiable. Electronic responses collected from surveys will be only accessible by the research team and stored in password protected computers. Hard copies from the collected data will be stored in a locked cabinet. The data will be stored for a minimum of three years after completion of the study.

Your rights to participate or withdraw
Participation in this research is voluntary. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. You may choose not to answer specific questions or to stop participating at any time.

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or in the very unlikely event of a research-related injury, please contact the researcher:

- Faizan Shafique, PhD Student: shafiqu2@msu.edu, 517-355-9682;

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 4000 Collins Road, Suite 136, Lansing, MI 48910.

By beginning this survey, you indicate your voluntary willingness to participate in this research project.

The survey might take around 10 min, please complete it based on your participation in sustainability and LEED goals of Indoor Practice Facility Project.

→

0% 100%

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Which organization do you represent on this project?

- Owner

Designer

- Architect
- Interior Designer
- Landscape Architect
- Other

Engineer

- Structural
- Electrical
- Mechanical

Geo-technical

Other

General Contractor

Subcontractor

Electrical

Mechanical

Roofing

Flooring

Carpenter

Other

Supplier (Please mention type)

What is your job title on this project? (Scheduler, project manager, foreman etc.)

What stage was the project at, when you were brought on-board?

Conceptual design (0-15% design complete)

Schematic design (15-30% design complete)

Design Development (30-60% design complete)

Construction documents (60-99% design complete)

Construction

←

→

0% 100%

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In the next couple of pages you will be asked questions related to sustainability and LEED in this project.

LEED (Leadership in Energy and Environmental Design) is a sustainability rating system. If teams succeed in earning a certain number of points in LEED, their project receives a certification.

Are you aware that Indoor Practice Facility Project is aiming for/received a LEED certification?

Yes

No

← →

0% 100%

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Please answer the following questions based on your experiences so far on Indoor Practice Facility Project team.

	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I frequently participate and contribute information.	○	○	○	○	○	○	○
I'm frequently encouraged to think outside my job responsibilities.	○	○	○	○	○	○	○
I can comfortably talk about my opinions/ideas.	○	○	○	○	○	○	○
I frequently participate in making decisions.	○	○	○	○	○	○	○

Members of my team collaborate with each other to perform our jobs.	○	○	○	○	○	○	○
Overall, the activities my team members perform, fit together very well.	○	○	○	○	○	○	○
I feel like I'm an integral part of the collective team effort pursuing shared sustainability and LEED project goals.	○	○	○	○	○	○	○

→

0% 100%

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Please answer the following questions based on your perception of Indoor Practice Facility Project team performance on **sustainability and LEED project goals.**

	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
The team has made sound decisions.	○	○	○	○	○	○	○
The output of the team has exceeded the initial project performance goals.	○	○	○	○	○	○	○
The team has chosen appropriate courses of action to meet project requirements.	○	○	○	○	○	○	○
The team has explored a wide array of options to choose the best available	○	○	○	○	○	○	○

The team has succeeded in achieving fewer rework/change orders.	○	○	○	○	○	○	○
The team has developed innovative solutions in pursuit of project goals.	○	○	○	○	○	○	○

← →

0% 100%

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In the next couple of pages you will be asked questions related to leadership practices in Indoor Practice Facility Project.

A "Transformational leader" is someone who facilitates and inspires his/her team fellows to create a clear vision for the project, and a marked passion for the work. "Transformational leadership" is a leadership style that can inspire positive changes in the followers. Transformational leaders are generally energetic, enthusiastic, and passionate. Not only are these leaders concerned and involved in the process; they are also focused on helping fellow members of the team succeed as well.

Do you know one or more members of the project team who provide you with transformational leadership regarding **sustainability and LEED goals** of Indoor Practice Facility Project?

Yes

No

← →

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Please list the members of project team who provide you with transformational leadership regarding **sustainability and LEED goals** of Indoor Practice Facility Project. You can write up to five names along with their role in Indoor Practice Facility Project.

For example, John Smith, Project Manager for GC.

Team member 1	
Team member 2	
Team member 3	
Team member 4	
Team member 5	

← →

0% 100%

This person inspires pride in me for being associated to a LEED project.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually ture	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person builds respect and regard among all team members.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person builds respect and regard among all team members.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person facilitates clarity regarding vision and goals for the project.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person facilitates clarity regarding vision and goals for LEED certification.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person effectively communicates a collective sense of mission regarding LEED certification.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person generates optimism about project's success in achieving LEED certification goals.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person is passionate to work on project's LEED certification goals.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person helps us evaluate the benefits and liabilities of each potential solution related to LEED certification.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person helps me think differently about sustainability.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

This person helps me in developing my strengths related to LEED certification.

