AN ABSTRACT OF THE DISSERTATION OF

Ali A. Karakhan for the degree of Doctor of Philosophy in Civil Engineering presented on February 12, 2020.

Title: Assessment of Social Sustainability for the Construction Workforce

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John A. Gambatese

Minimal research has focused on the social dimension of sustainability in the built environment especially as it relates to the construction workforce. As a result, there are few to no tools available to industry stakeholders to holistically assess and improve the social sustainability of the construction workforce. Given the high employee turnover rates and shortage of skilled workers in the construction industry, there is a paramount need to develop reliable and practical tools to assess and improve the social sustainability of the construction workforce. Being able to frequently assess and improve social sustainability at the workforce level will assist construction organizations, and ultimately the entire construction industry, develop, attract, and retain skilled workers. The overreaching goal of this research is to enable assessing and improving social sustainability in construction at the workforce level. To achieve the research goal, the attributes, indicators, and metrics influencing the social sustainability of the construction workforce were identified, categorized, and quantified. By integrating the identified attributes, indicators, and metrics into an evaluation procedure, a practical tool to assess and improve social sustainability of the construction workforce was developed. The developed tool is referred to as the workforce sustainability assessment tool (W-SAT). The present research contributes to the body of knowledge by fulfilling the industry need for an instrument to assess and improve the social attributes of the construction workforce.

Assessment of Social Sustainability for the Construction Workforce

by

Ali A. Karakhan

A DISSERTATION

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APPROVED:

Major Professor, representing Civil Engineering

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Ali A. Karakhan, Author

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DEDICATION

To my wife Ola and my daughters Sarah and Lana, the source of joy, happiness, and inspiration in my life.

1.0 General Introduction

1.1 Background and Specific Aims

Sustainable development has been defined as meeting “the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987). Further examination of the concept of sustainability indicates that sustainability is a balanced approach to development that incorporates the collective achievement of environmental stewardship (planet), economic prosperity (profit), and social equity (people). This approach means that for a project/product/process/etc. to be labeled “sustainable,” benefits to the environment, economy, and society must be achieved. With regard to construction, sustainable development has experienced rapid growth within the construction industry as it provides a substantial opportunity to improve environmental performance and reduce operating costs of building projects. However, the social context of sustainability has not been readily apparent in sustainable building construction. Further effort is needed to expand interest around, and develop practices and tools that assess and improve, social sustainability especially as it relates to the workforce – *social sustainability at the workforce level is referred to in the present study as workforce sustainability*. Available practices and tools in construction mostly focus on corporate social sustainability as opposed to workforce sustainability. The overarching goal of the present research is to enable assessing and improving social sustainability in construction at the workforce level. Enabling assessment and improvement of workforce sustainability in construction requires an understanding of the foundational qualities and characteristics affecting the social sustainability of the construction workforce, and can be enhanced through the development and implementation of a practical, user-friendly tool for assessing and improving workforce sustainability.

Ideally, and based on the definition of sustainability provided above, a high level of sustainability in construction must involve the elimination of potential negative impacts of construction operations on the environment, the reduction of operating and life-cycle costs of a facility, and the enhancement of the social aspects associated with a facility. The achievement of these goals (environmental, economic, and social) is referred to as the triple bottom-line of sustainability. The triple bottom-line of sustainability involves prioritizing the use of practices and products that benefit the fundamental elements of sustainability: planet, profit, and people.

In the US, sustainable construction is often implemented and assessed using the US Green Building Council’s (USGBC) Leadership in Energy and Environmental Design (LEED) rating system. The LEED rating system is a third-party metric certification program developed by the USGBC to promote sustainable goals in the built environment (USGBC 2015). The LEED certification system has become a nationally accepted benchmark for the design, construction, and operation of high-performance sustainable buildings.

Over the last few decades, LEED implementation has been progressively expanding. The USGBC expects that the total impact of the LEED rating system to reach over 3.3 million US jobs and $190 billion in labor earnings while contributing to 1.1 million green construction jobs all over around the world (USGBC 2017). Besides the economic benefits of sustainable construction, there are numerous environmental benefits that can be achieved through the implementation of the LEED elements to benefit the planet, such as lowering carbon emissions and energy consumption of building projects. Research has shown that sustainable technologies and practices can reduce energy consumption of operating building facilities by 30-50% of traditional non-sustainable counterparts (Robichaud and Anatatmula 2011). An abundance of information is available in the literature about the environmental and economic benefits of sustainable construction.

However, information available in the literature about the social aspects of sustainability is scarce. Minimal research has attempted to identify, assess, and improve the social aspects of sustainability at the workforce level and, therefore, such aspects remain uncertain. The present research aims to fill in this knowledge gap by identifying, categorizing, and quantifying the attributes, indicators, and metrics influencing the social sustainability of the construction workforce, and developing a practical tool to enable assessing and improving social sustainability in construction. Social sustainability in construction has been defined as a life-enhancing process to accomplish social equity among all industry stakeholders including construction workers in terms of health and safety, well-being, education, economic welfare, and other human rights (Karakhan and Gambatese, 2016). To reiterate, the overall goal of the study is to enable assessing and improving social sustainability in the construction industry at the workforce level (i.e., enable assessing and improving construction workforce sustainability). The specific research questions this study attempts to answer are:

1. How can construction workforce sustainability be assessed and improved?
2. What are the key attributes (foundational qualities and characteristics) that contribute to construction workforce sustainability?
3. What are the applicable indicators and metrics that can be used to assess and improve each attribute of construction workforce sustainability?

1.2 Research Plan

Although construction projects, including the construction of green buildings, may not address many aspects of social sustainability (Jensen et al. 2012), especially as they relate to the workforce, empirical evidence is needed before moving forward with this study. Accordingly, it was hypothesized that some aspects of social sustainability such as worker health and safety might already be adequately addressed on sustainable projects. This hypothesis will be tested in the first manuscript (Manuscript #1) as will be described below. Various indicators may be used to assess and improve social sustainability in construction, but as a starting point and due to time and resource limitations, the researcher selected worker health and safety as the primary indicator of the social context of sustainability. Hinze et al. (2013) argued that construction workers are the most valuable element of the building process and, therefore, taking active steps to address their health and safety is essential to maintain a high level of sustainability. Similarly, the United Nations International Children's Emergency Fund (UNICEF) stated that any sustainable development must start with the safety and health of individuals (UNICEF 2013). It should be noted that while several sustainability rating systems and programs exist (e.g., Green Globes, Living Building Challenge, and Estidama), Manuscript #1 will focus only on LEED-certified projects as examples of sustainable construction projects in the US.

The research plan follows a logical evaluation of the evidence available in current literature and generated as part of the study. If there is evidence that LEED-certified projects in the US adequately address the social aspects of sustainability, particularly worker health and safety, then further evaluation will be conducted to evaluate other aspects that may be addressed by the LEED certification. On the other hand, if the evaluation of the relative safety risks of design elements and construction practices associated with the implementation of the LEED rating system on worker health and safety is found to be equal or higher than the typical safety risks associated with conventional construction projects, then a recently released safety-related LEED pilot credit will be evaluated. The new safety LEED pilot credit aims at integrating worker health and safety in sustainable design and construction. Such an integration positively influences worker health and safety on green projects, and could be considered a potential solution to eliminate, or at least mitigate, the negative impacts of green practices on worker health and safety. The evaluation, if warranted, will include assessing the viability and extent of implementation of the new safety-related LEED pilot credit across the architecture, engineering and construction (AEC) industry. If this LEED pilot credit is a viable solution, can enhance worker health and safety, and is predicted to be implemented in high numbers across the AEC industry, then case study projects will be solicited to evaluate, measure, and quantify the social benefits of implementing this LEED pilot credit on construction projects.

Conversely, if the LEED pilot credit is found to be an inviable solution, does not enhance worker health and safety, and/or will not be implemented in high numbers across the AEC industry, then there will be a need to develop a different resource such as a standalone tool to assess and improve the social sustainability in construction at the workforce level. If so, the researcher will undertake a systematic research process to develop a standalone, practical tool rather than relying on the LEED rating system for assessing and improving social sustainability for the construction workforce. The decision-making process used to determine the path of the research is illustrated in Figure 1.1 below. The double line in the figure shows the path that the actual research took.

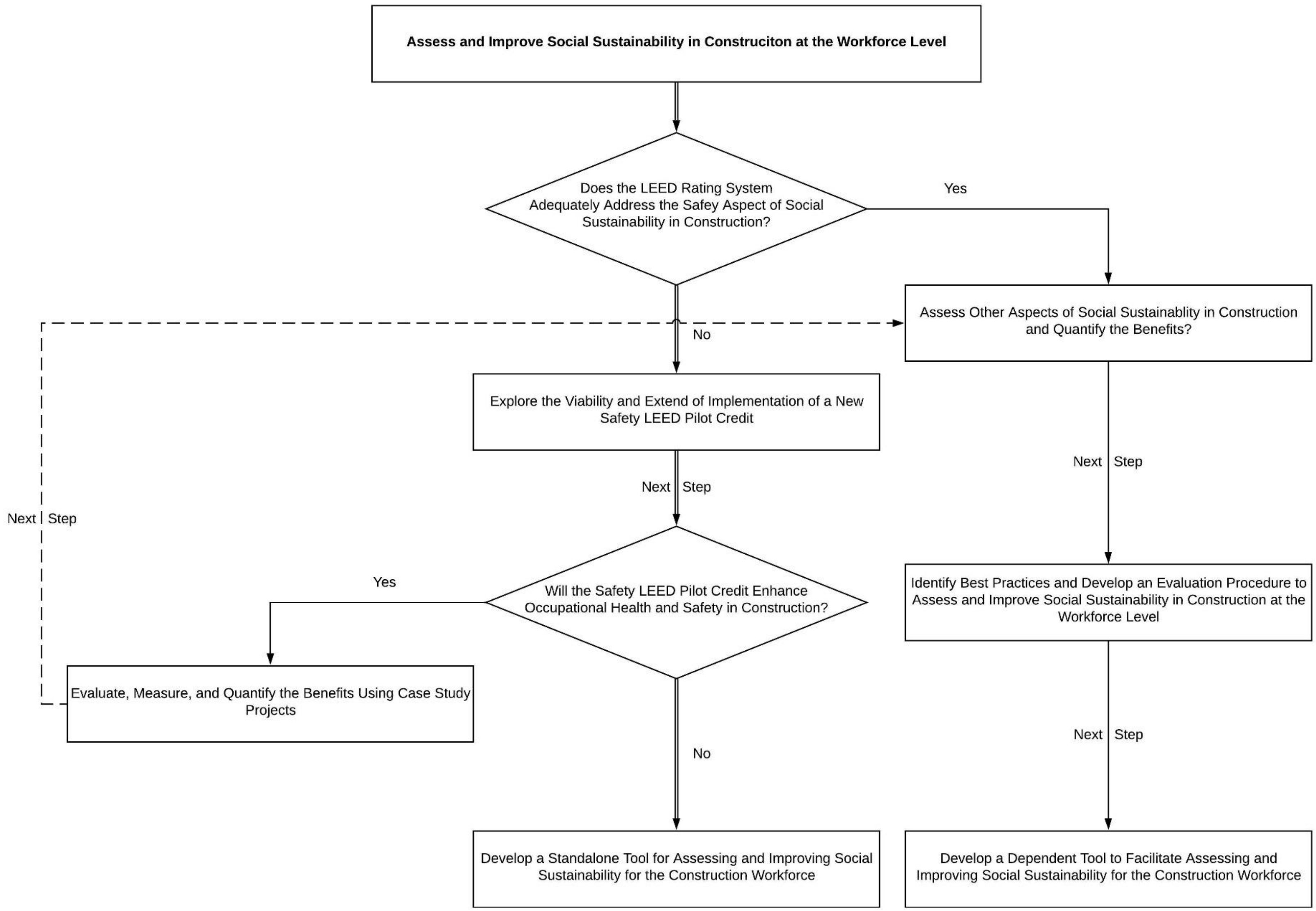

Figure 1.1: Decision Path of the Research Process

Existing social sustainability tools primarily focus on the organization, the end users (i.e., occupants), or the final product (i.e., the building), rather than the workforce constructing and maintaining the building. The intended assessment tool for workforce sustainability will focus on the workforce as opposed to the organization or the final product. The development of the intended tool can fulfill the industry need for an instrument to assess and improve social sustainability in construction at the workforce level. The intended assessment tool for workforce sustainability will expand beyond health and safety, and will include multiple key aspects of social sustainability such as diversity and equity.

The specific objectives of the study to achieve the research goal are summarized below and illustrated in Figure 1.2.

1. Evaluate, measure, and quantify the potential impact of design elements and construction practices associated with the implementation of the LEED rating system on the health and safety of construction workers (as a primary indicator of social sustainability);
2. Investigate the potential positive impact of a recently released safety-related LEED pilot credit on the health and safety of the construction workforce; and finally
3. Identify and quantify essential attributes and applicable indicators to assess and improve the social determinants of the workforce in the construction industry, including worker health and safety.

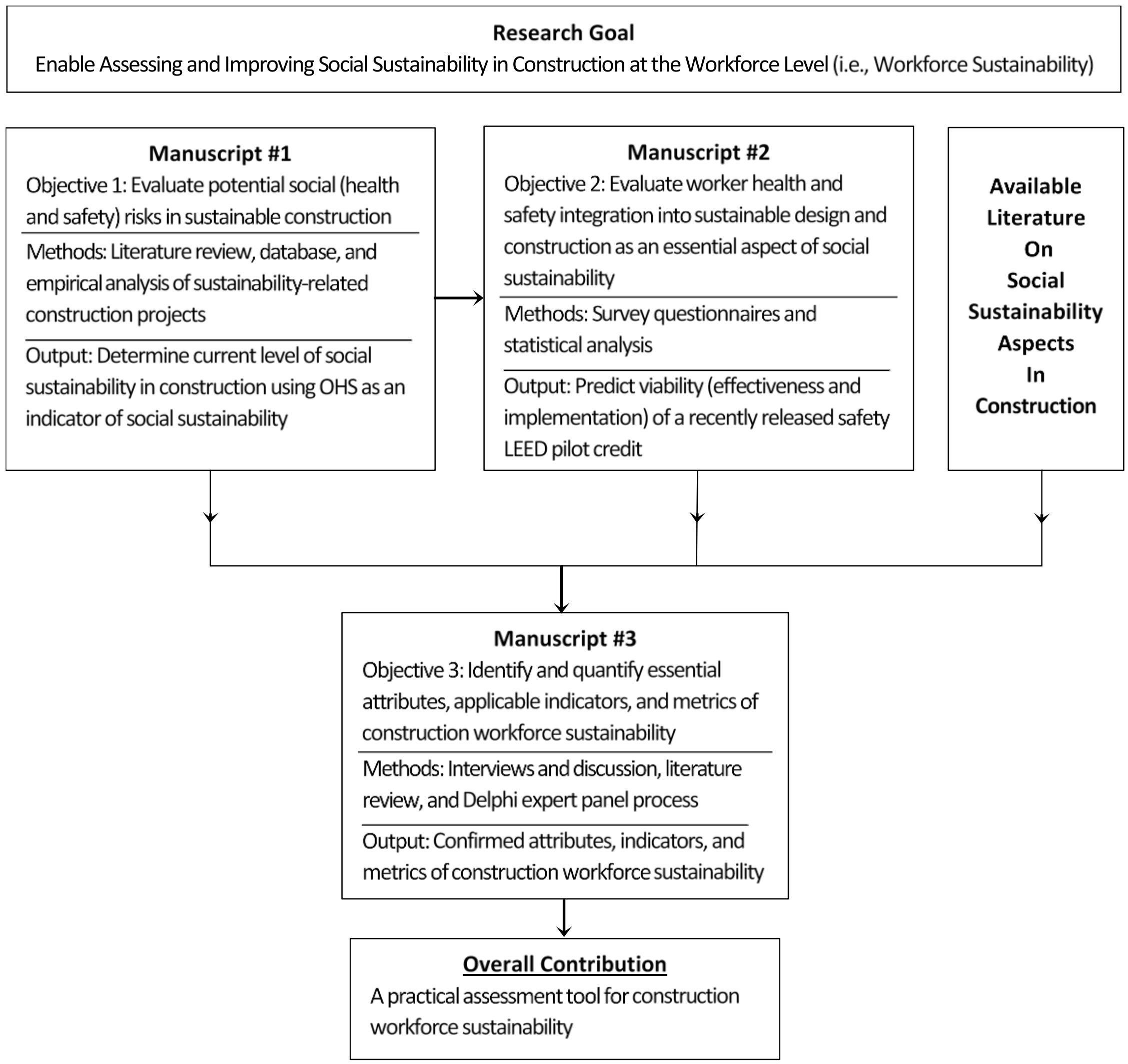

Figure 1.2: Flowchart Showing Research Plan, Objectives, and Expected Outputs

MANUSCRIPT #1: IDENTIFICATION, QUANTIFICATION, AND CLASSIFICATION OF POTENTIAL SAFETY RISK FOR SUSTAINABLE CONSTRUCTION IN THE UNITED STATES

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2.0 Manuscript #1 – Identification, Quantification, and Classification of Safety Risk in Sustainable Construction

2.1 Abstract

Sustainability is a balanced approach that puts equal focus on the environment, economy, and society. Research suggests that worker health and safety is an integral dimension of social sustainability. The present research contributes to the body of knowledge by assessing, quantifying, and classifying occupational health and safety (OHS) risk associated with the construction, operation, and maintenance of sustainable projects across the US construction industry and compares it with OHS risk encountered on non-sustainable counterpart projects. The researchers conducted a credit-by-credit review of the Leadership in Energy and Environmental Design (LEED) rating system to evaluate the relative positive or negative impact of green design elements and construction practices associated with the implementation of LEED credits on the OHS of construction and maintenance workers. The researchers also quantified OHS risk associated with LEED credits on 41 green projects distributed across the United States. The results show that even though a large number of LEED credits are neutral toward OHS, sustainable construction represented by LEED projects is associated with an increase in base-level safety risk. Finally, Manuele's risk model was integrated into a risk plane analysis to classify safety risk associated with each of the LEED credits. The risk classification analyses indicate that the Heat Island Effect (SSc 7.2) and Construction Waste Management (MRc 2) credits are associated with "unacceptable" risk to OHS across the US construction industry. It is expected that the findings from this research will benefit safety professionals, academics, designers, and all construction stakeholders by providing evidence of how their chosen sustainable designs may impact OHS on building projects.

