ABSTRACT

Title of Dissertation:	A STUDY OF GENDER DIVERSITY IN U.S. ARCHITECTURE, ENGINEERING, AND CONSTRUCTION (AEC) INDUSTRY LEADERSHIP
	Paul Joseph Hickey, Doctor of Philosophy, 2023
Dissertation Directed By:	Professor Qingbin Cui, Civil & Environmental Engineering

Anecdotally, men dominate the Architecture, Engineering, and Construction (AEC) field. This study contributes to the body of knowledge by quantifying the gender composition of the c-suite, identifying differences in career paths between women and men, and gathering in-depth information on women engineering executives' professional stories. Using the industry recognized Engineering News Record (ENR) Top 400 largest companies, initial phase of this research found women filled 3.9% of engineering executive positions in 2019, reducing to 3.5% in 2021. However, certain sub-segments, highlighted by firms with a public commitment to diversity, ENR Top 100 Green companies, and larger organizations, offer more opportunities to women. Exploring further into individual and collective career paths, researchers applied web scraping algorithms to extract LinkedIn data for 2,857 industry leaders. Data found that women work for more companies (+56%), hold more positions (+19%), earn more advanced degrees (53.9% to 31.2%), assemble larger professional networks (+14%), yet remain significantly underrepresented (-83%). Confirming a difference between the career paths of women and men, Machine Learning (ML) modeling predicted profile genders with 98.95% training sample and 89.53% testing sample accuracy. Final stage of research incorporates interviews with women engineering executives, seeking to learn about pathways and barriers in their respective and collective professional journeys and test the findings from the initial two phases of this study. An overriding theme throughout the progressive study, recommendations for increasing women's representation include directed Science, Technology, Engineering, and Math (STEM) scholarships for young girls, targeted recruiting of women, establishing mentoring relationships, and creating nurturing cultures to retain early and mid-career women.

A STUDY OF GENDER DIVERSITY IN U.S. ARCHITECTURE, ENGINEERING, AND CONSTRUCTION (AEC) INDUSTRY LEADERSHIP

by

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Dissertation submitted to the Faculty of the Graduate School of the
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Dedication

To my beloved Bonnie, your strength and perseverance served as the constant motivation to continue this journey, regardless of the hurdles and struggles. Watching your own career battle through the AEC industry inspired this work and the following endeavors to create positive change and opportunities for women practitioners. While no longer by my side, your spirit lives on in my heart.

Tom, your sage advice and scholarly guidance helped shine the flashlight to disperse the darkness and prevent me from wandering off the path.

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Chapter 4 – Ms. Melissa Rocco, Lecturer, from the University of Maryland College of Education, lent her qualitative research expertise to guide significant restructuring of the manuscript. Her vision allowed the presentation to align with research techniques designed to maximize the impact of the data collection and findings.

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List of Abbreviations

Abbreviation	Explanation
AEC	Architecture, Engineering, and Construction
BS	Bachelor of Science
CAQDAS	Computer Assisted Qualitative Data Analysis Software
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CIO	Chief Information Officer
COO	Chief Operating Officer
CSMM	Career Self-Management Model
CSNM	Career-Oriented Social Networking Markets
CSR	Corporate Social Responsibility
DEI	Diversity, Equity, and Inclusion
DOT	Department of Transportation
EEOA	Equal Employment Opportunity Act of 1972
ENR	Engineering News Record
FMLA	Family Medical and Leave Act
FN	False Negative
FP	False Positive
HBCU	Historically Black Colleges and Universities
HR	Human Resources
IRB	Institutional Review Board
JD	Juris Doctor
JME	Journal of Management in Engineering
MA	Master of Arts
MBA	Master of Business Administration
MBE	Minority Business Enterprise
ML	Machine Learning
MS	Master of Science
P3	Public Private Partnerships
PhD	Doctor of Philosophy
RF	Random Forest
RFP	Request for Proposal
SCCT	Social Cognitive Career Theory
SNS	Social Networking Service
STEM	Science, Technology, Engineering, and Math
TN	True Negative

Abbreviation	Explanation
TP	True Positive
VP	Vice President
VTC	Video Teleconferencing

Chapter 1: Introduction

Background

At the onset of this investigation, researchers considered the commonly accepted notion that men dominate engineering positions and organizational hierarchy throughout the domestic Architecture, Engineering, and Construction (AEC) industry. While federal statistics report men fill nine of out 10 jobs in the field (U.S. Department of Labor 2018), researchers found no prior studies or quantitative data on leadership, specifically leadership engineering composition. Structure of this investigation comprised three distinct interrelated phases, each generated as stand-alone segments for peer reviewed journal publication represented in Chapters 2 – 4. Research builds upon the prior investigations to expand on the concepts, findings, and potential impact to the industry. Ultimately, goals of this research quantify the current state of executive gender diversity, identify successful career decisions and milestones of current leaders, and offer a roadmap for early and mid-career women engineers to aid their progression, ideally accelerating integration of AEC leadership suites.

Perceptions on gender roles existed for millennium, dating back to Greek philosophy, Judeo-Christian, and Freudian theory (Bem 1993). Extending into American society, language in the U.S. Constitution excluded women with some laws remaining in force

until the Supreme Court legislated equal rights applied to sex in the 1970s (Bem 1993). In the early 1960s, Kennedy Administration civil rights platform increased the focus on women's rights, highlighted by professional and education advances (Jardina and Burns 2016). Civil Rights Act of 1964 directed an end to discrimination based on an individual's race, color, religion, sex, or national origin (U.S. Equal Employment Opportunity Commission 2021). However, even after almost half a century since passing the Equal Employment Opportunity Act of 1972 (EEOA), women remain underrepresented in engineering and construction sectors (Hatch 2008; Harrison 2010). This study tests the overall theory that this inequity persists today.

These Federal legislative milestones created opportunities previously unavailable and generated a seismic shift in the late 20th Century workplace. Women's participation in general U.S. labor force significantly increased over the past 50 years, both depth in fields viewed as female and breadth into traditionally male occupations. Despite landmark legislation, actual balance in the industries and individual firms failed to emerge. After early gains during the 1970s feminist movement, progress slowed in the 1980s – 2000s, partially offset by women filling 2.6 million of the 4.5 million new management billets created during this period (Scarborough 2018). As a result, affirmative action programs arose to further promote equality.

Changing composition of the workforce continues to create new challenges for employers, leadership, and employees alike. Introduction and expansion of underrepresented population segments drives the need for culture change from both company policy and daily operations perspectives (Lawless 2001). Due to its deep rooted identification with male traits, AEC firms face greater barriers to entry and internal resistance to culture change to adapt. Factors generating resistance to inclusion for women: work family balance, imbalanced advancement, and sexist culture act to slow participation and growth, contributing to the loss of talent and expertise (McCarthy et al. 2019). Recommended leadership actions to drive change need to be investigated and documented for industry implementation. Resultant refresh of the workforce combats future turnover rates and aligns with continued globalization. In addition, infusion of ideas generated from different perspectives and backgrounds drives better decisions by challenging the status quo, generating creative debate, and offering unique solutions (Pritchard and Miles 2018). Inclusion allows new views on old problems, devising project innovation and established differentiation in the market. Further, in today's environment, prominent commitment to diversity increases a firm's prominence in wider society, garnering intangible benefits of positive public relations and favor.

Through scientifically tested methodology, this study tests anecdotal views on AEC gender diversity, quantifying representation rates to assess validity of commonly held observational views. Pearson's law states that, "When performance is measured, performance improves. When performance is measured and reported back, the rate of improvement accelerates." Publication and distribution of the findings creates an industry baseline against which to measure future performance.

Knowledge Gap and Research Needs

Anecdotally, despite gains in women's representation in the general workforce, AEC remains a male dominated field. While industry gender diversity studies exist, researchers found no empirical study to report or dispute this claim for industry executives. Overall, this research contributes through quantifying percentage of women in leadership positions, defining distinct career components between genders, and examining professional experiences of women leaders as they relate to growth and progression.

Current labor shortages of 650,000 (Associated Builders and Contractors 2022) with half of the industry approaching retirement (Morello et al. 2018), coupled with an expanding market (Kim et al. 2020), companies must expand their initial recruitment and long-term employee care to a wider population. Comprising over half of the U.S. population, women offer the largest segment, especially considering a large, educated

group currently exists with women earning 21.9% of civil engineering degrees over the past 24 years (Department of Education 1995 – 1999; Yoder 2000 – 2018). Advancing more women into prominent engineering positions promises to promote recruitment as early and mid-career women see opportunities for career growth. This long-term perspective counteracts the "leaky pipeline" and loss of women from the talent pool (Pritchard and Miles 2018).

This investigation seeks to add to the body of knowledge by addressing the information gap regarding female representation on top AEC executive teams. Researchers identified insufficient knowledge on drivers behind women's success and documentation to aid the next generation of practitioners. Gathering data on individual and collective occupational decisions and actions offers insight into the similarities and differences between genders. In prior literature, authors identified no direct accumulation of experiential data from current AEC women leaders.

Research Objectives and Hypothesis

- Quantify gender composition of AEC leadership, initially targeting executive suites and then progressing deeper into the organization.
- Assess whether individual subsegments (e.g., revenue size or customer industry) impact overall diversity and understand the root causes for greater or lesser integration.

- Compare individual and collective career paths to determine whether women and men approach professional progression in similar ways.
- Investigate the impact of career related decisions (e.g., remaining with the same firm or pursuit of additional education).
- Learn about significant experiences / events which facilitated women's success and created challenges.
- Identify industry best practices to promote diversity.
- Generate a roadmap for early and mid-career women to accelerate their advancement up the corporate ladder.

Dissertation Structure

Depicted in Figure 1-1, this dissertation comprises three distinct, yet interrelated, phases building upon the prior efforts. Applying the three paper model, Chapters 2 – 4 each stand alone as fully contained research studies. Chapter 1 offers an overview of the study, interconnecting the common threads throughout the progressive investigation. Chapter 2 quantifies the state of practice for gender representation in the executive suite of the Engineering News Record (ENR) Top 400 firms, comparing select sub-segments to identify areas of greater diversity. Chapter 3 uses LinkedIn profiles of over 2,800 industry leaders to identify the characteristics of women and men's career progression. Machine Learning model processes profile results to test differences between genders. Chapter 4 delves deeper into the professional

experiences and stories of 20 women industry leaders, Vice President (VP) and above. Their individual and collective interview responses offer insight into successful activities and choices, offering a roadmap for early and mid-career women to accelerate their own climb up the corporate ladder. Chapter 5 fuses together the collective study results and outlines study limitations and recommended next actions to generate positive change in the industry.

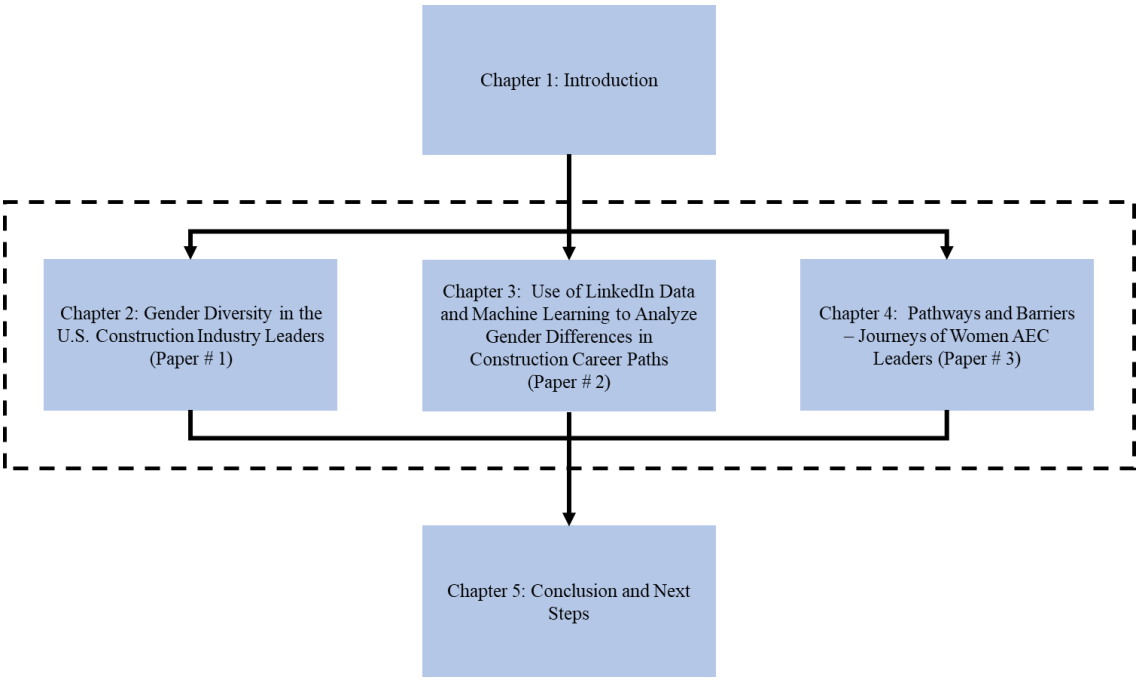

Figure 1-1 – Dissertation Structure

Chapter 2: Gender Diversity in the U.S. Construction Industry Leaders (Paper # 1)

This chapter is based on the paper published in Journal of Management in Engineering (Hickey, P.J. and Cui, Q. (2020). Gender diversity in us construction industry leaders. Journal of Management in Engineering, 36(5)).

Abstract

Despite a U.S. gender population distribution of 50.8% and 21.9% of civil engineering bachelor's degrees earned in the past 24 years, women are significantly under-represented in U.S. engineering and construction executive leadership positions. This current state of practice study adds to the body of knowledge by addressing the information gap regarding female leadership representation and quantifying executive team gender distribution of the top firms in the field, as identified by the Top 400 Engineering News Record (ENR). Anecdotally, this is a male dominated field, but no empirical study has reported the claim or proved otherwise for industry executives. New aspects of research evaluate impact of select industry subsets (e.g., revenue size, Green companies, and public commitment to diversity and inclusion) on actual diversity composition in the executive suite. Overall, this study reports that women fill 3.9% of executive engineering billets. However, certain industry subsets, highlighted by companies who publicly promote diversity show promise with higher integration levels. The paper also reports a

majority of these companies lack gender diversity in leadership culture and mission statements. With a looming workforce turnover and continued globalization, industry will benefit from the introduction of fresh ideas and perspectives, brought by integration in the executive suite.

Introduction

It should be noted that authors of this paper respect the ongoing evolution in the discussion on sex vs. gender. Per psychology research, "…sex refers to biological differences and gender to socioculturally delineated masculine and feminine roles." (Oldehinkel, 2017). For simplification of this study, scope of this research on c-suite diversity applied the assumption and use of the term "gender" throughout the paper as a binary distinction of male and female sexes.

The U.S. construction industry is notorious for being male dominated (Azhar and Griffin 2014; Scarborough 2018). Rooted in Judeo-Christian, ancient Greek philosophy, and Freudian psychoanalytic theory, women have been defined by their domestic responsibilities in the household and departure from the male standard (Bem, 1993). These core concepts on defining gender roles continued into American society from pre-Revolutionary War period and drafting of laws and the Constitution which excluded the rights of women (Bem, 1993). Many of these laws remained in place until the 1970s when the Supreme Court legislated that equal rights applied to

sex as well (Bem, 1993). Despite passing of Equal Employment Opportunity Act of 1972 (EEOA) landmark legislation almost half a century ago, a gender gap continues to exist in engineering and construction sectors (Hatch 2008; Harrison 2010). Recent gender diversity studies confirm less than 10% representation by women in all billets, including senior executives, middle management, and line workers. This persists even though more than 21% of engineering graduates are female (Allison and Kaminsky 2017, U.S. Department of Labor 2018; Zitzman 2019). Prior research indicates that existing culture within the industry negatively impacts recruitment and retention of women, reducing the potential talent pool and draining the trade of skills and expertise (McCarthy et al. 2019; Powell et al. 2009). Even during the interviewing and hiring process, underlying gender stereotypes play an unconscious role in assessing the ideal candidate for a position (Ridgeway, 2011). Civil engineering and construction job descriptions apply characteristics typically associated with men as preferences. This limits women from even entering the field in larger numbers, further reducing the available pool for executive leadership. Throughout all education and career stages, from Science, Technology, Engineering, and Math (STEM) education, graduation, early career departures due to workplace stressors, middle management, and post-maternity, there is a continual loss of women from the talent pool, referred to as a "leaky pipeline" (Pritchard and Miles 2018). Factors identified as deterrents for females to join and stay in the field include hostile work

environment, gender bias by male coworkers, and challenges of work-life balance (Allison and Kaminsky 2017; Morello et al. 2018).

Past research suggests that gender diversity promotes better communication, stakeholder engagement, and financial results (Pritchard and Miles 2018). Women have a lower tolerance for risk and their participation on audit and compliance committees decreasing an organization's risk position, increasing the likelihood of better returns (Major Projects Association 2017; Pritchard and Miles 2018; Zenou 2018). Non-monetary improvements manifest themselves through better communications, enhanced relationships with stakeholders, and higher innovation (Devnew et al. 2018).

As a result of this drain on talent, industry deprives itself from benefits gained through gender diversity (Sunindijo and Kamardeen 2017). Variety of thought challenges the status quo, creates positive discourse, drives innovation, and ultimately better decision making (Pritchard and Miles 2018). Further, from a company perspective, possessing a diverse workforce offers multiple perspectives for viewing problems, fresh ideas emerge from varying backgrounds, and unique solutions are not limited by a singular focus dominated mindset (Hatch 2008). Addressing gender diversity will particularly benefit the U.S. construction industry. Currently, the industry faces a labor shortage, which is expected to widen with projected 2016 –

2026 compounded annual growth of 1.2% (Kim et al. 2020). Peering into the near future, experts project a shortfall in available talent, as 50% of the current workforce approaches retirement (Morello et al. 2018). Recruiting and retaining women into engineering offers an expanded available workforce to close the gap. With the current construction boom, the next generation of civil engineers must be drawn from a wider pool of candidates.

While gender diversity at workforce level has been previously reported in the construction industry, this paper focuses on the gender diversity in leadership. After all, a high percentage of female leaders in the construction represents a diverse workplace that will create role models for career growth and employee retention. One core question examined in this study is whether a lack of gender diversity exists in the engineering executive suite for engineering and construction industry. This study of gender diversity in the c-suite of Architecture, Engineering and Construction (AEC) companies is limited to review of the 400 companies recognized by the ENR as the largest U.S. based companies. Therefore, no conclusions can be directly drawn as to gender diversity globally without careful examination of engineering and construction companies in other countries.

Ultimately, gender inequality is status inequality (Ridgeway, 2011). Societal assumptions have developed that men are superior, creating the gender hierarchy that

continues to persist today (Ridgeway, 2011). Androcentrism promotes the male experience, standardizing this behavior as the norm and marginalizes female actions as sex-specific derivations (Bem, 1993). If existing powerful social relational processes are not addressed, it will be difficult to overcome gender inequity in the modern world (Ridgeway, 2011).

Research Questions

Research questions were developed to examine whether organizational size, industry sector, or specialized designation impacted executive composition.

- Company size – Larger organizations have a greater employee base. If a bigger group of people inherently leads to more volume representation of all demographic segments throughout the team, would this lead to more women at all levels in the firm, ultimately creating a more balanced mix in the c-suite? ENR rankings were used to subdivide by revenue, e.g., under $250M, $250M - $500M, $500M - $1B, and Over $1B.
- Public commitment to diversity – Core aspect of this study investigates gender representation. For the specific purposes of this study, public commitment to diversity is considered where a sampled firm lists a specific message of inclusion or diversity on their website and affirms their dedication to offering fair opportunities to all employees. Unlike Equal Opportunity Employer statements, since there is no program standardization across the industry, a

wider aperture was applied to identify a positive finding. A binomial score of "0" or "1" coding scheme was applied with "1" equaling a positive test. Note that any statement, not only gender focused, was counted. Examples include: "…fosters a culture of diversity and inclusion…", "We leverage diversity to deliver the best solutions…", and "Diversity and inclusion - We look to our differences to bring a richness of perspective." Would firms who promote diversity and inclusion programs, not limited to hiring, perform differently than companies offering no statements. Would hiring align with their own published culture?

- Green companies – As reported in prior research, women have a greater desire to impact the environment (Harrison, 2010). Would this lead to more women joining firms listed on the ENR Top 100 Green, with long-term results of a more diverse mix in the c-suite?
- Design Build / P3 / Customer Sector – Also considered was whether the type of work and project complexity performed by the company impacted team composition. Would a firm including design opportunities, large wide-scale P3 projects, or an interesting customer mission offer more challenges that would attract women?
- Local population center – Expanding the concept beyond company boundaries that larger populations generate larger demographic subgroups, would surrounding resident size (e.g. New York metropolitan area at 20.0M vs.

Carson City, NV at 55K) impact company actions? While employees, especially senior executives, can be recruited from any geographic region, local areas offer readily available candidate pools. Regardless, employees typically live near their workplace and are influenced by external environment. Would potential diversity deltas between a large metropolis and smaller city drive different hiring results?

Theories and Practice in Gender Diversity

Prior Studies of Gender Representation in Management

An ordinal hierarchy between men and women continues to exist in the United States through historical transformational periods highlighted by shift from agricultural to industrial economy, increase of women in the general workforce, and most recently expansion of women's representation in previously male professions such as engineer, doctor, and lawyer (Ridgeway, 2011). Sampling of recent studies on middle management positions found improving gender balance across all industries, yet smaller gains in engineering and construction fields. Unlike the data set for this paper which concentrated on executives, surveys discussed below combined both middle management and c-suite leadership.

In one focused study developed in conjunction with the Rinker School of Construction Management at the University of Florida, surveys were developed to

gather data from women program alumni working in the construction field and their perceptions of the industry (Morello et al. 2018). Research methodology indicated that final respondent pool included non-alumni, including younger participants. While this survey covered all ages (18 – 65+) and positions (intern – owner), data provides comparative insight. 19 of 171 respondents (11.1%) reported their title as executive, principal, or owner. In this study, 68% of respondents estimated that women comprise more than 10% of the workforce, higher than the actual participation rate of 9% in the construction industry as reported by the U.S. Department of Labor. This high workforce participation rate in this study shows possible self-reporting bias in questionnaire survey based studies. Respondents tend to report high female participations for political reason or good public relationship. In contrast to other research outlining gender bias and women leaving the industry (McCarthy et al. 2019; Powell et al. 2009; Pritchard and Miles 2018), 92% of study participants planned to remain in the field. Participants felt that their respective company's installation of inclusion and recruitment programs for women contributed to higher retention rates.

Other studies in the current decade produced results consistent with U.S. Department of Labor figures. One study found only 8% of construction managers across the industry were female (Harrison 2010). Despite progress in select trades, this research identified management positions in engineering occupations were predominantly male, 92% in both construction and architecture / engineering (Scarborough 2018).

Another study polling the U.S. Bureau of Labor Statistics found approximately 9% of U.S. construction workers were women (Azhar and Griffin 2014). Four years later, figures for 2018 show 9.9% employment, moderate growth since the 2014 research (U.S. Department of Labor 2018). These low levels have been maintained in part due to early and mid-career women being driven out of the industry by the existing workplace culture.

In a study to evaluate management capabilities in the construction industry, Arditi and Balci (2009) tailored a survey to assess whether women possessed deficiencies in 20 key managerial competencies. Offering surveys to managers of both genders, women outscored their male peers in 17 categories. However, only results in three of these categories were considered as statistically significant. Overall, men and women responded similarly in most questionnaire competencies. Managing change, planning and organizing, interpersonal skills, result orientation, and leadership scored reasonably equal within statistical significance. From their results, gender cannot predict managerial prowess.

Comparing these results against figures from over a decade ago, only moderate progress has occurred. An article published in 2007 studied the then current state of women's employment in the construction field and outlined the embedded industry issues limiting female employment (Menches and Abraham 2007). It should be noted

that their review of U.S. Bureau of Labor Statistics focused on construction trades (average employment of 4.1% women), with construction manager (6.3%) and engineering manager (4.9%) representing middle management and not c-suite. Hindrances identified over a decade ago: male dominated culture, conflict and aggression, slow advancement compared to male peers, and work family balance; are the same challenges facing women today.

Recent History in Workplace Gender Diversity

Infusion of women into the workforce over the past four decades created one of the largest modifications in labor history. Progress in gender equity across the labor force slowed after the initial push of the feminist movement of the 1970s and has proved unsustainable in the 1980s through 2000s. Many fields remain sex segregated, where one gender dominates the workforce. (Ridgeway, 2011). Despite the increase in women entering male dominated industries over to reduce sex segregation in these fields, progress has slowed since the 1990s (Ridgeway, 2011). Continued status quo reinforces existing androcentrism, further solidifying this as accepted societal practice and "human nature" (Bem, 1993). However, this same period experienced significant growth of women in management. Of the 4.5 million new management positions created since 1980, 2.6 million are filled by women (Scarborough 2018). This data encompasses all levels of management and industries and not specifically engineering and construction executives as discussed in this paper.