	Never true	Usually not true	Rarely true	Occasionally true	Often true	Usually true	Always true
Leader 1	○	○	○	○	○	○	○
Leader 2	○	○	○	○	○	○	○
Leader 3	○	○	○	○	○	○	○
Leader 4	○	○	○	○	○	○	○
Leader 5	○	○	○	○	○	○	○

← →

0% 100%

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Please type your first and last names.

What is your gender?

Male

Female

Other

What is your age?

What is your race?

White

Hispanic or Latino

Black or African American

Asian

Native Hawaiian or Pacific Islander

Native American or American Indian

Other

Do not prefer to report

How many years have you been working full-time in architecture, engineering & construction industry?

How many years have you been working with your current organization?

How many years have you been working with your current organization?

In how many LEED projects have you worked in the past (Excluding the Indoor Practice Facility Project)?

Do you hold a sustainability related accreditation/certification?

- No
- LEED AP BD+C
- LEED AP Homes
- LEED AP ID+C
- LEED AP ND
- LEED AP O+M
- LEED Green Associate

Other (please mention)

←

→

0% 100%

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We thank you for your time spent taking this survey.
Your response has been recorded.

0% 100%

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Appendix D: Interview questions for Project Managers/Owner's representatives

Section 1: Project General characteristics

Please provide the following information about the project:

1. Project type:
   - ☐ New construction
   - ☐ Renovation
   - ☐ Addition

2. Building use
   - ☐ Commercial
   - ☐ Residential
   - ☐ Higher education
   - ☐ K-12 education
   - ☐ Health care
   - ☐ Other (Please mention) [ ]

3. Building size [ ] sq. ft.

4. Total budget $ [ ]

5. Number of floors [ ]

6. Building location [ ] (City/State)

7. Who is the owner of the project?

[ ]

Section 2: Project Delivery Characteristics

8. Which project delivery system which best describes that used on your project? The definitions for each are also given below.

- ☐ Design-Bid- Build
- ☐ Design-Build
- ☐ Construction Management at risk
- ☐ Integrated Project Delivery (IPD)

Design Bid Build: This is a traditional process in the US construction industry, where the owner contracts separately with a designer and a contractor. The owner normally contract with a design company to complete design documents. The owner or his/her agent then solicits fixed price bids from contractors to perform the work. One contractor is usually selected and enters into an agreement with the owner to construct a facility in accordance with the plans and specifications.

Design Build: This is a single agreement between an owner and a single entity to perform both design and construction under a single design build contract. Portions or all of the design and construction may be performed by the entity or subcontracted to other companies.

CM at Risk: The owner contracts with a design company to provide a facility design. The owner separately selects a contractor to perform construction a management services and construction work in accordance with the plans and specifications for a fee. The contractor usually has significant input in the design process and generally guarantees the maximum construction price.

IPD: Integrated Project Delivery (IPD) is a project delivery approach that brings all major stakeholders together from the very beginning of the project though intensive collaboration and risk sharing. Usually there is a single legally binding document for all.

9. What contractual terms were used for the design-builder or designer and contractor, and subcontractors?

a) Architect/Designer	☐ Lump-Sum	☐ GMP	☐ Cost plus fee	☐ Not applicable
b) Contractor	☐ Lump-Sum	☐ GMP	☐ Cost plus fee	☐ Not applicable
c) Design-Builder	☐ Lump-Sum	☐ GMP	☐ Cost plus fee	☐ Not applicable
d) Subcontractors	☐ Lump-Sum	☐ GMP	☐ Cost plus fee	☐ Not applicable

10. What was the procurement method used for the design-builder or designer and contractor, and subcontractors?

a) Architect/Designer	☐ Sole source selection	☐ Qualification based selection
	☐ Low bid	☐ Other ______________________________
b) Contractor	☐ Sole source selection	☐ Qualification based selection
	☐ Low bid	☐ Other ______________________________
c) Design-Builder	☐ Sole source selection	☐ Qualification based selection

d) Subcontractors	☐ Low bid ☐ Other ______________________________ ☐ Sole source selection ☐ Qualification based selection ☐ Low bid ☐ Other ______________________________	

11. At what stage of the project was each of the major project parties involved? Stages include: i) Conceptual design (0-15%), ii) Schematic design (15-30%), iii) Design development (30-60%), iv) Construction documents (60-99%), and v) Construction – Put an X in the relevant boxes -

Phase	Conceptual Design	Schematic Design	Design Development	Construction Documents	Construction
Design complete	0-15%	15-30%	30-60%	60-99%	100%
Owner					
Designer - Architect					
Designer - Interior					
Designer - Landscape					
Designer - Other (Please mention):					
Engineer - Structural					
Engineer - Geotech					
Engineer - Electrical					
Engineer - Mechanical					
Engineer - Other (Please mention):					
General Contractor					
Contractor - Electrical					
Contractor - Mechanical					
Contractor - Roofing					
Contractor - Flooring					
Contractor - Carpenter					
Contractor – Other (Please mention):					
Suppliers					