2.2 Introduction

Sustainability has gained significant attention over the last two decades within the construction industry. Sustainability is originally described as the desire to carry out activities to meet "the needs of the present without compromising the ability of future generations" (WCED 1987). Sustainable development in building design and construction is then defined as a dynamic process to enhance and protect "the health of the environment or the associated health and well-being of the building's occupants, construction workers, the general public, or future generations" using efficient resources and methods (Marjaba and Chidiac 2016).

Sustainability in building construction is often measured by the level of the Leadership in Energy and Environmental Design (LEED) certification given to the building. The LEED rating system is a third-party metric certification program developed by the US Green Building Council (USGBC) to promote sustainable goals in the built-environment (USGBC, 2015). The LEED certification system has become a nationally accepted benchmark (Silins 2009), industry standard (Bayraktar and Owen 2010), and the world's most widely used green rating system (Marjaba and Chidiac 2016) for the design, construction, and operation of high-performance sustainable buildings. The City of Seattle, for example, mandates city-funded projects with a certain area of occupied space to be LEED silver certified (Silins 2009). Four progressive levels of LEED certification are available: certified, silver, gold, and platinum. Projects pursuing LEED certification must earn points by satisfying specific credit thresholds and requirements across specified impact categories: Location and Transportation (LT), Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Indoor Environmental Quality (IEQ), and Innovation (IN) (USGBC 2015).

As sustainable development is expected to yield ecological, financial, and social benefits, life-cycle safety was found to be a fundamental aspect of social sustainability (Karakhan 2016a; Valdes-Vasquez and Klotz 2011). However, the LEED rating system puts minimal focus on social sustainability, especially worker health and safety (Hinze et al. 2013) compared with environmental and economic considerations. For example, during the construction of the MGM Mirage City Center resort and casino in Las Vegas, Nevada, which was awarded several LEED certifications, six work-related fatalities occurred (Silins 2009). A review of the construction site identified frequent fall hazards, flammable materials stored improperly, electrical hazards, and other safety hazard associated with construction activities (Las Vegas Sun 2008). This paper examines the relationship between safety and sustainability in building design and construction.

2.3 Literature Review

Information in the literature pertaining to occupational health and safety (OHS) risk associated with planning, construction, and maintenance of green buildings is scarce (EU-OSHA 2013a). Gambatese et al. (2007) indicated that LEED certification may not address all sustainable facets, such as construction worker safety, and if so, it cannot be considered a comprehensive measure of "sustainability." Subsequent research highlighted potential increase in OHS risk resulting from the use of some design features and construction practices implemented to achieve the LEED certification (Gambatese et al. 2007), such as installing photovoltaics and vegetation on building rooftops (Gambatese and Tymvios 2012). Consequently, Hinze et al. (2013) pointed out that the LEED rating system credits focus primarily on increasing energy efficiency, reducing carbon emissions, and re-using recycled materials, rather than address OHS. Even though some may argue that protecting worker health and safety is already addressed by governmental safety regulations [such as Occupational Safety and Health Administration (OSHA) regulations] and no further attention needs to be given to safety (Chen 2010), the construction workforce is viewed as "the most valuable" resource of the building process, and therefore, its health and well-being must be prioritized (Hinze et al. 2013) by any green building rating system.

Additional research studies have reported that several LEED credits impact construction safety negatively, escalate severity and frequency of work-related injuries, and increase duration of exposure to hazards (Fortunato et al. 2012). Building on Fortunato et al.'s research, Dewlaney et al. (2012) quantified the relative negative impact of green design elements and construction practices on safety performance during construction as follows: (1) 36% increase in lacerations, strains, and sprains generated from recycling construction materials; (2) 24% increase in fall hazards; (3) 19% increase in eye strain symptoms; and (4) 14% increase in exposure to harmful substances. Relatedly, a statistical analysis of 86 construction projects found statistically suggestive evidence that green projects incur more OSHA recordable incidents during their construction than traditional non-green projects (Rajendran et al. 2009).

With regard to maintenance work, Omar et al. (2013) evaluated the impact of five green features - geothermal well, storm-water design, renewable energy, green roofs, and daylights - on the OHS of preventive maintenance (PM) workers who operate and maintain a facility. In line with previous studies, sustainable construction represented by LEED projects was found to be associated with greater safety hazard to PM workers when compared against non-sustainable construction (Omar et al. 2013). Lastly, a preliminary evaluation of the relationship between LEED credits and OHS conducted by 26 subject-matter experts under the umbrella of the National Occupational Research Agenda (NORA), a research program supported by the National Institute for Occupational Health and Safety (NIOSH), revealed that only seven credits in the LEED rating system were identified to have positive impact on OHS. Eleven credits were found to have negative impact on OHS. One credit was classified as having both positive and negative impact on worker safety. The remaining credits (38 credits) were considered neutral toward OHS (NORA/NIOSH 2011). The assessment was based on group discussions and subjective judgments using personal experience.

Further examination of the LEED impact categories revealed that only the IEQ category explicitly considers the health and safety of the construction workforce (EU-OSHA 2013a; Rajendran et al. 2009). It should be noted that none of the IEQ credits is mandatory (except the prerequisites) in order for a building to be LEED certified. Even though several studies acknowledged that some LEED credits possess a positive safety impact and may reduce safety hazards faced by construction workers on the job site, such as the inclusion of indoor pollutant control to capture contaminants (NORA/NIOSH 2011), the safety benefit in sustainable construction was not found to outweigh the percent increase in base-level safety risk to construction workers, according to a study conducted by Dewlaney et al. (2012). In the study, the safety benefit-risk analysis was performed for ten injury classifications using questionnaire surveys and interviews with highly experienced industry professionals.

Based on the aforementioned discussion, it can be concluded that some green elements associated with LEED generate more safety risk to construction and maintenance personnel. The LEED rating system requirements may not explicitly address life-cycle safety. For example, considering glass-roof atria, large windows, and skylights in a building may improve many properties of the building interior such as the amount of indoor daylight, energy efficiency, indoor air quality, etc. However, these features may generate significant fall hazards during both construction and maintenance operations. Namely, constructing an atrium in a building is more complex and time-consuming than installing a typical roof system, which may escalate frequency and severity of injuries associated with constructing this portion of the building. In addition, methods of cleaning the glass-roof atrium during building use are challenging if not addressed during early stages of the design process. Another example of the emerging challenges for OHS in green jobs is the use of permeable parking and paving surfaces. Even though these feature can reduce storm-water runoff and allow water to easily penetrate through the paving (Gambatese et al. 2007), subsequent landscaping and snow removal activities can be challenging (Silins 2009) causing musculoskeletal overexertion injuries and affecting worker health and safety negatively.

With all that is being written about the relationship between worker safety and sustainable construction, no study has performed a formal risk analysis of the impact of LEED rating system credits on OHS from a life-cycle safety perspective and to the extent to which the LEED credits are actually attained in practice as a part of building construction projects across the United States. Dewlaney et al. (2012) and Fortunato et al. (2012) recommended conducting a study to examine the impact of LEED on safety from a holistic perspective that considers not only construction operations, but also maintenance activities. Similarly, Omar et al. (2013) identified an “urgent” research need to study the connection between OHS and sustainability using a “life-cycle” safety approach. Table 2.1 illustrates the development of knowledge present in literature that pertains to the risk assessment of OHS hazards in sustainable building design and construction and highlights the knowledge gap that the present research aims to bridge.

Table 2.1: Components of Previous Studies on LEED Credits for OHS

Study	Risk Components		Sample Size	Sample Distribution	Worker Considered		Risk Type			Version
	Frequency	Severity			Construction	Maintenance	Identification	Quantification	Classification	
Chen (2010)	✓		5 case study projects	-	✓	✓	✓			-
Gambatese & Tymvios (2012)	✓		100 projects	Entire U.S.	✓	✓	✓			LEED v2
Fortunato et al. (2012)	✓	✓	8 case study projects	One state	✓		✓			LEED v2
Dewlaney et al. (2012)	✓	✓	8 case study projects	One state	✓		✓	✓		LEED v2
Omar et al. (2013)	✓	✓	13 case study projects	Northeastern, U.S.		✓	✓	✓		LEED v2
Present study	✓*	✓	41 projects	Entire U.S.	✓	✓	✓	✓	✓	LEED v3 (2009)

Note: Frequency in the present study refers to the occurrence of each LEED credit application, which is different from how frequency is often viewed by other studies as "the time of worker exposure to risk."

2.4 Research Objective

The aim of the present study is to bridge the knowledge gap identified in the previous section by implementing a life-cycle safety approach to investigate the relative impact of green design elements and construction practices associated with the implementation of LEED on OHS across three main phases in the life-cycle of a facility: construction, operation, and maintenance. Such approach involves performing a formal safety risk analysis to quantify the safety risk associated with green aspects that is based on the extent to which LEED credits are applied by construction projects throughout the United States.

The main objectives of the present study are to: (1) identify the OHS impact type (positive or negative) of green design elements and construction practices associated with the implementation of LEED credits across a facility life-cycle ; (2) quantify the increase/decrease in OHS risk magnitude of each of the LEED v3 (2009) rating system credits, excluding pilot credits, when measured against design elements and construction practices implemented on alternative non-green projects; and finally, (3) classify and categorize such an OHS risk that each credit possesses according to its safety risk magnitude using risk plane analysis and Manuele's risk theory. Quantifying OHS risk associated with green jobs from a holistic approach that takes into account the frequency of implementation of LEED credits across the US construction industry enables an inference pertaining to the impact of sustainability on safety performance in the construction industry to be made which is the primary question this research aims to address.

2.5 Risk Identification: A LEED Credit-by-Credit Review for OHS Hazards

The researchers conducted a LEED credit-by-credit review of the five major impact categories of LEED v3 (2009) – SS, WE, EA, MR, and IEQ. The intent of the review was to determine the impact type (positive or negative) of green design elements and construction practices associated with the implementation of each of the LEED credits on OHS during construction, operation, and maintenance activities of a facility life-cycle when measured against technologies and practices implemented on conventional non-LEED facilities. A negative impact means that a particular LEED credit may increase the safety risk associated with the application of that LEED credit, while a positive impact of a LEED credit means that the credit requirements would possibly lead to safer work procedures compared with traditional, non-LEED practices.

The evaluation included the following step-by-step process. First, a comprehensive review of the literature was conducted to understand how each credit of the LEED rating system is implemented, what adaptations need to be made to satisfy credit requirements, and who on the project team must be involved. The first author completed more than 50 hours of continuing education offered by the USGBC (https://new.usgbc.org/education) to understand construction means and methods associated with the application of each credit and how they are different from those implemented on non-green counterpart projects. After that, a careful credit-by-credit examination of the LEED requirements was conducted by the researchers using experience and the knowledge gained from the previous process mentioned above to determine whether each credit possesses a negative or positive impact on worker health and safety. Such decision was based on whether the requirements of each LEED credit will increase/decrease the frequency of exposure to the hazard, escalate the outcome of injuries (severity), increase the task complexity, and so forth. Particular attention was given to the fours leading causes of worker fatalities in the construction industry: falls, struck by object, caught-in/between, and electrocution. Next, all findings were compiled and verified with peer-reviewed articles and technical reports. Un-verified information was disregarded and removed from the evaluation. This step helped ensure that any potential bias of the researchers' evaluation would be eliminated. Suhr (1999) mentions that basing subjective judgments on relevant facts leads to valid and reliable judgments (objective judgments). It is widely acknowledged that all decisions are subjective to some extent, but the challenge is to reduce subjectivity and anchor judgments on relevant facts, and that is exactly what the researchers did in this study by linking all judgments to previous research findings. For example, the Enhanced Commissioning (EAc 3) credit requires workers and commissioning agents to perform additional measurements, inspections, and/or tests of green practices on the job site (USGBC 2014a). These tasks could expose workers, inspectors, and commissioning agents to fall hazards while inspecting green elements especially for such building elements as heating, ventilation and air conditioning (HVAC) systems. Because the USGBC allows the owners' workers, independent contractors, and subcontracted designers to perform this task (USGBC 2014a), it was determined that EAc 3 credit has a negative impact on worker safety. However, these inspections are usually performed when no or few workers are on the site (Gambatese and Tymvios 2012), which decreases but does not eliminate the possibility of incurring an incident. This condition was carefully considered when assigning the level of impact on worker safety for the EAc 3 credit.

For the purpose of the present research, it was decided to choose LEED v3 (2009) DB+C: New Construction (NC) for review because this version has been identified as the most widely adopted LEED rating system in the United States (NORA/NIOSH 2011). It should be noted that the evaluation only examined the impact of green elements and practices implemented to achieve LEED certification on the health and safety of construction and maintenance workers over the life-cycle of a facility without taking building occupants into consideration.

The result of the evaluation, illustrated in Figure 2.1, indicates that a large number of LEED credits (34 credits) are neutral toward worker health and safety. However, twelve credits were found to have a negative impact on the health and safety of construction and maintenance personnel. Only four credits enhance OHS positively. Additionally, four credits were found to have mixed impact, both positive and negative, on OHS.

Sustainable Sites (SS)								
Pre 1	SSc 1	SSc 2	SSc 3	SSc 4.1	SSc 4.2	SSc 4.3	SSc 4.4	SSc 5.1
SSc 5.2	SSc 6.1	SSc 6.2	SSc 7.1	SSc 7.2	SSc 8			
Water Efficiency (WE)								
Pre 1	WEc 1	WEc 2	WEc 3					
Energy and Atmosphere (EA)								
Pre 1	Pre 2	Pre 3	EAc 1	EAc 2	EAc 3	EAc 4	EAc 5	EAc 6
Material and Resources (MR)								
Pre 1	MRc 1.1	MRc 1.2	MRc 2	MRc 3	MRc 4	MRc 5	MRc 6	MRc 7
Indoor Enviromental Quality (IEQ)								
Pre 1	Pre 2	IEQc 1	IEQc 2	IEQc 3.1	IEQc 3.2	IEQc 4.1	IEQc 4.2	IEQc 4.3
IEQc 4.4	IEQc 5	IEQc 6.1	IEQc 6.2	IEQc 7.1	IEQc 7.2	IEQc 8.1	IEQc 8.2	

: Negative potential impact on OHS
: Positive potential impact on OHS
: Mixed potential impact on OHS
: No impact on OHS

Figure 2.1: OHS Risk Identification of the LEED Rating System Credits Version 3 (2009)

After gathering all necessary information, it was interesting to find that the overall evaluation results of the present study are similar to, but more detailed and comprehensive than, those reported in NIOSH's NORA report (2011) previously mentioned in the Literature Review section. The major differences between the NIOSH NORA study findings and the present study can be summarized as follows. First, the NORA report (2011) indicated that credits MRc 4.1, MRc 4.2, and MRc 4.3 under the MR category have a positive impact on worker health and safety because these credits encourage the use of low volatile organic compound (VOC) materials which may enhance the comfort and well-being of workers. However, practitioners have reported that low VOC materials/paints are sometimes lower quality products than alternative non-green materials (Fortunato et al. 2012; Dewlaney et al. 2012) and may end up peeling off if used for the façade of a building in particular environments (Arroyo et al. 2014). As a result, this type of green product eventually requires more hours of work during installation and maintenance due to rework, frequent maintenance, and/or extra effort needed to finish the task. This condition may increase the frequency of occurrence of injuries per task and/or duration of exposure to the hazard, and therefore increase total safety risk associated with construction and/or maintenance operations as safety risk is affected by frequency of accidents, severity of outcome, and duration of exposure to hazard (Jannadi and Almishari 2003). Also, some of the low VOC materials may still be flammable (NORA/NIOSH 2011) even though they are odorless, harmless, and non-toxic. Similarly, research has indicated that green paints and adhesives may contain biocides to prevent the growth of harmful organisms (EU-OSHA 2013a). Such substances may be associated with allergic skin diseases (EU-OSHA 2013a). These factors can increase base-level safety risk during construction and maintenance activities.