Entry of higher volume of women in the workplace forces changes to update the traditional environment to meet the needs of both men and women (Lawless 2001). Concurrently, evolution of the construction industry threatens the continued use of traditional vertical organization approaches to projects and requires new approaches and perspectives. Increased complexity of projects requires teams to possess the ability to communicate and innovate effectively (Graham et al. 2020). Altering the composition of leadership teams drives change infusing different perspectives and ideas. However, evaluating recent industry history gender distribution in 2010, 2014, and 2018, gains have been limited (Azhar and Griffin 2014; Harrison 2010; U.S. Department of Labor 2018). Therefore, different strategies are required. Ideas proposed for recruiting and retaining more females in the field include clearly demonstrating to women there is interest in their progression, sponsoring female talent similar to their male counterparts, ensuring opportunities for advancement are equally publicized, and holding leaders accountable (Pritchard and Miles 2018).

Executive dissemination of formal communications (e.g., written directives) drive company culture (Allison and Kaminsky 2017). Active leadership efforts may be required to inject fairness into the hiring and promotion processes (Williams and Emerson 2019) to counteract the observation that women who demonstrate equal capabilities to their male counterparts are passed over for promotion more frequently (Morello et al. 2018). Often, women are faced with the choice of adapting to

masculine behaviors to conform in the workplace environment (Sunindijo and Kamardeen 2017). Assuming these assertive traits associated with masculinity, they risk alienating supervisors, further distancing themselves from future leadership positions. Studies show that when women incorporate traditionally associated female behavior of kindness and helpful and clear competence, they can mitigate those effects (Ridgeway, 2011). However, this strategy further promotes the previously accepted social norms (Ridgeway, 2011). In today's workplace, rapidity of change continues to accelerate. As women enter executive level positions, they act as agents of change, bringing new perspectives and modifying company practice. Human Resources (HR) and other non-engineering roles promise to accelerate transformation of organizational culture to accept greater diversity.

Benefits of Increased Diversity

Evolution of the discussion has progressed beyond simple increase of number of people with differing backgrounds to inclusion where culture shift actively solicits and embraces ideas and philosophies of the greater group (Williams and Emerson 2019). Inclusiveness promotes individual's feelings of value, generating higher levels of employee engagement and ultimately company loyalty. Greater commitment of team members leads to better project delivery and higher client satisfaction (Hatch 2008).

Evidence suggests that increasing women's participation on executive teams leads to value through fresh perspective and ideas, enhanced relationships with stakeholders, higher innovation, greater creativity, and a better bottom line (Devnew et al. 2018; Major Projects Association 2017; Sunindijo and Kamardeen 2017). Assembling a diverse team injects differing perspectives and counteracts "group think" (Pritchard and Miles 2018). Also, mixed gender workplaces experience fewer conflicts through females' ability to deescalate issues compared to their male counterparts (Sunindijo and Kamardeen 2017). Despite these benefits, women are not included on major projects in sufficient numbers and losing opportunities for prominent career growth (Major Projects Association 2017). Actions by existing leadership teams is critical to enact change, executive declaration and tracking of recruiting, hiring, and promotion targets drive culture and performance modifications (Major Projects Association 2017). Employing an integrated Human Resources system which tracks and publishes metrics, coupled with leaders who enforce accountability, provide better results (Major Projects Association 2017). Establishment of programs without active engagement, monitoring, and continual improvement threatens long-term success.

Additional research suggests that effectiveness of communication deteriorates in mixed groups (Allison and Kaminsky 2017). Homophily, idea that people of similar backgrounds communicate more efficiently, creates better exchange of ideas. This jobsite impact conflicts with research that supports women's ability to share ideas

more effectively (Devnew et al. 2018; Lawless 2001). In a multi-generational workforce, through their ability to communicate effectively, women play a key role in bridging the age gap between co-workers. Early retirements by experienced engineers threatens to rob organizations of their significant real-world knowledge. Capitalizing on their chemistry and charisma, women can foster more efficient knowledge transfer to the new entrants armed with the latest technological tools.

Evolving diversity in the global marketplace, both in competitors and clients, offers a stark contract to static, homogenous engineering leadership composition in current engineering and construction. Organizations assembled using a mirror technique, where all members look alike, increase the chance that a singular mindset exists. While this may streamline decision processes and apparent cohesiveness, it limits flexibility and creativity. Today's world is changing at a higher velocity than ever before. Placed in perspective, the invention of the eraser lagged the pencil by over 200 years. Company leadership needs to morph in the near term to match market trends (Zenou 2018). Companies seeking qualified candidates, regardless of gender, position themselves strongly in the global market.

Actions for Consideration

Chief Executive Officer (CEO) sponsorship - Visibility of diversity and inclusion has risen in recent years and CEOs who previously delegated responsibility for

operational changes should reassert their authority over implementation. Leadership style drives company culture and the accompanying conduct of middle managers and line workers, so active executive involvement will drive change throughout the organization (Sunindijo and Kamardeen 2017). To support implementation, executives require specialized instruction on the benefits of inclusion in order to communicate throughout the organization.

Key opportunities - Major projects, especially mega-projects and Public Private Partnerships (P3), are long-term, high-risk ventures. Faced with potential financial loss and negative public /perception, clients and firms are more likely to assign the most experienced candidate, one who is likely to perpetuate the status quo, establishing barriers for new entrants, including women (Pritchard and Miles 2018). Faced with this limitation to prove oneself, how would an aspiring senior middle manager prove themselves for the executive suite, regardless of gender? Extend equal opportunities to qualified candidates, possibly in conjunction with a mentoring program for deputy positions.

Mentoring - Despite the effectiveness of many mentoring programs tailored for women, there is a fundamental lack of success at the rectifying the gender imbalance in the executive suites (Pritchard and Miles 2018). Regardless of background, presence of role models, especially those “who look like me” provides a powerful

incentive for early and mid-career professionals. Lack of current representation presents a self-perpetuating glass ceiling effect with the current generation. While role models are effective to inspire junior employees, care must be taken to balance the types of people portrayed as successful. If all are high-flying over-achievers, there may be a reverse effect by discouraging promising young female engineers and middle managers, as they feel unable to compete.

Research Methodology and Data

Observational evidence in the engineering and construction sector supports the premise that leadership positions lack gender diversity and are overwhelmingly filled by men. The actual percentage has not been reported as well as the details of gender diversity among various industry section, by company size, organizational feature etc. ENR reporting of The Top 400 List was chosen as the primary company data set. Selecting the top 400 companies may not offer a random industry sample, but it represents a targeted assessment of the largest members of the industry. Data gathering retrieved information from company published websites during the period March 25 – April 22, 2019. Throughout data collection and analysis, there was no direct contact with firms. Source data on executive team composition and company position on diversity was extracted directly from public facing self-portrayal. Since this paper focuses on engineering and construction leadership, non-engineering operational support are segregated to more definitively assess representation of

women in engineering leadership roles. Manual counts were taken, separated by gender and engineering / non-engineering billets. Defined engineering positions included CEO, President, Chief Operating Officer (COO), and Business Area Executive Vice President (VP). Non-engineering titles were highlighted by Chief Financial Officer (CFO), Chief Information Officer (CIO), Chief Legal Officer, and Chief Human Resources (HR) Officer. Compiled counts across the primary ENR Top 400 firms formed the principal base data set. Comparative subsets were compiled using the ENR Top 100 Green Companies and ENR Top 100 Design Build Companies. While most companies on the primary Top 400 also appeared on Green and Design Build lists, in the few instances where a "new" firm appears, data collection followed the same process as with the core set. Additional subsets of company size, customer sector, and local population center utilized the ENR Top 400 data set.

When leadership data was omitted from respective sites, secondary sources such as Bloomberg were considered. However, in selected comparisons, executive listings were too narrowly focused (e.g. only the Chairperson and CEO) vice a larger actual group. These were excluded out of concern of unbalancing the data set. Additionally, use of third party social media websites such as LinkedIn were contemplated but rejected since all members of the executive team may not use a specific platform and the information is not company managed. Using this methodology, data from 303 of

ENR Top 400 businesses were compiled. This sample group delineated in Figure 2-1 by annual revenue totals $289.1B, representing 23.2% of the total $1.246T construction industry (Wang 2019).

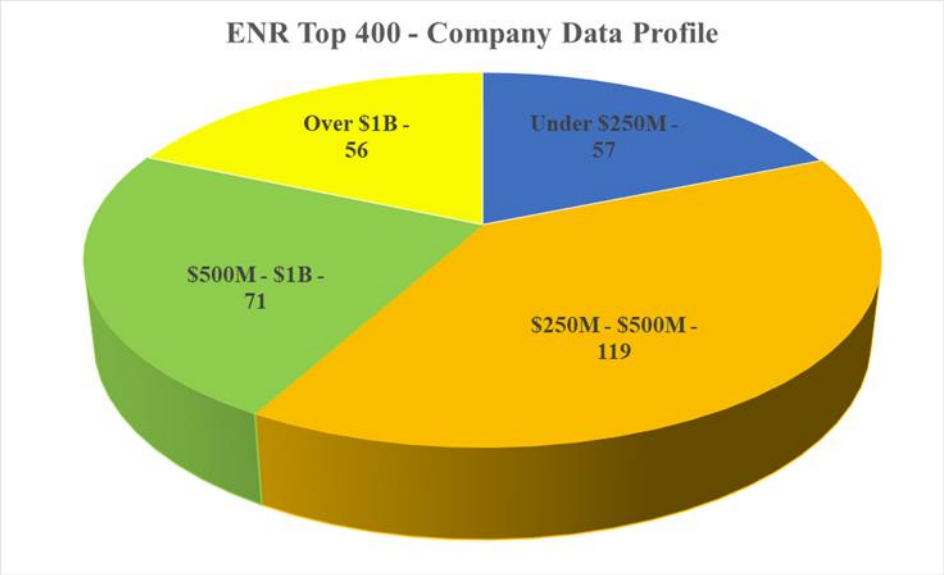

Figure 2-1 – Revenue Data Profile for ENR Top 400 Companies with Reported Leadership Teams (303 Companies)

As outlined in Research Questions section, company size, public commitment to diversity, green companies, design build, P3, customer sector, and local population centers were evaluated as subsets against the full sample size. Regarding public commitment to diversity, when no mention was located under mission statements, core values, or culture sections, a secondary check of subcontractor partner portal sections identified an additional 20 companies with key supplier teaming programs: women, minority, and veteran owned companies. After careful consideration,

companies with only supplier programs were excluded since this drove action by subcontractors vice hiring practices of the studied organizations. With the notable exception of Equal Opportunity Employer, which is considered a standard hiring practice in the U.S., a single mention of diversity or inclusion was considered a positive test, resulting in 77 of 400 (19.3%). Since the focus of the study was diversity, listing of "treating people right", "promoting team atmosphere", "people first", and other similar esprit de corps within the workforce were excluded.

Results and Discussion

Women in Leadership Positions

In any field, profession, or discipline, a sufficiently sized candidate pool is required to permit fair competition. At the onset of this study, authors questioned whether engineering and construction possessed a sufficiently sized, qualified group of female engineers to hire and promote. With the notable exceptions of nepotism or joining a start-up company, ascension to the corner office requires time served in the workforce. As reported as part of a 10-year study of more than 17,000 executives, average time required to reach c-suite positions was 24 years (Bothelo et al. 2018). In order to evaluate this premise for engineering and construction, a review of civil engineering graduation rates for the past 24 years, 1995 – 2018, was conducted to assess the basic pool of industry candidates. Data extracted from the Department of Education, National Center for Education Statistics (Department of Education 1995 –

1999) and American Society of Engineering Education (Yoder 2000 – 2018) were compiled for bachelor's, master's, and doctorate civil engineering degrees. In actual practice, individuals with other engineering and non-engineering degrees, and even candidates with no college education may be considered for engineering executive positions. However, since this study focuses on engineering and construction industry, analysis of potential candidate pool focused on civil engineering graduates.

Over the past 24 years, women comprise a reasonably consistent percentage of the civil engineering bachelor's graduate pool at 21.9%. As in any field, graduate degrees and the accumulation of additional knowledge contribute to candidate readiness for advancement, so civil engineering bachelors is only one component of consideration. Recognizing that executive positions typically require business acumen in additional to engineering expertise, many candidates likely augmented their education with other degrees, including Master of Business Administration (MBA). Compiling civil engineering master's degree data, women were well represented at a 24-year average of 25.2%. While doctorate degrees may be considered as a different career path, these showed a similarly strong rate at 20.5%. These results demonstrate a consistent volume of qualified female candidates entering the workforce.

Despite strong graduation rates over the past 24 years, women's underrepresentation in leadership positions continues. Total participation, including non-engineering

roles, is well below 20% in most organizations studied. In total, 3,237 positions were identified, 340 female and 2,897 male. Of these, 2,238 were classified as engineering (88 women and 2,150 men) and 999 as non-engineering (252 women and 747 men). Therefore, women fill 10.5% of all leadership billets, in particular 3.9% of engineering.

While the sample includes all large businesses, the sizes of top 400 companies range from over $18B to under $200M. At a macro level, individual company leadership team size skews data (e.g. 1 of 4 = 25% vs. 3 of 15 = 20%), so percentage representation was used with the focus on standardizing scale of reported results. Assessing individual companies by their gender distribution returns that 117 of 303 (38.6%) organizations have no women included as part of their leadership team, including both engineering and non-engineering billets (Figure 2-2). Another 59 (19.5%) companies filled 1% - 10% of billets with women. Of all 303 companies, only one exceeded 40.0% of the entire leadership team with 57.1%.

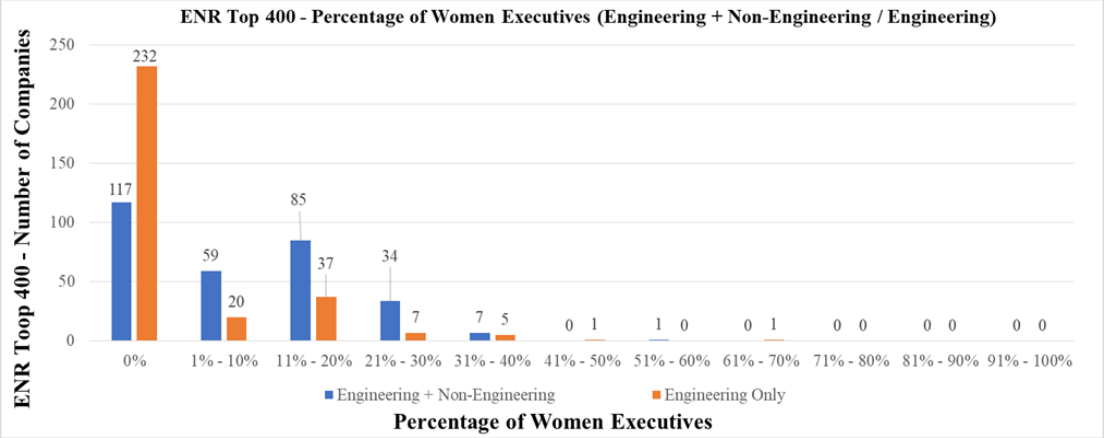

Figure 2-2 – Women Representation on Executive Teams (Engineering + Non-Engineering / Engineering)

Figure 2-3 provides a stark depiction of gender representation in the ENR Top 400 companies. Less than 1% of the ENR 400 companies have more women than men in the c-suite. Bolstered by 25.2% overall representation, many of the positions filled by women are non-engineering (e.g. CFO). Consistent with the intent of this study, segregating the engineering roles, the gap widens further as depicted in Figure 2-3. 76.6% (232 of 303) of the companies hired or promoted 0.0% of women to executive engineering roles. Only 16.8% (51 of 303), included more than 10.0% females. Sex segregation creates a more challenging path for the minority gender (Ridgeway, 2011). Women are more likely to reach c-suite positions in sales or finance vice a male dominated field such as construction, where women are often relegated to Human Resources, “the female ghetto of the corporate world” (Ridgeway, 2011). In supervisory positions, women are more likely to be promoted in staff roles than operational responsibilities (Ridgeway, 2011). This supports findings from the initial

stage of our study of ENR Top 400 firms where 25.2% of non-engineering executive billers were filled by women compared to only 3.9% engineering jobs.

Observation 1: Women comprise over 20% of the college educated pool, under 10% of the industry workforce, and under 4% of engineering c-suite positions. In addition to recruiting and retention issues, the construction industry significantly lacks gender diversity in leadership roles.

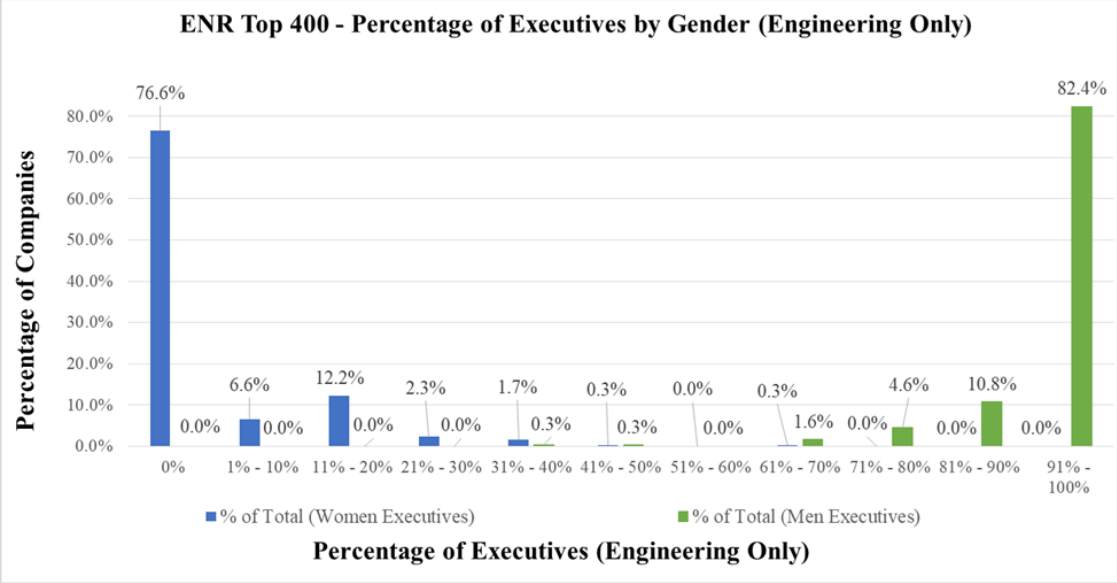

Figure 2-3 – Women and Men Representation on Executive Teams (Engineering Only)

Size of Organizations and Gender Diversity

Conducting a deeper dive into the data provides additional insights. Recognizing the ENR Top 400 covers a wide array of companies, from over $18B to under $200M, collected data was segmented in five groups by revenue, under $250M, $250M -

$500M, $500M - $1B, and over $1B. While larger companies show promise for greater diversity, results from this study are statistically insignificant. Smaller companies were more apt to have no women in engineering leadership. Of the 57 companies Under $250M, 49 (86.0%) (Figure 2-4) lacked a single female in an engineering executive billet. Whereas 38 of 56 (67.9%) of businesses Over $1B were comprised of an all-male engineering team.

When viewing total engineering leadership positions, large businesses again outperform. Under $250M organizations elevate 2.4% (8 of 327) women. Results steadily increase with growing company size from $250M - $500M = 3.9% (30 of 779) through Over $1B = 4.5% (26 of 578). As outlined in the Research Methodology and Data section, factors contributing the different sample size are companies self-publishing their leadership teams, number of team members listed, and ENR identification of revenue size.

Observation 2: Company size provides no statistically significant contribution to gender diversity.

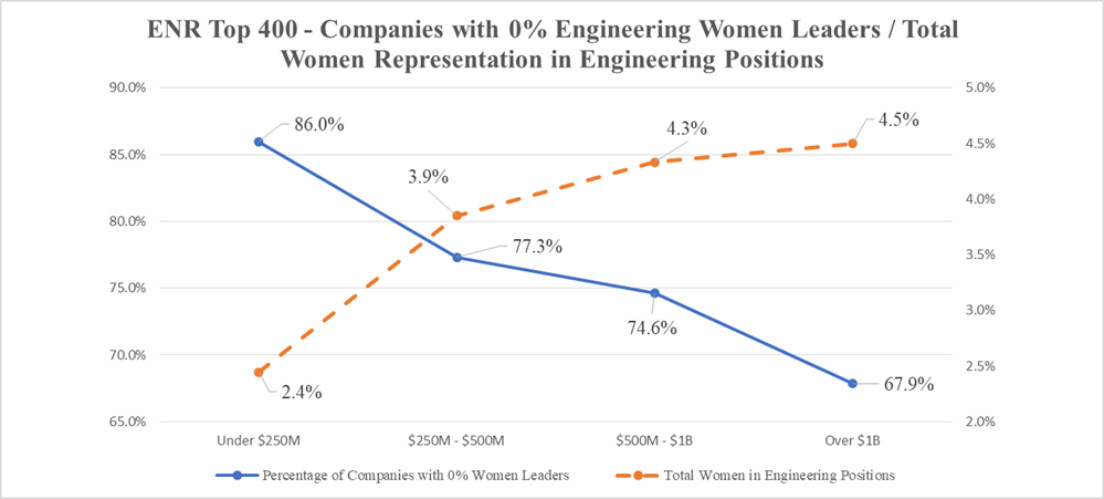

Figure 2-4 – Percentage of ENR Top 400 Companies with All Male Engineering Teams / Total Women Representation in Engineering Positions

Public Commitment to Diversity

Of the 77 companies highlighting some mention of inclusion, whether as part of the mission / vision statements, or hiring a woman to top roles of Chairperson, CEO, or COO roles, 20 are of particular note.

- Ten companies promoted women into senior executive positions of Chairperson (2), CEO (7), or COO (1). Of these, eight individuals shared a family connection with the company. In reviewing the top 400 companies, there are numerous instances of multi-generation ownership for male counterparts, which were not counted as part of this study. Consider that only 2 in 303, 0.7%, of companies have women in these key positions by other than family connections.

- Seven companies prominently listed a diversity officer, only one of which is listed as a leadership position and included in the data set as VP of Diversity, Inclusion & Community.
- Two other companies are certified Minority Business Enterprise (MBE). However, neither hired any women to engineering executive positions. Only one included a non-engineering position of Controller (lead finance position at the company) as part of the leadership team.
- Finally, one company lists a 30% women board member participation target by 2020 as part of their Director Selection Policy, dated 12/15/15. While this study focused on executive team, not Board of Directors, as of April 2019, 17% (2 of 12) of all executives and 18% (2 of 11) of engineering billets are filled by women, decidedly above the 3.9% average. It should be noted that the firm's parent headquarters is based in Madrid, Spain and similar to other European countries, gender quotas for boards are mandated by the Spanish Government law.

Compared to the total data set, companies promoting their commitment to diversity returned more favorable results. 62 of these 77 organizations published their leadership teams and composition shows more gender balance. Overall, advertised commitment to inclusion appears to positively impact performance with doubling overall engineering representation (3.2% to 6.2%). Depicted in Figure 2-5, all male

teams from companies with public commitment to diversity decreases from 56.5% with better distributed balance in all categories from 1% - 10% through 41% - 50%.

This study focuses on the company published leadership structure from their own websites. Are established organizations' value sets established over a century ago less progressive than newer companies publishing buzzwords popularized in the past few decades? Interestingly, some companies promote diversity hiring for subcontractors, yet their own hiring, at least at the executive level, lacks the same promise of inclusiveness.

Observation 3: Companies with a public commitment to diversity assemble more gender balanced executive teams. Gender diversity in the construction companies starts with public commitment and inclusive statements in organizational mission and vision.