Section 3: Project Sustainability Characteristics

12. Who initially proposed the idea of incorporating green or sustainable attributes in the project?

- ☐ Owner
- ☐ Developer
- ☐ Designer/design-builder
- ☐ Other(Please mention): ____________________________

13. Why is the project team pursuing green building objectives?

- ☐ Mandated by the client or state
- ☐ Owner driven factor/vision statement
- ☐ Energy use/cost
- ☐ Productivity of occupants
- ☐ Other(Please mention): _____________________________

14. At what point during the design phase was the notion of green building introduced?

- ☐ Conceptual design (0-15% design complete)
- ☐ Schematic design (15-30% design complete)
- ☐ Design Development (30-60% design complete)
- ☐ Construction documents (60-99% design complete)
- ☐ Bidding (Full completion of design)

15. Who is/are responsible for the LEED/sustainability implementation of project? How are the LEED/sustainability related responsibilities distributed officially?

16. Was there any official training conducted to educate participants regarding LEED?

Section 4: Project Cost Performance

17. What were the following project costs?

    Provide separate Construction Costs if known otherwise enter Total Project Costs only indicating whether the cost data provided is **estimated (E)** or **actual (A)** Please deduct all property costs, owner costs, costs of installed process or manufacturing equipment, furnishings fittings and equipment or items not a cost of the base building.

	Construction Costs	Total Project Costs
Contract Award	E ☐ A ☐	E ☐ A ☐
Final Cost	E ☐ A ☐	E ☐ A ☐

Are there any unresolved costs or change orders? ☐ Yes ☐ No

Has the project ever been in litigation? ☐ Yes, resolved ☐ Yes, unresolved ☐ No

If applicable, are the costs of litigation and/or claims included in the project costs listed above?
☐ N/A ☐ Yes ☐ No

What is your level of satisfaction with the cost performance of the project?

☐ Strongly Dissatisfied ☐ Dissatisfied ☐ Neutral ☐ Satisfied ☐ Strongly Satisfied

Section 5: Project Schedule Performance

18. Please provide the following schedule information.

	Planned (mm/dd/yyyy)	Actual (mm/dd/yyyy)
Design Start Date (Notice to proceed)		
Construction Start Date (Notice to Proceed)		
Construction End Date (Submittal Completion) actual or expected		

What is your level of satisfaction with the schedule performance of the project?

☐ Strongly Dissatisfied ☐ Dissatisfied ☐ Neutral ☐ Satisfied ☐ Strongly Satisfied

Section 6: Project Quality Performance

19. Relative to your expectations, evaluate the quality of the facility and systems (1 = low, 5 = high)

Systems	1 (Low)	2	3	4	5 (High)
Envelope, Roof, Structure, Foundation	☐	☐	☐	☐	☐
Interior finishes	☐	☐	☐	☐	☐
Lights, HVAC	☐	☐	☐	☐	☐
Exterior aesthetics	☐	☐	☐	☐	☐

What is your overall level of satisfaction with the quality performance of the project?

☐ Strongly Dissatisfied ☐ Dissatisfied ☐ Neutral ☐ Satisfied ☐ Strongly Satisfied

Section 7: Project Sustainability Performance

20. What level of LEED certification was planned and awarded/expected to be awarded?

Planned [ ] No. of points/credits [ ]

Achieved/expected [ ] No. of points/credits [ ]

What is your overall level of satisfaction with the sustainability performance of the project?

☐ Strongly Dissatisfied ☐ Dissatisfied ☐ Neutral ☐ Satisfied ☐ Strongly Satisfied

21. What was the process used to align Project Team members around the purpose and targeted outcomes of this project?

22. How many multidisciplinary team workshops were convened before design began?

23. How many design charrettes/workshops have been conducted?

Appendix E: R codes and Results for CFA and SEM

R codes and results for CFA

```
#Importing data
library(haven)

> StudyData <- read_sav("Dropbox/Data Collection/StudyDataNew.sav")

> View(StudyDataNew)

#loading lavaan package

> library(lavaan)

This is lavaan 0.6-5

lavaan is BETA software! Please report any bugs.

#model definition

model1 = '#Defining latent variables

lead1 =~ L1+L2

lead2 =~ L3+L4

lead3 =~ L5+L6

lead4 =~ L7+L8

lead5 =~ L9+L10

lead =~ lead1+lead2+lead3+lead4+lead5

perf =~ P1+P2+P3+P4+P5+P6

integ1 =~ I1+I2+I3+I4

integ2 =~ I5

integ3 =~ I7+I8+I9

integ =~ integ1+integ2+integ3

L2 ~~ 0*L2

L7 ~~ 0*L7

lead2 ~~ 0*lead2'

#model fit

fit1 = lavaan::cfa(model1, data=StudyDataNew, estimator = "MLM")
```