Table 2.2 presents detailed information pertaining to the impact of the LEED credit requirements on the health and safety of construction and maintenance workers. Maintenance workers are defined in the present research as those responsible for the upkeep of a facility, preserving or repairing equipment, operating a facility, carrying out diagnostic inspections, and cleaning or replacing components of a facility. Construction workers, on the other hand, are defined as those who construct and build the facility relying on construction drawings and specifications. Only credits that positively or negatively impact worker health and safety are listed in Table 2.2 (neutral credits are not considered in the analysis because they have no impact on OHS). To clarify how to interpret the information presented in Table 2.2, the IEQ 3.1 credit is given as an example which generates both negative and positive impact on the OHS of the construction workforce. That is, in order for this credit to be satisfied, construction workers often use ladders to keep HVAC ducts and vents enclosed with plastic coverings (Dewlaney and Hallowell 2012). This practice may impact OHS negatively by exposing construction workers to fall hazards, the leading cause of fatalities in the United States (CPWR 2013). However, this practice can also enhance OHS positively by increasing the health and well-being of construction workers and building occupants (USGBC 2014a) by improving indoor air quality.

Table 2.2: LEED – NC Credit Review for Health and Safety Impact (NORA/NIOSH 2011, modified)

Category or Credit	Impact Type	Worker Affected	Impact Level
Sustainable Sites (SS)			
Pre 1: Construction Activity Pollution Prevention	Positive	C	High
Credit 3: Brownfield Redevelopment	Negative	C & M	Medium
Credit 6.2: Stormwater Design – Q.C	Negative	C & M	Medium
Credit 7.2: Heat Island Effect- Roof	Negative	C & M	High
Energy and Atmosphere (EA)			
Credit 2: On-Site Renewable Energy	Negative	C & M	High
Credit 3: Enhanced Commissioning	Negative	C	Low
Materials and Resources (MR)			
Credit 1.1: Building Reuse-Maintain Existing Walls, Floors, & Roofs	Negative	C	Medium
Credit 1.2: Building Reuse-Maintain Existing Interior Elements	Negative	C	Medium
Credit 2: Construction Waste Management	Negative	C	High
Credit 3: Materials Reuse	Negative	C	High
Indoor Environmental Quality (IEQ)			
Credit 2: Increased Ventilation	Positive	M	Medium
Credit 3.1: Construction IAQ Management Plan – During Construction	Negative	C	Medium
	Positive	C	Medium
Credit 4.1: Low Emitting Materials – Adhesives and Sealants	Positive	C & M	High
	Negative	C & M	Medium
Credit 4.2: Low Emitting Materials – Paints and Coatings	Positive	C & M	High
	Negative	C & M	Medium
Credit 4.3: Low Emitting Materials – Flooring System	Positive	C & M	Medium
	Negative	C & M	Low
Credit 4.4: Low Emitting Materials – Composite Wood & Agrifiber Products	Positive	C & M	Medium
Credit 5: Indoor Chemical & Pollutant Source Control	Positive	M	High
Credit 6.1: Controllability of System – Lighting	Negative	C	Low
Credit 8.1: Daylights	Negative	C & M	High
Credit 8.2: Views	Negative	C & M	High

Note: "C" stands for construction and "M" stands for maintenance.

2.6 Risk Quantification of LEED Credits

2.6.1 Establishing Risk Equation

The second objective of the present study is to quantify OHS risk associated with implementation of the LEED credits across the US construction industry. Safety risk is measured based on "severity" and "frequency" of hazard. Severity (S) refers to the type and level of relative impact of each LEED credit on OHS, and itself includes *type* and *level* of impact. Even though the term "risk" inherently implies a negative outcome, safety risk can also indicate a positive outcome (Burdorf and Sorock 1997) inferring risk mitigation or safety enhancement. Therefore, the type of impact is a categorical variable inferring the type of risk (positive or negative), while impact level is an ordinal variable indicating the level of impact of each LEED item on OHS. On the other hand, frequency is a numerical variable referring to the occurrence of LEED credit application. Based on the aforementioned discussion, safety risk magnitude (SRM) is viewed in the present study as the product of Frequency and Impact (type and level of impact) of each credit of the highlighted 20 credits shown in Table 2.2. Equation 2.1 illustrates the components of the safety risk magnitude.

Safety risk magnitude (SRM) = − [Impact type (T) * Impact level (I) * Frequency (F)] ….. Equation 2.1

Accordingly, if the output of Equation 1 is a positive value for a particular credit, OHS risk across the construction industry would be increased. This increase is a result of implementing that particular credit, which in turn impacts safety performance in the construction industry negatively when measured against alternative counterparts involving similar but non-green elements. Conversely, when the output of Equation 2.1 is a negative value, OHS across the construction industry would be enhanced, affecting the overall safety performance in the construction industry positively when measured against non-green elements typically implemented in practice. Incorporating both frequency and severity of hazard into the risk equation ensures obtaining comprehensive results (Baradan and Usmen 2006). Even though some studies also incorporated time of "exposure" to hazard into the risk formula (Hallowell and Gambatese 2009), this type of exposure is project-specific, and therefore was not considered as a component of the safety risk calculation. Instead, frequency of exposure to hazard in this study is incorporated into the risk equation by including the occurrence of each LEED credit application, represented by the term "frequency".

2.6.2 Selection of Sample Size

To quantify the OHS risk associated with green design and construction elements across the US construction industry, the frequency of attaining each LEED credit by project teams should be identified. To provide the most up-to-date information, only new construction-type buildings certified in 2015 using LEED v3 (2009) or above, and located in the United States were considered. After specifying the limitations, a filtered search of the USGBC Directory revealed 790 LEED projects (population size of the study) matching these criteria at the time of the present study. To determine a representative sample size, the following equations were used (Lohr 2009):

$$n = \frac{z_{\alpha/2}^2 S^2}{e^2 + \frac{z_{\alpha/2}^2 S^2}{N}}$$

…….…………................……. Sample Size Calculation (Equation 2.2)

In the equation, "*n"* is the number of required observations, "Z" is the area under the normal curve which is determined by specifying the desired level of confidence, "S" is the population variance which, for large populations, can be approximately equal to p*(1-p) (Lohr 2009). "p" in this case is the variability of responses [an even 50-50 chance is typically used to determine a conservative sample size (Israel 1992; Lohr 2009)], and finally "e" is the sample error.

A confidence level of 95% is often used to signify statistically valid outputs in a normally distributed data set (Israel 1992). Accordingly, the area under the curve (Z) is 1.96. On the other hand, a sample error (e) of 0.15 was selected for this study. Even though this error limits the accuracy of the study, the researchers decided that it is reasonably plausible to make inference to the population with this magnitude of error. Since N is known and adequately large (N = 790), the finite population correction was determined to approximately equal 1. After performing the calculations, the required sample size needed for this study was found to be 41. Therefore, 41 LEED-certified projects distributed over 25 states were randomly selected from the identified 790 projects. The documentation of each project contained a LEED scorecard that summarizes the credits earned under each impact category, and other information regarding the level of certification and project location. The levels of certification were diverse. The majority (17 buildings) gained LEED gold certification. Thirteen projects were LEED silver certified. Only a small portion of the projects earned platinum and certified levels (2 and 9, respectively). All selected projects were certified using the LEED v3 (2009).

2.6.3 Outputs of Safety Risk Calculations

In order to quantify the SRM associated with each credit using Equation 2.1, three pieces of information are needed: type of impact (positive or negative) on worker health and safety, level of impact of each credit on OHS (low, medium, or high), and the frequency of occurrence of each LEED credit application in the construction industry. The type of impact whether positive or negative, or both, was determined based on the information obtained from the risk identification process and the LEED credit-by-credit review (see Figure 2.1). Next, the level of the impact of each credit on OHS was mainly obtained from previous work available in literature as shown in Table 2.2. The impact of the risk was then quantified using the values 1, 2, or 3 which respectively correspond to a low, medium, or high level of impact on OHS. Previous studies used both geometric (Jannadi and Almishari 2003; Hallowell and Gambatese 2009) and linear (Manuele 2010; Omar et al. 2013) scales for severity scores. In the present study, it was decided, for simplicity purposes, to use a linear scale for the levels of impact of LEED credits on OHS. For those credits that have no impact on OHS, a value of zero was assigned to each credit. What is noteworthy is that the difference in safety risk when compared against conventional non-LEED buildings would be zero, not the risk itself. A value of zero risk does not necessarily mean that there would be no risk associated with the implementation of the credit; zero-risk merely means that there would be no increase in base-level safety risk encountered on green projects when compared against non-green projects. In contrast, a positive impact suggests that the safety hazards on green projects would be mitigated when compared against traditional non-green counterparts. However, this condition does not necessarily indicate that risk would be eliminated. Finally, frequency of attaining LEED credits by project teams was obtained by reviewing the LEED scorecard credit-by-credit for each of the identified 41 LEED projects.

Information obtained pertaining to the components of the risk equation was compiled in Table 2.3, and then the gross SRM for each credit was calculated. The result indicates that twelve of the credits are found to produce a positive SRM (safety hazard/risk), and thus impacting the overall safety performance across the construction industry negatively. On the other hand, only seven credits were found to produce a negative SRM (safety enhancement/risk reduction), affecting the overall safety performance in the construction industry positively. However, the overall cumulative SRM was calculated to be a value of 47 which indicates a negative aggregate outcome. This aggregated value means that sustainable construction is associated with an increase in base-level safety risk, and may impose additional safety hazards to construction and maintenance workers impacting the overall safety performance of the US construction industry negatively. Ideally, one expects sustainable construction to be far safer for construction and maintenance workers, in which the cumulative SRM would be a negative value to indicate a risk mitigation/safety enhancement compared to non-sustainable construction. However, the result reveals that sustainable construction represented by LEED projects may not bring safety improvement to the construction industry.

Similarly, the aggregated SRM was also calculated for each individual project of the identified 41 LEED projects. Not surprisingly, it was found that the majority of projects (25 out of 41) were impacted negatively by LEED practices when measured against alternative non-LEED practices. Only 11 projects (27%) were impacted positively by pursuing credits that enhance OHS and avoiding credits that impact OHS negatively. While 5 projects (12%) maintained the same level of risk expected to be encountered if green features were not implemented. The level of certification was not found to have any statistically significance impact on safety risk.

Table 2.3: Safety Risk Magnitude for each LEED Credit

Category and Credit	Frequency (F)	% of Projects Attaining Credit	Impact Type (T)	Impact Level (I)	SRM	Gross SRM	Type of Risk
SS Category							
SS Pre. 1	41	100	Positive	3	-123	-123	Safety Enhancement
SSc 3	7	17	Negative	2	14	14	Safety Hazard
SSc 6.2	22	54	Negative	2	44	44	Safety Hazard
SSc 7.2	34	83	Negative	3	102	102	Safety Hazard
EA Category							
EAc 2	6	15	Negative	3	18	18	Safety Hazard
EAc 3	24	59	Negative	1	24	24	Safety Hazard
MR Category							
MRc 1.1	7	17	Negative	2	14	14	Safety Hazard
MRc 1.2	1	2	Negative	2	2	2	Safety Hazard
MRc 2	33	80	Negative	3	99	99	Safety Hazard
MRc 3	1	2	Negative	3	3	3	Safety Hazard
IEQ Category							
IEQc 2	11	27	Positive	2	-22	-22	Safety Enhancement
IEQc 3.1	34	83	Negative	2	68	0	Same as in non-sustainable const.
	34		Positive	2	-68		
IEQc 4.1	37	90	Positive	3	-111	-37	Safety Enhancement
	37		Negative	2	74		
IEQc 4.2	39	95	Positive	3	-117	-39	Safety Enhancement
	39		Negative	2	78		
IEQc 4.3	35	85	Positive	2	-70	-35	Safety Enhancement
	35		Negative	1	35		
IEQc 4.4	38	93	Positive	2	-76	-76	Safety Enhancement
IEQc 5	19	46	Positive	3	-57	-57	Safety Enhancement
IEQc 6.1	32	78	Negative	1	32	32	Safety Hazard
IEQc 8.1	10	24	Negative	3	30	30	Safety Hazard
IEQc 8.2	18	44	Negative	3	54	54	Safety Hazard
			Cumulative Risk		47	47	Safety Hazard

2.7 Risk Classification of LEED Credits

2.7.1 Risk Plane Analysis

The third and last objective of the present study is to classify and categorize safety risk associated with the implementation of each of the 20 LEED rating system credits identified with having an impact on OHS relying on the SRMs calculated in Table 2.3. It was decided to use the "risk plane" analysis technique for this purpose because it is identified as the most widely used method for classifying risk besides the risk assessment matrix (Baradan and Usmen 2006). The risk plane concept is used in the present study to classify and categorize those credits within the 20 LEED credits identified in the risk identification process (Figure 2.1) which influence OHS the most, whether positively or negatively, over the life-cycle of a facility. In the risk plane method, two axes are required. The x-axis represents the "frequency" of occurrences of an event in a given time period. For the present study, the x-axis is the frequency (F) of attaining each LEED credit within the US construction industry based on the identified sample. On the other hand, the y-axis represents the outcome of the risk, or the severity of the risk (level and type). SRM can be found by multiplying “F” and “S.” As mentioned previously, “S” refers to the type and level of relative impact of each LEED credit on OHS. In addition, a risk plane is often divided into a number of zones by iso-risk contour lines (R) to indicate different risk levels. All points of a contour line should give the same value of risk when multiplying their x-coordinate (F) and y-coordinate (S).

Typically, most studies classified risk into three to five zones with four being the most frequent number of risk zones used. For example, Manuele (2010) separated risk into four zones in his explanation of the “As Low As Reasonably Practicable” (ALARP) theory, and identified risk zone #4 as an “unacceptable” region that requires immediate action and should not be permissible except in rare circumstances. In addition, Manuele (2010) highlighted risk in zones #2 and #3 as “reasonably practicable” if remedial actions were taken. Manuele (2010) also indicated that risk in zone #1 is negligible and does not require urgent or immediate actions. The present study incorporated Manuele’s ALARP theory into the risk plane analysis to classify safety risk into four zones. Accordingly, three iso-risk contour lines were identified (R1, R2, and R3) which represent a risk value of 30, 60, and 90 respectively, as shown in Figures 2.2 and 2.3. These contour lines were established by taking the ratio of the maximum value of risk that can be obtained (123 rounded to 120) to the number of risk zones (four zones according to the ALARP theory). As a result, zone #1 indicates a risk value of zero to 30, with an incremental increase of 30 for each subsequent risk zone ending with zone #4 which represents a risk value of more than 90. After incorporating the contour lines into the risk plane, the calculated SRM values of each of the 20 LEED credits identified with having an impact on OHS were plotted on the risk plane to determine which risk zone each credit belongs to, as shown in Figures 2.2 and 2.3.