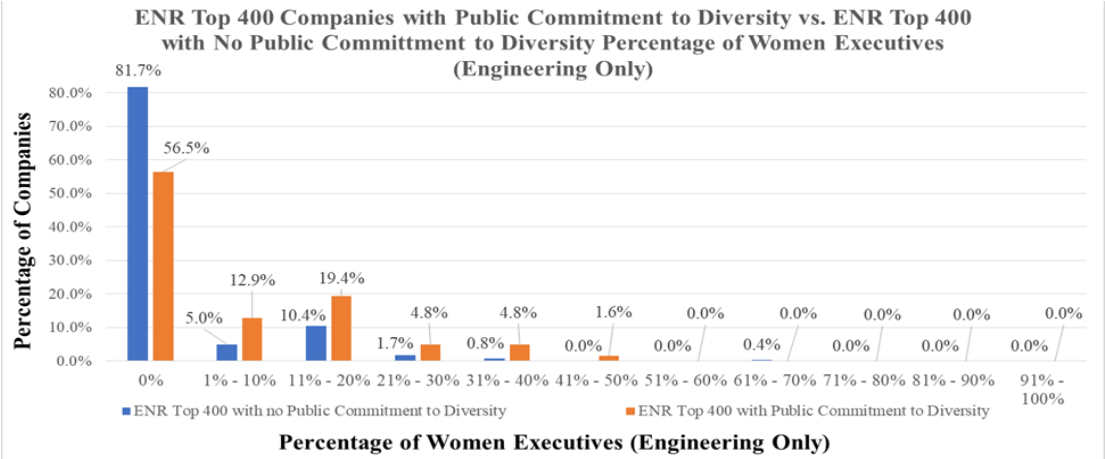

Figure 2-5 – ENR Top 400 Companies with Public Commitment to Diversity vs. ENR Top 400

Green Design Companies

Women tend to actively participate in activities benefiting the environment, including sustainability (Harrison 2010). Hence, data analysis considered the potential lure of making a larger impact on the world associated with green engineering. Applying ENR's 2018 Top 100 Green Contractors rankings to the previously collected data, 99 of 100 were included in the Top 400. The single firm outside the original top 400 provided no leadership data on their website and therefore was excluded from the sample. Of the original set, 76 of the 99 organizations listed executive team information. While results are not statistically significant, segregating the green companies, an increase in women leadership representation emerges, ranging from 6.0% for non-engineering (24.8% to 26.3%) to 68.0% for engineering billets (3.3% to 5.5%).

Consistent with the approach applied to the core sample, due to differing sample sizes, comparative analysis was based on percentage representation vice pure number of companies. Comparing non-Green vs. Green companies, all male teams decrease from 80.2% to 65.8%, accompanied by gender increases in most remaining categories: most notably 11% - 20% (9.3% to 21.1%). Diversity steadily increases with revenue size for the ENR Top 400. While ENR Top 100 Green Companies outpace non-green ENR Top 400 organizations in all revenue segments, results offer no regular pattern (Figure 2-6).

Observation 4: Green industries offer no statistically significant contribution to executive team gender diversity.

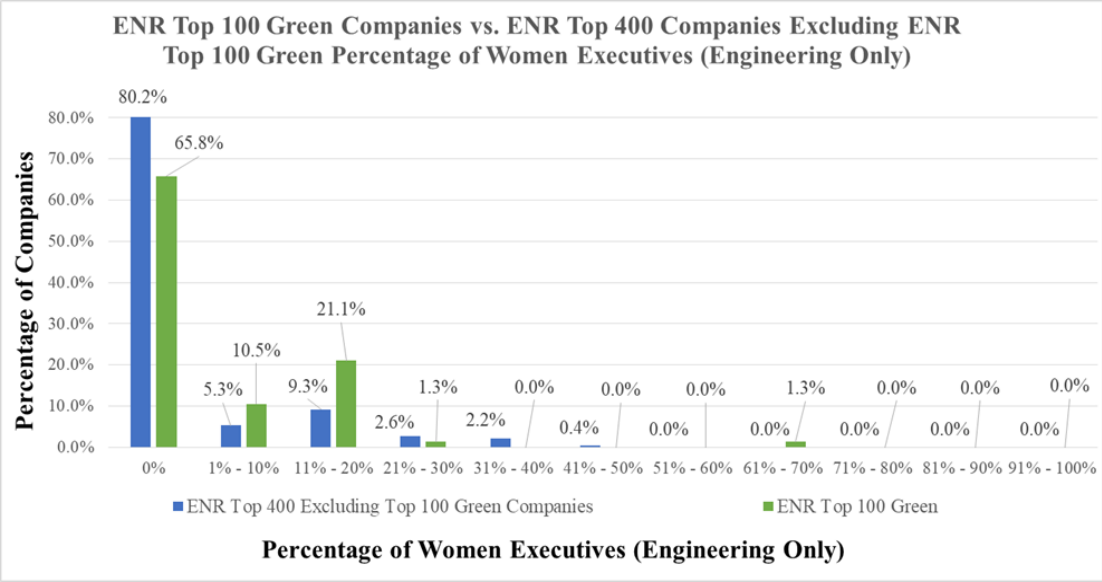

Figure 2-6 – ENR Top 100 Green Companies vs. ENR Top 400 Companies Excluding ENR Top 100 Green Percentage of Women Executives (Engineering Only)

Other Data Set Analyses

Design Build

Comparing ENR 2018 Top 100 Design Build Contractors rankings to the full data set returned 97 companies on both lists. Using the same techniques outlined in Research Methodology and Data, reviewing company websites of the three additional entrants, all included leadership data and were added to the Design Build data set, for a total of 76 listed teams. Design Build subset shows an increase in women engineering positions by 45.1% (3.5% to 5.1%). Concurrently, non-engineering roles exhibit a

decrease of 6.5% (25.7% to 24.0%) for the same company grouping, totaling 9.1% (10.3% to 11.2%) overall improvement in gender diversity. However, these results are statistically insignificant and no benefits can be concluded. Similar to other subset selections, evaluation of Top 100 Design Build against the non-Design Build list used percentage of gender distribution to standardize reported leadership teams. All male engineering teams decrease from 78.3% to 68.4% with resultant increased representation in all categories from 1% – 11% through 31% - 40%.

Observation 5: Design Build companies offer no statistically significant contribution to gender diversity.

P3 Companies

Data for P3 companies not previously included on the ENR Top 400 were collected using the same process listed in Research Methodology and Data. While available data only included a smaller sample size of 18 companies, diversity increased significantly, highlighted by 187.5% (3.9% to 11.3%) in engineering billets. Companies with no engineering women dropped to 44.4% with noticeable improvements in 11% - 20% at 38.9% and 31% - 40% at 11.1% (Figure 2-7).

Observation 6: Companies working on innovative methods for delivering large scale public projects attract candidates from a wider swath of experts.

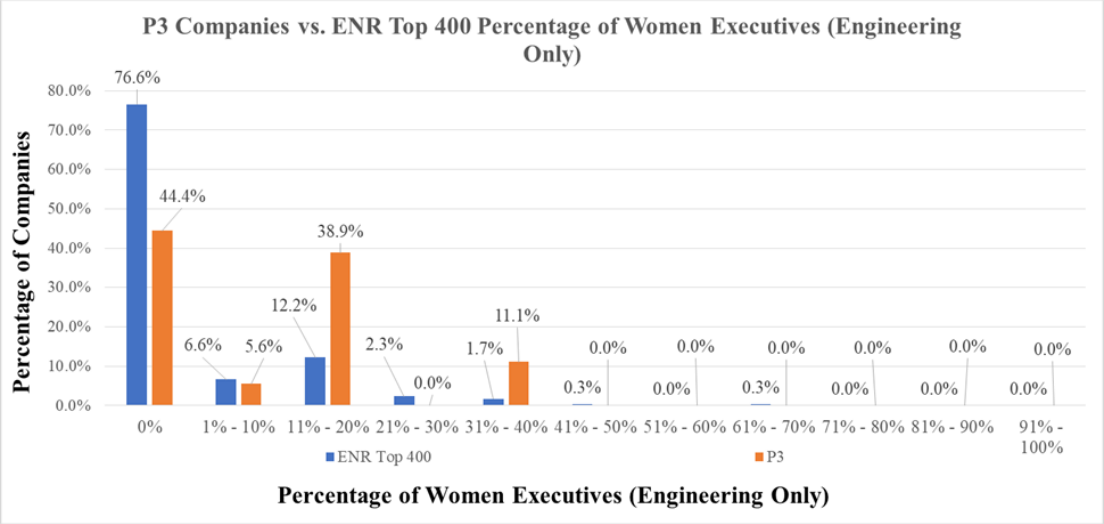

Figure 2-7 – P3 Companies vs. ENR Top 400 Percentage of Women Executives (Engineering Only)

Customer Industry

ENR Top 400 original source dataset included a break-out of work by customer industry (e.g., General Building, Power, and Water / Sewer). Using previously collected leadership team composition data, impact of participation in different sectors was assessed against the total sample. After excluding Hazardous Waste as too small a sample with only nine companies, evaluating the results for each of the remaining seven industry segments sub-sets revealed no appreciable delta in the results, ranging from 76.6% of all-male boards (ENR Top 400) to 69.0% (Water / Sewer).

Observation 7: Customer industry sector creates no significant difference in gender diversity.

City Population Size

Further analysis assessed impact of the vicinity of company headquarters to population centers. Using the ENR Top 400 listed locations, each company was mapped against the U.S. Census Bureau 2018 estimated metropolitan city figures. While companies in the study likely operate from multiple offices, this study concentrates on the executive team and therefore this segmentation considers the headquarters location only. Considering downtown metropolitan offices may generate higher rent costs, companies may locate their offices outside city limits in surrounding suburban locations. Therefore, 383 areas designated by the U.S. Census Bureau as "Metropolitan Statistical Area" (United States Census Bureau 2018) were used to assess proximity to major population centers. Census population size ranged from "New York-Newark-Jersey City, NY-NJ-PA" at 19,979,477 citizens to "Carson City, NV" with 55,414 residents. Firm headquarters located in towns not specifically listed as a Metropolitan Statistical Areas were linked to the nearest location via Google Maps distance data. Findings are statistically insignificant that a modest shift to higher gender diversity occurs with growing population base over 1M citizens. All male engineering teams decreased from 84.1% (Under 1M) to 74.4% (Over 1M).

Observation 8: Proximity to larger population centers offers no impact to higher inclusion rates.

Conclusion

As an industry, engineering and construction lags behind other professions in achieving true gender diversity. Despite half of the population, over one in five civil engineering graduates, and almost 10% of the industry, this study shows only 3.9% of women in engineering leadership positions. Imbalance inhibits benefits gained from varied viewpoints, limits innovation, and hinders progress. Infusion of new ideas and perspectives offer opportunities to adapt to the accelerating changes in the field. Concurrently, AEC industry faces labor shortages due to looming retirements of half the workforce. Active recruitment and expansion of women's membership, highlighted in the executive suites, offers potential solutions to address these challenges. Prior research offers factors deterring women from joining or remaining in the field: male dominated culture, conflict and aggression, slow advancement compared to male peers, and work family balance; and recommended actions to reverse the trend: active executive engagement, equal opportunities for key positions, and directed mentoring.

Study findings show areas of progress, specifically companies with a public commitment to diversity and P3 sector, with higher representation of women in

engineering executive positions. Intriguing areas of further study include a deeper investigation of Green engineering firms and organization size. Follow-up research intends to expand the study to smaller companies beyond the ENR rankings, delve deeper into the career paths of current executives, and add middle management positions to the analysis. Ultimate goals of the research are developing guidelines to increase women's participation throughout the education and employment lifecycle to promote balanced gender diversity throughout the industry, including the executive suite.

This study represents only the initial step in the research on gender diversity in leadership roles. The study focuses on ENR top construction companies but may not examine a typical sample of the U.S. construction industry. Also, subset analysis of public commitment to diversity is limited to company broadcast of culture or policy. These statements were not scientifically validated as part of the study and therefore require further study to assess intent behind corporate hiring and promotion policies. Executive corporate biographies, education levels, years of experience, and background varied significantly between firms and were therefore excluded from reporting. These demographics reflect key areas of study planned for the follow-on research. Next phase of investigation includes development of a targeted survey to gather data on women's experiences and path to c-suite positions. Drivers behind and hindrances to their individual success may provide foundational data for developing

tailored programs to increase female representation in leadership. Additional investigation could quantify the impact of several factors identified as deterrents for females to join and stay in the field, highlighted by hostile work environment, gender bias by male coworkers, and challenges of work-life balance. These contribute to women's representation shrinking from 21.9% of civil engineering graduation down to 10% of the industry population and ultimately 3.9% of engineering executives. Wider scope studies can evaluate why 50.8% population reduces to 21.9% of civil engineers, including application of STEM programs in high schools.

Chapter 3: Use of LinkedIn Data and Machine Learning to Analyze Gender Differences in Construction Career Paths (Paper # 2)

This chapter is based on the paper submitted to Journal of Management in Engineering (Hickey, P.J., Erfani, A., and Cui, Q. (2022). Use of LinkedIn Data and Machine Learning to Analyze Gender Differences in Construction Career Paths. Journal of Management in Engineering, 38(6)).

Abstract

Will women and men follow distinctively different paths to achieve executive engineering leadership positions in the U.S. Architecture, Engineering, and Construction (AEC) industry? Using Engineering News Record's (ENR's) 2019 Top 400 list, this research analyzes LinkedIn profiles for over 2,800 executives to assess career differences between genders. Statistical comparisons of important features, highlighted by number of companies, titles, education, and network size, revealed a significant impact of gender on individual career paths. A key finding, men ascend to leadership with a single firm throughout their career, outpacing women almost fourfold (37% to 10%). Applying Random Forest (RF) as an ensemble classifier, researchers successfully predicted profile gender with accuracy of 98.95% for training and 89.53% for testing samples. Collating and categorizing the activities and

milestones of individual and collective executives offer insight regarding successful experiences, skills, and choices to reach leadership roles. This creates a roadmap for current and future early and mid-level professionals to model their own vocational journey and accelerate progression up the corporate ladder. From an industry perspective, firms deprive themselves and customers of the proven wide-ranging benefits of diversity.

Introduction

Historical perspective on diversity traditionally focused on legal and moral perspectives (Grant and Kleiner 1997). Coupled with the Kennedy Administration's legislative efforts in the early 1960s, the civil rights movement propelled women's rights into the forefront of social consciousness, driving change in educational and professional outcomes (Jardina and Burns 2016). This paradigm change allowed women to pursue opportunities previously unavailable, creating a significant shift in the late 20th Century workforce. Passing of the Civil Rights Act of 1964 offers a key milestone in U.S. society, seeking to end discrimination based on an individual's race, color, religion, sex, or national origin (U.S. Equal Employment Opportunity Commission 2021). Nonetheless, even laws and regulations accompanying this landmark legislation failed to generate fair balance. As a result, affirmative action programs emerged to bridge the gap and eliminate the imbalances. With the continuing growth of women in the workforce and associated greater prominence of

gender diversity, policies must continue to evolve to address the 21st Century workplace (Byrd and Scott 2014). Despite greater public visibility and scrutiny, women's AEC representation still lags general U.S. population distribution. Even in the engineering field, women gravitate towards disciplines offering societal impact (Dzombak and Mehta 2017). Targeted efforts to increase participation by women only generated modest gender diversity improvements in select engineering sub-segments (National Academy of Engineering 2018). Specifically in the civil and construction engineering field, programs yield only minimal market penetration where women fill approximately one in 10 industry positions and less than one in 25 executive engineering leadership billets (Hickey and Cui 2020).

This investigation further quantifies hierarchal organizational imbalance in AEC companies, adding a detailed analysis of career path components. While significant research exists on gender studies with an accelerating corpus focused on the civil engineering and construction industry, authors found a lack of data driven measurement of career paths, underlying professional decisions, and comparison between women and men. Today's early and mid-level career women lack role models to inspire them for continued growth, hindering their ability to achieve future leadership positions (Roebuck and Smith 2013). Further exacerbating the issue, a recent study found that women supervisors leave their jobs more often than men (Maurer, et al. 2021). In an effort to identify factors to off-set this imbalance, authors

extracted profiles of leading industry firms' executive teams to provide roadmaps of successful actions and behaviors. With over 774 million users from more than 200 countries and territories, LinkedIn consolidates the largest corpus of professional experience. When considering the accuracy of self-populated career information, authors considered the adverse professional ramifications resulting from discovered falsehoods embedded in profiles. Therefore, authors deemed the published LinkedIn information as peer reviewed and accurate. However, reliance on full disclosure or propensity to inflate their accomplishments by all candidates offers study limitations and creates potential for risk in the dataset. As part of the data integrity process, applied statistical testing found no difference in reporting detail or completeness between genders. Across the larger workspace, focus on professional social media ethical practices relating to accuracy, validity, and documentation continues to grow (Kettunen and Makela 2019). As detailed in the methodology section, a further step to maintain accuracy included data cleaning analysis to exclude unmaintained profiles containing minimal data. A strategic objective of this study investigated the potential impact of gender on individual career paths using Machine Learning (ML) techniques and statistical tests considering important career path features extracted from LinkedIn data of construction leaders' profiles.

Authors recognize the ongoing evolution regarding gender identity and its importance in society. For the purposes of this study, we applied a binary definition of female and male in compiling, analyzing, and reporting gender.

Literature Review and Hypothesis Development

Prior to extracting profile data, authors drafted an initial set of research questions and hypotheses considering prior academic theories. After data collection and cleaning, researchers applied Social Capital Theory and Social Cognitive Career Theory (SCCT) to the resultant LinkedIn data set. Examination includes primary features of individual career paths such as: number of firms and positions, highest level of education earned, and professional network size.

Koch, et al. (2017) found that career minded individuals who maintain a singular focus on work achieve executive levels faster and at higher rates than counterparts who seek a balance between work and personal lives. Since women traditionally shoulder a greater responsibility in the family responsibilities, they experience a significant disadvantage due to competing obligations. In fact, U.S. women suffer more single parent households than men and experience a higher risk of dropping out of the workforce after childbirth (Aisenbrey and Fasang 2017). As a result of these external influences, professional women temporarily exited the workforce at higher rates, 37% (43% for women with children) to 24% for men (Hewlett and Luce 2005).

While most of these women, 93%, planned on resuming their vocation, gaps disrupted their career arc. Even high profile women left key positions, including CEOs of Fortune 500 companies, to focus on family, both aging parents and young children (Hewlett and Luce 2005). Ultimately, these contributing factors create career drag, inhibiting long-term progression, especially compared to their male colleagues.

Throughout a person's career, they continually redefine and reassess the relationship between work and personal lives. Prior research documents women's greater desire for work-life balance (Koch, et al. 2017). That equilibrium underlies women citing family and unsatisfying jobs as key reasons for leaving the workforce, while men's predominant motivations included switching careers, obtaining greater levels of education, or starting a business (Hewlett and Luce 2005). When viewed from the company perspective, gender diverse leadership teams create cultures offering policies which create better work life balance (Baker, et al. 2021). However, despite recent progress and public commitment to change, most AEC firms fail to achieve fair implementation in practice (Hasan, et al. 2021).

Social Capital Theory

Social capital represents the theory of capturing resources residing in social relationships and leveraging them into better business outcomes (Lin 2001). Social networks generate benefits, including physical and monetary resources, social support, and access to information (Alaa et al. 2018). Since its inception, researchers dedicated significant research to social network theory and developed divergent concepts to the topic (Brass 2003). In their 2001 study, Seibert, Kraimer, and Liden tested social capital theory, applying it against networks and relationships, assessing the resultant impact on career progression. Two theories emerged: weak ties - connections outside the core group, and structural holes - where direct connections of the individual remain separate from each other (Seibert, Kraimer, and Liden 2001). Follow-on studies identified strong ties which generate bonding social capital while bridging social capital emerges from weak ones (Alaa et al. 2018; Neumeyer et al. 2019). These otherwise disparate network combinations from bridging social capital offered unique information unavailable to the other members of the direct group, often leading to opportunities for new jobs. Overall, Seibert's (2001) study found that both theories positively relate to a person's accessibility to social resources and resultant career progression.

All interactions between people require communication, whether verbal, written, or other methods. Resultant social networks depend more on the structural links rather than the nodes, e.g., relationships vice the individual players (Brass 2003). Over time, prolonged interaction between individuals establishes the structure of relationships and resultant bonding social capital within an organization (Górska et al. 2022). In a hierarchal configuration, basis for some relationships anchors in positional hierarchy while others grow organically. Ultimately, these collective personal behaviors, coupled with the overarching structure, impact the overall network. Add that each new generation of incoming talent challenges the status quo and entrenched leadership's ability to maintain existing traditions. Recent focus on social justice, including gender equality, promises to create a lasting impact on future direction of organizations.

Even in the early 1980s, experts recognized the need to access leadership talent from previously untapped groups, including women and minorities (Kanter 1981). Conversely, selection of candidates like oneself reflects homosocial reproduction and perpetuates the status quo (Kanter 1993). This homophily, preference of one's own type, strengthens the bonding social capital within the core group (Alaa et al. 2018). With men filling most senior positions (Hickey and Cui 2020), this provides opportunities to exercise self-similar preference and hire / promote the next generation of industry leaders (Elliott and Smith 2004). Reversing this trend and

generating improvements in diversity requires organizations to reflect upon and change their hiring and promotion practices. Specifically, building formal and informal workplace networks offers opportunities for women to strengthen bridging social capital across functional areas and externally from the firm (Górska et al. 2022). As society continues to evolve its perceptions on equity, downstream impact to industry follows. Kanter (2021) coined the term "advanced" leadership to describe evolving change beyond the traditional hierarchal management to encompass broad cross functional and multi sector operations and interactions. Formalization of these concepts further emphasizes the need for firms to recognize this seismic change for future success. An opportunity for companies to positively contribute to forwarding diversity, transitioning from vague goals and objectives to a specific, clearly defined vision increases emphasis on the importance and group focus (Kanter 1981). Expanded understanding of bonding and bridging social capital offers insight for firms to provide equal opportunities for all employees (Górska et al. 2022). This supports findings from this paper's authors' prior study on executive suite leadership (Hickey and Cui 2020). Results found that a public commitment to diversity, defined as prominent publication of inclusion on a company's website, resulted in higher women's representation.

While this LinkedIn investigation concentrates on the senior and executive organizational levels, some prior studies focused on impact of corporate board diversity. Arguably, each group offers different impact on the daily operation of the company, where boards may only meet a few times per year. However, Kanter's (1993) homosocial reproduction theory positions a diverse board to disrupt perpetuating hiring and promoting similar individuals, specifically white men. Despite proven benefits of diversity (Sunindijo and Kamardeen 2017), a study of board diversity and firm reputation found that impact of women on boards created positive impacts on service industries and negative one for producing sectors including construction (Brammer, Millington, and Pavelin 2009). Brammer's results aligned with the proximity linkage between the company and end users. Therefore, AEC's insulation from the general public contributes to its slower pace of inclusion compared to other industries. Another study found gender diversity on boards created a positive relationship on greater organizational innovation (Miller and Del Carmen Triana 2009). However, a consideration of possible lower impact of women on boards resides in the fact that women hold fewer chairperson or committee lead positions (Miller and Del Carmen Triana 2009). Other research identified Corporate Social Responsibility (CSR), a measurement of self-regulating business model for social accountability, increases with inclusion of women on boards (Zhang et al. 2013).

Number of Career Firms

Researchers considered impact of internal and external influences on women's and men's respective career arcs. Even with the significant increase in female entry into the workforce, turnover for women exceeds that of men (Yousaf, et al. 2014). Across all industries, women experience higher instances of separation, including both voluntary and involuntary (Frederiksen 2008). This study assesses whether this trend would apply to the AEC industry and women reaching equivalent organizational levels with fewer career changes. Evaluating career mobility provides insight whether individuals achieve greater success, as defined in this study by reaching leadership positions, either by remaining with a single organization or switching to multiple companies. Inherently unequal, organizations exhibit increasingly stronger social capital with higher levels of leadership (Alaa et al. 2018). Limited accessibility to these assets creates disadvantages for women in their progression to the executive suite. Tight organizational bonding social capital promotes the status quo and hinders minority groups from progressing, so they must engage in bridging activities to reach their full potential in leadership (Górska et al. 2022).

Short term promotions and pay increases often drive decisions to join a new firm, but will long-term career progression benefit as well? Contrary to perceptions that company changes lead to accelerated growth, most companies continue to select internal candidates who already possess significant networks and a deep

understanding of the company philosophy (Koch, et al. 2017). This concentrated focus on bonding social capital, whether conscious or not, favors homophily and selection of those mirroring the current leadership team. As an extension, Koch (2017) and Hamori and Kakarika (2009) found that CEOs with more frequent job changes and less time served at their current company took longer to reach the top position with insider track presenting the more frequent pattern to reach executive leadership, remaining with one company for much of their career.

H1: Male dominated executive teams' bonding social capital perpetuate the status quo, limiting opportunities for women, causing them to change firms more often during their career progression to leadership.

Professional Network Size

Authors considered impact of accumulating industry connections, both internally and externally to their companies, on women's and men's respective career arcs. Women generate greater links and associated contacts (Roebuck and Smith 2013). This study assesses whether this benefits their growth within the industry. Professionally, networking embodies the specific pursuit of accumulating relationships to benefit one's career. While traditionally associated with job seeking, effective implementation requires continuous application of this practice throughout a career (Eason and Krause 2001). Creating a diverse group of professional advocates offers a

support group to seek advice, gain insight, and access opportunities. Proven to expedite career progression, increase earnings, job performance, and career satisfaction, networking offers an important tool for anyone in the workforce (Davis, et al. 2020). Explosion of social networking shows the potential benefits of electronic media, highlighted by sites such as LinkedIn, in vocational progression (Buettner 2017). However, prior to introduction of Social Networking Service (SNS), gaining these benefits typically required in person meetings to develop a foundation of trust. In the digital age, electronic invitations link secondary and tertiary connections with no direct contact. This lack of intimate knowledge of the person undermines the quality of reference. Although Davis' (2020) examination of LinkedIn usage found that online networking clearly generated career benefits and supports use of Career-Oriented Social Networking Markets (CSNM) as a prominent factor in career self-management success.