#summary

summary(fit1, fit.measures=TRUE, standardized=TRUE)

```
avaan 0.6-5 ended normally after 230 iterations

  Estimator                              ML
  Optimization method                NLMINB
  Number of free parameters              55

  Number of observations                103

Model Test User Model:
                                 Standard     Robust
  Test Statistic                  482.696    347.002
  Degrees of freedom                  245        245
  P-value (Chi-square)              0.000      0.000
  Scaling correction factor                    1.391
    for the Satorra-Bentler correction

Model Test Baseline Model:

  Test statistic                 5897.334   4265.313
  Degrees of freedom                  276        276
  P-value                           0.000      0.000
  Scaling correction factor                    1.383

User Model versus Baseline Model:

  Comparative Fit Index (CFI)       0.958      0.974
```

Tucker-Lewis Index (TLI) 0.952 0.971

Robust Comparative Fit Index (CFI) 0.974
Robust Tucker-Lewis Index (TLI) 0.971

Loglikelihood and Information Criteria:

Loglikelihood user model (H0) -3036.304 -3036.304
Loglikelihood unrestricted model (H1) -2794.956 -2794.956

Akaike (AIC) 6182.607 6182.607
Bayesian (BIC) 6327.517 6327.517
Sample-size adjusted Bayesian (BIC) 6153.782 6153.782

Root Mean Square Error of Approximation:

RMSEA 0.097 0.064
90 Percent confidence interval - lower 0.084 0.050
90 Percent confidence interval - upper 0.110 0.076
P-value RMSEA <= 0.05 0.000 0.050

Robust RMSEA 0.075
90 Percent confidence interval - lower 0.056
90 Percent confidence interval - upper 0.093

Standardized Root Mean Square Residual:

SRMR 0.070 0.070

Parameter Estimates:

```
  Information                                 Expected
  Information saturated (h1) model        Structured
  Standard errors                           Robust.sem
```

Latent Variables:

```
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  lead1 =~
    L1              1.000                         8.204    0.996
    L2              1.026    0.010  101.082    0.000    8.420    1.000
  lead2 =~
    L3              1.000                         8.472    0.999
    L4              1.008    0.010  100.916    0.000    8.537    0.998
  lead3 =~
    L5              1.000                         8.383    0.998
    L6              1.017    0.008  120.487    0.000    8.524    0.999
  lead4 =~
    L7              1.000                         8.355    1.000
    L8              1.007    0.007  135.498    0.000    8.410    0.997
  lead5 =~
    L9              1.000                         7.880    0.992
    L10              0.998    0.022   44.883    0.000    7.867    0.988
  lead =~
    lead1            1.000                         0.999    0.999
    lead2            1.033    0.011   90.643    0.000    1.000    1.000
    lead3            1.020    0.019   55.046    0.000    0.997    0.997
```

lead4	1.017	0.012	87.441	0.000	0.998	0.998
lead5	0.948	0.030	31.710	0.000	0.986	0.986
perf =~						
P1	1.000				0.884	0.864
P2	1.196	0.129	9.310	0.000	1.058	0.800
P3	1.065	0.088	12.103	0.000	0.942	0.909
P4	1.173	0.126	9.350	0.000	1.038	0.798
P5	0.948	0.173	5.473	0.000	0.839	0.630
P6	1.152	0.146	7.900	0.000	1.019	0.800
integ1 =~						
I1	1.000				0.754	0.870
I2	1.213	0.144	8.417	0.000	0.914	0.716
I3	0.675	0.099	6.796	0.000	0.509	0.697
I4	1.337	0.151	8.827	0.000	1.008	0.758
integ2 =~						
I5	1.000				0.829	1.000
integ3 =~						
I7	1.000				0.590	0.855
I8	1.242	0.101	12.301	0.000	0.733	0.885
I9	1.241	0.187	6.652	0.000	0.733	0.692
integ =~						
integ1	1.000				0.791	0.791
integ2	1.232	0.197	6.255	0.000	0.887	0.887
integ3	0.896	0.137	6.528	0.000	0.905	0.905

Covariances:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
lead ~~						

perf	2.454	0.718	3.418	0.001	0.338	0.338
integ	1.643	0.527	3.118	0.002	0.336	0.336
perf ~~						
integ	0.465	0.117	3.969	0.000	0.882	0.882