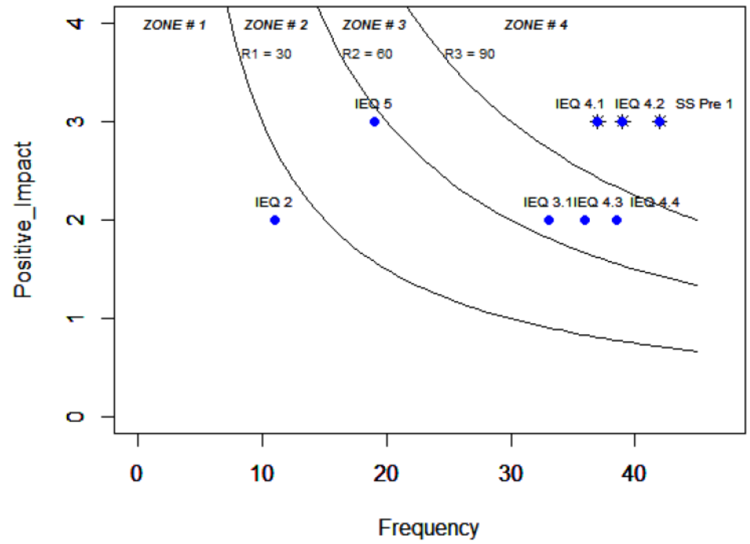

Figure 2.2: LEED Credits with Positive Impact on OHS

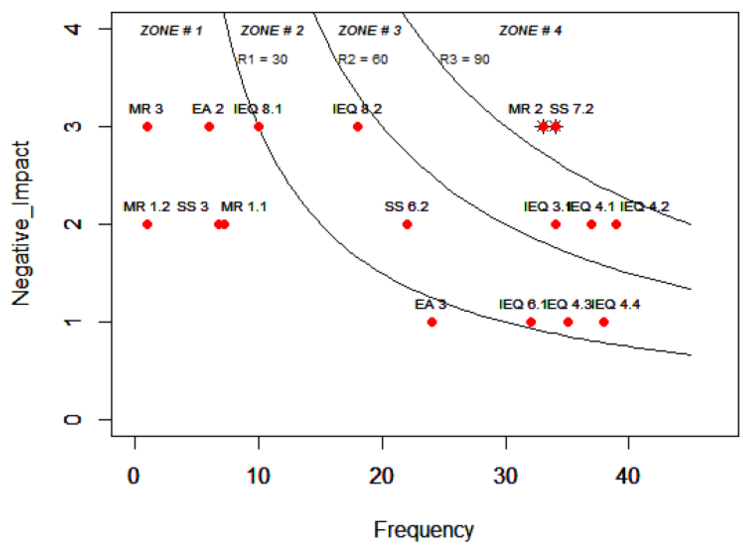

Figure 2.3: LEED Credits with Negative Impact on OHS

2.8 Results and Discussion

Figures 2.2 and 2.3 highlight the positive (risk mitigation/safety enhancement) and negative (safety hazard) SRM of each of the LEED credits on worker health and safety. In Figure 2.2, risk zone #4 on the risk plane carries a value of 90 or more, which contains those credits which influence OSH the most positively, namely SS pre 1, IEQc 4.1, and IEQc 4.2. These credits, by having a positive impact, improve the safety performance during construction, operation, and maintenance of high-performance sustainable building construction across the US These credits are not only found to be attained by most projects (100%, 90%, and 95% respectively), but also carry a high positive impact on OHS, as shown in Table 2.2.

SS Prerequisite 1 is a mandatory credit that must be attained by all LEED projects in order to be considered for LEED certification. The main purpose of this credit is to prevent pollution of the air during construction operations by controlling soil erosion, waterway sedimentation, and dust transported by air (USGBC 2014a). SS Prerequisite 1 explicitly enhances construction worker health and safety. All of the identified 41 projects implemented the SS Prerequisite 1. With regard to the other two credits, both IEQc 4.1 and IEQc 4.2 involve the use of low emitting materials in order to reduce concentrations of chemical contaminants that can damage air quality, human health, productivity, and the environment (USGBC 2014a). Low VOC materials are typically used for this purpose to protect worker health and safety. However, there are some concerns regarding the quality and characteristics of some VOC materials, as noted previously.

On the other hand, credits lying in risk zone #4 in Figure 2.3, namely SS 7.2 and MR 2, affect OHS negatively and to a great extent. As mentioned previously, Manuele (2010) labeled risk in zone #4 as "unacceptable" risk that requires immediate attention. Alternative practices that better address the safety of construction and maintenance workers must be taken into consideration when seeking these credits, especially taking into account that more than 80% of the identified 41 projects were found to attain these credits. Future studies should investigate alternative practices that can mitigate OHS risk associated with the implementation of these credits.

The Heat Island Effect - Roof credit (SSc 7.2) encourages the use of vegetated roofs (option 1) to minimize effects on microclimates and human and wildlife habitats by reducing heat islands. As vegetation requires regular irrigation, mowing, maintenance, and weeding, the frequency of risk to landscapers who maintain and operate the roof increases considerably when compared against maintaining conventional non-vegetated roofs. This condition may expose landscapers used to conducting work on the ground to fall injuries, the leading cause of fatalities in the US (CPWR, 2013). An investigation of 19 vegetated roofing systems in the US showed a pattern of improper fall protection systems, unsafe access, proximity of vegetation to skylights, proximity of vegetation to hazardous machines or unprotected roof-edges, and other building hazards (Behm 2012). Another study found an increase in physical workload pertaining to the construction of green roofs caused by the manual transport of soil required for vegetation (EU-OSHA 2013b). These findings indicate an apparent presence of negative safety risk in association with green roofs. On the other hand, if vegetated roofs are to be avoided, project teams have to use high-albedo roofs (option 2) to satisfy this LEED credit, namely specifying white thermoplastic polyolefin (TPO) materials with high solar reflectance index (SRI) for a minimum of 75% of the roof surface (USGBC 2014a). However, TPO roof membranes are found to be slippery (Omar et al., 2013), heavy to carry, and "blindingly bright"

(Dewlaney et al. 2012) when compared to traditional black roofing materials typically used on most construction projects.

Similarly, the Construction Waste Management credit (MRc 2) is found to increase OHS risk associated with recycling activities. This credit can be earned when contractors divert waste and demolition debris from landfills and incineration facilities by recovering, reusing, and recycling materials (USGBC, 2014a). Research has shown that before material is recycled, workers typically climb into waste dumpsters to retrieve and sort materials out manually as recycled materials are usually placed in the wrong dumpsters (Dewlaney and Hallowell 2012; Fortunato et al., 2012). Furthermore, the use of single-stream recycling (commingled collection) is sometimes imposed on construction sites, due to limited space, which may necessitate manual sorting. The use of manual separation of recyclable materials explicitly increases the risk of injuries (EU-OSHA 2013b), and may cause serious illnesses. Additionally, to be satisfied, this credit involves extra work performed by construction workers that may not be required on conventional non-LEED projects that do not use recycling strategies. Labeling waste dumpsters with clear text that describes the allowable content in the dumpsters, or having a worker oversee the waste management process, is an easy solution to protect workers from exposure to the hazards. Motorized equipment can also be used to eliminate the manual handling of recycled materials.

Although identifying injury prevention and mitigation strategies is beyond the scope of this study, mitigation and prevention measures are briefly addressed throughout the study to provide the reader with insights on how to mitigate green job hazards. Careful selection and implementation of construction safety management strategies by project teams prior to construction operations can effectively enhance safety performance throughout a project. It is recommended that the USGBC incorporate formal mitigation and prevention strategies into the LEED rating system, especially for credits SSc 7.2 and MRc 2 as these credits are responsible for generating "unacceptable" risk to worker health and safety (see Figure 2.3). The challenge is that implementation of these credits in high-performance sustainable construction is progressively expanding because of several environmental and economic benefits these green features generate. Moreover, these green features can provide project teams with numerous LEED credits in different categories. For instance, vegetated roofs may help project teams earn 15 LEED points (Behm 2012). It should be noted, however, that the increase in base-level safety risk found in association with the construction of LEED buildings may not necessarily indicate a cause-and-effect relationship between OHS risk and LEED requirements. There are perhaps many confounding variables that may be responsible for the generation of such risk. Improper planning and/or execution, unfamiliarity with construction means and methods required to satisfy LEED requirements (Dewlaney et al. 2012; Karakhan 2016a), lack of a skilled and experienced workforce, and absence of required training and resources (EU-OSHA 2013b) are all potential causes of the increase in safety risk on green projects.

Most importantly, the USGBC recognized this issue, and accordingly released new LEED pilot credits that explicitly address the social pillar of sustainability, including life-cycle safety (USGBC 2014b). For instance, the Prevention through Design (PtD) LEED pilot credit explicitly addresses safety throughout the facility life-cycle by paying early attention during the design process to worker health and safety (Karakhan 2016a). However, none of the identified 41 projects has reported implementation of any of these pilot credits.

2.9 Research Implications

The present study contributes to the body of knowledge by identifying and quantifying the impact (type and level) of green design elements and construction practices on OHS based on the extent of application of each LEED credit as a part of building construction projects across the US construction industry. The study also contributes to construction safety knowledge by categorizing LEED credits according to their SRM and labeling green technologies/practices that generate "unacceptable" safety risk across the construction industry. The study findings can be used by all construction stakeholders, including safety, health, and environment (SH&E) professionals and USGBC committee members, to incorporate more intervention strategies into the requirements of those credits that introduce unacceptable negative risk on OHS in the construction industry. Doing so will enable a more holistic approach to sustainability that incorporates environmental, economic, and social benefits including life-cycle safety. The use of a life-cycle safety approach reduces construction hazards and yields numerous benefits to worker health and safety.

In addition, using the SRMs and risk zones associated with each credit can inform sustainable/green rating agencies (such as USGBC), federal and state regulatory agencies (such as OSHA), and research organizations (such as NIOSH) about how to start and where to focus their efforts. Previous studies have found that the on-site renewable energy credit (EAc 2) is the second-most impactful credit that increases the frequency of fall injuries on construction projects by 33% (Dewlaney et al. 2012). In contrast, the present research study reveals that safety risk associated with the implementation of the EAc2 credit in the built-environment across the United States is minimal as many projects (about 85%) do not seek the EAc 2 credit. This discrepancy between both studies can be attributed to the fact that Dewlaney et al.'s study was limited to one geographical location. Consequently, the authors argue that in order to correctly assess the impact of LEED credits on the frequency of injuries, a life-cycle approach that incorporates the frequency of attaining each credit by green projects across the construction industry must be adopted. As the frequency of application of the EAc 2 credit is very low, the negative impact associated with the implementation of this credit on safety performance in the entire construction industry is negligible (the credit falls in the risk zone #1: reasonably acceptable risk that does not require urgent attention) based on the ALARP theory, as shown in Figure 2.3. Accordingly, future efforts to develop national mitigation strategies or potential updates to the LEED requirements to minimize green job safety hazard should be directed toward generating alternative strategies and practices to be incorporated into the requirements of SSc 7.2 and MRc 2 credits rather than focusing on the EAc 2 credit. This recommendation is based on the finding that SSc 7.2 and MRc 2 are accompanied with “unacceptable” safety risk on building operations and maintenance activities, while the EAc 2 credit is only attained by 15% of green projects.

2.10 Research Limitations

The primary limitation of the present study is that the research findings cannot be extended to all LEED facilities as this study focused solely on a particular type of a facility: LEED-NC buildings. Moreover, a sample size of 41 projects selected for the risk quantification analysis possessed a margin of error of 15% meaning that 95% of the time when conducting this observational study in the same manner, the obtained result would be 15% less or more extreme than the observed results. Nevertheless, the selected sample size was found to be representative of the US construction industry.

Another limitation is the fact that personal judgments were initially used in the process of assessing the impact of LEED credits. However, the authors believe that anchoring questions to relevant research findings available in literature produces valid judgments (Suhr 1999).

Finally, it was presumed that the 41 projects did not implement prevention controls and elimination measures (such as PtD strategies) for LEED design and construction methods. PtD strategies are not frequently implemented in the US construction industry (Gambatese 2000) as designers are typically not required either legally or contractually to address construction worker health and safety (Toole 2005) as well as other potential barriers that inhibit the implementation of PtD such as the lack of PtD training and education (Tymvios and Gambatese 2015).

2.11 Conclusions and Recommendations

Sustainable development is a comprehensive mission aiming primarily at the achievement of intergenerational equity on three key aspects: ecological, economic, and social. Social sustainability in construction is a life-enhancing process to accomplish social equality among all construction stakeholders in terms of health, education, economic welfare, and other human rights. For a project to be considered “sustainable”, the three pillars of sustainability must be equally achieved (Marjaba and Chidiac 2016) where worker health and safety is "engineered into the built environment" (Silins 2009). The present study conducted empirical analysis that involved a credit-by-credit review and formal risk assessment of LEED rating system credits to the extent each credit is attained in practice. The study results reveal that some design elements and construction practices implemented in sustainable construction to achieve the LEED certification may generate a negative impact on OHS. Of the 54 credits available in the LEED-NC v3 (2009) main categories, the majority of credits (37 credits) do not impact the health and safety of construction and maintenance personnel when compared with traditional design and construction features typically implemented on non-LEED buildings. However, 12 credits were found to influence worker health and safety either positively or negatively. The Heat Island Effect (SSc 7.2) and Construction Waste Management (MRc 2) credits were found to generate "unacceptable" safety risk to construction/maintenance personnel, which suggests that immediate attention is required. Only four credits were found to explicitly address worker health and safety, but two of them (IEQc 2 and IEQc 5) are not frequently attained by green projects. Finally, four credits were found to have a mixed impact on OHS, both positive and negative.

Most importantly, an aggregation of the cumulative SRM associated with sustainable construction is found to increase base-level safety risk, impacting safety performance across the construction industry negatively. Despite the undesired results, the inclusion of worker health and safety in the LEED rating system has recently gained momentum. The USGBC has released, and is in the process of testing, a new PtD pilot credit that explicitly addresses safety across the facility life-cycle.

To conduct future work that logically follows this study, the authors believe that developing a "workforce sustainability" practice guide or rating system for construction would be a valuable contribution to the body of knowledge on the relationship between safety and sustainability. It is also suggested that in depth analysis to evaluate the feasibility of the new PtD LEED pilot credit as a mean to improve safety performance in sustainable design and construction be carried out. Furthermore, the willingness of industry professionals to implement the PtD pilot credit should be investigated, and potential barriers and enablers for such implementation should be examined. Finally, further research to develop additional LEED pilot credits and investigate alternative green design suggestions for vegetated roofs and solar roofing systems in order to enhance OHS in sustainable construction is also encouraged.

2.12 Direction for Next Phase of the Research

Based on the aforementioned findings, construction and maintenance workers on LEED projects may be exposed to equivalent or even more health and safety risks than on alternative non-LEED counterpart projects. This is apparent evidence of a lack of social emphasis within the LEED rating system requirements especially at the workforce level. This lack of social emphasis (health and safety) raises concerns about the completeness of the LEED rating system as a method/approach to achieve sustainable development in the built environment. That is, the LEED rating system may not address all facets of sustainability, especially the social pillar of sustainability and at the workplace level, and if so, it cannot be considered an accurate measure of, or a method to achieve, sustainability in the built environment. Interestingly, the USGBC recognized this limitation of its LEED rating system and responded to this matter by releasing a new safety-related LEED pilot credit, titled Prevention through Design (PtD). The PtD LEED pilot credit explicitly addresses worker health and safety throughout the facility's lifecycle (USGBC, 2016), predominantly during the design phase. Examining the potential positive impacts of the new PtD LEED pilot credit and the degree of implementation to which this credit would be applied across the US construction industry is the objective of the second manuscript (Manuscript #2). This LEED pilot credit can be a potential solution for the lack of health and safety input on LEED-certified projects. Such a solution could address the lack of emphasis within the LEED rating system requirements on the social sustainability of the construction workforce.

MANUSCRIPT #2: INTEGRATING WORKER HEALTH AND SAFETY INTO SUSTAINABLE DESIGN AND CONSTRUCTION: DESIGNER AND CONSTRUCTOR PERSPECTIVES

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3.0 Manuscript #2 – Integrating Worker Health and Safety into Sustainable Design and Construction

3.1 Abstract

Sustainable building design and construction is gaining rapid growth within the architecture, engineering and construction (AEC) industry as a substantial opportunity to improve the efficiency of building projects by incorporating efficient and effective materials, technologies, and strategies into the building process. However, these approaches have been found to be associated with negative potential impact on the health and safety of field personnel. Prevention through Design (PtD) strategies are well-suited to prevent potential construction hazards in green jobs. The aim of the present study is to examine the perception of construction industry professionals about incorporating PtD practices into sustainable design and construction. To gauge the perception of professionals, a survey questionnaire was developed and distributed to two construction industry groups (designers and constructors). The present study contributes to the body of knowledge by providing evidence of the level of viability and extent of implementation of PtD practices into sustainable design and construction as well as identifying prevailing barriers and potential enablers of PtD implementation in the AEC industry. The findings of this research indicate that a large segment of construction industry professionals, especially designers, are resistant to the implementation of PtD practices into sustainable projects at this point in time. Fear of liability, contractual methods, and lack of safety knowledge were found to be the most prevailing barriers to the acceptance of PtD practices within AEC industry. On the other hand, ethics was regarded as the primary potential enabler for the implementation of PtD practice within the AEC industry. The authors recommend that the AEC industry move further toward collaborative project delivery methods. This transformation can facilitate a wider implementation of PtD practices within the AEC industry, especially in sustainable design and construction.