Two types of interconnections emerge in Social Capital Theory, bonding where strong ties form within closer organizations and bridging which utilizes weak ties to reach beyond the group (Alaa et al. 2018; Neumeyer et al. 2019). Forms of bridging capital include non-office connections highlighted by school, alumni, and professional organizations. Leveraging these channels provides access to unique information. In the male dominated AEC industry, homophily persists, reinforcing leadership's bonding social capital and subsequent hiring of the next generation (Alaa

et al. 2018). Faced with altering the status quo, as women enter management, they tended to expand their focus to incorporate bridging social capital, recognizing the added benefits of larger networks in their continued growth (Górska et al. 2022).

Conversely, individuals without effective support systems lack beneficial connections, delaying progression into leadership positions (Roebuck and Smith 2013). Early and mid-career workers pursuing career growth should strive to amass quality contacts to recognize the benefits. Notably, two studies found that CSNMs of 150 and 157 connections respectively offer the optimal size to locate new jobs, while larger groups produce lower success rates (Buettner 2017). Recruiters often view excessively large networks as noisy information, suggesting weak connections throughout the group (Buettner 2017). This contrasts the perspective that larger networks enhance women's skills including compliance, civic virtue, and organizational development (Roebuck and Smith 2013) and that weak ties contribute to optimizing social capital (Seibert, Kraimer, and Liden 2001). Most effective implementation of SNS networks lies not in the sheer size and volume of connections, but the understanding of how those individuals can positively impact their career (Davis, et al. 2020). Ultimately, balancing a larger group with one's ability to genuinely connect, dictates the value of a network.

References with knowledge of a candidate's past professional experience often generate prospects for career growth, whether within the current company or a move to an external opening. Expansion of the Internet over the past 25 years and associated emergence of social media, this facilitated exponential connections with local and remote colleagues. Launched in 2003, LinkedIn entered the professional networking space and grew into an industry leader. Considering women create larger formal and informal career networks than men (Roebuck and Smith 2013), would results reflect a disparity in size?

H2: Faced with the disadvantage created by bonding social capital homophily in the male dominated AEC field, women seek unique knowledge obtained by assembling larger external bridging social capital networks.

Social Cognitive Career Theory

SCCT creates a framework to study career development through the lens of educational and professional pursuits (Lent, Brown, and Hackett 1994; Lent and Brown 2019). Its five interconnected models: interest development, decision making, performance in education and vocational domains, satisfaction and well-being in educational and vocational contexts, and career self-management offer a comprehensive analysis of career choice motivations and outcomes (Lent and Brown 2019). Even before entering the workforce, SCCT self-efficacy drives students to

select academic fields aligned with their personal interests, leading to early career choices (Fouad and Santana 2017). During mid-career, when considering additional formal education or professional training, workers balance these internal interests with external professional influences. Ultimately, SCCT creates a structure linking three interrelated aspects of career development: career interests, academic and professional choices, and their performance in these pursuits (Lent and Brown 2019). Its principles provide a path to understand the factors creating continued women's underrepresentation (Blaique and Pinnington 2021).

21st Century careers embody mobile, non-linear paths, changing directions in response to both personal and professional influences, including temporarily opting out for family and other interruptions (Knowles and Mainiero 2021). SCCT provides a contextual reference on how self-efficacy beliefs, outcome expectations, and personal goals affect educational and career decisions (Burga, Leblanc, Rezania 2020). Selection of career choices align with one's interests and based in part on self-confidence (Lent, Brown, and Hackett 1994). Further, SCCT offers perspective to evaluate one's career progression and analyze prior choices and subsequent outcomes (Fouad and Santana 2017). Among the variable factors, Lent's theory assessed the impact of gender and culture on career advancement (Lent and Brown 2019). SCCT's framework shows that perceived sexism builds a barrier for women and impacts their decisions throughout a career (Fouad and Santana 2017). As a result,

women felt the need to repeatedly prove themselves capable to work alongside their male counterparts and exert the extra effort to prepare themselves for the same work (Clayton 2022). This self-perpetuating cycle drives women out of the workforce or to other firms as they believe advancement opportunities are unavailable (Knowles and Mainiero 2021). Findings from this LinkedIn study confirm this external pressure generates higher turnover frequency for women and alters their career trajectory. Even those who temporarily opted out of the workforce often decide to find new firms rather then return to their former employer due to preexisting discriminatory practices (Knowles and Mainiero 2021).

Primary aspects of SCCT include self-efficacy, social supports, and goal setting which shape one's educational and professional journey throughout their decades long career (Lent and Brown 2019). Prior SCCT studies connected perceived entry barriers and the resultant lack of participation by segments of the population, recommending an industry response of altering their recruitment and retention strategies to increase diverse representation (Clayton 2022). Firms' reinforcement that employees and managers possess the correct skills and abilities, coupled with the belief that their education and experience align with industry goals increases the quality of work and likelihood of retention (Burga, Leblanc, Rezania 2020). Further, SCCT suggests that success in past projects reinforces self-efficacy beliefs and generates better future performance (Burga, Leblanc, Rezania 2020).

Number of Career Positions

Women and men experience different paths climbing the corporate ladder (Lyness and Thompson 2000). Guy (2020) discussed the "broken rung" impeding progression into entry level management positions, delaying women's long-term progression into executive billets. Assessing the current industry leadership teams' LinkedIn profiles, would women require more total jobs to reach higher rungs on the ladder? Whether remaining with a single company or working for multiple firms, how many rungs exist on the climb up the corporate ladder? Would women face additional long-term challenges from smaller, incremental steps compared to male counterparts benefiting from fewer, larger career leaps? Regardless of number of firms, collected data identifies each reported title. Note that when a candidate switched companies and retained the same title (e.g., VP to VP), these constitute two positions.

Women engineers build knowledge and skill through experience and professional development in preparation for career advancement (Marinelli, Male, and Lord 2021). Blaique and Pinnington (2021) propose implementing Career Self-Management Model (CSMM), an extension of SCCT, to help women develop adaptive behaviors to respond to negative career events. These adverse occurrences, including lower promotion potential, sexist culture, and hostile work environment deteriorate the greater drive women possess at the beginning of their careers than men, discouraging them and draining their motivation (Knowles and Mainiero 2021). Human Resources

departments creating a CSMM incorporating the needs of both women and men help them commit to their occupations and retain their positions despite negative events (Blaique and Pinnington 2021). Regardless, women experience higher representation in non-engineering occupations compared to their percentage of overall engineering graduates (National Academy of Engineering 2018), suggesting they either leave or never enter engineering at higher rates compared to men.

H3: Adverse career occurrences disproportionally impact women, slowing career progression and creating a greater number of positions, including company changes, required to reach leadership.

Highest Level of Education

This study considers impact of accumulated education, specifically graduate studies, on women's and men's respective career arcs. A key cornerstone of SCCT, education selection significantly impacts a career arc (Lent and Brown 2019). Would women achieve the same level of organizational success with comparable education? Since the mid-1980s, women have entered the workforce at the same rate as men, however, remain significantly underrepresented in leadership, even for graduates of leading institutions (Ely, et al. 2011). By the early 2000s, women's college graduation rates exceeded those of men (Jardina and Burns 2016; Sandberg 2013) and remain well represented at lower and middle management positions but not in the executive suite

(Roebuck and Smith 2013). Despite more formal education, one study found that women received significantly lower levels of craft specific training (Perrenoud, et al. 2020), a potential contributor to slower advancement.

Despite gains over the past few decades, selection of college majors often aligns with self-perceived femininity or masculinity (Beutel, et al. 2018). Traditional roles reinforced by society contribute to pre-career "leaky pipeline" drain by syphoning off quality talent even before reaching the workforce. Despite these hindrances, women earned 21.9% of U.S. civil engineering degrees conferred between 1995 – 2018 (Department of Education 1995 – 1999; Yoder 2000 – 2018).

While this study concentrates on engineering, career progression often shifts between functional disciplines, especially as management positions require auxiliary soft skills beyond hard technical engineering knowledge. As such, earning an undergraduate engineering degree may not directly lead to an engineering career or represent only the start of a career. In Marinelli, Male, and Lord's (2021) study of engineers' progression into management and leadership, women felt the need to reestablish their engineering competence and credentials throughout their careers. This repeated search for self-efficacy follows the SCCT model. Additional advanced degrees, especially for executives, include business management, finance, and administration. One prior study found that only 36% of engineering baccalaureates and 42% of

engineering master's degrees worked in engineering positions. Contributing to this divergence, over 25% of professionals with undergraduate engineering accreditation reported that managing people and teams as their primary responsibility (National Academy of Engineering 2018). SCCT's foundational focus on persistence in educational domain progresses throughout a career (Lent and Brown 2019). Alternatively, non-engineering undergraduates working in the AEC industry could pursue graduate engineering degrees to align with their career trajectory in the industry.

In today's workforce, across most U.S. industries, graduation from a traditional four-year college or university typically serves as a pre-requisite, especially for management positions. This study quantifies earned education, focusing on the highest level achieved. While not mandatory, graduate degrees further differentiate candidates and aid their ascension into executive leadership. Comparing women and men, would the level of education be comparable for similar positions, or would women need to accumulate additional schooling to maintain pace?

H4: Women continually reevaluate their preparedness and performance in educational domains, attaining additional advanced degrees to achieve similar organizational hierarchal status as men.

Research Methodology and Data

Data Collection and Cleaning

With women holding 10.9% of the total positions (U.S. Bureau of Labor Statistics 2020), AEC remains a male centric field. An extension from prior research, this analysis focuses on individual and collective career histories of 2,857 industry leaders extracted from LinkedIn profiles. Reviewing leading firms' websites listed on the 2019 ENR Top 400 list, our research team assembled the list of leadership teams publicly reported by individual companies. Note that firms' classification of their respective senior and executive managers impacted the available sample.

With the explosion of technology and relatively recent introduction of SNS, available online data significantly increased. Application of web scraping automatically extracts large quantities of information from web-based sources (Patel 2020). This method quickly creates structured datasets from unstructured content for further analysis. After assembling leadership teams from websites, often listed under "Leadership" or "Meet Our Team", researchers located the matching LinkedIn profiles. Initial validation data points included names, position titles, and if available, photos. Considering some industry firms, especially family owned companies, possess multi-generational teams, reviews applied extra care to ensure accuracy.

Permission to access all collected information required only a basic LinkedIn account with no special connections or links. This approach maintained equal access of data rights for all profiles. Applied to unique URLs, Python script coded using the available packages "Urllib" and "BeautifulSoup" performed web scraping, capturing information including companies, titles, years of experience, education, and network size. Web scrapping facilitates repeatable high speed data extraction, ease of code adjustment, and structuring for analysis. This flexibility enabled multiple rounds of review, code adjustments, and data cleaning (Diouf et al. 2019).

Three rounds of data validation and cleaning maximized accuracy of the final dataset. During the initial cycle, we tested a smaller sample where two researchers independently manually validated 20% of records. Combining results of identified discrepancies, code adjustments improved the quality of the data pull. As an additional check on the compiled data set, authors assessed whether differences exist between women and men in the level of reporting for individual profiles. Would one gender provide fewer details in their career history (e.g., omit early career positions, degree earned, or years served)? Before conducting further analysis, the team evaluated the data integrity, specifically analyzing each educational listing as split into three individual components: school, degree, and graduation year to compare listed level of detail. No statistical differences existed between women and men,

therefore researchers determined consistent levels of accuracy exist which increased the confidence level about the dataset.

Statistical Test and Analysis – Machine Learning Model Development

ML refers to a set of algorithmic structures designed to provide computer systems with the ability to learn and improve their performance via the discovery of patterns in data. Applying ML algorithms to engineering problems develops predictive models based on a set of training features. Accuracy of such predictions generally depends on the amount and quality of input data, as well as the algorithm's ability to extract the patterns (Ray 2019). Generally, practitioners consider ML models as supervised, unsupervised, and reinforcement learning techniques. Supervised ML involves user specification of algorithm targets. Thus, algorithms focus on modeling the relationship between a set of input variables (e.g., career path features) and the specified target (e.g., gender). Flexibility of ML models in comparison to statistical models, which typically include rigid requirements and the clear explanation of model's accuracy using testing data set for validation, justify applying ML models in this study. Therefore, authors applied supervised learning classifiers, cases with categorical targets, to investigate the impact of gender on individual career paths as a whole picture.

Models easily learn patterns to classify the gender when significant different relationships exist in the career paths of female and male construction leaders. While many ML techniques exist in research and each technique involves its own unique attributes, a group of top utilized ML classifiers apply in the construction studies (Seyrfar et al. 2021). In this study, researchers employed RF to investigate the relation of career path features and target class of gender. A flexible, straightforward, and easy-to-use ensemble ML algorithm, RF yields highly accurate results dealing with various input data types. Merging multiple base decision trees, RF produces a single optimal predictive model (Zhang and Ma 2012). Further, parallelization contributes toward reducing overfitting, overcoming bias issues, and enhancing classification performance (Jiang et al. 2020). These features, in addition to the capability to rank feature importance, offer a useful algorithm to implement in this study.

In terms of application, ML classifiers demonstrate significant contributions in a recent variety of related engineering and construction issues. Jafari et al. (2020) developed a ML model to classify potential employees under the Wage Inequality in Engineering Organizations. Awada et al. (2021) trained a RF classifier to predict acceptance or rejection of contractor submitted inspection requests. Khalef and El-adaway (2021) developed a ML classifier to categorize substantial and non-substantial changes in construction projects. Moreover, researchers applied ML

classifiers to extract textual information from social media posts (Li et al. 2021). This study of LinkedIn profiles employed ML classifiers to categorize female and male construction career paths.

Model development included data pre-processing, algorithm testing, model validation, and feature importance extraction. Among multiple cross validation techniques, stratified random sampling evaluated the performance of classifiers using the number of True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN) results based on predicted and actual classes. Then models calculate performance metrics: precision, recall, and F1-score (Liberty et al. 2016).

Results and Discussion

Compiled dataset segregates each individual reported company to quantify movement throughout the individual's career. Python software packages "Urllib" and "BeautifulSoup" extracted LinkedIn profiles and segmented individual candidates' listed company history. Coding cleaned the dataset, identified and removed unmaintained profiles (e.g., a President with only one position listed for the past 40 years), and counted the number of unique firms throughout individual careers. Accumulated totals, sorted by gender and engineering / non-engineering, formed the resultant dataset for analysis. This basic methodology applies to all research questions.

This study focuses on executive and senior level leaders including Presidents, C-suite officers, Executive VPs, VPs, General Managers, and Directors. Further, analysis segregates engineering and non-engineering billets to align with technical focus of the field. Sample size (Table 3-1) comprises 2,857 total profiles (422 women and 2,435 men). Of the executives identified across the ENR Top 400 firms, women fill 14.8% of the total positions, including 5.2% of engineering and 33.2% of non-engineering roles. Consistent with the prior study in this research series, disproportional levels of finance, legal, and business development roles necessitated this separation (Hickey and Cui 2020). While these values lag compared to the overall women's percentage of the U.S., these figures exceed women's overall industry total of 10.9% (U.S. Bureau of Labor Statistics 2020).

Table 3-1 – Study Population Composition

Class	Engineering	Non-Engineering	Total
Female	97 (5.2%)	325 (33.2%)	422 (14.8%)
Male	1,780 (94.8%)	655 (66.8%)	2,435 (85.2%)
Total	1,877	980	2,857

Even though women earn a sufficient proportion of formal civil engineering degrees (Department of Education 1995 – 1999; Yoder 2000 – 2018) and form an industry focused candidate pool, females holding engineering positions decreases with increasing organizational levels. Assessing progress of this study compared to the preceding 2019 research of this multi-phase study (Hickey and Cui 2020), executive market penetration regressed from 3.9% to 3.8%. Climb to the top remains daunting

despite progress in other areas, with continually fewer filled billets with each organizational hierarchal step from Director (8.8%) to VP (5.5%) and ultimately Executive Suite (3.8%).

Predictive Machine Learning Analysis

Data preprocessing forms a critical step in developing ML models. Many ML algorithms cannot operate on categorical data directly, requiring all input variables in numeric format. Categorical variables with no such ordinal relationship apply one hot encoding to transfer data into the appropriate format for further analysis (Seger 2018). Table 3-2 presents the list of career path attributes extracted from LinkedIn for each professional. In the first step, utilizing the available Python packages such as "Matplotlib" and "Seaborn", authors plotted the relation of career path features. Effective data visualization transforms a complicated dataset into an understandable format. Figure 3-1 includes multiple joint plots that describe the behavior of career path features comparing gender classes. All available data points generated each component of Figure 3-1. It should be noted that some profiles omit educational background, therefore, the sample size in Figure 3-1 (e) differs from other figures. According to Figure 3-1 (a), women's distribution of number career positions and companies differs from men leaders. Figure 3-1 (b) suggests women need to change more companies to achieve their current role. Figure 3-1 (c) demonstrates that females reported a larger professional network overall. Figure 3-1 (d) illustrates the

importance of company size on leaders' career paths, specifically showing that females generally work in larger companies. It explains that large company leaders possess significantly more experience. Finally, Figure 3-1 (e) offers that women leaders achieve higher education degrees compared to their men peers. Data visualization explained a general picture of potential differences, in the following steps, we dig into how to consider multiple career path features in the ML model and provide detailed quantitative analysis for each career path feature.

Table 3-2 – Career Path Attributes

Variable	Data Type	Description
Number of Career Firms	Numerical	Number of unique companies
Number of Career Positions	Numerical	Number of unique career positions
Highest Level of Education	Categorical	Highest achieved degree (e.g., Doctor of Philosophy (PhD), Master of Arts (MA), Master of Science (MS), Master of Business Administration (MBA), Juris Doctor (JD), Bachelor of Science (BS))
Professional Network Size	Numerical	Number of followers
Years to Current Position	Numerical	Duration to achieve the current position
Company Revenue Size	Categorical	Under $250M, $250M - $500M, $500M - $1B, Over $1B
Position Type	Categorical	Executive Suite, VP, Director
Role Type	Categorical	Engineering, Non-Engineering

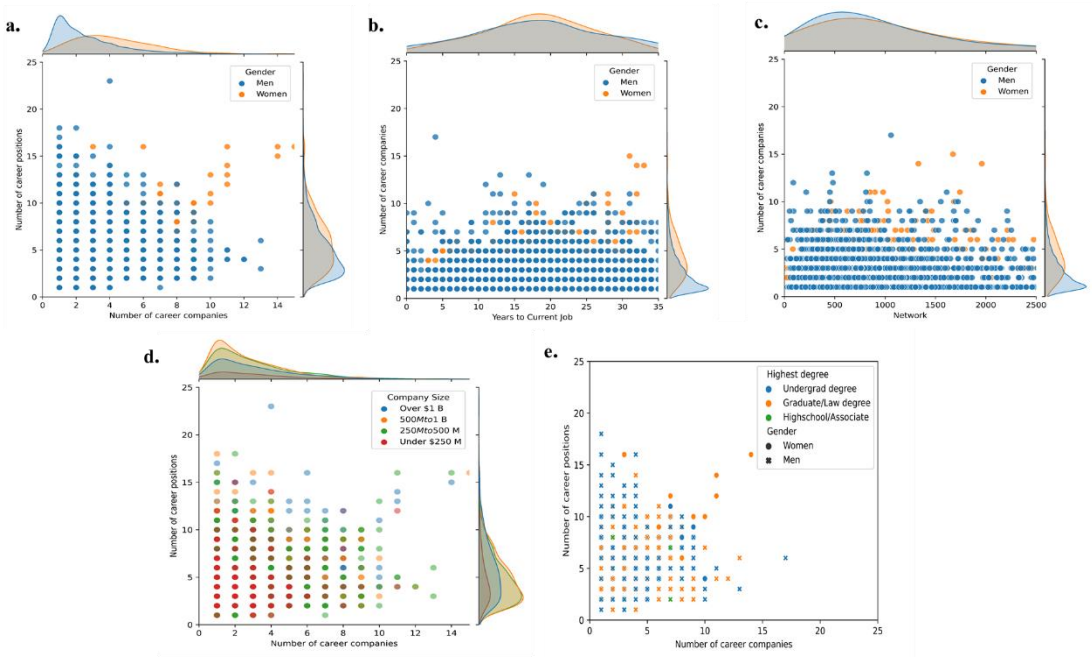

Figure 3-1 – Dataset Career Path Features Visualization: (a) Number of Career Companies; (b) Years to Current Job; (c) Network Size; (d) Company Size; (e) Highest Level of Education Earned.

Deploying Python program using the "Sklearn" library, researchers built a pipeline to apply a ML classification algorithm. ML algorithms tend to bias towards classes with greater instances and imbalanced classes risk generating unsatisfactory classifiers. Therefore, authors followed an under-sampling approach to balance classes distribution, including 10 repeated random selection of male profiles, placing them beside all female profiles, and reporting average results (Haixiang et al. 2017). Following multiple iterations, the balanced dataset divided into 70% training and 30% testing samples. Building the RF model requires important features established such as the number of trees (n_estimators), maximum number of levels in each tree

(max_depth), maximum number of features considered for splitting at each node (max_features), and the method for resampling with or without replacement (bootstrap). Process of calculating best values for the model's parameters is called hyperparameter tuning (Probst et al. 2019). Using the "Sklearn" library hyperparameter grid search, authors optimized the RF model's parameters. Resultant optimized RF model reported high performance with 98.95% training and 89.53% testing accuracy including a balanced performance for both classes which offers a positive indicator of the potential impact of gender on construction leaders' career paths. Table 3-3 summarizes RF model performance indicators. Among important RF model's parameters, selected values include n_estimators =100, max_depth =12, max_features= Auto, bootstrap =True.

Table 3-3 – Random Forest Detailed Performance

Class	Precision	Recall	F1-Score	Number of Tests
Female	0.89	0.89	0.89	115
Male	0.90	0.90	0.90	125
Average	0.90	0.90	0.90	240

Using the "Sklearn" library feature importance attribute, career path elements sort based on their significance to explaining the target gender class. Figure 3-2 outlines attribute importance in the RF model, calculated by averaging the decrease in impurity over trees (Han et al. 2016). In summary, model results reveal significantly different patterns in the career path of female construction leaders compared to their male counterparts. In other words, viewing elements of leaders' career arcs, women

follow a different direction to arrive at the top of the corporate ladder. Important features classify the construction leaders' career paths, highlighted by company revenue size and role type, reinforce key variables found in the prior study by the authors, including higher representation of women in larger firms and non-engineering roles (Hickey and Cui 2020). Other important items sorted as number of career firms, professional network size, and number of career positions. Following sections detail statistical comparisons of important career path components to evaluate the study's proposed hypotheses.