Variances:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
.L2	0.000			0.000	0.000	
.L7	0.000			0.000	0.000	
.lead2	0.000			0.000	0.000	
.L1	0.501	0.127	3.938	0.000	0.501	0.007
.L3	0.123	0.041	3.019	0.003	0.123	0.002
.L4	0.311	0.116	2.680	0.007	0.311	0.004
.L5	0.265	0.125	2.124	0.034	0.265	0.004
.L6	0.166	0.125	1.326	0.185	0.166	0.002
.L8	0.366	0.108	3.396	0.001	0.366	0.005
.L9	0.983	0.556	1.766	0.077	0.983	0.016
.L10	1.527	0.836	1.828	0.068	1.527	0.024
.P1	0.266	0.054	4.957	0.000	0.266	0.254
.P2	0.630	0.089	7.115	0.000	0.630	0.360
.P3	0.187	0.046	4.106	0.000	0.187	0.174
.P4	0.616	0.131	4.684	0.000	0.616	0.364
.P5	1.067	0.261	4.096	0.000	1.067	0.603
.P6	0.585	0.136	4.301	0.000	0.585	0.361
.I1	0.182	0.050	3.607	0.000	0.182	0.243
.I2	0.792	0.165	4.811	0.000	0.792	0.487
.I3	0.273	0.050	5.466	0.000	0.273	0.514
.I4	0.753	0.224	3.362	0.001	0.753	0.426

.I5	0.000			0.000	0.000	
.I7	0.128	0.035	3.706	0.000	0.128	0.269
.I8	0.150	0.040	3.768	0.000	0.150	0.218
.I9	0.583	0.125	4.683	0.000	0.583	0.521
.lead1	0.102	0.039	2.583	0.010	0.002	0.002
.lead3	0.388	0.140	2.776	0.006	0.006	0.006
.lead4	0.338	0.080	4.208	0.000	0.005	0.005
.lead5	1.683	0.420	4.002	0.000	0.027	0.027
lead	67.210	10.450	6.431	0.000	1.000	1.000
perf	0.782	0.231	3.385	0.001	1.000	1.000
.integ1	0.213	0.058	3.671	0.000	0.374	0.374
.integ2	0.147	0.043	3.399	0.001	0.214	0.214
.integ3	0.063	0.025	2.517	0.012	0.181	0.181
integ	0.356	0.114	3.122	0.002	1.000	1.000

R codes and results for Hypothesis 1

```
#model definition
modelH1 = '#Defining latent variables
lead1 =~ L1+L2
lead2 =~ L3+L4
lead3 =~ L5+L6
lead4 =~ L7+L8
lead5 =~ L9+L10
lead =~ lead1+lead2+lead3+lead4+lead5
perf =~ P1+P2+P3+P4+P5+P6
perf~lead
lead~c1
lead~c2
```

```
lead~c3
lead~c4
lead~c5
lead~c6
lead~c7
lead~c8
perf~c1
perf~c2
perf~c3
perf~c4
perf~c5
perf~c6
perf~c7
perf~c8
L2 ~~ 0*L2
L7 ~~ 0*L7
lead2 ~~ 0*lead2'

#model fit
fitH1 = lavaan::sem(modelH1, data=StudyDataNew, estimator="MLM")

#model summary
summary (fitH1, fit.measures = TRUE, standardized=TRUE)

lavaan 0.6-5 ended normally after 301 iterations

  Estimator                                         ML
  Optimization method                           NLMINB
  Number of free parameters                         51
```

Number of observations	103	

Model Test User Model:

	Standard	Robust
Test Statistic	449.133	332.275
Degrees of freedom	213	213
P-value (Chi-square)	0.000	0.000
Scaling correction factor		1.352
for the Satorra-Bentler correction		

Model Test Baseline Model:

Test statistic	5308.508	4402.249
Degrees of freedom	248	248
P-value	0.000	0.000
Scaling correction factor		1.206

User Model versus Baseline Model:

Comparative Fit Index (CFI)	0.953	0.971
Tucker-Lewis Index (TLI)	0.946	0.967
Robust Comparative Fit Index (CFI)		0.968
Robust Tucker-Lewis Index (TLI)		0.963

Loglikelihood and Information Criteria:

Loglikelihood user model (H0)	-2208.528	-2208.528

Loglikelihood unrestricted model (H1) -1983.961 -1983.961

Akaike (AIC) 4519.055 4519.055

Bayesian (BIC) 4653.426 4653.426

Sample-size adjusted Bayesian (BIC) 4492.326 4492.326

Root Mean Square Error of Approximation:

RMSEA 0.104 0.074

90 Percent confidence interval - lower 0.090 0.060

90 Percent confidence interval - upper 0.117 0.087

P-value RMSEA <= 0.05 0.000 0.003

Robust RMSEA 0.086

90 Percent confidence interval - lower 0.067

90 Percent confidence interval - upper 0.103

Standardized Root Mean Square Residual:

SRMR 0.038 0.038

Parameter Estimates:

Information Expected

Information saturated (h1) model Structured

Standard errors Robust.sem

Latent Variables:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
lead1 =~						
L1	1.000				8.204	0.996
L2	1.026	0.010	101.636	0.000	8.420	1.000
lead2 =~						
L3	1.000				8.472	0.999
L4	1.008	0.010	101.431	0.000	8.537	0.998
lead3 =~						
L5	1.000				8.383	0.998
L6	1.017	0.008	120.956	0.000	8.524	0.999
lead4 =~						
L7	1.000				8.355	1.000
L8	1.007	0.007	136.050	0.000	8.410	0.997
lead5 =~						
L9	1.000				7.880	0.992
L10	0.998	0.022	45.357	0.000	7.867	0.988
lead =~						
lead1	1.000				0.999	0.999
lead2	1.033	0.011	91.226	0.000	1.000	1.000
lead3	1.020	0.019	55.078	0.000	0.997	0.997
lead4	1.017	0.012	87.560	0.000	0.998	0.998
lead5	0.948	0.030	31.750	0.000	0.986	0.986
perf =~						
P1	1.000				0.895	0.874
P2	1.177	0.129	9.143	0.000	1.053	0.796
P3	1.045	0.082	12.738	0.000	0.935	0.902
P4	1.150	0.122	9.447	0.000	1.029	0.791
P5	0.953	0.171	5.562	0.000	0.853	0.641

P6	1.144	0.146	7.838	0.000	1.024	0.803

Regressions:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
perf ~						
lead	0.035	0.009	3.764	0.000	0.323	0.323
lead ~						
c1	2.170	3.035	0.715	0.475	0.265	0.091
c2	3.630	2.971	1.222	0.222	0.443	0.147
c3	-1.730	2.586	-0.669	0.504	-0.211	-0.062
c4	1.354	3.001	0.451	0.652	0.165	0.044
c5	0.976	2.825	0.345	0.730	0.119	0.038
c6	4.674	3.531	1.324	0.186	0.570	0.161
c7	2.803	3.377	0.830	0.407	0.342	0.117
c8	2.645	3.174	0.833	0.405	0.323	0.117
perf ~						
c1	0.683	0.473	1.442	0.149	0.763	0.262
c2	0.521	0.469	1.110	0.267	0.582	0.193
c3	0.672	0.496	1.356	0.175	0.752	0.223
c4	0.530	0.450	1.179	0.238	0.593	0.159
c5	0.980	0.459	2.134	0.033	1.095	0.351
c6	1.053	0.463	2.271	0.023	1.177	0.332
c7	0.512	0.464	1.104	0.270	0.572	0.196
c8	0.673	0.503	1.338	0.181	0.752	0.272

Variances:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
.L2	0.000				0.000	0.000

.L7	0.000			0.000	0.000	
.lead2	0.000			0.000	0.000	
.L1	0.501	0.127	3.947	0.000	0.501	0.007
.L3	0.123	0.041	3.014	0.003	0.123	0.002
.L4	0.311	0.115	2.696	0.007	0.311	0.004
.L5	0.265	0.125	2.129	0.033	0.265	0.004
.L6	0.166	0.125	1.326	0.185	0.166	0.002
.L8	0.366	0.108	3.392	0.001	0.366	0.005
.L9	0.982	0.560	1.753	0.080	0.982	0.016
.L10	1.527	0.824	1.853	0.064	1.527	0.024
.P1	0.248	0.051	4.852	0.000	0.248	0.237
.P2	0.641	0.090	7.109	0.000	0.641	0.367
.P3	0.201	0.049	4.059	0.000	0.201	0.187
.P4	0.635	0.139	4.560	0.000	0.635	0.375
.P5	1.043	0.256	4.078	0.000	1.043	0.589
.P6	0.575	0.132	4.371	0.000	0.575	0.354
.lead1	0.102	0.039	2.585	0.010	0.002	0.002
.lead3	0.388	0.139	2.782	0.005	0.006	0.006
.lead4	0.338	0.079	4.272	0.000	0.005	0.005
.lead5	1.683	0.422	3.990	0.000	0.027	0.027
.lead	64.316	9.677	6.646	0.000	0.957	0.957
.perf	0.648	0.188	3.454	0.001	0.810	0.810