3.2 Introduction

Sustainable construction has experienced rapid growth over the past few decades, providing a substantial opportunity to create greener projects that benefit the environment, economy, and society. In 2013, more than 90% of construction stakeholders (architects, engineers, contractors, and owners) around the globe reported engagement with green technologies and approaches (SmartMarket Report 2013). In the United States, more than 70% of construction projects involved some level of green aspects in 2011 (CPWR 2013). Green jobs in construction are those businesses that genuinely and legitimately contribute to the achievement of sustainable development in which ecological, economic, and social elements are advanced. The growth of green jobs in the construction industry is expected to further expand through the end of 2016 during which 22% of construction companies are expected to work predominantly with green facilities (CPWR 2013). Even though the health and well-being of construction stakeholders has been found to be a fundamental element of sustainable development (Hinze et al. 2013; Valdes-Vasquez and Klotz 2011), previous studies have shown that worker health and safety may be overlooked in high-performance sustainable building construction (Dewlaney and Hallowell 2012; Dewlaney et al. 2012; Fortunato et al. 2012; Hinze et al. 2013; Karakhan and Gambatese 2017; Rajendran et al. 2009) and if so, a building cannot be truly "sustainable".

With regard to green buildings, it is widely believed in the construction industry that the presence of green building rating systems is beneficial, in terms of both providing mutually understandable industry language among stakeholders (SmartMarket Report 2013) and having an independent third-party oversee the process of transforming the built environment toward a more sustainable process. In the United States (US), the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) rating system is the predominant approach for the transformation of building design and construction toward sustainability (O'Connor et al. 2016). LEED is a consensus protocol developed by the USGBC in the 1990s to promote design, construction, and operation of sustainable buildings (USGBC 2016a). The overarching purpose of the present study is to investigate the connection between the LEED rating system and worker health and safety and to determine whether, and to what extent, worker health and safety will be integrated into sustainable design and construction as an innovative method to advance social sustainability. The term innovative method refers to a product/process/approach that is internally and externally valid. That is, in order to label a product/process/approach as innovative, it has to be *highly effective* (internally valid) yet can be *readily applicable* in practice (externally valid).

3.3 Safety Risk in Sustainable Construction

Design features and construction practices associated with the adoption of the LEED rating system generate numerous benefits to construction stakeholders—such as reducing operating costs and enhancing the health and well-being of building occupants (USGBC 2016a). However, several studies have reported a negative potential impact of some green features associated with the achievement of LEED requirements on worker health and safety. Rajendran et al. (2009) found statistically suggestive evidence that green buildings encounter higher recordable incident rates (RIRs) than non-green counterparts. Further research involved formal analysis of safety risk associated with the implementation of LEED requirements, and found that some green design elements and construction strategies tend to expose construction workers to unfamiliar tasks and hazardous work environments due in part to the incorporation of new materials, technologies and innovative strategies (Fortunato et al. 2012; Dewlaney and Hallowell 2012; Dewlaney et al. 2012). Such materials, technologies, and strategies may add another layer of complexity to construction processes as workers are unfamiliar with required methods and procedures (SmartMarket Report 2013). This condition may increase safety risk and hazard exposure to field personnel during construction and maintenance operations when compared to non-green alternatives.

In a recent study, researchers performed a quantitative risk analysis of the impact of LEED rating system credits on occupational health and safety (OHS) and to the extent to which LEED credits are actually implemented across the US construction industry (Karakhan and Gambatese 2017). Based on the analysis of 41 LEED-certified projects, the study findings indicated that LEED requirements are associated with increases in base-level safety risk across the construction industry. Specifically, green strategies used to reduce urban heat island effects on building rooftops and recycling methods implemented to manage construction waste on construction jobsites were classified as having "unacceptable" safety risks to field personnel (Karakhan and Gambatese 2017). An example of an unacceptable safety risk is exposure to the risk associated with the activity of covering the building rooftop with vegetation—as vegetation typically requires frequent maintenance near unprotected roof-edges (Behm 2012; Fortunato et al. 2012). Similarly, recycling building materials was found to present potential safety hazards to construction workers as this task involves diverting waste and demolition debris from disposal in landfills. In this regard, recyclable materials were found to expose workers to health problems and safety issues due to the presence of sharp and heavy objects among disposed materials (Dewlaney et al. 2012), or harmful substances associated with construction waste diversion (EU-OSHA 2013a). Accordingly, determining effective safety measures [e.g., prevention through design (PtD) strategies] that are capable of proactively eliminating green job hazards seems to be of paramount significance in order to create truly sustainable development in the built environment. The following section describes the concept of PtD in relation to safety risk elimination, especially with regard to sustainable design and construction.

3.4 Prevention through Design in Sustainable Construction

Construction projects contain many safety hazards. In 2018, 1,007 construction work-related fatalities were reported in the United States (BLS 2019). Studies have shown that the high number of construction fatalities may be attributed to the lack of safety input during the design process (Behm, 2005; Gambatese et al. 2008). According to the hierarchy of controls (Manuele 2005), a PtD approach that targets eliminating hazards is the most effective and reliable means of preventing occupational injuries, illnesses, and fatalities. Such an approach requires paying attention to worker health and safety early in the design process by making design modifications to the permanent features of the facility so that construction hazards are eliminated upstream in the building process prior to construction. It is important to realize that preventing hazards through design does not imply that design professionals should be involved in specifying construction means and methods; rather, preventing hazards at the source mainly requires modifying the facility design prior to construction activities so that the building system can be easily and safely constructed (Karakhan 2016b).

Advocates of PtD suggest that prevention strategies be integrated into green designs to facilitate the social dimension of sustainability—the concept of social equity (Valdes-Vasquez and Klotz 2011). Achieving the goal of social equity among construction stakeholders involves ensuring that construction worker health and safety remain equally important as the health and well-being of future building occupants. Following this propensity, the National Occupational Research Agenda (NORA) in its Strategic Goal 13.0 called for a need to implement PtD practices as an important facet of sustainability in building design and construction (NORA 2008). As a response to this call, the National Institute for Occupational Safety and Health (NIOSH) launched an initiative referred to as "Going Green: Safe and Healthy Jobs" to gain input from various construction stakeholders on how to ensure that OHS is prioritized on green jobs. Once more, PtD strategies were identified as being of imperative importance in the effort to embrace the social goals of sustainability, including the promotion of OHS.

Following this momentum, Behm (2012) developed PtD suggestions to mitigate safety hazards associated with the construction and maintenance of green roofs. Specifying a minimum of 1-meter (39-inches) for the height of parapet walls around the entire perimeter of a roof was suggested as the most effective measure to eliminate fall hazards on vegetated roofs (Behm 2012). In the same regard, Dewlaney and Hallowell (2012) created a decision support tool for sustainable building design and construction. The researchers conducted a series of interviews with highly experienced industry professionals representing different construction stakeholders to identify PtD solutions for sustainable construction, which were then incorporated into the decision support tool (Dewlaney and Hallowell 2012). One of the suggestions included modifying the facility's design to locate heating, ventilating, and air conditioning (HVAC) systems under the ground instead of in the ceiling slab. Situating the HVAC system under the ground can help prevent fall injuries by eliminating the need to work at high elevation.

3.5 Point of Departure

Following interest in the PtD concept within the architecture, engineering and construction (AEC) industry, researchers recommended that PtD practices be incorporated into the LEED rating system as an effective approach to enhance the health and safety of those who construct, operate, and maintain green facilities (Rajendran and Gambatese 2009; Hinze et al. 2013). Due in part to this impetus, the USGBC has recently released a new LEED pilot credit titled "Prevention through Design" to address worker health and safety throughout the facility's life-cycle (USGBC 2016b). The new PtD pilot credit includes suggestions to address worker health and safety across the facility life-cycle by paying early attention to workplace safety during the design process (USGBC 2016b). Karakhan (2016b) stated that the implementation of this PtD pilot credit can facilitate the holistic approach of sustainability which should ideally include not only the achievement of ecological and financial benefits, but also the fulfillment of social factors (e.g., life-cycle safety).

In addition to safety benefits, PtD strategies, such as those incorporated into the PtD LEED pilot credit, are expected to bring financial and non-financial benefits to construction stakeholders in terms of schedule, worker morale and productivity, project constructability, and quality of the final product (Gambatese et al. 1997). However, a question of interest is: "Are PtD practices as a part of the LEED rating system pilot credit program considered an "innovative" approach (i.e., highly effective and readily applicable) to advance workplace safety on sustainable building projects?" To ensure that the PtD approach is highly effective (internally valid), it must be able to eliminate a substantial percent of workplace safety hazards. Previous research has already verified the effectiveness of PtD practices in mitigating workplace safety hazards on sustainable projects (Behm 2012; Dewlaney and Hallowell 2012). Yet, the implementation of PtD practices throughout the United States AEC industry is limited. It is unknown whether PtD practices have the ability to be broadly diffused into the green market of the AEC industry. Advocates of PtD claim that PtD practices can experience greater diffusion in sustainable design and construction than in traditional non-sustainable construction (Albattah et al. 2013; Dewlaney and Hallowell 2012). Based on this claim, it is hypothesized in the present study that PtD is a valid approach (internally and externally) to improve workplace safety in sustainable design and construction. However, previous studies provided no empirical evidence of the level of viability and extent of implementation of PtD in sustainable design and construction. Verifying the research hypothesis means that the new PtD pilot credit may outweigh the negative impact of the LEED rating system on worker health and safety. If so, this PtD pilot credit can be regarded as an innovative approach to advance the social elements of sustainability within the AEC industry especially as they relate to the workforce. Given current knowledge, it is unknown whether construction industry stakeholders, including sustainability professionals, perceive the PtD pilot credit in a positive or negative manner, or are even aware of the existence of the credit. The present study aims at bridging this knowledge gap by investigating the extent to which the new PtD LEED pilot credit will be implemented in sustainable design and construction across the United States AEC industry. The answer to this primary objective will be determined based on the following research questions:

1. Are construction industry professionals (both designers and constructors) aware of the existence of the PtD LEED pilot credit?;
2. How does each construction industry group perceive the process of designing for construction worker health and safety in sustainable construction (i.e., the potential impact of implementing this PtD pilot credit)?;
3. To what extent would the PtD pilot credit be sought by industry professionals across the AEC industry?; and,
4. What are the prevailing barriers and potential enablers of the implementation of this PtD pilot credit across the AEC industry?

The answers to the aforementioned questions can indicate whether the NORA strategic goal to incorporate PtD practices into sustainable design and construction can be practically achieved; and if so, what actions and modifications are required to facilitate such achievement. To proceed with this study, the authors decided to select only two construction industry groups (designers and constructors) as the study participants, as these groups are typically the key parties that lead the planning and designing effort for a sustainable project.

3.6 Research Methodology

3.6.1 Data Collection Method

Asking in-depth questions in a systematic way is an effective method for gathering useful data. As such, the researchers adopted a survey as the primary data collection method for the present study. A primary reason behind the use of a survey for this research is the fact that no empirical data about the PtD pilot credit is available, either in existing academic literature or in the USGBC's Directory. Other reasons for selecting a survey as the primary data collection method includes the ability of the research involving survey to collect insights from a large number of diverse professionals distributed across different geographical locations. The subsequent sections will describe the survey design, the sampling method used to recruit participants, and the method used to distribute the survey.

3.6.2 Survey Design

The researchers designed the survey questionnaire to capture qualitative data using open-ended questions and quantitative data using closed-ended questions, following guidelines provided by Abowitz and Toole (2010) and Leedy and Ormrod (2016). Abowitz and Toole (2010) indicated that collecting qualitative and quantitative data improves the reliability of the research findings. The questions developed solicited information pertaining to participants' demographics and credentials, attitudes about workplace safety, perceptions about designing for worker health and safety in sustainable construction, and viewpoints about prevailing barriers and potential enablers for the implementation of PtD practices as a part of the LEED rating system. To account for the specific roles of each occupation, each AEC industry group (designers and constructors) received a separate questionnaire that contained slightly different wording. The surveys included factual, behavioral, and attitudinal type-questions in the format of closed-ended, open-ended, and multiple-choice questions, as recommended by Abowitz and Toole (2010). Closed-ended questions were designed to ask participants to state their level of agreement/approval/etc. with particular statements. A Likert scale was used for this purpose, as it is one the most prevalent scaling techniques used in surveys to measure the extent to which a participant agrees or disagrees with a particular statement (Azari and Kim, 2015). On the other hand, open-ended questions aimed to solicit detailed viewpoints relevant to the questions of interest, ensuring internal validity to the survey. Multiple-choice questions were also integrated into the questionnaire to collect participants' insights about potential barriers and enablers to PtD implementation in the AEC industry. All of the aforementioned procedures are expected to provide a high level of reliability to the findings and improve the validity of the research.

3.6.3 Sampling Method

There are two types of sampling methods: probability sampling and non-probability sampling (Leedy and Ormrod 2016). Probability sampling is generally more adequate from a statistical standpoint to study the behavior of the entire population because it involves the study of a randomly selected sample. However, in construction research, a randomly selected sample is challenging and may not be feasible in many cases. Therefore, purposeful (non-probability) sampling is frequently used instead in construction research (Abowitz and Toole 2010). Accordingly, the study sample of the present research was purposefully selected to form a list of highly experienced industry professionals in the field of building design and construction.

The survey targeted those design professionals who are actively involved in the design process of building construction. The researchers obtained a list of designers from the member database of the American Institute of Architects (AIA). Similarly, a list of constructors was generated from the member directories of the American Institute of Constructors (AIC) and the Associated General Contractors of America (AGC). Lastly, a search of the USGBC directory expanded both lists to include highly experienced green design and construction professionals, such as LEED accredited professionals (APs). The combined list consisted of 2,641 industry professionals—2,324 designers and 317 constructors.

3.6.4 Survey Distribution and Sample Demographics

The questionnaires were designed to answer the research questions mentioned previously and to solicit relevant information about the perception of different construction industry groups about workplace safety. The questionnaires used in the present study built upon previous construction safety questionnaires available in literature. The questionnaires were initially pilot tested and then revised to ensure clarity and understanding of the specific aim of each question. Next, the researchers distributed the questionnaires to the targeted participants in the form of an email containing a personal link to the questionnaire. Of the 2,641 construction industry professionals in the study sample, 1,300 professionals (of which 1,118 were design professionals while 182 were constructors) were successfully contacted. A total of 122 responses were received, yielding an overall response rate of 9.5% which is relatively low. Specifically, the response rate of the design group was found to be 9% (101 received out of 1,118), while the response rate of the constructor group was slightly higher (11.5%) with 21 out of the 182 questionnaires successfully delivered to the constructor group members returned. The relatively low response rate was expected as the targeted industry professionals were neither motivated by their professional organizations to participate in the survey nor offered any tangible incentive.

After collecting the survey data, it was found that the demographics of both groups represented a diverse pool of respondents. Responses from the design group came from 95 architects, 2 landscape architects, 2 sustainable designers, 1 building design engineer, and 1 interior designer, representing 35 states across the United States. On the other hand, responses from the constructor group were completed by 12 superintendents, 5 project managers, 3 project engineers, and 1 specialty trade manager, who are located in different geographical locations (12 states across the United States).

In terms of experience, participants had extensive experience in the AEC industry. Approximately 90% of the design professionals and 80% of the constructors who responded to the survey have had more than 10 years of experience in the field of design and/or construction of various types of facilities. In addition, more than 53% of the design professionals and 33% of the construction professionals are LEED APs, yielding a total of 61 LEED APs who participated in the survey. In total, the participants were involved in the design and/or construction of more than 700 LEED-certified projects throughout the United States. The participation of a diverse and highly experienced sample distributed over 36 states may outweigh the limitation of having a low response rate in the data collection process. Table 3.1 illustrates the sample distribution and response rate of each group of construction industry professionals.

Table 3.1: Sample Distribution and Response Rate of Construction Industry Groups

Industry Group	Contacted	Responded	Response Rate	Sample Distribution	LEED APs
Designers	1,118	101	9%	35 states	53% (54 out of 101)
Constructors	182	21	11.5%	12 states	33% (7 out of 21)
Overall	1,300	122	9.5%	36 states	50% (61 out of 122)

3.7 Results and Analysis

3.7.1 General Views from Construction Industry Professionals about Workplace Safety

As mentioned previously, designing out hazards such that a facility can be safely constructed is the most effective and reliable means of preventing work-related injuries, illnesses, and fatalities according to the hierarchy of controls. Hazard elimination, represented by PtD, involves early attention to worker health and safety throughout the design process. However, unlike other counties, the involvement of design professionals throughout the US in construction site safety is not legally mandated nor typically required contractually. The Occupational Safety and Health Administration (OSHA) places the responsibility for providing a safe workplace for construction workers on their employer (typically the construction general contracting and sub-contracting firms). In a similar manner, construction contracts typically do not include provisions to require designer involvement in the construction site safety effort. Toole (2005) reported that the AIA model contracts between an owner and designer, and between an owner and contractor, may "disclaim designer safety responsibility." However, designers can play a role in safety and have a positive influence on safety. Decisions made during the design process influence construction means and methods (Tymvios and Gambatese 2015), and thus can directly or indirectly impact construction site safety. Yet, this direction is not widely adopted by design professionals in the United States. Many designers are reluctant to the idea of playing an active role in construction site safety due in part to the highly litigious nature of the construction industry (Gambatese and Hinze 1999).