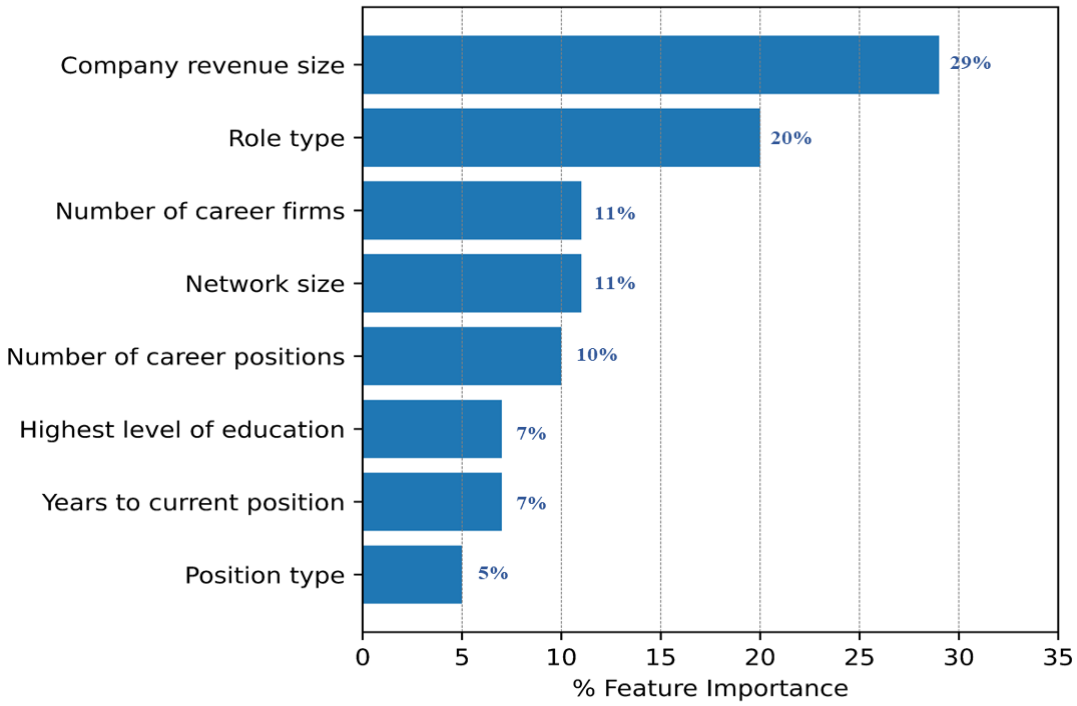

Figure 3-2 – Feature Importance Sorting

Statistical Comparison of Career Path Features

Number of Career Firms

Comparing careers of women and men finds that women switch firms 56% more frequently, 4.2 to 2.7 companies, during their careers (P<.001). A key finding centers around the leaders remaining with a single firm throughout their careers. Prior research found that internal candidates ascend faster than external (Koch, et al. 2017). That study, however, reports that the faster promotion for internal candidates applies more to men than women. These strong ties, bonding social capital (Neumeyer et al. 2019), serve to continue the male dominated hierarchal structures. As shown in Figure 3-3, almost four in 10 men remain with one company (37%) while that figure drops to 10% for women. Extrapolating to early and mid-career professionals, internal vertical progression benefits men, while their female counterparts should consider moving to another company. Social capital theory studies found that colleagues' similarities, including sex, age, ethnic, and racial backgrounds, contributed to strengthening network linkages, while greater differences create a higher likelihood of organizational turnover (Brass 2003). Low numbers of women in executive billets contributes to differences and greater frequency of turnover for women overall.

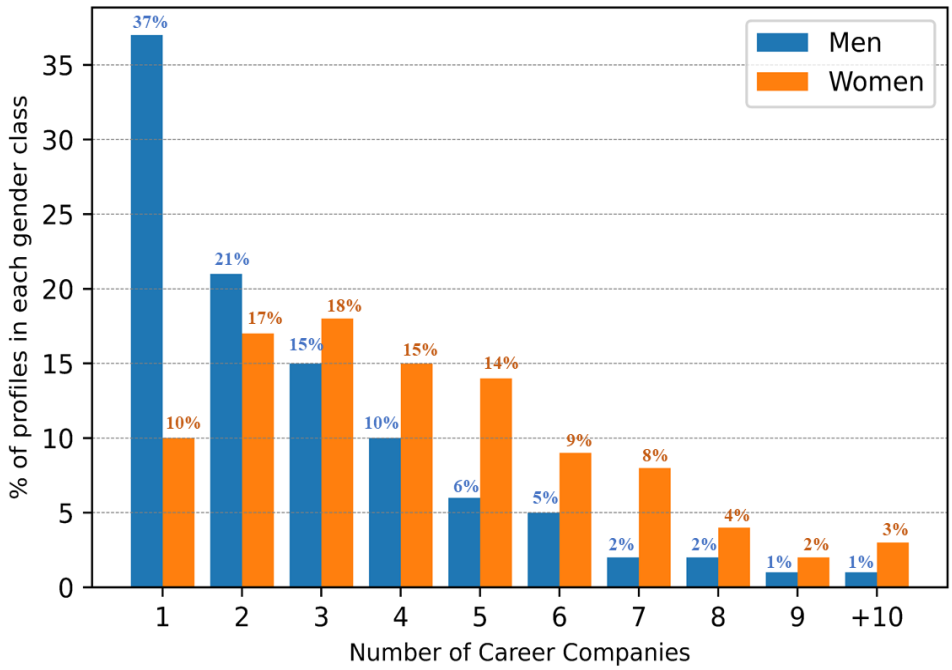

Figure 3-3 – Number of Career Companies

H1 (True): Male dominated executive teams' bonding social capital perpetuate the status quo. Study results demonstrate 56% higher turnover for women than men during their career progression, 4.2 to 2.7 companies. 58% of men and only 27% of women achieve leadership positions with only one or two firms.

Professional Network Size

Women demonstrate superior communication skills and develop better connections with stakeholders (Devnew, et al. 2018) and cultivate larger formal and informal career networks than men (Roebuck and Smith 2013). A gender based study of engineers and their continued pursuit of knowledge found that women perceive the

highest accessibility of information from other women, while men seeking knowledge from women as the lowest (Poleacovschi, et al. 2021). Analyzing the size of assembled networks, results support women's ability to create more connections. Women generate 14% larger groups (1,200 to 1,049) than men (P=.011) (Figure 3-4). In social capital theory, larger networks create greater volume of weak ties and structural holes (Seibert, Kraimer, and Liden 2001). This bridging offers not only access to unique data, but also the opportunity to control access to the acquired information (Alaa et al. 2018), which could explain the higher turnover rate and number of firms.

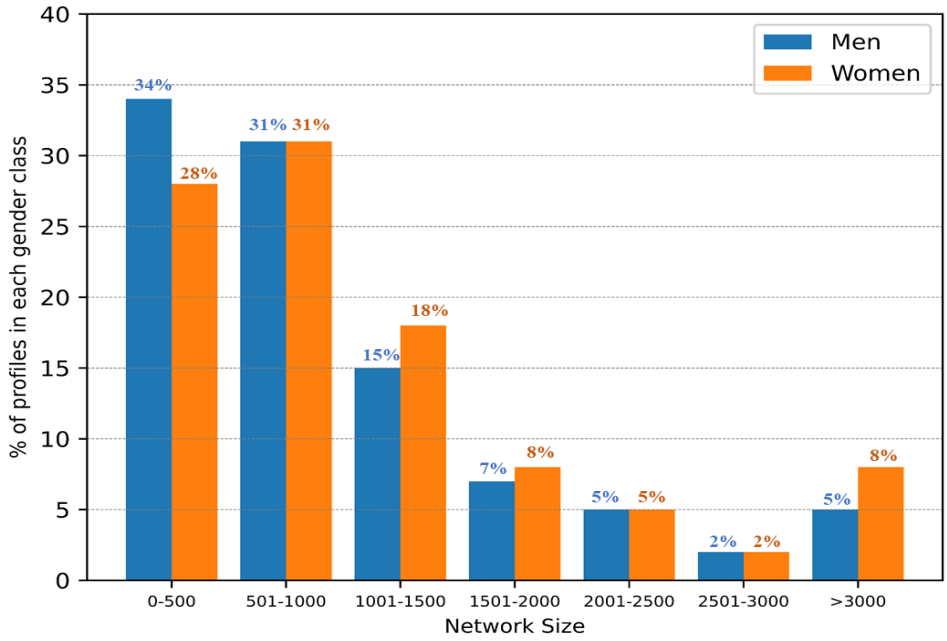

Figure 3-4 – Network Size

More experienced women build stronger networks, suggesting that mentoring would benefit early / mid-career professionals (Neumeyer et al. 2019). Cultivating professional contacts early and often maximizes their growth potential. However, Buettner (2017) argues that an individual can only maintain 100 – 200 stable relationships with a decreasing value of larger networks. Co-workers, clients, vendors, and competitors comprise LinkedIn connections, which include passing introductions at business meetings, industry conferences, and opportunistic "professional networkers". Reflecting on the sheer size of the networks, how can an individual maintain valuable interactions? While averaging 1,200, 59% of sampled women assembled followers under 1,000. Extreme results return 32 profiles listing 200 or fewer connections and 33 with over 3,000.

An item of note in the data collection, due to LinkedIn privacy settings beyond first connections, connection counts above 500 displayed as "500+". In order to retrieve consistent information for all candidates, authors would need to connect directly with each of the 2,857 leaders in this survey. Recognizing the challenges of obtaining these linkages, authors chose to quantify network size through use of the followers, which includes an uncapped limit.

H2 (True): In order to offset men's bonding social capital homophily, women seek unique knowledge obtained by assembling 14% larger professional networks, 1,200 to 1,049, than men.

Additionally, a sign of interactivity and strength of relationships manifests itself in professional recommendations. Women actively assist fellow professionals by offering and receiving 64% more recommendations (2.1 to 1.3) (P<.001). In the sample, less than half of either gender submitted or received recommendations. Of those demonstrating activity with over five total, women outpaced men by a factor of two, 14% to 7%.

Number of Career Positions

Career mobility itself embodies different paths. Progression may involve promotion through the technical job family tree (e.g., engineer, senior engineer, engineering manager, and beyond into leadership); changing between functional areas (e.g., engineering to finance); changing employers; or a combination. Aside from possibility the vertical functional paths, the remaining options often occur when employees perceive superior opportunities exist or they lose their current position. "Climbing the corporate ladder" embodies a common path to the executive suite. SCCT requires continual reassessment of career decisions (Lent, Brown, and Hackett 1994; Lent and Brown 2019), including impact of negative outcomes (Blaique and

Pinnington (2021). Authors assessed whether women and men climb equivalent number of "rungs" to reach leadership. On average, women held almost one more position, 5.8 jobs to 4.9, 19% more (P<.001) (Figure 3-5).

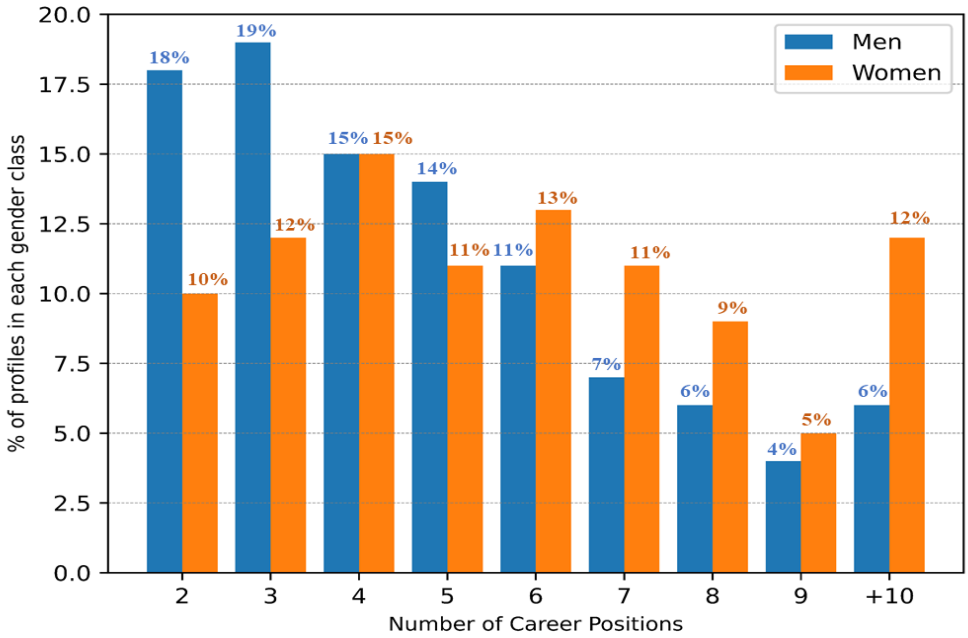

Figure 3-5 – Number of Career Positions

As outlined in the Data Collection and Cleaning sub-section, before conducting the data analysis, authors assessed whether women and men provide similar detail in reporting career accomplishments. Using three components of educational data: school, degree, and graduation year, no statistical reporting differences were identified between genders, increasing the confidence level of data integrity. As shown in Figure 3-5, men consistently listed fewer positions to reach leadership,

indicating that women need to climb additional rungs on the corporate ladder to achieve similar positions. 22% of women and 37% of men reported two or three career positions while on the other extreme, women list 10 or more positions twice as often as men (12% to 6%).

H3 (True): Adverse career occurrences disproportionally impact women, slowing career progression and requiring 19% more positions, 5.8 compared to 4.9, on the corporate ladder than their male counterparts during their career progression to leadership.

Reviewing deeper to assess any impacts of company size, regardless of revenue levels, women consistently held more positions (Figure 3-6). However, both genders reported increasingly frequent title changes with corresponding organizational magnitude. Larger firms typically integrate additional hierarchical layers of management as employee base of a $250M company allows a flatter organization than one over $1B. This creates extra rungs, driving higher incidence of job changes to reach leadership. While members' mobility includes shifts between small and large firms, Figure 3-3 in the preceding sub-section shows propensity of less frequent changes for men.

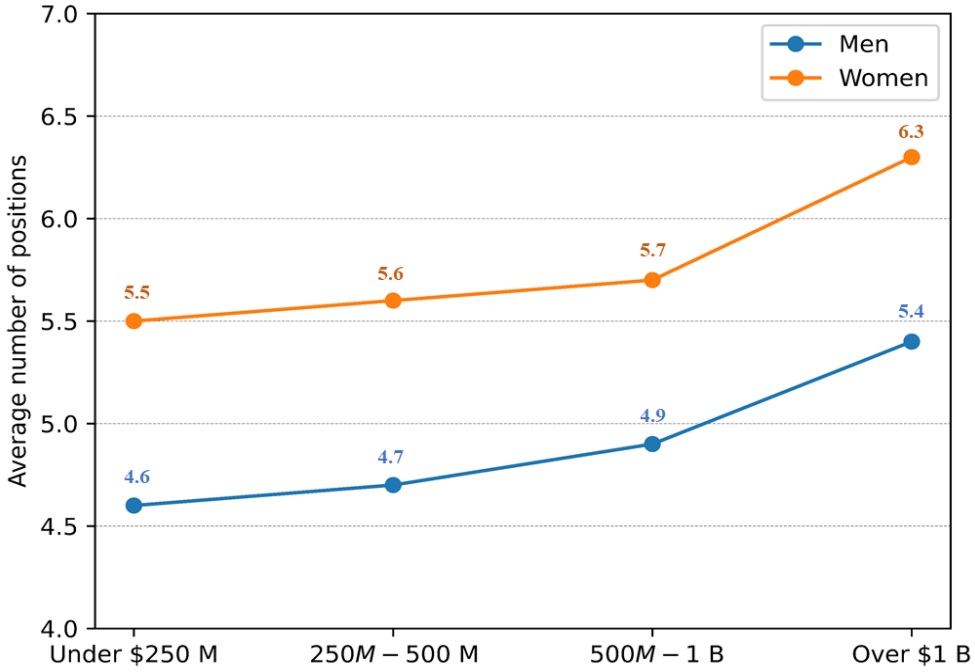

Figure 3-6 – Average Number of Positions Held by Company Revenue

Highest Level of Education

Analyzing educational histories for the sample (Figure 3-7), more than half of women earn advanced degrees (53.9%) while men achieve these milestones less 1/3 of the time (31.2%). These results support earlier studies which found women earn the majority of all college degrees (Jardina and Burns 2016; Sandberg 2013).

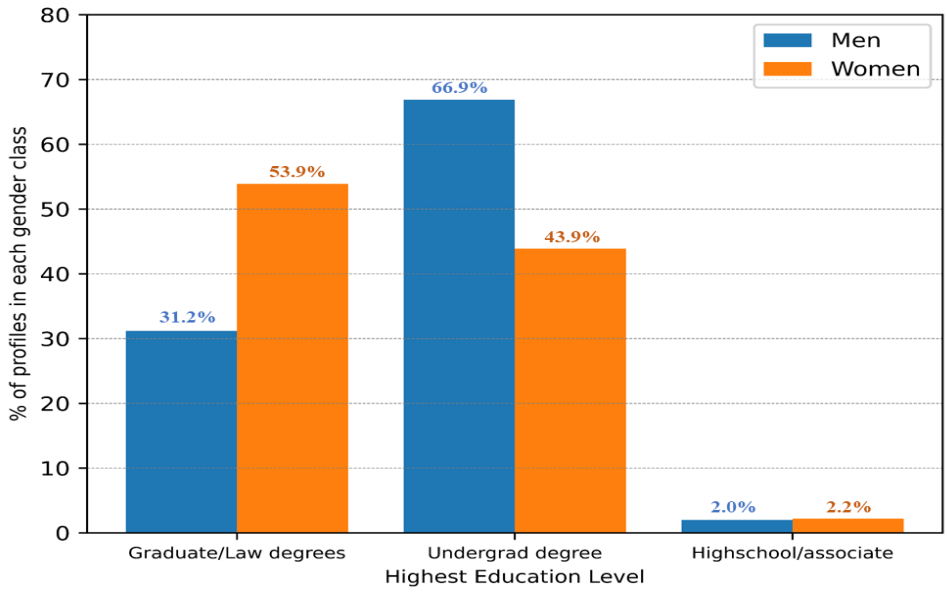

Figure 3-7 – Highest Education Level

Subdividing Figure 3-7 results by type of graduate degrees, Table 3-4 offers more detailed insight how both genders focus advanced studies, specifically directions that women pursue to further their careers. As previously discussed, most positions filled by women classify as non-engineering. These include legal roles, supporting the disparate volume of JD degrees, 12.2% for women compared to only 4.1% of men.

Table 3-4 – Breakdown of Graduate Degrees

Degree	Female	Male
PhD	1.7 %	0.5 %
JD	12.2 %	4.1 %
MBA	20.0 %	16.4 %
MS / MA	20.0 %	10.2 %
Graduate / Law degrees	53.9 %	31.2 %

Pursuit of and satisfaction with one's continued education forms a cornerstone of SCCT in the analysis of a career trajectory (Lent and Brown 2019). This focuses on interaction between self-efficacy and expected outcomes, positively impacted by earning graduate degrees (Clayton 2022). Further, best practices for forwarding a career include formal education, training, and mentoring (Schultheiss 2021).

H4 (True): Women continually reevaluate their preparedness and performance in educational domains, obtaining more advanced degrees, 53.9% compared to 31.2%, than men to achieve similar organizational hierarchal status as men.

Years to Current Position

Reflecting on initial study results, specifically that women hold more positions on the corporate ladder, researchers considered whether the time to reach their current position required additional years of service. Analysis calculations consider the duration from the initial reported employment to the start of the current job (e.g., a professional life started in 1995 holding a VP title from 2015 – 2021 equals 20 years, not 26). While not statistically significant (P=.242), actual results returned that women achieved their current position with the same accumulated years of experience.

Managerial Implications

Practical Applications

AEC firms miss out on benefits derived from assembling teams possessing varying backgrounds and experiences. Increasing diversity in the industry injects new perspectives when assessing business opportunities and problem solving into the daily workplace. However, this represents only a secondary application offered by this study. Authors primarily focused on collecting and analyzing career paths of successful AEC women and men to assess whether discernable patterns exist in behaviors and decisions throughout decades long evolution of individual careers. Subsequent cumulative results showed distinctly different paths between genders from the LinkedIn profiles of 422 women and 2,435 men. Results offer potential roadmaps for early and mid-career professionals to assess when considering key decisions. In addition to a primary choice of remaining with an organization or changing companies, pursuit of further education and assembling professional networks impact growth opportunities. Specifically, results suggest that women should strive to earn more advanced degrees, create larger networks, and seek opportunities to change firms more often than men. Developing policies and programs supporting these areas assist firms to attract and retain top talent.

Company Impact

Effectively implemented, gender diversity creates an environment providing women and men fair and equal treatment. Unfortunately, women perceive greater obstacles in joining and advancing in AEC (Infante-Perea, et al. 2021). Firms lacking healthy inclusive cultures generate higher turnover of women leaders (Figure 3). This prevents advancement of qualified people based solely on gender, including driving them out of the pool (True-Funk 2021) and limiting overall participation of women, currently 5.2% of engineering leadership billets (Table 1). Whereas the origins of affirmative action focused on gaining entry to the market, even 30 years ago advancements beyond entry level positions stalled at middle management (Thomas 1990). This creates poor Human Resources practice, not only for short term organizational performance, but also long-term signals to potential future leadership candidates (Powell 2020). Firms must identify underlying reasons for higher turnover and develop recruiting and retention techniques and practices that address the root causes in order to retain this talent. Hindering progress, Table 1 shows the current dearth of women in leadership roles, offering few role models for current women workers and middle managers. Despite AEC industry efforts to attract and retain more women, even those who reach supervisory roles leave their positions more often than men (Maurer, et al. 2021). This detracts from the ability to guide younger people into future leaders. Firms instituting formal and informal networking programs increase cross functional connections and foster a more cohesive working

environment. Educating the team on the role of social capital levels the playing field for everyone (Górska et al. 2022). A key challenge of successfully implementing a diversity program remains identifying and training qualified candidates, not just increasing the numerical volume for optics (Thomas 1990). Will firms integrate proper identification, mentoring, and training programs to increase internal qualifications and subsequent talent pool? Anecdotally, what is worse than investing in an individual and they leave? Not investing and they stay.

Education reimbursement offers companies with a key element of a competitive total compensation package and demonstrates a commitment to long-term employee growth. As shown in Figure 3-7 and accompanying Table 3-4, women earn advanced degrees at a higher rate than their male counterparts, 53.9% to 31.2%. Understanding expenses associated with implementation of continuing education benefits, firms should evaluate costs related to employee turnover and tailor programs to ensure both women and men benefit, especially for engineering related disciplines.

As a sign of changing times and perspectives, company focus on diversity evolved from checking a box to an integral component of culture and financial performance (Morgan 2020). On the other hand, premature departure of women (Figure 3) drains unrealized potential gains. Firms prioritizing retention and growth programs position themselves with a competitive advantage (Hewlett and Luce 2005). With the

growing societal discussion of diversity and fairness, propelled by the accelerating speed of social media, company actions create greater risk / reward results. Establishment of a thoughtfully crafted diversity program promises positive short and long-term benefits. Ultimately, companies need to reenvision how they see their workforce and humanize the culture.

Early and Mid-Career Professionals

Commonly recognized as a beneficial career enhancing activity, mentoring provides practical advice and recommendations directly from senior professionals. Executives pass along experiences, positive and negative milestones, and lessons learned gained over a career to aid the next generation's growth. In its best form, mentoring imparts knowledge that allows the protégé to capitalize on career enhancing activities and avoid pitfalls of their predecessors. Compilation of this LinkedIn corpus of career decisions gathers experiences of 2,857 successful women and men for the benefit of early / mid-career professionals. Equal availability of the results, especially for those without access to personal mentoring or marginalized by homophily, partially levels the imbalance of opportunities.

This article identifies actions taken by senior and executive women and men in their individual and collective career journeys to achieve success. Accompanying recommended actions (e.g., consider switching companies) reflects these prior paths.

Authors wish to note that changing the paradigm to expand opportunities for women resides with AEC companies and imply no implication that women must shoulder the responsibility or created the current imbalance.

Prior research found that women navigate different paths to executive positions than men (Lyness and Thompson 2000). Through an analysis of over 2,800 executives' careers, this study confirms identifiable career patterns based on gender. While each individual encounters unique opportunities and challenges, results offer suggestive paths for women to navigate the male dominated executive levels.

Women experience higher turnover rates with only 27% of engineering leaders remaining with one or two companies during their career. Conversely, men ascend at more than double that rate, 58%, for the sample. Similarly, women reported three or fewer positions 22% of the time compared to 37% for men. Despite being counter to evidence of an accelerated promotion path by remaining with the same firm (Koch 2017; Hamori and Kakarika 2009), women seeking advancement should carefully consider seeking opportunities in other firms and areas. Further, a key element of SCCT, accumulation of additional training and education aligns with career progression. Results show the importance of advanced degrees for females to maintain pace with their male counterparts. Despite over half of the group, 53.9% (Figure 3-7 and Table 3-4) earning post baccalaureate education, their progression

still lags. Lack of documented knowledge risks further career drag, so early and mid-career women should consider pursuing continuing formal education. In the AEC field, engineering undergrads possess the option of augmenting technical knowledge with business and law degrees or continuing on the engineering track.

Careful selection of mentors offers enhanced opportunities for women to successfully progress. Prior research discovered that mentored women reach middle management billets 56% more often (Roebuck and Smith 2013). Results of this study demonstrate that women executives understand the value of developing relationships through creation of 14% larger networks (Figure 4). Ascending in the corporate structure, current junior and mid-level managers should consider leveraging their social capital skills, creating larger networks, seek out mentorship, and gain a high-level sponsor in the organization.

Conclusion

This study contributes to the body of knowledge by identifying career choices by current women and men in the AEC industry. While prior studies discussed theories and offered insight into origins and reasons behind the lack of diversity in AEC and other fields, authors found minimal information on career paths of senior and executive leaders, especially divided and compared by gender. Application of ML

techniques to validate observational analysis confirms women follow different paths than men in their ascension on the corporate ladder.

Extracting executive profiles of 2,857 representatives in the field, women move 56% more often, require 19% additional jobs, earn more education (53.9% to 31.2% graduate degrees), and leverage social capital to grow 14% greater professional networks, yet only fill 14.8% of total executive pool, declining to 5.2% of engineering leadership positions. Testing RF classifier from the assembled dataset demonstrates the significance impact of gender on career path data patterns by achieving accuracy of 98.95% during training and 89.53% during testing to predict the gender of a profile based on the career path features.