R codes and results for Hypothesis 2

```
#model definition
modelH2 = '#Defining latent variables
lead1 =~ L1+L2
lead2 =~ L3+L4
```

```
lead3 =~ L5+L6

lead4 =~ L7+L8

lead5 =~ L9+L10

lead =~ lead1+lead2+lead3+lead4+lead5

perf =~ P1+P2+P3+P4+P5+P6

integ1 =~ I1+I2+I3+I4

integ2 =~ I5

integ3 =~ I7+I8+I9

integ =~ integ1+integ2+integ3


#Defining Regressions

integ ~ a*lead

perf ~ b*integ + c*lead

lead~c1

lead~c2

lead~c3

lead~c4

lead~c5

lead~c6

lead~c7

lead~c8

perf~c1

perf~c2

perf~c3

perf~c4

perf~c5

perf~c6
```

```
perf~c7

perf~c8

integ~c1

integ~c2

integ~c3

integ~c4

integ~c5

integ~c6

integ~c7

integ~c8


L2 ~~ 0*L2

L7 ~~ 0*L7

lead2 ~~ 0*lead2


indirect := a*b

direct := c

total := c + (a*b)'


#model fit

fitH2 = lavaan::sem(modelH2, data=StudyDataNew, estimator="MLM")


#summary

summary(fitH2, fit.measures=TRUE, standardized=TRUE)

lavaan 0.6-5 ended normally after 284 iterations


  Estimator                                         ML
```

Optimization method	NLMINB
Number of free parameters	79
Number of observations	103

Model Test User Model:

	Standard	Robust
Test Statistic	719.980	608.070
Degrees of freedom	413	413
P-value (Chi-square)	0.000	0.000
Scaling correction factor		1.184
for the Satorra-Bentler correction		

Model Test Baseline Model:

Test statistic	6161.153	5232.157
Degrees of freedom	468	468
P-value	0.000	0.000
Scaling correction factor		1.178

User Model versus Baseline Model:

Comparative Fit Index (CFI)	0.946	0.959
Tucker-Lewis Index (TLI)	0.939	0.954
Robust Comparative Fit Index (CFI)		0.959
Robust Tucker-Lewis Index (TLI)		0.953

Loglikelihood and Information Criteria:

Loglikelihood user model (H0)	-3023.036	-3023.036
Loglikelihood unrestricted model (H1)	-2663.046	-2663.046
Akaike (AIC)	6204.072	6204.072
Bayesian (BIC)	6412.216	6412.216
Sample-size adjusted Bayesian (BIC)	6162.669	6162.669

Root Mean Square Error of Approximation:

RMSEA	0.085	0.068
90 Percent confidence interval - lower	0.075	0.057
90 Percent confidence interval - upper	0.095	0.078
P-value RMSEA <= 0.05	0.000	0.005
Robust RMSEA		0.074
90 Percent confidence interval - lower		0.061
90 Percent confidence interval - upper		0.086

Standardized Root Mean Square Residual:

SRMR	0.062	0.062

Parameter Estimates:

Information Expected

Information saturated (h1) model Structured

Standard errors Robust.sem

Latent Variables:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
lead1 =~						
L1	1.000				8.204	0.996
L2	1.026	0.010	101.636	0.000	8.420	1.000
lead2 =~						
L3	1.000				8.472	0.999
L4	1.008	0.010	101.416	0.000	8.537	0.998
lead3 =~						
L5	1.000				8.383	0.998
L6	1.017	0.008	120.958	0.000	8.524	0.999
lead4 =~						
L7	1.000				8.355	1.000
L8	1.007	0.007	136.050	0.000	8.410	0.997
lead5 =~						
L9	1.000				7.880	0.992
L10	0.998	0.022	45.352	0.000	7.867	0.988
lead =~						
lead1	1.000				0.999	0.999
lead2	1.033	0.011	91.226	0.000	1.000	1.000
lead3	1.020	0.019	55.074	0.000	0.997	0.997
lead4	1.017	0.012	87.554	0.000	0.998	0.998
lead5	0.948	0.030	31.749	0.000	0.986	0.986

perf =~						
P1	1.000				0.887	0.866
P2	1.190	0.129	9.234	0.000	1.055	0.798
P3	1.060	0.084	12.560	0.000	0.940	0.906
P4	1.166	0.125	9.312	0.000	1.034	0.794
P5	0.952	0.173	5.509	0.000	0.844	0.635
P6	1.156	0.147	7.851	0.000	1.025	0.804
integ1 =~						
I1	1.000				0.756	0.873
I2	1.206	0.143	8.435	0.000	0.912	0.715
I3	0.670	0.098	6.812	0.000	0.507	0.695
I4	1.333	0.152	8.747	0.000	1.008	0.758
integ2 =~						
I5	1.000				0.829	1.000
integ3 =~						
I7	1.000				0.591	0.856
I8	1.237	0.101	12.210	0.000	0.732	0.882
I9	1.241	0.186	6.670	0.000	0.734	0.693
integ =~						
integ1	1.000				0.788	0.788
integ2	1.231	0.194	6.334	0.000	0.886	0.886
integ3	0.901	0.135	6.667	0.000	0.908	0.908