It is also believed that a lack of knowledge and education about construction hazards may discourage architects and engineers from taking active steps in the effort to address worker health and safety (Tymvios and Gambatese 2015). The separation and adversarial relationships between project team members, especially designers and constructors on those projects delivered using traditional delivery methods [e.g., Design-Bid-Build (DBB)], can be another reason behind the lack of designers' interest in designing for worker health and safety (Tymvios et al. 2012).

In response to a question about the potential relationship between safety and sustainability, the majority of both groups (65% of constructors and 54% of designers who responded to the question) either agreed or strongly agreed that life-cycle safety, including the safety of construction workers, is an integral aspect of sustainable development, as illustrated in Figure 3.1. Life-cycle safety is defined by Karakhan (2016a) as "a holistic approach considered during the early stages of the design process of a facility to ensure that the safety, health, and well-being of all people (construction workers, building users, and maintenance personnel) are addressed throughout a project's lifetime." However, the responsibility for protecting worker health and safety was viewed differently by each construction industry group. While both groups, constructors and designers, unanimously acknowledged that construction site safety is primarily the contractors' and sub-contractors' responsibility, a large percent of designers did not seem to support the idea of having a collective and collaborative safety effort that requires designer involvement (see Figure 3.2). Only 28% of designers agreed that they are responsible in some way for worker health and safety, and that they should be participating in workplace safety efforts. On the other hand, contractors viewed worker health and safety as the responsibility of all parties, including designers, owners, and construction workers.

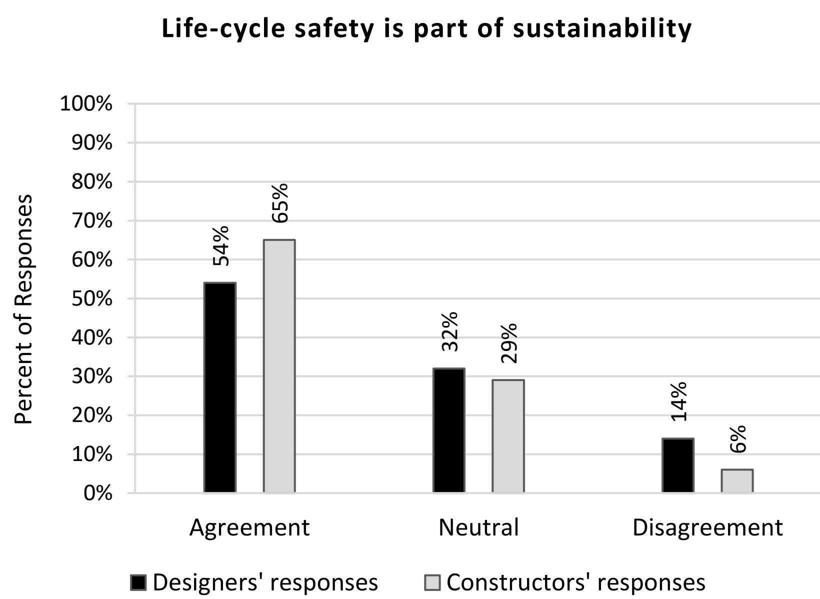

Figure 3.1: Viewpoints from Industry Professionals on Safety and Sustainability (n = 95)

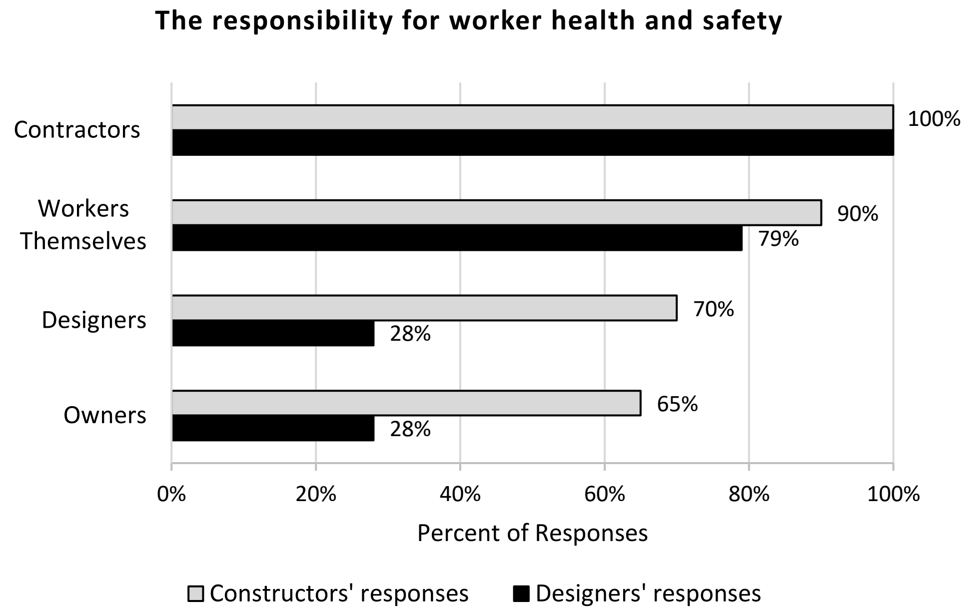

Figure 3.2: Viewpoints from Industry Professionals about Workplace Safety (*n* = 115)

With regard to sustainable development, it is unknown whether including PtD in the LEED certification would facilitate the diffusion of PtD in the AEC industry. Piispanen (2015) argued that there is an opportunity for architects and engineers not only to improve worker health and safety on sustainable projects, but also to claim the LEED credit point for the PtD effort. However, there is no empirical evidence that this tangible benefit (the one-point LEED credit) would generate adequate interest in the implementation of PtD on green projects. This lack of evidence is why the need for the present research study is imperative. The remainder of the paper includes: (1) a statistical analysis of the survey results to answer the first three research questions, stated previously; and (2) a discussion about prevailing barriers and potential enablers for the implementation of PtD practices within the AEC industry.

3.7.2 Statistical Methods

The primary objectives of the present study are to investigate the perception and awareness of two key construction industry groups (designers and constructors) about the PtD credit in terms of acceptance and the extent of implementation throughout the AEC industry, in addition to highlighting prevailing barriers and potential enablers for such implementation. Based on these objectives, performing inferential statistical analysis is more appropriate to answer the questions of interest because inferential statistics can help the investigators infer something about the larger population by relying on data obtained from a sample. Nevertheless, it should be mentioned that because non-probability sampling was adopted in the selection of the sample size, only inference of association between the independent and dependent variables, as opposed to cause-and-effect inference, is possible (Leedy and Ormrod 2016; Ramsey and Schafer 2013).

Inferential statistical analysis typically involves either parametric or non-parametric tests (Ramsey and Schafer 2013). With regard to analyzing Likert scale types of data, both parametric and non-parametric statistical analyses have been used in the literature to reveal valid conclusions (Winter and Dodou 2012). However, parametric analysis typically requires that a set of data meets specific assumptions about the underlying population being examined (Ramsey and Schafer 2013), such us normality. As normality is suspicious in the distribution of the questionnaire responses in the present study, non-parametric statistical tests were adopted were adopted to analyze the survey results.

Selecting a particular statistical test to conduct the data analysis relies significantly on the question of interest under investigation. For the first three research questions mentioned previously, examining the multiplicative difference or degree of association between responses of both groups (a comparison between agreement/disagreement of one group to another) is a primary objective. Additionally, testing the statistical significance of association between the types of responses (whether agreement or disagreement) and the group to which the respondents belong (whether design or constructor group) is another primary purpose of the statistical analysis for these three questions of interest. Accordingly, the odds ratio (OR) was adopted to measure the degree of association (degree of independence) between the responses of the design group and the constructor group, while the Chi-Square test of independence (X^2) was used to test whether the type of response (agreement versus disagreement) is statistically related (not independent) to the group of construction industry professionals being examined at a significance level of 5%. Such a level of statistical evidence considers a proof that the degree of association between type of responses and group of professionals is not due to a normal random chance of variations, and is mainly caused by different perceptions of both groups. The Chi-Square test is recommended and used by several researchers in the existing academic literature for analyzing Likert scale types of data (Allen and Seaman 2007; Tymvios and Gambatese 2015).

However, in order to perform a Chi-Square analysis, responses need to be truncated and arranged into a 2 x 2 table (Ramsey and Schafer 2013). Accordingly, the survey responses were grouped into two categories (agreement versus disagreement) instead of three and five categories, as shown in Figure 3.3. To be consistent with literature (Tymvios and Gambatese 2015) and provide conservative conclusions, the authors decided to group uncertainty or neutral behavior-type answers into the non-agreement category. It is worth mentioning that, for many of the survey questions, participants were asked to express their degree of agreement or disagreement, or approval or disapproval, with a particular statement using a five-point Likert scale (e.g., “strongly disagree,” “disagree,” “neutral,” “agree,” and “strongly agree”) as it is claimed to provide “the highest reliability” (Azari and Kim 2015). However, a three-point Likert scale, which asks participants to select an answer pertaining to whether they completely agree with, completely disagree with, or are uncertain about a statement, was also used for some of the survey questions because it was more appropriate to be specific when asking those questions. Figure 3.3 shows an example of how the survey responses were truncated into a 2 x 2 contingency table. It should be noted that the Chi-Square test is not recommended when any of the cells of the truncated data contain less than five responses. Therefore, Fisher's Exact test was performed, as recommended by Ramsey and Schafer (2013), whenever one or more of the cells had less than five responses. Both Chi-Square and Fisher's Exact tests are used to test the association between two categorical variables, in this case the group to which a professional belongs and the type of response to a question. Under the null hypothesis, it is hypothesized that the two variables are statistically independent. On the other hand, the alternative hypothesis indicates that there is a statistically strong association between the categorical variables (industry group and type of response), suggesting that the group to which a participant belongs may impact his/her response significantly from a statistical standpoint when compared against a sample from the other group.

Groups	Raw Data (Source Data)				
Designer Grp	$DR_{SA/Yes}$	DR_A	$DR_{N/U}$	DR_D	$DR_{SD/No}$
Constructor Grp	$CR_{SA/Yes}$	CR_A	$CR_{N/U}$	CR_D	$CR_{SD/No}$

Groups	Truncated Data (Cooked Data)	
Designer Grp	Designer Agreement Responses ($DR_{SA/Yes}$ + DR_A)	Designer Disagreement Responses ($DR_{N/U}$ + DR_D + $DR_{SD/No}$)
Constructor Grp	Constructor Agreement Responses ($CR_{SA/Yes}$ + CR_A)	Constructor Disagreement Responses ($CR_{N/U}$ + CR_D + $CR_{SD/No}$)

Note: DR (designer responses); CR (constructor responses); SA (strongly agree); A (agree); N (neutral); U (uncertain); D (disagree); and SD (strongly disagree).

Figure 3.3: Truncation of Likert-Scale Data

3.7.3 Awareness of PtD LEED Pilot Credit

One objective of the survey was to examine whether the participants had prior knowledge about the PtD LEED pilot credit. The results of the analyses reveal that designers are 1.82 times more likely than constructors to be aware of the PtD pilot credit. However, both construction industry groups (90% of designers and 94% of constructors who responded to the question) were found to be either entirely unaware of, or not familiar with, the intent and requirements of the PtD pilot credit at this point in time. The statistical analysis revealed no evidence that the group to which a participant belongs affects the participant's degree of awareness about this credit [Fisher's Exact test (n = 95): p-value ~ 1.00; 95% confidence interval (CI) =

0.22-86.11]. Even those professionals who are LEED APs were found to have either no or limited knowledge about designing for worker health and safety as a part of the LEED pilot credit program. Only 12% of LEED APs indicated that they had prior knowledge about the PtD pilot credit. Among those LEED APs, constructors are 1.33 times more likely than designers to be aware of the requirements to achieve the pilot credit. However, the level of awareness regarding the PtD pilot credit requirements among the group consisting of LEED APs was statistically insignificant [Fisher's Exact test (n = 52): p-value ~ 1.00; 95% CI = 0.02-15.44]. A breakdown of the responses is shown in Figure 3.4, summarizing the level of awareness of construction industry professionals about the new PtD LEED pilot credit.

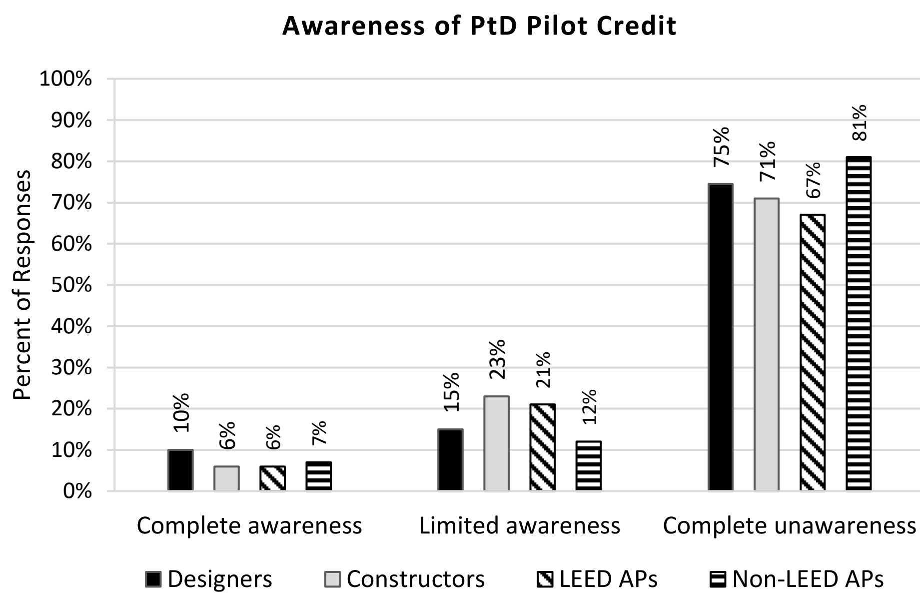

Figure 3.4: Prior Knowledge of Industry Professionals about PtD LEED Pilot Credit (n = 95)

3.7.4 Perception of Construction Industry Professionals about PtD LEED Pilot Credit

According to the PtD LEED pilot credit, to attain the credit project teams are required to incorporate worker health and safety into construction plans and specifications. The requirements entail considerations for two key building phases—operation and maintenance (O&M) and construction. In the O&M phase, one part of the requirements is directed toward evaluating worker access to roof systems (including green roofs and solar panel installations). This evaluation is important to protect landscapers, solar panel installers, and other workers against fall hazards (USGBC 2016b), the major cause of fatal injuries in the United States (BLS 2015). Attention is also given to minimizing safety risks in association with building exterior enclosure and daylighting systems as well as storage and collection of hazardous waste steams (USGBC 2016b). On the other hand, the credit requirements during construction call for using passive safety systems (e.g., specifying innovative and creative safe designs) in order to address construction hazards associated with overhead power lines, brownfield soil exposure, deconstruction and re-use of building materials, waste recycling techniques, working in confined spaces and near roof-edges, and so forth (Piispanen 2015; USGBC 2016b). Passive safety measures (e.g., specifying a tall parapet around the perimeter of the roof) are preferable over active measures (e.g., using safety harness) because passive measures eliminate the root causes of hazard and do not require worker involvement in activating the system (Behm 2012).

To gauge the perception of construction industry professionals about the PtD pilot credit requirements, one survey question asked, “Do you think the PtD pilot credit, if pursued, will improve safety performance and reduce occupational injuries and illnesses during construction/maintenance operations?” Contractors were found to be 5.12 times more likely than designers to agree that the PtD credit requirements, if satisfied, would improve safety performance on construction projects, revealing a statistically significant association between the type of response and the industry group from which a participant comes [$X^2_{(1, 93)} = 7.18$; *p*-value ~ 0.01; 95% CI = 1.40-19.03]. That is, approximately half of the constructors (47%) who responded to this question appeared to show complete agreement that the PtD pilot credit requirements can be an effective method to improve worker health and safety (versus only 12% who showed complete disagreement). On the other hand, a larger percentage of design professionals (86%) indicate either disagreement or uncertainty about the effectiveness of the PtD credit requirements. Only 14% of designers believe that the credit requirements can be effective in enhancing construction worker health and safety. To justify their point of view, designers stated that there are sometimes no effective communication channels between designers and general contractors, especially in DBB project delivery methods, to communicate safety hazards to constructors or participate in a collaborative constructability review process.