Attracting and retaining top talent requires inclusion of the wider workforce. Unfortunately, women experience greater obstacles in joining and advancing in AEC. Peering into the future, current lack of prominent women in workforce threatens to hinder expansion of the available pool of candidates to create diverse teams and recognize the associated benefits. Reversing underrepresentation of women in the industry requires comprehensive and collaborative efforts from industry, academic institutions, and policymakers. Organizations should examine their policies and practices for hiring, promotions, and compensation benefits to ensure fair treatment of all employees.

Limitations of this study include accuracy and consistency of self-reported data level of detail. While authors considered the public nature of the information and specter of potential negative professional ramifications as professionally peer reviewed, specific experiences and education may be under or over reported, especially for candidates with longer careers and higher volume of companies / positions. Further, with no direct contact with individuals, researchers applied existing concepts, including social capital theory and SCCT, and applied them to data trends. Further investigation into internal and external influences offer better insight into career decisions. Additionally, AEC industry would benefit from research into other industries' initiatives to improve diversity and investigate refinement and application in the field.

This study represents the second phase of AEC gender diversity research, building on prior quantification of executive industry representation. Delving deeper into executive LinkedIn profiles, this paper links to the planned third segment which entails interviewing key leaders and exploring their individual journeys. Applying foundational data collected during this LinkedIn analysis, discussions will focus on impact of job and company mobility, education, and network development on their career progression. In addition, external factors identified during the initial study, highlighted by gender bias, sexism, and work-life balance, will be explored to

understand executives' resultant actions. Collectively, authors' intent focuses on expanding the pathway for women to advance in the AEC industry.

Chapter 4: Pathways and Barriers – Journeys of Women Architecture, Engineering, and Construction (AEC) Leaders (Paper # 3)

Abstract

This investigation explores the career professional journeys of 20 women leaders, Vice President (VP) and above, in Architecture, Engineering, and Construction (AEC) leadership. Selected from Engineering News Record's (ENR's) Top 400 firms, women shared richness of their stories, discussing successes, challenges, and significant experiences impacting their path up the corporate ladder. Resultant corpus of responses offers insight to assess underlying root causes for women's underrepresentation in the industry. Further, in developing a career roadmap for early and mid-career women, discussions sought best practices for deployment across AEC to improve diversity via initial recruiting and long-term career nurturing. Participants highlighted success drivers including a supportive partner, early mentoring, and passion for the project mission. When viewed through the long lens, retaining women in the industry requires contributing external factors. If companies seek to differentiate themselves, gaining innovation and better business outcomes benefits offered by diversity, firms should consider establishing a diversity program, establishing a culture to nurture women throughout their careers, conducting

intentional recruiting of young women, and funding pre-college girls Science, Technology, Engineering, and Math (STEM) programs and scholarships. Initiatives promise to increase initial entry and lower early departures rates, closing the industry workforce shortage gap.

Keyword: Construction industry, leadership, gender, diversity, career path

Introduction

This study expands on prior research of AEC leadership gender diversity. Deeper investigation into career progression explores the distinct differences between women and men in their respective experiences, successes, and challenges in the climb up the corporate ladder. Prior research quantified and confirmed the long-held belief that men dominate the field with women holding only 3.9% executive engineering positions (Hickey and Cui 2020). Another study investigated differences in how women and men progress through their career leadership paths, where a trained Machine Learning (ML) model predicted a LinkedIn profile's gender with 89.53% accuracy rate (Hickey, Erfani, and Cui 2022).

Long considered a male dominated industry, AEC held an anecdotal label as an "old boys' network". Cambridge Dictionary (2022) defines the term as "the way in which men who have been to the same expensive school or university help each other to find good jobs". Women face the challenge of gaining access to this closed network.

Capitalizing on resources such as mentoring, specifically sharing women's experiences with experienced ear, helps break down existing barriers (Searby and Tripses 2006).

Power and inequality between women and men arise from long held societal beliefs vice genuine authority (Berdahl et al. 2018). Contrary to prolonged common attitudes, gender scholars disproved the theory that personality attributes associated with women and men originate from biology (Berdahl et al. 2018). Established in 1920 and recently celebrating its 100th anniversary, U.S. Department of Labor's Women's Bureau researches and pioneers innovative solutions on key issues to overcome gender based workplace barriers (United States Women's Bureau 2022). Extending to individual firms, true corporate social responsibility incorporates gender equity as part of its mission (Grosser and Moon 2005). As an industry, AEC must embrace these concepts to achieve its own business objectives. U.S. construction industry faces significant workforce shortages of 650,000 workers in 2022 (Associated Builders and Contractors 2022), projected to escalate over the next decade with looming labor retirements (Morello, Issa, and Franz 2018). Excluding women, who comprise 50.5% of the population (United States Census Bureau 2020), from primary recruitment, hiring, and long-term career retention offers an unsustainable option for the industry.

U.S. Department of Labor reported since 2003, women filled an average of 9.5% of AEC industry positions, from 9.6% in 2003 to 10.9% in 2020 (United States Bureau of Labor Statistics (2022). Reasonably consistent over the past two decades, AEC produced only moderate progress. This persists even before reaching the workplace, as women face similar hostile environments during college (Dresden et al. 2018). This prolonged, multi-phased oppression drives woman out of AEC. Prior research found that increasing women's participation on executive teams leads to value through fresh perspective and ideas, enhanced relationships with stakeholders, higher innovation, greater creativity, and a better bottom line (Devnew et al. 2018, Pritchard and Miles 2018). Inherently, team diversity gathers an assortment of different perspectives, fostering an environment welcoming unique ideas and innovations (Diaz-Garcia, Gonzalez-Moreno, and Saez-Martinez 2013). Firms and industries resisting this open exchange deny themselves of the benefits of multiple viewpoints and the potential technical and process orientated advancements, especially in the competitive AEC market.

Confirming previously held anecdotal perception that men dominate the AEC leadership, this study further explores the state of practice of the industry. Active recruitment and expansion of women's membership, highlighted by middle, senior, and executive management offers potential solutions to address workforce shortages and improve business outcomes. Further, increasing representation today attracts the

next generation through self-identification with similar people. Fundamental changes, highlighted by firms publicly promoting inclusion and altering recruiting methods, promise to create more diverse environments. In addition, review of successful segments currently showing higher diversity totals (Hickey and Cui 2020) likely gleans additional insights for new training programs and policy changes. Ultimately, underlying factors deterring women from joining or remaining in the field: male dominated culture, conflict and aggression, slow advancement compared to male peers, and work family balance require attention. Recommended actions to reverse the trend include targeted funding of STEM scholarships for young girls, equal opportunities for key positions, and directed mentoring of early and mid-career women.

Literature Review

Discussion of the framework focuses on the theories applied throughout the research, specifically Social Capital Theory and Social Cognitive Career Theory (SCCT). Researchers applied these underlying concepts to assess career influences and choices by the study participants. Their journeys provide cumulative validation and their applicability to the study.

Social Capital Theory

Extracting benefits from embedded workplace relationships to generate positive business results captures the essence of social capital (Lin 2001). Benefits from networks range from resource availability to data access to public support (Alaa et al. 2018). Following its introduction, significant research expanded the original scope of social capital theory. A key emerging concept concentrated on weak ties, unique connections with outside parties, and structural holes, otherwise unrelated connections of the nodal individual (Seibert, Kraimer, and Liden 2001). Later research discovered strong ties, creation of bonding social capital to accompany the bridging created by weak connections (Alaa et al. 2018; Neumeyer et al. 2019). Creation and maintenance of these networks, especially in early career phases, promote opportunities to identify formal and informal mentoring options. Further, weak connections offer accessibility to data unavailable to the larger group, potentially leading to unique information, business intelligence, and even job offers. Rajkumar et al. (2022) challenged the prevailing belief that weak ties generate higher job mobility in their recent analysis of over 20 million LinkedIn profiles. However, their experimental analysis confirmed relatively weaker ties promote higher job mobility. Purposeful generation and application of social capital positions a young or mid-career professional to access mentoring opportunities, both from strong ties inside the local group and weak ones across or outside the firm. Regardless of the association between the parties or selected methods, all relationships require

communication. These associations between the players impact the effectiveness of the resultant networks more than the individuals themselves (Brass 2003). Especially in a workplace setting, reinforced by the formal organizational relationship, regular interaction in these groups establishes a hierarchical structure formed through bonding social capital (Górska et al. 2022).

Kanter's (1981, 1993) studies identified limitations of imposed by homophily, selection of similar candidates, and the related need to add leadership talent from underrepresented population segments, specifically women and minorities. While this core group benefits from increased bonding social capital, status quo limits innovation for the organization (Alaa et al. 2018). Since men occupy most AEC leadership positions (Hickey and Cui 2020), this risks perpetuation of male dominated industry by hiring via homophily (Elliott and Smith 2004). Sourcing of new candidates requires reevaluating hiring and promotion policies and procedures. Targeted recruitment to seek women and minority applicants expands the potential talent pool beyond returning to the same colleges and university job fairs each year. Participants in this study remarked that the industry overall lags societal evolutions. With the groundswell of diversity, industry adoption of Kanter's (2021) advanced leadership, promoting a wider perspective beyond traditional organizational structure, will dictate the success of future staffing initiatives. Further, leadership's clearly defined vision stresses the significance of the initiative throughout the organization

(Kanter 1981). If adopted, diversity benefits improve firm innovation, decrease risk, and promote better business outcomes (Sunindijo and Kamardeen 2017).

Social Cognitive Career Theory

SCCT offers a lens through which to connect professional and educational pursuits to long-term career development (Lent, Brown, and Hackett 1994; Lent and Brown 2019). Interest development, performance in education and vocation, satisfaction and well-being, decision making, and career self-management comprise SCCT's five interconnected models (Lent and Brown 2019). This 2019 update expanded the theory from the original three models (Lent, Brown, and Hackett 1994). Fouad and Santana (2017) found that SCCT self-efficacy attracts students to fields of study consistent with their interests. Expanding the supporting SCCT body of knowledge, Lamb et al.'s 2018 study of STEM high school students identified external influences impacting students' career choices even before college matriculation. While countless professionals alter their professional direction throughout their lifetime, secondary and college education curriculum significantly impact early career choices, especially those requiring specific knowledge or experience.

During mid-career, self-reflection combined with external perspectives, facilitates progress assessment and identifies necessary adjustments. Whether supervisor, mentor, or co-worker, incorporating outside evaluations provides an unofficial 360

degree review. Adversely, in this process, negative feedback creates roadblocks and potential self-doubt. 10 of the 20 interviewees (50%) highlighted poor supervision when asked about significant experiences and events during their career. Shifting to the educational aspect of SCCT, 53% of women in the ENR Top 400 sample earned graduate degrees (Hickey, Erfani, and Cui 2022). Notably, in this focused pool, 17 (85%) women earned a graduate degree, two others Executive Education, and the remaining one a bachelors. During discussions regarding the need to augment their personal mid-career toolbelt with additional skills and abilities, 75% (15 of 20) of study participants noted the importance of education and professional certifications in their ascension up the corporate ladder. Wholistically, SCCT links academic and professional choices, career interests, and performance in those areas (Lent and Brown 2019). Blaique and Pinnington (2021) state underlying theory principles offer insight to root causes for continued underrepresentation by women.

SCCT offers an explanation how personal goals, outcome expectations, and self-efficacy beliefs affect career and educational decisions (Burga, Leblanc, Rezania 2020). Personal confidence and alignment with self-interest play significant roles in determining career selections (Lent, Brown, and Hackett 1994). In addition, SCCT provides a lens through which to assess past choices and their impact on career outcomes (Fouad and Santana 2017). Gender serves as a key SCCT factor in advancement (Lent and Brown 2019). Its structure shows sexism creates barriers for

women and influences career choices (Fouad and Santana 2017). Therefore, women feel the need to continually demonstrate their capabilities and commit additional effort to prepare compared to their male peers (Clayton 2022). This creates an environment pushing women either to other firms or out of the workforce (Knowles and Mainiero 2021), counter to the goal of true diversity.

Impostor Phenomenon

Impostor phenomenon, often referred to as impostor syndrome, encompasses a person's perception of inadequacy to perform the duties of the position they hold (Hawley 2019). More often found in women, even highly successful ones with industry and academic achievement, they feel underserving of credentials earned and praise received (Clance and Imes 1978). In a recent qualitative study, Simon (2020) found women repeatedly expressed doubts in their abilities to complete required tasking. Imposters believe their lack of experience, expertise, and knowledge await notice by the wider group and live under constant strain of imminent exposure (Hawley 2019).

Lack of self-confidence in one's capabilities impacts speed of career progression (Wade 2001). Willingness to advocate for oneself and apply for promotions to entry level management accelerates early advances. Contrastingly, impostor phenomenon impedes the sense of belonging, potentially leading to departure from the field

(Chakraverty 2022). Since women exhibit more hesitancy to self-advocate for their career progression (Wade 2001), these factors contribute to widen the gap between women and men's climb up the corporate ladder. Even successful women in this study expressed internal concerns that they lacked qualifications of their male peers.

Research Methodology and Data

Discussions surrounding gender identity prevail today throughout society and academic study. Authors appreciate the developing narrative and reclassification of gender for inclusiveness of all people. Research performed in this study focuses on the specific gender categories of women and men in development, analysis, and reporting.

Recognizing the richness of available information exploring career stories, researchers selected narrative inquiry to conduct the analysis. This research seeks to learn deeper life experiences of the professional leaders and convert them into industry recommendations to improve diversity. Narrative inquiry's purpose focuses on gleaning insight into the human experience, not necessarily generalizing across a population of people (Saldaña 2021). Therefore, the selected sample size of 20 facilitates a deeper understanding of the phenomena in career advancement.

Narrative Inquiry

Narrative inquiry centers around working with persons' accounts, exploring content to gain storytellers' experiential insights (Barkhuizen and Consoli 2021, Benson 2014). This qualitative interviewing methodology offers an adaptable research technique to gather people's thoughts and perspectives on a wide variety of topics (Prior 2018). This study strove to gather professional narratives from women AEC leaders, with results diving deeply into their professional journeys and experiences. In order to learn anecdotal events from this select group, researchers chose interviews as the format for data collection (McGrath, Palmgren, and Liljedahl 2019).

Construction of the interview format itself impacts the study execution and results. Since investigators develop the setting arrangements, question list, and meeting cadence, they guide the discussion to focus on the desired topics. Balancing the structure while facilitating flexibility permits deeper and wider exploration of the participants' experiences (Barclay, Stoltz, and Clemente 2019). In preparation for meetings, an interview guide comprised of tailored questions provided general structure for data collection (McGrath, Palmgren, and Liljedahl 2019). As a primer, authors wrote one-page Executive Summaries outlining the results from prior research and reviewed the findings with each candidate prior to starting the question section of the discussion.

Sharing a personal account from one's life solicits a measure of emotion connected to the event. Questions in this study extracted career defining moments from the women involved. Recognizing the potential for both positive and negative feelings, researchers strove to create a supportive rapport and demonstrate genuine empathy before, during, and after the interview (Prior 2018). Regardless of the level of expertise or experience of the interviewer, their active participation in the act of recalling stories impacts the shared observations (Barkhuizen and Consoli 2021). Their rapport with candidates, ability to establish an environment of trust, and level of interaction all influence the depth and richness of individual and collective responses. Researchers strove to create an atmosphere encouraging freedom of expression and open exchange.

Positionality

As the principal investigator, Paul Hickey discloses his background and relationship to the studied topic. As a former senior industry leader, Mr. Hickey possesses extensive operational experience in leading large, geographically disbursed teams. Within large corporations, he effectively served as Chief Executive Officer (CEO) of a $60M, Chief Operating Officer (COO) of a $100M, and Chief Financial Officer (CFO) of a $200M business unit. This experience provides insight into comparable daily operation of the participants' firms. Also, his wife worked as a woman engineer in the AEC community for 25 years, serving as the inspiration behind the research.

Despite these personal experiences, Mr. Hickey remains objective in conducting the data collection, analysis, and reporting.

Sampling

Since this research focuses on the AEC field, researchers used purposive sampling procedures to identify women AEC leaders with educational and career backgrounds applicable for this study (Dierckx de Casterlé et al. 2012). Criteria included candidates from ENR Top 400 firms with profiles containing undergraduate and graduate engineering or architecture education coupled with engineering, architecture, or project management experience. Researchers reviewed women leaders' LinkedIn profiles to find and confirm potential participants. Regarding career progression, authors recognize the potential fluidity between engineering and non-engineering (e.g., finance, legal, and business development) career tracks. Notably, practitioners progressing into senior positions regularly trade hard technical expertise for soft people management skills. In fact, some study participants shifted their focus into Diversity, Equity, and Inclusion (DEI), administration, and finance. Despite these late career choices, all candidates possess significant engineering, project management, and / or architecture experience. Maintaining the focus of leadership gender diversity, all invitees held titles of VP or above. Recognizing that individual titles differ between firms, authors applied industry knowledge to establish the VP

level as the minimum organizational level for consideration. In summary, primary criteria for selection:

- Firm - ENR Top 400
- Title - VP or above
- Education - engineering or architecture degree, either undergraduate or graduate
- Career Path - engineering, project management, and / or architecture

Selection of sample size follows no formulaic pattern, rather dependent on the research design and goals (Edwards and Holland 2013). Invitations to 172 women AEC leaders yielded 20 participants who met the study criteria and demonstrated willingness to participate. Participants collectively represent 15 different ENR Top 400 firms with three interviews as the highest total from a single company. While excluded from the study, the significant time commitment and challenge to secure participants underscores the scarcity of women in the overall engineering leadership pool and supports earlier findings.

Interviews

Prior to conducting any interviews, authors received approval from University of Maryland's Institutional Review Board (IRB). Throughout the process, authors complied with IRB requirements to safeguard participant identities and any potential identifying personal information.

Due to the geographic distribution of candidates across the U.S., coupled with limited research budget, researchers elected to conduct interviews via Zoom Video Teleconferencing (VTC). In qualitative studies, VTC offers a cost-effective tool to interact with participants without the need for travel (Gray et al. 2020). Further, this platform offers extensive benefits to researchers through its ability to record, transcribe, and securely store sessions (Archibald et al. 2019). Originally, researchers allocated 60 minutes for individual meetings. However, after the initial two interviews, discussions offered significant depth, exceeding this timeframe. Therefore, authors adjusted the format (McGrath, Palmgren, and Liljedahl 2019), extending the remaining 18 timeslots to 75 minutes. Interviews, all conducted by the primary author to create consistency, included a brief overview of previous research of gender inequity in AEC (Hickey and Cui 2020; Hickey, Erfani, and Cui 2022), followed by semi-structured dialogue guided by a 13 question interview protocol (Table 4-1). While open ended responses offer imperfect measurements (Conrad, Couper, and Sakshaug 2016), this format design strives to learn individual stories and experiences. Semi-structured format allowed researchers to purposefully interact with participants, injecting clarifying and amplifying questions to enable the full richness of participant stories to emerge (Edwards and Holland 2013; McGrath, Palmgren, and Liljedahl 2019) while maintaining flexibility to explore emerging topics (Foley et al. 2021).

Table 4-1 – Interview Questions

Define leadership.
What drove you to select the AEC field? What motivates you today?
Discuss significant experiences and events which facilitated success and created challenges.
At what stage of your career was leadership a career goal?
Discuss the evolution of your leadership perspective throughout your career.
What significant personal skills, abilities, and capabilities facilitated success? Any that required refinement or learning new skills?
Tell me about your experience with recruiting, hiring, and promotions.
How has work / life balance shaped your career perspective?
Describe the impact of your personal / professional network on your growth.
Identify any industry best practices to promote gender diversity.
Discuss evolution of the industry during your career. How have perspectives towards diversity and inclusion changed?
No adverse ramifications, if you had the opportunity to close the door and advise your CEO, what would you say?
You arrive at your undergraduate graduation and place an arm around yourself. What would you say?

Analysis and Coding

Authors applied a robust coding and theming process to transcribe interview data for analysis. Coding applies words or phrases to symbolize concepts and ideas captured in language-based data (Saldaña 2021) and facilitates extraction of a more holistic view of the information (Consoli 2021). In this study, researchers applied inductive coding methods, maintaining an open mind and developing the code to align with actual data (Saldaña 2021), creating an evolving code map. Initially, authors reflected on the collective interviews using the primary 13 questions in Table X-X as top level codes (e.g., “Significant Experiences and Events” and “Work Life Balance”)

in the list. Following completion of the individual interviews, the primary researcher watched the video recording, updating the Zoom transcript to correct any errors and remove identifying information. Specific sanitized items included "[NAME]", "[COMPANY]", and "[UNIVERSITY]". These sanitized versions transferred to another secure, limited access folder for the remainder of the research team to review. Authors then reviewed the cleaned transcripts, adding breadth and depth to the code map as additional concepts and themes emerged. Researchers employed the descriptive method of coding, where labels comprise one word or short phrase (Belotto 2019, Saldaña 2021). Throughout data analysis, authors utilized the CAQDAS NVivo, which offers capabilities to quickly gather, analyze, and report large qualitative datasets, including interview transcriptions (O'Kane, Smith, and Lerman 2021, Saldaña 2021). Understandably, individual responses cover aspects of multiple questions. During text coding, researchers applied care to categorize and group responses consistent with answer content vice initiating question. For example, discussion of significant experiences covered family events highlighted by impact of children. Response components apply both to significant experiences and work life balance and coded accordingly.

Publication constraints limit researchers' ability to convey the extensive time and effort required to assemble, collate, and examine information (Consoli 2021). While not specifically tracked, authors conservatively estimate over four hours for each

interview to identify and confirm the candidate, plan and conduct the interview, watch and clean the video for transcription, and conduct the NVivo coding.

Findings

Accumulating approximately 20 hours of interview results, capturing collective professional career journeys of women leaders, offers an imposing corpus of data. Distilling that voluminous quantity of experiences posed a daunting task. Aligned with the theme of investigating successful career paths and offering roadmaps for early and mid-career women, authors concentrated on methods, behaviors, and choices that generated success for the women in this study. As discussed in the Research Methodology and Data section, authors applied splitting techniques and coded responses at the lowest applicable level (e.g., "Work Life Balance / Family / Supportive Partner") (Saldaña 2021). This captured disparate individual pieces of data related to topics listed under all questions. In evaluating the collective responses, common themes emerged in participants' rise up the corporate ladder including supportive partners, mentoring, and commitment to mission.

Interpersonal Factors and Strategies for Success

Impact of Family - Supportive partner

Genuine satisfaction and well-being require a balance between work and home lives. SCCT's satisfaction and well-being model incorporates family influences (Lent and

Brown 2019). Four decades after identification as the top 1% of mathematics students as children, a study revisited them as adults. Lubinski, Benbow, and Kell (2014) found that women focused more on family and advanced less than their male counterparts, this higher career drag drove more overall departures from STEM fields. However, women pursuing STEM careers achieve greater success when selecting a supportive partner (Barth, Dunlap, and Chappetta 2016). When asked about work / life balance, eight women (40%) in the study specifically highlighted the positive support at home from their partner. One participant shared about the career encouragement she received from her husband:

> "Yeah, and I think my husband always jokes. He's like 'one more promotion [for you and] I get to retire.' … I think there's very few men that would be okay with their, you know, girlfriends or partners or wives being gone Monday through Friday, leaving Monday, coming home on Friday… You see them on the weekends, maybe, and you know we did that for 7 years, and the whole time, you know, my career was just on a completely different trajectory, and the entire time [my husband] was just, you know, my biggest champion.".

Another participant described how she and her partner split home and child care duties: "And then, when we had kids, he was the one who was taking them on the hours long blocks on Saturday and Sunday, when I was either working at the job site

or working at the dining room table." One interviewee shared her husband's commitment as a dedicated stay at home Dad: "My husband has a degree in architecture and he was in the Navy and said hey, 'I'd like to stay home and raise the kids.'"

Impact of Family - Children

Family and Medical Leave Act (FMLA) requires employers to offer unpaid leave of up to 12 weeks for significant health related events, including birth of a child (United States Department of Labor 2022). However, federal regulations abstain on offering paid leave during FMLA periods. One participant lamented older men's negative perception of maternity leave:

> "Parental leave, paid parental leave, I [have been] fighting that battle here. … We were just in throws of this, and you know it is the perceptions of older men who many had stay at home wives, [perceive being] on parental leave like that it's some sort of beach going, bon bon eating vacation."

In their 2022 study, Liu et al. found that industries experiencing a dearth of highly skilled women offer more generous maternity benefits to attract and retain women. To assess applicability to AEC, unavailability of equal access to all companies' benefits plans prevented authors ability to assess impact of family related policies on individual company success.