Regressions:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
integ ~						
lead (a)	0.025	0.007	3.517	0.000	0.341	0.341

perf ~							
integ	(b)	1.332	0.264	5.045	0.000	0.895	0.895
lead	(c)	0.002	0.006	0.342	0.733	0.020	0.020
lead ~							
c1		2.169	3.035	0.715	0.475	0.265	0.091
c2		3.632	2.971	1.222	0.222	0.443	0.147
c3		-1.730	2.586	-0.669	0.504	-0.211	-0.062
c4		1.354	3.001	0.451	0.652	0.165	0.044
c5		0.977	2.825	0.346	0.730	0.119	0.038
c6		4.674	3.531	1.324	0.186	0.570	0.161
c7		2.801	3.377	0.830	0.407	0.342	0.117
c8		2.645	3.174	0.833	0.405	0.323	0.117
perf ~							
c1		0.460	0.302	1.525	0.127	0.519	0.178
c2		0.848	0.317	2.671	0.008	0.956	0.318
c3		0.674	0.311	2.167	0.030	0.760	0.225
c4		0.721	0.358	2.012	0.044	0.813	0.218
c5		0.592	0.284	2.080	0.038	0.667	0.214
c6		0.648	0.320	2.024	0.043	0.730	0.206
c7		0.700	0.321	2.182	0.029	0.789	0.270
c8		0.667	0.281	2.369	0.018	0.752	0.272
integ ~							
c1		0.151	0.223	0.678	0.498	0.254	0.087
c2		-0.257	0.290	-0.887	0.375	-0.432	-0.143
c3		-0.008	0.268	-0.031	0.975	-0.014	-0.004
c4		-0.154	0.210	-0.736	0.462	-0.259	-0.069
c5		0.277	0.212	1.308	0.191	0.464	0.149

c6	0.289	0.203	1.424	0.154	0.486	0.137
c7	-0.152	0.216	-0.707	0.479	-0.256	-0.088
c8	-0.006	0.253	-0.025	0.980	-0.010	-0.004

Variances:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
.L2	0.000				0.000	0.000
.L7	0.000				0.000	0.000
.lead2	0.000				0.000	0.000
.L1	0.501	0.127	3.947	0.000	0.501	0.007
.L3	0.123	0.041	3.018	0.003	0.123	0.002
.L4	0.311	0.115	2.697	0.007	0.311	0.004
.L5	0.265	0.125	2.129	0.033	0.265	0.004
.L6	0.166	0.125	1.327	0.185	0.166	0.002
.L8	0.366	0.108	3.392	0.001	0.366	0.005
.L9	0.982	0.560	1.753	0.080	0.982	0.016
.L10	1.528	0.825	1.853	0.064	1.528	0.024
.P1	0.262	0.051	5.131	0.000	0.262	0.250
.P2	0.637	0.087	7.291	0.000	0.637	0.364
.P3	0.192	0.043	4.415	0.000	0.192	0.179
.P4	0.625	0.132	4.728	0.000	0.625	0.369
.P5	1.058	0.259	4.077	0.000	1.058	0.597
.P6	0.573	0.129	4.438	0.000	0.573	0.353
.I1	0.178	0.050	3.570	0.000	0.178	0.238
.I2	0.795	0.165	4.824	0.000	0.795	0.489
.I3	0.275	0.050	5.546	0.000	0.275	0.517
.I4	0.753	0.223	3.374	0.001	0.753	0.426

.l5	0.000			0.000	0.000	
.l7	0.127	0.034	3.741	0.000	0.127	0.267
.l8	0.152	0.039	3.868	0.000	0.152	0.222
.l9	0.582	0.124	4.695	0.000	0.582	0.519
.lead1	0.102	0.039	2.586	0.010	0.002	0.002
.lead3	0.388	0.139	2.782	0.005	0.006	0.006
.lead4	0.338	0.079	4.271	0.000	0.005	0.005
.lead5	1.683	0.422	3.989	0.000	0.027	0.027
.lead	64.316	9.678	6.646	0.000	0.957	0.957
.perf	0.136	0.053	2.561	0.010	0.173	0.173
.integ1	0.217	0.057	3.795	0.000	0.379	0.379
.integ2	0.148	0.042	3.523	0.000	0.215	0.215
.integ3	0.061	0.023	2.699	0.007	0.175	0.175
.integ	0.283	0.089	3.184	0.001	0.795	0.795

Defined Parameters:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
indirect	0.033	0.010	3.361	0.001	0.305	0.305
direct	0.002	0.006	0.342	0.733	0.020	0.020
total	0.035	0.009	3.763	0.000	0.325	0.325

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