3.7.5 Extent of Implementation of PtD LEED Pilot Credit

To evaluate the extent of implementation of the PtD LEED pilot credit on sustainable projects, the survey included two questions pertaining to the degree of implementation of the PtD pilot credit requirements across both the selected sample size and the AEC industry as a whole. The first question asked, “Would you consider implementing this PtD pilot credit in your next LEED project(s) … in the near future?” The majority of constructors (69%) stated that they would consider pursuing the PtD credit as a part of the LEED certification in their future projects. It is worth mentioning that only 6% of constructors were resistant to the idea of implementing the PtD pilot credit requirements. Critics of PtD felt that facility owners would not be willing to pay extra cost for safety design reviews conducted by design and construction professionals.

On the other hand, design professionals showed less support for the adoption of PtD practices on green projects. Only 47% of designers indicated that they would consider implementing the credit requirements on their future sustainable projects. Compared to the constructors' responses, design professionals were 2.48 times less likely to show support for the implementation of the PtD pilot credit suggestions on LEED projects. However, there was no statistically significant evidence that the responses of participants depend upon their profession [$X^2_{(1, 93)} = 1.76$; p-value ~ 0.18; 95% CI = 0.71-10.01].

In response to the second question which asked respondents to predict the degree of implementation of the PtD pilot credit as a part of LEED projects throughout the AEC industry, constructors were 3.59 times more likely than architects and engineers to expect frequent or very frequent implementation of the PtD pilot credit. The statistical analysis revealed moderate evidence that there is an association between the profession of the respondents and their responses [$X^2_{(1, 94)} = 3.45$; p-value ~ 0.06; 95% CI = 0.89-13.83]. Interestingly, respondents who are LEED APs were not found to support the implementation of the credit requirements. In contrast, non-LEED APs were 7.42 times more likely than LEED APs to expect frequent adoption of the pilot credit in the built environment. This discrepancy between viewpoints of LEED APs and non-LEED APs was found to be statistically significant [Fisher's Exact test (n = 93): p-value ~ 0.00; 95% CI = 1.82-44.04], revealing that non-LEED professionals may be less reluctant to the implementation of PtD practices in green designs. LEED APs attributed their opposition to the implementation of PtD practices in green jobs to the lack of knowledge among project team members about designing for worker health and safety, the possibility of increasing project cost and the likelihood of adding another layer of complexity to green building design and construction. The results of this section are summarized in Figure 3.5.

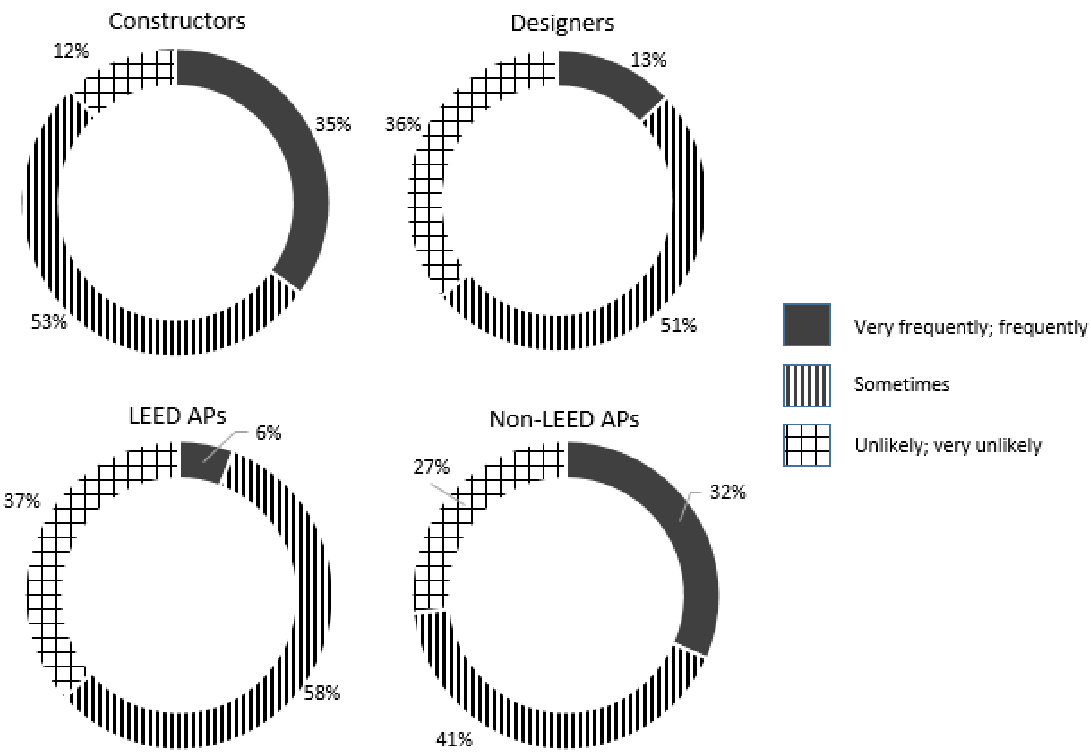

Figure 3.5: Professionals' Viewpoints on the Diffusion of PtD Pilot Credit across Industry (*n* = 93)

A review of literature reveals that incorporating PtD practices into the design process is a collaborative effort that requires both designer and constructor involvement throughout the design process (Gambatese et al. 2013). Designers have the influence and authority to modify design elements in order to address worker health and safety, while constructors have the experience and understanding of the impact of design elements on construction means and methods implemented in the field, and therefore can provide useful input on such modification. Given the importance of collaboration among project teams when designing for worker safety, the USGBC suggests that PtD requirements be incorporated into the "integrative process" LEED requirements (a new credit to achieve synergies across different disciplines) in order to reinforce teamwork and collaboration (USGBC 2016b). However, based on the survey results, it seems that the diffusion and implementation of the PtD pilot credit requirements could be sparse. As such, it was imperative for the present study to investigate the barriers inhibiting the diffusion of the PtD concept in the AEC industry. In addition, potential enablers, especially for designers, to address worker health and safety in the design process were explored. It should be acknowledged that facility owners can have a great influence on the implementation of the credit across the AEC industry, especially if they are concerned about worker safety during the building process. However, this objective is beyond the scope of the present research and therefore not discussed.

3.7.6 PtD LEED Pilot Credit: Barriers and Enablers

Though PtD practices have been identified as an effective method of eliminating hazards, implementation of the PtD concept in the AEC industry remains sporadic and is faced with great aversion by the design community as observed in the survey responses discussed previously. The questionnaire asked designers to prioritize barriers inhibiting the design community from adopting PtD practices. Ninety percent of designers who responded to the question indicated that liability issues are the main reason why PtD implementation may not be feasible. Many of the designers stated that their involvement in addressing workplace safety would increase their professional liability and may cause problems with their insurance carriers. Also, some of the designers claimed that their lawyers advised them not to be involved in safety efforts or presume responsibility for workplace safety in order to avoid any potential liability for safety injuries. Seventy-nine percent of designers highlighted contractual methods as the second critical reason why they cannot effectively participate in safety constructability reviews or other safety efforts required for PtD implementation. Some designers contended that traditional project delivery methods inhibit collaboration and foster segregation of the industry (designers versus contractors) in addition to the fact that, in many cases, the contractor is not identified until the design is complete. Lack of knowledge in construction safety and limited resources were identified as the third most prevalent obstacle to the acceptance of PtD practices amongst those in the design community. Many of the designers claimed that they did not receive any training or continuing education about PtD. This is not surprising given the finding that only 38% of the surveyed designers mentioned that they had received safety training sometime in their career. The fourth contributing factor inhibiting the diffusion of PtD in the AEC industry is believed to be cultural; that is, the disengagement of design professionals in the effort toward workplace safety has been “a standard historic practice” in the United States.

In addition to the four factors mentioned above, approximately half of the designer responses (51%) indicated that there is sometimes insufficient funding and time available for designing for worker health and safety as designers are obligated to address other important criteria in the design process (e.g., regulatory requirements, building codes, etc.). Moreover, 32% of the responses contributed the lack of PtD adoption in the AEC industry to the lack of motivation for designers to be involved in the safety effort. Finally, a low percentage of responses (13%) identified other potential barriers to PtD practices. For example, one designer contended that eliminating construction hazards depends primarily on construction means and methods and, therefore, PtD practices may still be ineffective if the contractor selects the wrong means and methods. Figure 3.6 summarizes the results of this section.

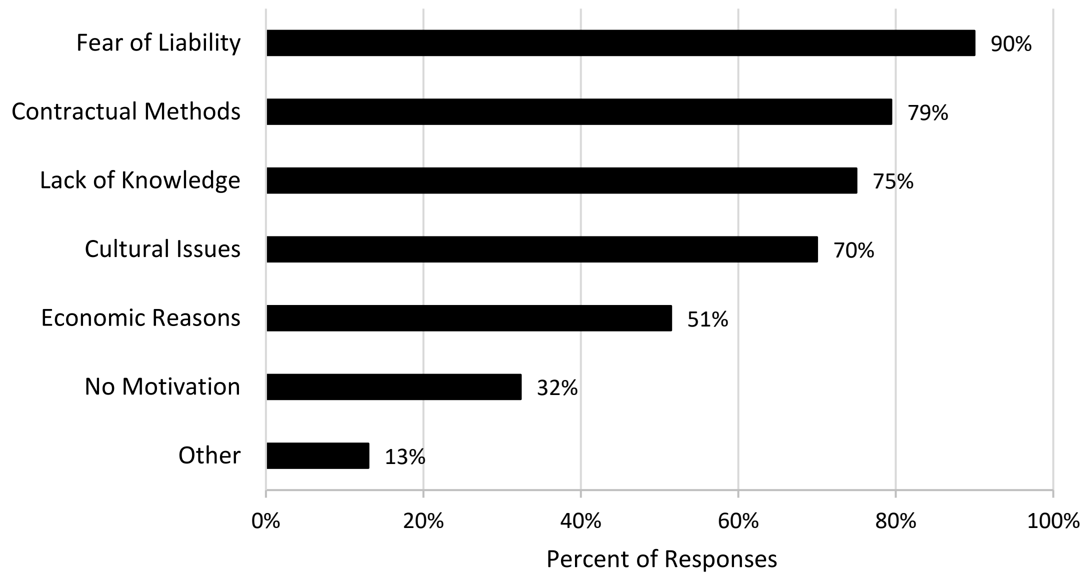

Figure 3.6: Potential Barriers to Design for Worker Health and Safety – Designer Perspective (*n* = 86)

In the same regard, constructors confirmed the aforementioned barriers, contending that from their point of view, fear of liability and potential budget overruns and schedule delays are the main reasons behind the limited adoption of PtD practices. Constructors also added that some designers may not acknowledge that designing an assembly that is easily constructed brings numerous safety and non-safety benefits to construction stakeholders. One constructor claimed that designers typically focus primarily on aesthetics and the safety of end users, and may disregard the importance of ensuring safety during construction operations.

Regardless of the presence and extent of barriers, there are enablers for implementing the PtD concept in the AEC industry. In response to a question about potential enablers of the implementation of PtD practices, ethics was viewed by design professionals as the most prominent enabler of the implementation of PtD practices. Codes of ethics prepared by professional organizations often address safety related to a professional work. However, for design professions, the safety targeted is commonly limited to those who use and are impacted by the design after it is complete. Extending this obligation to the safety of those constructing the facility can be an additional enabler.

Moreover, the respondents believed that legal and contractual conditions can enable diffusion of PtD practices across the AEC industry in the United States. That is, some designers believe that addressing worker safety during design may reduce a designer's liability for workplace injuries. It is believed that construction accidents are one of the main reasons behind litigation and, if so, eliminating the hazard at the source using PtD practices can reduce the exposure of designers to potential lawsuits. In that regard, Karakhan (2016b) concluded, after reviewing several legal cases, that design professionals have no legal immunity for workplace injuries unless they show due diligence in protecting worker health and safety.

The business case method was mentioned by 31% of designer responses as another possible enabler for the implementation of PtD practices by the design community. Some designers also commented that integrating worker health and safety in the project design can bring about financial savings in the long run. Karakhan et al. (2016) conducted a value-cost analysis using the choosing-by-advantages (CBA) decision-making system to select fall protection measures on the rooftop of a one-story physical utility building, and confirmed the potential benefits. In the study, the researchers found that the PtD solution generated the greatest value and was the most affordable safety measure in the long run.

Lastly, 24% of designers who responded to this question felt that there are other conditions and practices, such as training and education, that can enable greater diffusion of the PtD concept in the AEC industry. It is worth noting that the findings of the present study about the enablers of and barriers to PtD implementation in the US are consistent with previous studies (Gambatese et al. 2008; Toole 2005; Tymvios and Gambatese 2015). However, the present study is unique in the sense that it focuses particular attention on the implementation of PtD practices in sustainable building design and construction.

3.8 Research Validation and Limitations

Validation of the research methodology and its results is an essential element of a rigorous and reliable research process to reveal scientific and legitimate research findings that contribute to the advancement of scholarly endeavors. Internal, external, face, and construct validities are typically the most applicable elements of the validation process in construction research (Abowitz and Toole 2005; Fellows and Liu 2015; Lucko and Rojas 2010). Internal validity refers to the causal relationship that can be established based on the results of a study or an experiment. In the present study, the sample size was conveniently selected using purposeful sampling. This limitation inhibits the possibility of drawing causal inference to the larger population due to the presence of potential confounding variables. Therefore, the internal validity of this research study is limited, and conclusions extracted from this research can only be used to draw inference of association between the independent and dependent variables as opposed to cause-and-effect types of conclusions.

External validity, on the other hand, refers to the extent to which the findings of a study or an experiment can be generalized beyond the sample studied. Even though participants were not randomly assigned, the sample size was found to be representative of the United States AEC industry in which 36 states were represented in the study. Moreover, the survey respondents were highly experienced in the fields of both design and construction of building projects. Accordingly, the authors feel confident that adequate external validity was established and the study findings can be generalized with a high level of reliability beyond the sample size to provide at least an indication about the perception of industry professionals regarding designing for safety in sustainable building design and construction. That being said, the potential limitation of the relatively low survey response rate (9.5%) must be acknowledged. The low response rate may raise some suspicions about the results of the survey; that is, it cannot be ruled out with a high level of confidence that those who responded to the survey questionnaire may not represent those who did not. Low response rate to surveys is a persistent issue in construction research (Abowitz and Toole 2005; Fellows and Liu 2015). This limitation can be even more substantial taking into consideration that some participants did not respond to all questions. However, the number of responses obtained from the survey (n = 101) is adequate for statistical analysis.

To ensure face validity of the research endeavors, subject-matter experts represented by LEED APs were involved in the study. Lucko and Rojas (2010) indicated that the most reliable method to establish face validity is through "the involvement of domain experts" in the research process. LEED APs typically go through an intensive evaluation process and have to demonstrate expertise and substantial knowledge of green building design and construction practices in order to be certified as LEED professionals. The authors believe that the participation of LEED APs in the research process is a significant addition and differentiation of the present study from previous research that studied the relationship between safety and sustainability.

The final element of the research validation process is to ensure that a high level of construct validity was established. Construct validity refers to the validity and accuracy of the inference drawn from a study or an experiment (i.e., the process of ensuring that the research measures what it is supposed to measure). To establish construct validity, prior to its dissemination, the questionnaire was pilot tested with several respondents as recommended by Lucko and Rojas (2010) to ensure that it is effectively designed and its content is easy to understand.

Other potential limitations of this study stem from the use of an online survey as opposed to interviews and focus group discussion. Tymvios et al. (2012) indicated that online surveys limit the collection of detailed data and, therefore, in-depth insights may be difficult to obtain. Finally, because of the limited geographic distribution of the survey e-mails, extrapolating the research findings to countries other than the United States is invalid. Safety culture and regulations in the United States can vary significantly from that in some other countries. However, the research methods and process can be replicated by researchers outside the United Stated to study related safety topics in similar or different contexts. Future research is encouraged to investigate the validity of the PtD pilot credit outside the United States AEC industry and compare the findings with the results from this study.

3.9 Summary and Conclusions

As sustainable construction evolves, there is a need to prevent construction hazards at the source. This need is especially important given that some green design elements and sustainable practices of the LEED rating system were found to present increased health and safety risks to construction and maintenance workers. PtD is well-suited to minimize these risks as its practices are considered the most effective means of preventing workplace hazards at the source according to the hierarchy of controls (CDC 2015). Accordingly, the USGBC recently incorporated the concept of PtD into its LEED rating system in the form of a pilot credit. This PtD LEED pilot credit helps construction stakeholders not only to eliminate workplace safety hazards throughout the facility life-cycle, but also to claim the one-point credit (a tangible benefit) toward the LEED certificate. However, preventing construction hazards requires early involvement of designers to optimize teamwork and collaboration between different project teams throughout the project's life-cycle. The willingness of construction industry professionals to be involved in a safety effort through the application of PtD practices in sustainable design and construction as a part of the LEED certification has not yet been examined. It is crucial that the PtD LEED pilot credit be highly effective (internally valid) yet readily applicable (externally valid) to green building projects in order to be considered a valid and innovative approach to advance social sustainability in construction at the workforce level. This research study aimed at investigating the perception of two industry groups (designers and constructors) about designing for worker health and safety on green projects as a part of the LEED rating system requirements by distributing a survey questionnaire to both groups.