For study participants, family, specifically children, created a significant impact on career decisions. In preparing the questions, researchers decided to retain consistency with the open style and not ask specifically about children, rather inquiring about work / life balance. Unprompted, 18 (90%) women discussed influence of children on their career progression, one indicated no children, and the remaining one provided no confirmable information. Despite Federal law, company and management reactions differ when learning of a pregnant employee. One participant lauded the support provided by her firm:

> "Yeah, so I have a two year old and a four year old. I will say that my company has been extremely supportive of me … each time I got pregnant, as long as I came to them with a plan of like, just like anyone. If they were gonna be out for three months, hey, I'm gonna be out at this time. Please tell me who is available to backfill [and] I will work with them for a transition plan."

However, in other circumstances, women receive negative or dismissive responses.

> "And when I went on maternity leave, I was on a staff of three. I went to our Vice President at the time, and when we were talking about it, he said, 'So who should I have replace you on the job?' and I said 'No one' and [he] said "Well, how's that working, you're gonna have twins.' 'I'm like, well, I'm well aware that I'm gonna have twins', and he's like 'You don't know what that's

> gonna be like.' [She replied] 'No, I don't and neither do you.' and he said 'Well, how are you gonna, you don't know what you're getting into? How are you gonna navigate to this?' and 'I'm like I have no idea but my ask of you is that you give me a shot.'"

Today's job and career mobility embodies flexible, non-linear paths, influenced by professional and personal choices, including focus on family, whether as a dual income partnership or temporarily opting out of the workforce (Knowles and Mainiero 2021). In their study on gender roles in dual income families, Besen-Cassino and Cassino (2014) found that men earning less than their wives tended to perform fewer household tasks, increasing stress at home and perpetuating the workplace imbalance. A participant suggested that women's propensity for nurturing naturally fills the voids left by partners:

> "You know as much as we strive for gender equity and changing gender roles to be more non-binary, the fact is that women just are more nurturing that that. You know women still are primary caregivers in the household as much as I rail against it in my own household. You know I don't want to be the one who's always making dinner and always taking care of the kids. It falls to me. I think they're just some primal you know this is nature versus nurture aspect to it."

Mentoring

Regardless of profession choice, external forces influence our individual perceptions on capabilities and limitations throughout life, guiding towards or away from specific career fields. Applying social capital from strong ties, inside the close knit group, and weak ties, unique connections outside the organization, offers an expanded pool to draw mentoring relationships (Seibert, Kraimer, and Liden 2001; Alaa et al. 2018; Neumeyer et al. 2019). Especially during the formative years of college into early career, when gendered stereotypes imprint societal norms on vocation (Simon and Clarke 2016). Insufficient or faulty guidance during this period risks curtailing or derailing a promising professional career. Conversely, securing a mentor during these early years promises better outcomes and long-term growth (McDonald and Lambert 2014). 14 (70%) interviewees noted the importance of a supportive supervisor or need for mentorship to facilitate growth:

> "My first boss, he's often [the] one I credit with being hugely important to my overall career trajectory. He put me in a position of leadership on construction projects much earlier than someone normally would have and he also, you know, did not let the fact that I was a woman get in the way of any of those opportunities either."

Symptomatic of impostor phenomenon, one participant offered this advice to her younger self. "I would say, when you land in that office in Florida, find a mentor. Go

to lunch with them or grab coffee immediately, don't wait until you're comfortable or you think you're ready." Outside influences, ranging from nurturing STEM teachers (Lamb et al. 2018) to initial industry supervisors, often redirect early career trajectory. One participant discussed how formalizing company programs creates a culture that promotes opportunities.

> "You know, start early and start talking to people and start mentoring people. And so we have a mentoring initiative where we require everyone on the team to mentor two people who are diverse from themselves. And that means in gender or ethnicity or location that they need to be different from you."

Both in researching this topic and personal experience, researchers recognize the value of quality mentoring, especially at the launch of a professional journey. Continually building and leveraging social capital expands their available professional network. Notably, selection of supervisors resides with company management, not the employee. However, motivation to seek guidance internally or externally from the organization resides within each person. Pursuit of these opportunities throughout a career promises greater returns and performance. One participant credits mentoring with her success: "I would say the day to day coaching and mentoring that I've gotten from my male mentors and advocates here at my company is one of the reasons that I've gotten to where I to where I am."

Organizational Supports and Barriers

Commitment to Mission

Aligning professional pursuits with interests and subsequent job satisfaction forms a cornerstone of SCCT (Lent and Brown 2019). With the growing issues of global resource shortages and climate change, sustainability engineering continues to grow and attract new talent (Klotz et al. 2014). Recognizing the benefits of diversity to sustainability, engineering educators apply a concentrated focus on methods to increase representation (Borrego and Bernhard 2011). In addition, U.S. Department of Labor recognizes the need to increase representation of women. With a particular focus on green industry, "A Women's Guide to Green Jobs" outlines opportunities, required background, and suggested methods to enter the market (United States Women's Bureau 2010). While not a specific question posed during interviews, several women discussed their leadership of environmental related organizations, highlighted by water. As outlined in SCCT (Lent, Brown, and Hackett 1994; Lent and Brown 2019), participants stressed alignment with their interests, job satisfaction, and the overall impact of AEC on the general public. "You really need civil engineers. When, you know, we flood half of Eastern Kentucky, and you can't get clean water to them, and the roads wash out." Or as another participant commented on the positive impact of providing clean water to communities:

> "We use a lot of chemicals for treating wastewater, and the fact that it was such a biological process that there was so much thought and sustainability in it. It really just resonated with me and so I just started specializing more and more into the water and wastewater part of the civil engineering department."

An item for future study, what primary drivers lead women to green fields, a greater draw to nurture or merely a new industry segment without entrenched hierarchy?

Pre-College STEM and Directed STEM Scholarships

Homophily, identifying with one's own type or "someone who looks like me", attracts more members of that common group, creating bonding social capital (Alaa et al. 2018). Existing dearth of AEC women repels potential girl entrants even before they reach college. One participant highlighted the impact of the next generation seeing successful women actively participating: "So the girls are seeing girls, women at [COMPANY] in engineering, doing those things so they can see. … It isn't just guys showing me I can do that." Sometimes basic knowledge of the industry poses a barrier to entry, even women in this study themselves remained unaware of AEC's opportunities until college. This phenomenon persists today as one participant commented on the lack of basic industry knowledge:

> "We're finding that maybe there are girls who don't even know that [AEC is] an option, and don't even realize … That it is something to do and the

qualities that they could identify in themselves. That would make it seem like it's a good fit for them.”.

Intentional Recruiting and Internships

Exposing a wider population to company openings only expands the available talent pool. Returning to the same, familiar sources produces similar results, diminishing the proven benefits of diversity on business financial outcomes (Poletti-Hughes and Briano-Turrent 2019). Adding non-traditional sources generates fresh perspectives. One interviewee lauded her firm’s efforts to seek non-traditional candidates:

> “I'm particularly excited about an opportunity which we're endeavoring, and right now with one of our brands, which is to intentionally go out to five HBCUs (Historically Black Colleges and Universities), and to reach out to their professors, learn about their students.”

While individual managers may exhibit a broader perspective, reinforcement from leadership establishes a common goal across the organization. Another interviewee maintained the balance between selecting the best applicant while injecting new sources into the process: “I always feel like I'm gonna try to hire the best candidate. I do challenge my team to look for female and male candidates for us to interview.” Regardless of the underlying approach, bottom line business outcomes remain high priority for women practitioners: “But I think that the worst thing that can be done is

to lower your standards for any reason to hire somebody based on gender. I think it creates bias [where] bias didn't exist."

Create an Inclusive Culture

Negative perception of working mothers provides faulty justification of gender discrimination (Verniers and Vala 2018). Aligning with SCCT's components of satisfaction and well-being (Lent, Brown, and Hackett 1994; Lent and Brown 2019) to execute successfully, subjugating women's needs diminishes the feeling of self-worth. Designating an accessible, secure location for personal needs offers a sanctuary for all employees. One respondent noted that she established a dedicated room in the job site trailer, labeling it for non-work usage. This space remained open for any activity, including nursing mothers, religious practices, and meditation.

> "So you know the quality of the restroom facilities, the set aside of a room or nursing moms right out of the gate. You don't need to call it nursing moms' room. But you can call it [a] personal room for reflections, or something where anyone on the team could utilize the space for a non-work related purpose."

Another interviewee commented on the shame of sitting in her car covering up while pumping for her newborn. "No woman is gonna sign up for that. … Yeah, that's what I want to be hiding under a blanket in my car in a parking ramp."

Government and Private Client Issues

As with any industry, selection for progressively greater responsibility requires expertise in the chosen field. Typically, gaining pre-requisite experience requires performing in similar and complementary roles. However, when the overall structure limits or even prevents access to those interim opportunities, long-term growth slows or stalls. A few respondents mentioned the impact of client desired change on company and industry evolution, "They want a diversity spend on their projects." However, government and private clients share a portion of the burden. Issuing Request for Proposals (RFPs) with restrictive personnel requirements stifles innovation and limits bidding and execution flexibility.

> "DOT (Department of Transportation) puts out a project where the project manager has to have 40 years of experience and built this type of bridge that's only built twice in the last 50 years. … I'm not saying it's impossible to find a woman that meets those criteria, but it's very difficult."

Diversity Program / Officer

Firms with a public commitment to diversity, designated as a specific message of inclusion or diversity on their company website, almost doubled the percentage of executive women engineering representation at their firms (3.2% to 6.2%) (Hickey and Cui 2020). While those results suggest increasing the firm's visible commitment

generates improvements, establishment of a formal diversity program / officer signals application of tangible financial resources. However, transparency and accountability, or lack thereof, form opinions from the employee base on the overall effectiveness, potentially generating negative backlash. "So our company has a DEI task force…That task force really just lives in a bubble. … We don't even know what the damn mission or vision is with the task force."

Discussion and Implications

Documented benefits generated through overall diversity include better financial performance, greater innovation, and more cohesive workplaces (Devnew et al. 2018, Pritchard and Miles 2018). Further, with the construction industry facing significant staffing shortfalls (Associated Builders and Contractors 2022), excluding over half of the U.S. population from primary recruiting and retention efforts promises a difficult task to meet personnel goals. This study explores the representation gap between women and men, underlying root causes, and recommendations for improvement.

Authors emphasize that responsibility for changing the paradigm and expanding opportunities for women resides with industry firms and imply no implication that women created the disparity in representation or assume responsibility for implementing improvements.

Risk of Negative Response

While formal initiatives offer positive benefits, risks of negative backlash exist to the targeted demographic groups. Industry as a whole and individual firms directly impact operating workplace environments to reinforce or counteract well intentioned programs. Adopting a long-term view aimed at recruiting, nurturing, and career progression promotes a more balanced workplace and retains qualified talent. As with any implementation of this type, concerns exist surrounding adverse responses from other population sub-segments, especially the dominant group. Establishing formal programs risk creating doubt surrounding the effected group's capabilities. One person cautioned about the potential ramifications: "I think it creates a level of doubt or makes people think [you] got where you are because you're a female, or you're a minority. … I would joke that I'm the token female on interviews." For well-intentioned programs, resultant overinvolvement for the few women leads to disproportionate "extra" work, transforming a positive intent into further consistent career drag. Another participant warned about the potential adverse impacts on the organization's culture: "And it's something that can do more damage than good." Regardless of the positive intentions, each organization must evaluate and tailor actions to align with their respective circumstances.

Recommendations for Women Practitioners

Seek Mentorship

Mentorship, both formal and informal, offers insight from more experienced professionals and provides accounts of lessons learned from a lifetime of experience. Interviewees highlighted the benefits gained from supportive supervisors, complementary technical and business subject matter experts, and career coaches. When connected in a non-supervisory relationship, protégés gain valuable feedback without the specter of negative performance appraisals. While beneficial at any career stage, early pursuit of sponsorship promises to accelerate growth and accumulate connections within the organization.

A key life transition, joining the workforce presents a different dynamic for new professionals after a lifetime of schooling. Supervisors' primary focus remains on project delivery, not delivering regular feedback and encouragement normally received from teachers and professors (Barger 2015). However, targeted mentor programs for underserved groups derive successful outcomes by offering common communities and guidance for future decisions (Wadia-Fascetti and Leventman 2000). Particularly important for women, these programs help off-set exclusion which otherwise occurs through establishment of natural mentoring relationships (Wadia-Fascetti and Leventman 2000).

- Join an industry association (e.g., Society of Women Engineers) and volunteer for a committee, expanding the professional network while creating an impact on the industry.
- Form a relationship before asking for career advice. Sharing capabilities, gaps, and goals first allows the mentor time and background information to formulate a more tailored set of recommendations.
- Assemble a team of formal and informal mentors, including peers, to gather different perspectives. Whenever possible, include women in the circle to learn from their unique experiences. Further, respect senior mentors' time and only utilize their expertise for important career questions.
- Leverage male allies to expand network connections to senior leaders, clients, and other influencers. Applying social capital transforms cold calls to warm handoffs, generating new ties to key power brokers.

Invest in Supporting Personal Relationships

Assembling a group of family and friends offers a positive network who understand and support career goals. They act as a sounding board and buffer from the workplace stresses and politics. Identifying people with shared goals and mutual support negates the need for a binary decision between career and family success (Barth, Dunlap, and Chappetta 2016). Study participants mentioned the invaluable benefits from their partners' assistance in gaining freedom to pursue their career

goals. Authors recognize that selection of a life partner represents a deeply personal decision and resides outside of the scope of this study. However, career minded women may want to reflect upon SCCT principles, understand the value of family impact on their own well-being (Lent and Brown 2019), and incorporate that into the personal criteria set when evaluating important life decisions.

Bolstering one's support system includes maintaining social capital bonds through both personal and professional connections. In the workplace, male allies offer avenues to leverage social capital (Madsen, Townsend, and Scribner 2020). Men risk less in advocating for women, possess more clout in the organization to create change, and provide an example for fellow men (Madsen, Townsend, and Scribner 2020).

- Build a supportive personal network independent of work. This provides an opportunity to share thoughts, feelings, and experiences without potential political repercussions.
- Cultivate professional relationships with male allies, especially organizational leaders. Men demonstrating interest and support for women's advancement heightens visibility and the potential to alter other's perspectives.
- Overlapping with mentoring, seek a career coach for unbiased performance assessments. Obtaining external advice provides non-punitive feedback, including recommendations on obtaining work / life balance.

Recommendations for Companies and Clients

As this study maintains a focus on generating positive change in the industry, inquiry included thoughts on best practices and recommendations to promote diversity. Since men comprise the bulk of leadership teams, too few women possess sufficient power to enact change (Madsen, Townsend, and Scribner 2020). This requires a collaborative effort to generate positive transformation.

STEM Scholarships

Funding directed programs and targeted college scholarships offer opportunities to increase visibility, interest, and openings to pursue AEC as a career choice. Partnering with local schools and launching directed STEM programs with active participation by professional women introduces positive role models. Soliciting non-traditional population segments and geographic locations expands the pool of candidates. While anecdotal and in a different industry, directly due to discussions on gender diversity efforts, a professional colleague of the primary author redirected their company's existing STEM scholarship donation to focus on qualified young women. These incremental steps accumulate into positive change.

Funding without accompanying support merely offers the individual student an initial opportunity, not a means of success. Lack of a comprehensive program plan, including academic guidance and tutoring, leaves each person dependent on their

existing skills and knowledge to navigate through the college experience. In their study of STEM scholarship recipients, Ononye and Bong (2018) found supporting academic and enrichment programs increase retention and graduation rates. Implementation of a full complement of program aspects, starting with initial welcome to campus through graduation, promises greater performance.

- Welcome orientation and social gathering to connect the STEM cohort and generate a peer support system from the beginning of their academic career.
- Regular (e.g., weekly) academic sessions with a dedicated advisor to track progress, including performance reports from all professors to drive accountability and allow early intervention.
- Establishment of a tutoring center dedicated to the STEM cohort, providing continuity of support throughout their course of study.
- Invitation of topical guest speakers to augment classroom learning, highlighted by working STEM alumni and industry leaders, to discuss application of concepts to industry projects.

Intentional Recruiting / Internships

While natural for firms to recruit their respective alma maters due to familiarity, this perpetuates homophily and risks stagnating the company's culture. Maintaining the predominantly white male image creates a perception that those deviating from societal norm are incongruent from engineering, driving them from the industry

(Ross, Huff, and Godwin 2021). As discussed under to STEM scholarships, seeking applicants from varied schools, cultures, and even other industries, injects new perspectives and methods of approaching problem solving. One participant shared their success story of increasing women's representation to over 50% by actively participating in job fairs. Later, her women protégés reinforced the organization's inherent diversity by staffing the recruiting tables at events. These propel the firm forward to face the evolving challenges of society.

Exiting college and progressing into the workforce involves pursuit of new career opportunities. With the notable exception of graduates securing positions through pre-existing connections or prior internships, most newly minted graduates participate in a parade of interviews and meeting multiple firms. Recruiting framework followed by technology companies promotes participation by men, relegating women's contributions and ultimately job opportunities (Wynn, and Correll 2018). To disrupt the status quo, firms must reevaluate messaging, both verbal and non-verbal, communicated during the recruitment and hiring process.

- Comparable to recommendations outlined in the STEM Scholarship sub-section, establishing a formal structure to the intern program, including a welcome meeting with company leaders and regular group meetings reinforces the cohort's community feel and increases the positive experience. Creating a similar program for early and mid-career new hires offers a

foundation for their long-term growth, reducing turnover and retaining corporate knowledge.

- Participate in job fairs and events by bringing a diverse team to the recruiting table. Women seeing women in key engineering roles, not just recruiters, creates positive homophily, attracting like for like.
- Remove gender-stereotypical images (e.g., Star Trek, sports, or video games) from presentations and marketing materials. These portrayals reinforce male oriented culture discourage women from pursuing STEM careers.
- Rewrite job descriptions to deemphasize technical experience and insert inclusive language. For example, a firm added "nurture" to the narrative, creating a more balanced job advertisement.

Create an Inclusive Culture

In general, establishing a company culture accepting of everyone's beliefs and needs promotes a welcoming environment that facilitates the benefits of diversity. However, firms need to overcome any existing negative predetermined viewpoints by its workforce. Understanding and dismantling roadblocks for women's advancement, requires awareness of unconscious bias prevalent in the company, especially any held by leadership (Madsen, Townsend, and Scribner 2020). A prevailing bias centers around working parents. Raising children creates a disproportionate impact on working mothers, perpetuating justification behind gender inequalities (Verniers and

Vala 2018). Destigmatizing motherhood as a deterrent reduces mid-career talent losses.

More specifically, leaders designate a location, especially on the job site, for all employees to use for non-work related activities, whether parenting, religious, or meditation needs. Offering this space promotes inclusiveness and eases workplace angst that might otherwise drive away early and mid-career employees.

- Designate a dedicated space for employee non-work commitments, one with privacy and a door. AEC firms face a unique situation where workplace locations often reside in work trailers on remote job sites. Assign a room where nursing mothers, religious practitioners, or employees performing self-care activities satisfy their respective needs without impacting the job site or creating a negative stigma.
- Actively recognize the accomplishments of women leaders and practitioners. Integral to SCCT's model of satisfaction and well-being (Lent and Brown 2019), receiving deserved praise and awards promotes feelings of self-worth. Further, women seeing women succeed promotes a belief of long-term success and greater connection to the organization.
- Educate senior leadership on the benefits of diversity. Hire an external diversity expert to detail the positive impact of differing viewpoints on greater innovation, higher client satisfaction, and better business outcomes.

- Expose women to learning more about business operations, including leadership decision making processes, key input data, and strategic planning. Assign women to more leadership roles on committees and task forces. This active promotion not only increases individuals' experience for larger roles, but also normalizes the perception of capable women in key roles across the organization.

Diversity Program / Director

Firms publicly committing to diversity show higher integration in their executive suites (Hickey and Cui 2020). Establishing a diversity program further demonstrates a definitive fiscal pledge by dedicating resources. Accompanied by a transparent mission and program goals, firms send a clear message to their employees, clients, and vendors regarding their commitment to diversity. Companies embracing proactive views and adoption gain competitive advantages over otherwise stagnant competitors and position themselves for the challenges ahead.

Diversity officers guide efforts to devise, create, implement, and monitor diversity as an organizational resource (Williams and Wade-Golden 2007). Comprehensive diversity programs encompass culture, leadership development, supplier procurement, and external relations (Worthington, Stanley, and Lewis 2014). Purposeful implementation requires leadership support, transparency of its mission and vision

statements, and active interaction with all levels of the firm. Organizational assignment reporting directly to the executive level ensures that issues receive proper visibility and oversight (Williams and Wade-Golden 2007).

- Recognize and understand the benefits of diversity, highlighted by greater employee and client engagement and better business outcomes. This appreciation of the positive contributions to the firm's core missions generates greater adoption by leadership and resultant executive sponsorship.
- Establish a multi-year budget line item to support the office. Assigning complementary duties to a current manager or Human Resources (HR) representative doom the program to become a secondary responsibility. Authorizing a single year risks the ability to hire a qualified professional and signals leadership's limited commitment to the initiative.
- Instill policy enforcement power to the diversity officer and publicize throughout the organization. Authority grounded in persuasion and reporting limits the impact of the role and mission. Experienced managers recognize lack of genuine power and understand how to navigate around unenforced policies.
- Align the office with both Recruiting and HR, to proactively monitor hiring, personnel reviews, raises, and promotions. This integrated effort promotes diverse initial recruiting and internships, carried through the career progression and retention.

Reevaluation of Proposal Requirements

Embracing new ideas and methods to align with 21st Century technological advances through RFP modernization offers new opportunities for the next generation of professionals, both women and men. Reevaluating overly restrictive requirements, (e.g., 40 years of experience and expertise in a highly specialized technical area) expands offeror's flexibility in providing innovative solutions. Resultant opening of the aperture to fill key personnel billets not only improves the chances of current women, but also signals the next generation that long-term career advancement exists.

- Reevaluate RFP conditions, highlighted by personnel requirements. Assess whether key technical specifications must be assigned specifically to the project manager or possessed by the larger team. This injects flexibility into company proposal offerings with a different mix of management and technical teams.
- Clients often drive industry change, including clauses requiring diversity spend on contracts. Depending on RFP terms and conditions, Federal solicitations contain clauses requiring minimum subcontractor and vendor diversity award levels (e.g., women owned). Customer addition of personnel diversity targets injects an external stimulus to hire and promote women.
- Aligned with internal company position descriptions, restructure contract language to replace male centric terms with gender neutral phrasing. This

counteracts unconscious bias against women, encouraging firms to assemble more balanced teams.

Conclusion

This investigation researches AEC leadership gender diversity. In-depth interviews with 20 women senior professionals, VP and above, explored successes, challenges, and significant events impacting their career journeys. Semi-structured discussions, framed with open ended questions, extracted the richness of individual stories to create a full corpus of professional experiences. This study's construct targeted better understanding of underlying reasons for women's underrepresentation.

In developing a roadmap for early and mid-career women, identification of successful activities of current leaders provides suggestions to implement in their own climb up the corporate ladder. Key emergent themes developing a support system and seeking early mentoring. However, long-term career progression requires company support and actions to retain women in AEC. Establishing a diversity program, fostering an inclusive culture, conducting intentional recruiting of young women, and funding pre-college girls STEM programs and scholarships promise to increase initial entry and lower early departures rates.

In devising the study methodology, investigators maintained a dual focus on both the current effort and expanded future research. With streamlining and automation, applying study construction to deeper levels of the organization (e.g., middle management through junior engineers), underserved groups (e.g., race or ethnicity), or industries (e.g., finance or medicine), further expands the impact of the research. As mentioned throughout the manuscript, researchers sought to create a positive impact on gender diversity in AEC. Authors intend to continue publicizing findings through participation in conferences and direct solicitation of industry firms.

Chapter 5: Conclusion and Next Steps

Summary of Research Findings

Constructed utilizing the three-paper model, this dissertation consists of three distinct, yet interconnected, phases of research into Architecture, Engineering, and Construction (AEC) leadership gender diversity. As such, Chapters 2 - 4 each detail results from an expanding and deepening investigation, building on the prior studies to explore beyond the quantified state of practice to explore underlying drivers and methods to create positive change. In consideration of the imbedded conclusions in the preceding chapters, this piece offers a short summary with a focus on future activities to expand the impact of this research. As explored in the previous sections, benefits of diversity extend to individuals, firms, industry, and beyond to customers and the general public recipients of AEC projects. In general, diversity infuses new perspectives and methods of thinking, generating innovative ideas to propel AEC into the 21st Century. At the more practical level, AEC faces significant workforce shortages, with 650,000 vacancies in 2022 with risks of expanding further when faced with impending large scale employee retirements (Associated Builders and Contractors 2022).

Gender Diversity in the U.S. Construction Industry Leaders (Chapter 2) - This study started by quantifying executive team gender composition of the largest AEC firms. Using industry recognized 2018 Engineering News Record (ENR) Top 400 civil engineering and construction firms listing, researchers extracted leadership information from the company self-published websites, subdividing women and men into engineering and non-engineering (e.g., finance, marketing, and legal) billets. Women comprise over half of the U.S. population and 21.5% of the civil engineering graduates over the past 24 years. When viewing the industry as a whole, including non-engineering billets, women fill 9.9% of total industry positions. However, when narrowing the focus on executive engineering positions, researchers found that women fill only 3.9% billets (decreased to 3.5% in 2020). Figure 5-1 displays the stark differences between women and men on the path to AEC leadership.

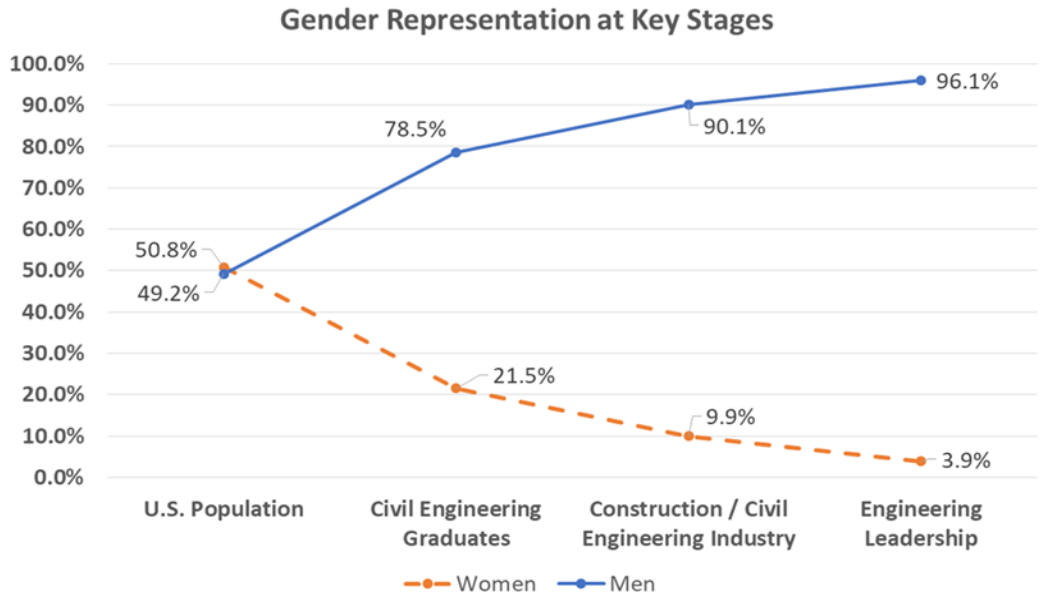

Figure 5-1 – Gender Representation at Key Stages (Chapter 2)

As shown in Figure 5-1, contributing factors to the “leaky pipeline” occur from prior to college throughout professional careers. Key drivers of losses of women from AEC include:

- U.S. Population to Civil Engineering Graduates
    - Primary and secondary education age girls lack basic awareness that AEC offers a viable career option. Women in this study remarked on the scarcity of industry data during their formative educational years.
    - Young girls see few women role models in AEC and someone “who looks like me”. This discourages any feelings of homophily, one’s tendency to seek groups similar to themselves.
- Civil Engineering Graduates to Construction / Civil Engineering Industry
    - Male centric interview structure for entry level STEM positions drives qualified women from AEC even prior to initial entry.
    - Applicable for all phases post college, prevalent factors created by the male dominated culture drive early and mid-career women from the industry. Hostile work environment and sexism apply consistent pressure on professionals.
- Construction / Civil Engineering Industry to Engineering Leadership
    - Disproportional responsibilities in childcare generate career drag, including transitions to other industries or temporarily leaving the

workforce. Even our successful study participants noted the impact of children on work life balance.

- Greater number of rungs on the corporate ladder requires women to hold more positions and experience higher career mobility. Despite additional education and larger networks, inertia of the long standing industry status quo limits women's growth to the c-suite.

Use of LinkedIn Data and Machine Learning to Analyze Gender Differences in Construction Career Paths (Chapter 3) - As the second stage of this continuing investigation into gender diversity in the AEC leadership, deeper analysis evaluated the career paths of 2,857 LinkedIn members (422 women and 2,435 men). Using ENR's 2019 Top 400 list, researchers compiled leadership teams from leading firms and cross referenced with published LinkedIn summaries to ensure accurate data collection. Analysis of LinkedIn summaries assessed career differences between genders for number of companies, position titles, education, and network size.

Results of this study found women only fill 3.5% of executive engineering leadership (down from 3.9% in 2019) and 4.9% of total senior engineering positions. In the sample, women demonstrate higher career mobility between companies (+56%), hold more career titles (+19%), earn greater numbers of advanced degrees (53.9% to 31.2%), and gather larger professional networks (+14%), yet fill fewer leadership

positions (14.8% to 85.2%) (Figure 5-2). Further validating the differences in women and men's career paths, researchers applied Machine Learning (ML) to accurately predict gender of LinkedIn profiles 89.53% of the time. Women face greater obstacles than their male counterparts in career advancement in the industry. Their path requires extra rungs on the corporate ladder, more frequent job changes, and greater accumulation of education and connections.

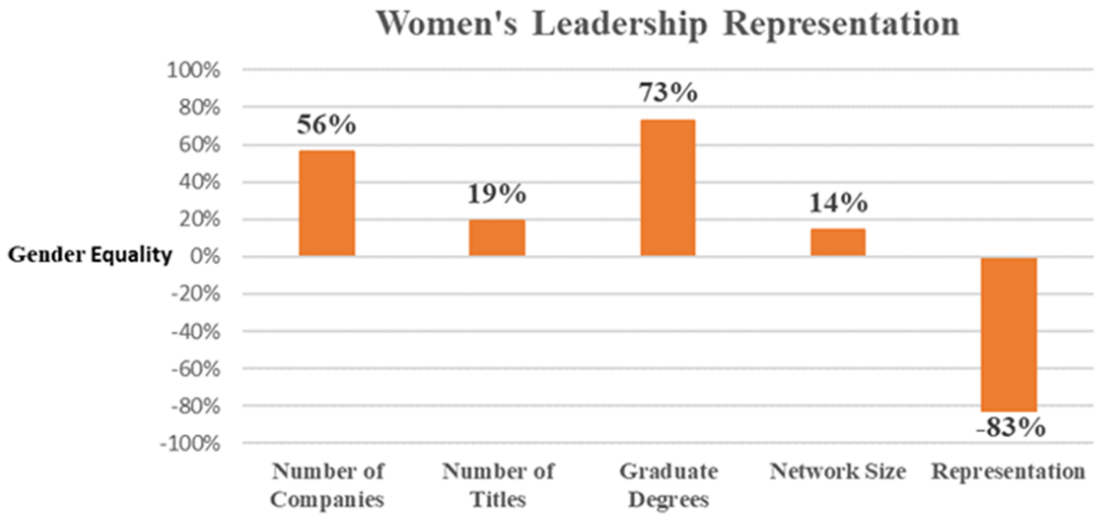

Figure 5-2 – Women's Leadership Representation – LinkedIn (Chapter 3)

Pathways and Barriers – Journeys of Women Architecture, Engineering, and Construction (AEC) Leaders (Chapter 4) - Culmination of this three stage doctoral study into AEC leadership gender diversity, this investigation explores the career professional journeys of 20 women leaders, Vice President (VP) and above. Selected from ENR's 2021 Top 400 firms, these women shared the richness of their stories, discussing successes, challenges, and significant experiences impacting their path up

the corporate ladder. Resultant corpus of responses tested earlier findings to assess underlying root causes for women's underrepresentation in the industry. Maintaining the multi-phase theme of developing a career roadmap for early and mid-career women, discussions sought best practices for deployment across AEC to improve diversity via initial recruiting and long-term career nurturing. Participants highlighted success drivers including investing in supportive personal relationships, early mentoring, and passion for the project mission.

Knowledge Contribution and Implications

Evidence suggests that increasing women's participation on executive teams leads to value through fresh perspective and ideas, enhanced relationships with stakeholders, higher innovation, greater creativity, and a better bottom line. Concurrently, AEC industry faces labor shortages due to looming retirements of half the workforce. U.S. Department of Labor reported women fill 9.9% of all industry positions in 2019 (since increased to 10.9% in 2020). Since women comprise 50.8% (since decreased to 50.5%) of the U.S. population, the field effectively excludes half of the potential current and future workforce.

Confirming the previously held anecdotal perception that men dominate the AEC executive suites, this study offers a state of practice assessment of the industry. Active recruitment and expansion of women's membership, highlighted by middle,

senior, and executive management, offers potential solutions to address workforce shortages and improve business outcomes. Fundamental changes highlighted by firms publicly promoting inclusion and altering recruiting methods promise to create more diverse environments. In addition, review of successful segments currently showing higher diversity totals (e.g., ENR Top 100 Green companies) likely gleans additional insights for new training programs and policy changes. Ultimately, underlying factors deterring women from joining or remaining in the field: male dominated culture, conflict and aggression, slow advancement compared to male peers, and work family balance must be addressed. Recommended actions to reverse the trend: active executive engagement, equal opportunities for key positions, and directed mentoring.

Collating and categorizing the activities and career paths of individual and collective executives offers insight regarding successful experiences, skills, and choices to reach leadership roles. This creates a roadmap for current and future early and mid-level professionals to model their own vocational journey and accelerate progression up the corporate ladder. Demonstrating long-term career potential for underrepresented groups promises to attract new talent while retaining current professionals to expand the potential workforce and offset the projected labor shortages in the industry.

When viewed through the long lens, retaining women in the industry requires contributing external factors. In order to differentiate themselves and gain innovation and better business outcomes benefits offered by diversity, firms should consider establishing a diversity program, designating on-site safe spaces for non-work related needs (e.g., nursing, religious, or meditation), conducting intentional recruiting of young women, and funding pre-college girls Science, Technology, Engineering, and Math (STEM) programs and scholarships promise to increase initial entry and lower early departures rates.

During this on-going research, authors shared results by presenting at academic and industry conferences. Venues included the Construction Research Congress (CRC) 2020 and 2022 respectively for Gender Diversity in the U.S. Construction Industry Leaders (Chapter 2) and Use of LinkedIn Data and Machine Learning to Analyze Gender Differences in Construction Career Paths (Chapter 3). A primary focus of these efforts remains to generate positive impact by opening opportunities for women at all career stages and documenting successful career paths. Therefore, authors accepted industry invitations to share data with Groundbreaking Women in Construction (GWIC) 2021 and Maryland Center for Construction Education and Innovation (MCCEI) 2022. This parallel focus supports the academic integrity of the process while connecting directly with the industry agents of change.

Research Limitations and Future Directions

As this dissertation culminates and researchers evaluate the next steps to galvanize the academic findings into concrete change, authors envision founding a diversity center of excellence in the University of Maryland Engineering School. A portion of this study captured, collated, and developed recommendations for industry best practices. Even within the largest firms, gender diversity decreased with revenue size. While untested, trends suggest smaller firms offer even fewer opportunities for women. Codification of a set of flexible processes and procedures could be shared with AEC firms, beyond the ENR Top 400 sample, to companies lacking the resources to invest in unproven programs. Further, aligning with the evolving societal discussions on diversity, this center expands beyond gender, addressing disenfranchised segments of the population. Preliminary work on a Diversity Index began concurrently with this study to rank firms' diversity success (e.g., Best Places to Work). Formalization and ultimate publication of this index would enhance University of Maryland's standing as an academic leader in the field of diversity.

A key element not yet discussed, methodology for the entire study offers portability to other demographic classifications (e.g., race or ethnicity) or engineering fields (e.g., mechanical or electrical), or industries (e.g., finance or education). As expected with any new process, initial implementation posed efficiency challenges and lessons learned for the research team. Ability to evaluate, streamline, and automate the data

collection and analysis will determine whether this methodology efficiently ports over for wider usage.

This investigative journey into AEC leadership gender diversity began as a personal tribute to my wife and her own fight through the industry against many of the same circumstances discussed throughout this dissertation. Throughout, response and support from academic and industry groups, both women and men, provided the inspiration to continue. Ultimately, the goal of this research remains to generate positive change in the industry. Continued publicization of findings and translating recommendations into industry action offer the next challenge for increasing the impact of this study.

Appendix A – NVivo Codebook

Name	Description
Additional Thoughts	Opportunity for candidates to share any thoughts not otherwise covered during the interview.
Advice at Graduation	Top level interview question - You arrive at your undergraduate graduation and place an arm around yourself. What would you say?
Ask for More	Encouraging their younger self to be more self-promoting and pursue opportunities.
Create Your Brand	Develop their own identity as defined by their skills, ability, and drive.
Education	Pursue additional certifications and education, including graduate degrees.
Enjoy the Ride	Have fun! Challenges are ahead but remember to appreciate the moment.
Evolve	Reliance on existing skills, abilities, and perspectives risk stagnating your career.
Find a Mentor	Pursue subject matter experts, both technical and business, to learn from their experiences.
Persevere	Regardless of the challenges ahead, maintain a focus on the long-term goals and continue to forge ahead.
Take Risks	Willingness to accept new responsibilities and assignments regardless of the perceived unknowns.
Best Practices	Top level interview question - Identify any industry best practices to promote gender diversity.
Accurate Representation of Company	Programs should align with actual company performance and not project an inaccurate view.
External Consultant Evaluation	Obtaining an objective assessment of the company's programs.
Formal Program	Establish a formal program to capture and implement best practices.
Competing with Other Programs	Gender diversity initiatives risk competing for limited resources with other programs.
Employee Resource Groups	Establishing Employee Resource Groups targeted for specific needs or requirements.
Publicizes Company Commitment	Creating diversity programs sends a clear message regarding leadership's commitment.

Name	Description
Risks Negative Response	Formalization of targeted programs may generate adverse reactions from the general company population.
Succession Planning	Identification of the next generation of leaders, including diverse candidates.
Tailored for Each Firm	Programs need modification to match the individual culture of the company.
Training	Offer diversity training for all employees, including leadership to promote an inclusive environment.
Intentional Recruiting	Concentrate recruiting efforts on non-traditional groups (e.g., women's colleges).
Mentor Program	Establish a company program to guide early and mid-career practitioners.
Pre-College STEM	Participate in elementary and secondary schools and clubs (e.g., Girl Scouts) programs to promote STEM for girls.
Publicizing Metrics	Share diversity statistics within the firm and publish on your website.
Sharing Across Industry	Identify best practices and programs that generate positive change and share with industry firms.
Targeted Events	Establish and support specific diversity events (e.g., International Women's Day).
Work Environment	Discussion about the workplace and influencing factors.
COVID	Impact of COVID on the work and family.
Flexibility	Ability to adjust schedules and work locations, including working from home.
Job Site	Factors relating to the physical on-site job locations.
Leave Policy	Company implementing leave policies more aligned with family and childcare needs.
Define Leadership	Top level interview question - Define leadership.
Common Goals	Establishing and communicating project and organizational objectives to the team.
Confidence	Demonstrating and instilling confidence in the team and their capabilities.
High Level Perspective	Maintaining a focus on the big picture and long-term goals of the organization.
Inspire Team	Lifting individuals to achieve more together than they would be otherwise capable of individually.

Name	Description
Provide Guidance	Impact technical and business knowledge to the team, instructing them on project activities and career goals.
Servant Leadership	Focus primarily on the growth and well-being of people and the communities to which they belong.
Discussion with CEO	Top level interview question - No adverse ramifications, if you had the opportunity to close the door and advise your CEO, what would you say?
Direction of the Company	Discussions concerning future goals of the firm.
Implement Diversity Group	Recommend creation of a targeted diversity program.
Insufficient Progress	Firm needs greater promotion and action to change the culture.
Level of Support	Direct comments on the CEO's contribution to their own growth.
Appreciation	Positive support from the CEO.
Mixed Signals	Inconsistent support from the CEO.
Need to Create Environment of Inclusion	Culture at the firm needs to evolve to meet the needs of the greater workforce.
People Orientated	Policies and environment align with the needs of the employee base.
Drivers for AEC Career Choice	Top level interview question - What drove you to select the AEC field? What motivates you today?
Commitment to Mission	Connection with the project objectives and resultant reinforcement of the benefits on their career choice.
Converted from Another Field	Migration from a non-engineering field into AEC.
Family Connection	Prior generations worked in AEC.
Growth Opportunities	Identifying long-term career opportunities.
External to Company	Job openings at other firms or industries.
Internal to Company	Growth with their current firm.
High School - College Advisor	Support from academic sources to encourage them into AEC.
Higher Percentage of Women	Specific industry subsectors that attract more women.
Internship	Participated in interesting internships prior to graduating college.
Proficient at STEM	Displayed a natural propensity for STEM education.
Working Environment	Discussions on the workplace environment.

Name	Description
Excitement of Working in the Field	Interest in a dynamic workplace.
High Energy Environment	Appreciation of the vibrant energy of construction work.
Remote Opportunities	Ability to more between geographic locations to support projects.
Evolution of Leadership Perspective	Top level interview question - Discuss the evolution of your leadership perspective throughout your career.
Balanced Team Composition	Assemble a team representative of society.
Directing People	Provide guidance and clear definition of organizational requirements.
Inspire and Support	Offer a positive example for the team and listen to their needs.
People Orientated	Focus on team and their needs.
Project Orientated	Focus on projects and client needs.
Watch and Learn from Others	Observe existing leaders and glean lessons learned from their success and failure.
Industry Evolution	Top level interview question - Discuss evolution of the industry during your career. How have perspectives towards diversity and inclusion changed?
Client Driven Change	Company responding to customer needs, either through formal RFPs or adjusting to meet their profiles.
Driven from Top Down	Leadership assuming responsibility for change and clearly communicating to the workforce.
Generational Impact	Mixing of multiple generations and their respective perspectives.
Older Generation	Attitudes of experienced workforce, including views developed before recent diversity emphasis.
Younger Generation	New entrants into the workplace, possessing different perspectives on diversity.
More Balanced	Industry offers a better environment than past generations.
Need Faster Progress	Progress has been insufficient.
Sexist	Male dominated environment persists today.

Name	Description
Tolerance of Others	Need for the environment to be accepting of others' views.
Leadership as Career Goal	Top level interview question - At what stage of your career was leadership a career goal?
Always a Goal	Leadership positions were a goal from the beginning of their career.
Created New Position	Company created a new job or division.
Insufficient Progress	Career progression has been too slow.
Natural Progression Through Advancement	Leadership was not a necessarily a goal, but their rise through the ranks led to senior positions.
Need to Possess All Qualifications	Felt the need to accumulate sufficient skills before seeking the next promotion.
Shift of Responsibilities	Career change between technical and non-technical responsibilities.
Technical Leader	Focus on technical efforts, not people oriented leadership.
Networking	Top level interview question - Describe the impact of your personal / professional network on your growth.
Developing Connections	Collecting professional relationships to increase network.
Diversity	Large network due to geographic and career movement.
Exclusion Due to Gender	Male co-workers developing exclusive groups.
Insufficient Time	Concentrated on actual work performance, not creating connections.
LinkedIn	Discussions on use of LinkedIn.
Professional	Targeting connections for benefit of the company goals.
Purposeful Selection	Very selective in assembling their network.
Social Interaction	Introverts find cultivation of connections exhausting.
Team Building	Creates a team environment.
Organizational Structure	Comments relating to the company leadership composition.
Entrenched Hierarchy	Long standing leadership team limits advancement.
Family Owned	Advancement limited due to family ownership.
Field Personnel vs Office Staff	Conflict between different attitudes inside the organization depending on role.

Name	Description
Homophilia	Hiring those who look and feel like me.
Open Opportunities	Firm places performance and capability first.
Women Dominated Segment	Area contains a higher percentage of women.
Women in non-Engineering C-Suite Roles	Selection of women to finance, legal, or other non-engineering positions.
Recruiting, Promotions, and Hiring	Top level interview question - Tell me about your experience with recruiting, hiring, and promotions.
Available Pool	Discussion on methods to identify candidates.
Continue Targeting Same Sources	Maintaining the status quo established over past generations.
Wider Pool of Sources	Expanding candidate searches to new areas.
Balanced Team	Creation of groups with diverse backgrounds.
Company Culture	Impact of prevailing environment on hiring.
Company Policy	Discussion on formal policies on staffing decisions.
Mandate Candidate Interviews	Requirement for diverse candidates.
Publicize Job Openings	Ensure that employees are aware of internal opportunities.
Evaluation Process	Discussion on company hiring and promotion decisions.
Biased and Favouritism	Firm's selections limit diversity.
Fair and Balanced	Firm conducts performance-based assessments.
Glass Ceiling	Limitation for women to advance.
Internships	Targeted recruitment of young women college students.
Interviews	Purposeful reviews engaging the team's participation.
Self-Advocate	Clearly state interest and intention for career progression.
Significant Experiences and Events	Top level interview question - Discuss significant experiences and events which facilitated success and created challenges.
Company Purchased	Firm underwent an acquisition.
Competitive Nature	Personal drive for success.
COVID	Impact of COVID on the workplace and family.
External Societal Events	Circumstances beyond the control of the individual or firm.

Name	Description
Family Upbringing	Support from parents and siblings during formative years.
Fewer Opportunities than Male Peers	Discrimination due to gender.
Flexibility	Willingness to adapt to evolving situations and recognize opportunities.
Large vs Small Population Density	Impact of the proximity to population centers.
Likeability vs Competency	Discussion on how a woman's projected competency impacts perception of her likeability.
Only Woman Representative	Member of an organization with no other women.
Project Work	Impact of client projects on career progression.
Challenging Projects	Interesting project opportunities.
Developing Employees	Using the position of leader to enhance team skills.
Geographic Move	Opportunity to accept assignment to key projects requiring relocation.
High Visibility Project	Acceptance of project with prominent clients or attention from executive leadership.
Shift Between Disciplines	Accepting an opportunity to move from engineering and non-engineering roles.
Team Building	Focus as a leader to create team unity.
Supervisor	Discussion on the impact of their supervisor.
Effective and Inspiring Supervisor	Created an environment for team and individual success.
Poor Supervisor	Demonstrated bias and negative attitude towards diversity.
Vendor Relationships	Interactions with vendors and treatment on job sites.
Work Environment	Discussion on the overall culture and workplace climate.
Balanced Between Genders	Ability to create a fair and respectful environment.
Creating Positive Environments	Focus on steps and pathways to attain inclusive workplaces.
Gender Based Barriers	Proliferation of pre-existing impediments to diversity.
Hostile Work Environment	Clients, employers, or vendors actively creating negative atmosphere.

Name	Description
Significant Skills and Abilities	Top level interview question - What significant personal skills, abilities, and capabilities facilitated success? Any that required refinement or learning new skills?
Additional Education and Certifications	Interest in gaining new knowledge for advancement.
Business Knowledge	Augmenting technical skills with business acumen.
Career Drag	Factors that delayed advancement compared to male counterparts.
Decisive Decision Making	Ability to act and implement difficult choices.
Internal Drive to Succeed	Possessing an inherent motivation to project and professional success.
Mentoring	Discussion on obtaining additional guidance.
External Career Coach	Hiring of a professional coach to provide objective feedback.
Internal to the Company	Seeking out technical and business knowledge within the firm's hierarchy.
Resiliency	Demonstrating the ability to withstand pressure.
Soft Skills for Team Leadership	Discussion on increasing their team building skills.
Ability to Accept Criticism	Recognition that external input provides opportunities for improvement and growth.
Assertiveness	Willingness to self-promote ideas and interests.
Communication	Open sharing of ideas and project goals.
Empathy	Genuine connection with team members.
Humility	Solicitation of other's opinions and feedback.
Technical Knowledge	Possessing the basic and advanced understanding of the project required tasks.
Time Management	Ability to multi-task multiple projects and personal requirements.
Translating Ideas Between Groups	Ability to communicate concepts with both technical and non-technical teams.
Work Life Balance	Top level interview question - How has work / life balance shaped your career perspective?
Balancing Time	Challenges of managing work and life requirements.
Deadline Driven	AEC industry is based on client and supplier driven deadlines.
Example for Team	Clearly demonstrating to the team your priorities and how to manage them.

Name	Description
Family	Impact of immediate and extended family on career trajectory.
Aging Parents	Attending to the needs of older family members.
Children	References to the impact of childcare and FMLA work absences.
Supportive Partner	Impact of their partner on assuming home duties and encouragement of their career.
Medical Leave	Policies related to medical needs.
Psychological Safety	Emergent field focused on employee well-being.
Travel	Balancing long-term travel to remote job sites with personal needs.
Unattainable	There is no work life balance, only the illusion.
Working Environment	Establishing a culture that recognizes employees have a life outside of the job site.

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