The study findings indicate that a large percentage of both construction industry groups, including LEED APs, are not aware of the PtD LEED pilot credit requirements at this point in time. However, there is a difference in how each group perceives the PtD LEED pilot credit requirements. While the majority of constructors (69%) expressed their interest in pursuing the PtD LEED pilot credit on future LEED projects, designers felt that there are several barriers to the implementation of the PtD LEED pilot credit in the AEC industry. The discrepancy between designers' and constructors' responses was evident when they were asked whether PtD practices would be frequently implemented on green projects across US construction industry. To be specific, constructors were 3.59 times more likely than designers to expect frequent implementation of the PtD LEED pilot credit requirements in the built environment.

The overall conclusion is that a large percentage of design professionals are resistant to the implementation of PtD practices on green projects at this point in time, and, therefore, the PtD pilot credit may face limited implementation across the AEC industry. This finding is significant in the sense that it suggests that the PtD LEED pilot credit cannot yet be regarded as a valid and innovative approach to advance the social sustainability of the workforce in the construction industry, due to mainly to the lack of potential implementation. Even though previous research identified the PtD approach as a highly effective method to eliminate workplace accidents, its implementation in sustainable design and construction is associated with various barriers and may not be readily applicable in the AEC industry at this point in time, which places serious limitations on the external validity of this approach. This finding logically follows from current knowledge and suggests that alternative methods to advance social sustainability in the built environment especially with respect to the workforce be developed.

To examine the identified barriers and investigate the potential enablers, designers were systematically asked to express their concerns and thoughts. In terms of PtD barriers, fear of liability, segmentation of the construction industry, and lack of safety knowledge among designers were the most prominent drawbacks to the implementation of PtD in the United States. On the other hand, the ethical motive was the main driver for designers to consider incorporating PtD practices in their designs, according to the survey results. The research findings of the present study contribute to the body of knowledge in two ways. First, the findings provide evidence of the lack of external validity of the PtD LEED pilot credit in sustainable design and construction. Second, the study identifies prevailing barriers and potential enablers of the implementation of PtD in the AEC industry.

It should be noted that PtD barriers are not insurmountable. To enable greater diffusion of PtD methods in the AEC industry, the authors recommend: (1) more transformation within the AEC industry toward the implementation of collaborative project delivery methods [e.g., design-build (DB) or integrated project delivery (IPD) arrangements] to overcome the segmentation between different professions and promote teamwork and collaboration; (2) incorporating PtD language into liability insurance policies to expedite the acceptance of PtD methods among designers and constructors (Toole and Erger 2019); (3) developing contract models that regulate roles and responsibilities of designers and constructors when incorporating PtD methods into a project; (4) including case studies and benefit-cost analysis of successful implementers of PtD strategies into continuing education programs provided by the USGBC; and (5) developing specific PtD and construction site safety training to design professionals offered by professional organizations (e.g., ASCE, AIA, and NIOSH) which can increase designers' acceptance to the concept of PtD. Future studies are also encouraged to investigate the potential synergies between PtD and design requirements including the implementation of the PtD requirements in conjunction with the integrative design process LEED credit, a standalone credit that was recently released as part of the LEED rating system version 4.

3.10 Direction for Next Phase of the Research

The main conclusion from the second manuscript is that the release of the PtD LEED pilot credit has not led, at this point in time, to a significant enhancement to the OHS component of social sustainability in the US construction industry, due in part to the lack of interest in implementing PtD practices in sustainable design and construction. Industry professionals especially designers are resistant to the implementation of PtD practices on construction projects, even green projects. Designers believe that their involvement in designing for safety will increase their professional liability for workplace injuries and fatalities. Other barriers to a wider implementation of the PtD LEED pilot credit lie within the fact that (1) designers do not have adequate training and knowledge on how to identify workplace hazards and prevent such hazards during the design phase and (2) traditional project delivery methods make it extremely difficult to communicate with the general and trade contractors during early stages of the project life-cycle regarding worker health and safety. To validate the expected lack of implementation of the PtD LEED pilot credit, a contact made by the researcher with the USGBC staff at the end of 2017 to find out about the number of projects implemented the new pilot credit in the US. The USGBC’s response showed that none of the LEED-certified projects across the US in 2015/16 implemented the PtD pilot credit requirements. A different publication made by NIOSH in 2019 confirms that the PtD LEED pilot credit is still not being widely implemented in the US. This information presented above validates the research findings and is considered additional evidence of the potential lack of implementation of this credit within the AEC industry at this point in time. That being said, only time can confirm for real whether the PtD LEED pilot credit would lead to an enhancement in worker health and safety in sustainable construction.

Based on the findings from Manuscripts #1 and #2, alternative methods to enhance the OHS component of social sustainability in the construction industry are needed. A question that also arises is whether other aspects of social sustainability (e.g., diversity and equity) should be enhanced as well especially as they relate to the workforce. To investigate this matter, a supplemental literature review on the social aspects of sustainability, especially as they relate to the construction workforce, was conducted and is presented in the next section.

3.11 Literature Review on Social Aspects of Sustainability at the Workforce Level

A review of prior studies and publically available data on the social aspects of sustainability in construction revealed that social sustainability is lacking especially as it relates to the workforce. The lack of OHS input on sustainable projects shown in Manuscripts #1 and #2 is one example of the poor social sustainability in construction. <u>The high number of occupational fatal and non-fatal injuries</u> in the construction industry is another example of the lack of social sustainability in construction. According to the Bureau of Labor Statistics (BLS 2019), over a thousand fatalities in the US construction industry were reported in 2018. Due to working in a highly demanding work environment, approximately 70% of construction professionals suffer anxiety, depression, and/or stress in construction (Sunindijo and Kamardeen 2017). Over 1.5 million construction workers (nearly 25% of the overall workforce in construction) did not even have health insurance in 2015 (CPWR 2018).

Other essential worker needs including training opportunities and education attainment are lacking in construction. Between 11 and 29% of construction workers do not have a high school diploma (CPWR, 2018). Moreover, worker productivity in construction is an issue of concern. Previous studies indicate that worker productivity in construction has been flat, if not declining, especially when compared with other industries (Allmon et al. 2000; Rojas and Aramvareekul 2003). The low level of productivity may be attributed to the lack of social sustainability in the built environment.

Furthermore, construction is identified as an industry that struggles to attract and retain skilled and new workers. Large numbers of the workforce have either already retired or are reaching retirement age, and there is an insufficient number of skilled workers entering the industry to replace those retired, experienced workers. According to the SmartMarket Report (2012), over two-thirds of those in the AEC industry who participated in an industry survey are concerned about skilled workforce shortages. Relatedly, statistics publically available through CPWR (2018) indicate that, in 2015, about 15.5% of the construction workforce were temporary rather than permanent workers with tenured contract. On average, construction had the highest proportion of temporary workers after agriculture among the major US industry sectors (CPWR, 2018). With respect to attracting new workers, there is overwhelming evidence that the millennial generation (people born between 1982 and 2002), especially among high school students, does not desire to pursue careers related to construction (Escamilla and Ostadalimakhmalbaf, 2016). However, a young and diverse workforce is urgently needed in the construction industry. Statistics published in the CPWR Chart Book indicate that the workforce within the construction industry is aging (CPWR 2013). The proportion of older workers in construction (workers aged from 45-65 years) increased from 25% to 39% between 1985 and 2010, while the proportion of younger members in the workforce (workers aged under 35 years) substantially decreased by about 50% over the same period of time (CPWR 2013).

Apart from that, the construction workforce in the US is significantly less diverse than the workforce in other industries. Employment patterns indicate a trend of racial disparities in the industry. The proportion of racial minorities is lower than in most other industries (CPWR, 2018). Racial minorities in this matter refer to a combined group including all races except “white only.” Relatedly, gender imbalance continues to be an issue and women are still underrepresented in the construction industry. Only 9% of the construction workforce in 2015 were females (CPWR, 2018). Many factors are turning women away from construction related careers including the aggressiveness of construction work (e.g., loud machinery) and the challenges related to a balanced work-family life (Morello et al. 2018). Construction workers have limited control over their schedule (Lingard and Turner, 2017). Many construction workers in the US work more than 40 hours per week (CPWR, 2013) and on weekends (Lingard and Turner, 2017), and sometimes in extreme weather conditions. Long working hours influence people's health and comfort negatively and can lead to a conflict between work and family responsibilities (Pfeffer, 2010; Lingard and Turner, 2017), causing fatigue, work-life stress, and potential work-related errors. Previous research reported that construction workers are twice as likely to commit suicide that other people in the same community (Lingard and Turner, 2017).

The result of the supplementary literature review on social sustainability in construction reveals that different aspects of social sustainability in construction are lacking especially as they related to the workforce. These aspects include but are not limited to health, safety, diversity, work-family balance, performance and productivity, training, and career development opportunities. This absence necessitates a concerted effort to address and enhance social sustainability in construction and the development of a social sustainability model for the construction workforce – also referred to as workforce sustainability. The intended model, referred to as construction workforce sustainability, is expected to address the essential social aspects of sustainability at the workforce level. The model will be transformed into a practical tool to assess and improve workforce sustainability in construction. The tool will include consideration of multiple aspects of social sustainability that are beyond just worker health and safety. The third manuscript (Manuscript #3) aims to develop an assessment model and tool for construction workforce sustainability. The development of the assessment model and tool for construction workforce sustainability will help achieve the overall goal of this PhD research which is to enable the assessment and improvement of social sustainability in construction at the workforce level.

MANUSCRIPT #3: DEVELOPMENT OF ASSESSMENT TOOL FOR WORKFORCE SUSTAINABILITY

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4.0 Manuscript #3 – Development of Assessment Tool for Workforce Sustainability

4.1 Abstract

The work environment in construction is physically and mentally demanding. This demanding environment can place adverse risks on the construction workforce including emotional, physical, and financial challenges. To minimize such challenges, continued development and cultivation of the construction workforce is required. Continued development and cultivation can sustain the workforce and lead to both personal and business growth. The process of developing and cultivating the workforce enhances construction workforce sustainability, a measure of the social sustainability of the construction workforce. The aim of the present study is to develop a practical tool for assessing workforce sustainability in construction. A mixed-methods research approach that relied on a review of literature, semi-structured interviews, and a multi-round expert survey was utilized to achieve the aim of the study. The developed workforce sustainability tool includes three levels of components (attributes, indicators, and metrics) organized in a hierarchy to characterize a workforce. The use of the assessment tool yields a final aggregated score that reveals the level of sustainability of a workforce. The present study contributes to the body of knowledge by providing a means to assess and ultimately improve workforce sustainability in construction. Widespread use of the tool is expected to help the construction industry develop and nurture its workers to produce a healthy, productive, and resilient workforce.

4.2 Introduction and Background

The physical work environment and nature of construction operations can be harsh. This intensive environment leads to challenges and places high physical demands on workers. These challenges and physical demands have impacted the construction industry and its workforce negatively, and along with other factors have led to undesired outcomes such as high turnover rates, poor safety performance, and labor shortages (Abdelhamid and Everett 2000; Hinze 2010; FMI Survey 2017). In the past few years, the number of work-related fatal injuries in the construction industry was the highest among all US industries (BLS 2019). In 2018 alone, over a thousand fatalities were reported in construction (BLS 2019). Construction fatalities typically account for approximately 20% of all US work-related fatalities, while construction comprises only about 5% of the overall US workforce (Abdelhamid and Everett 2000). The industry is taking steps to improve the safety and health of its workforce, yet continued efforts and vigilance are needed to prevent severe injuries and fatalities from occurring.

The hazardous nature of construction commonly limits interest in working in the industry, which is likely one of the reasons for the recognized labor shortage in the industry. Research has shown that, among millennials (individuals born between 1982 and 2002), a large percentage of high-school students are reluctant to pursuing careers related to building and construction (Escamilla and Ostadalimakhmalbaf 2016). Other studies indicate that the workforce in construction is aging (Choi 2009; Schwatka et al. 2012). According to the CPWR Chart Book, the proportion of workers aged from 45 to 64 years has increased from 25% to 40% between 1985 and 2015, while the proportion of younger workers (aged under 35 years) has noticeably decreased by roughly 50% over the same period of time (CPWR 2018).

Furthermore, education attainment in the construction industry is lower than that in all other US industries except for agriculture (CPWR 2018). Lack of education attainment affects productivity in the industry adversely. This could be one reason why the level of productivity in construction is relatively lower than in other industries (Allmon et al. 2000; Rojas and Aramvareekul 2003) such as manufacturing (see Figure 4.1). The aforementioned conditions – along with other factors such as long working hours – can put the construction workforce at high risk of injury and illness. For example, working for long hours influence a person’s health and prosperity, and can perhaps lead to between work-family conflict (Holden and Sunindijo 2018; Pfeffer 2010), causing work-life stress and potential performance errors in the workplace (e.g., safety incidents). Many construction laborers work more than 40 hours per week in extreme environments (CPWR 2018; Hinze 2010). The high physical demand required for construction jobs can make construction laborers vulnerable to encountering work-life conflict, fatigue, physical/emotional harm, and other risks.

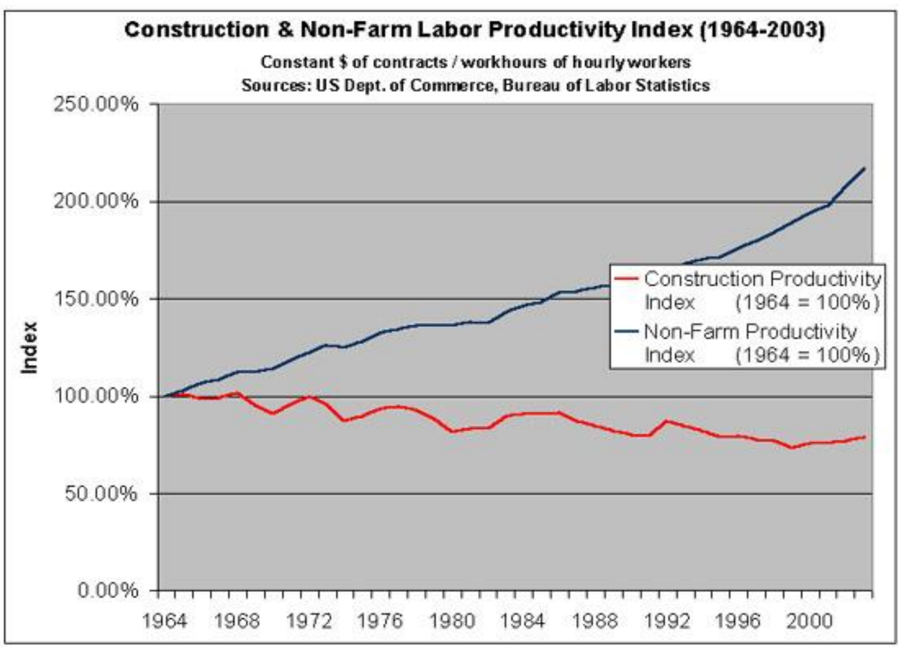

Figure 4.1: Labor Productivity Index for Construction Industry vs. Other Industries

To minimize these issues, the level of attention to workforce support and development in the construction industry must be improved, especially for the millennial workforce. The sustainable development movement started two decades ago is aimed at improving the conditions for the construction workforce and helping enhance workforce development in construction. Sustainable development has been defined as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987). Sustainable development emphasizes three fundamental dimensions: environmental protection, economic viability, and social equity (Kibert 2016). The social dimension of sustainability focuses, in part, on employees including their wellness, health and safety, growth, prosperity, and education. (Kossek et al. 2014). Sustaining employee health and safety, for example, can enhance productivity, lead to positive safety performance, reduce costs of insurance premiums, and improve job satisfaction and employee retention.

That being said, sustainable development in practice primarily focusing on the environmental and economic dimensions of sustainability associated with the design, construction, and use of facilities, with minimal attention to the social dimension of sustainability (Hinze et al. 2013). Little work has been conducted on the social dimension of sustainability, especially as it relates to the workforce. Most effort related to social sustainability has focused on organizational sustainability. The motivation behind the present study is to facilitate enhancing the level of workforce development in construction organizations and maintaining such enhanced levels. Embracing and maintaining workforce development is referred to in literature as “workforce sustainability” (Kossek et al. 2014). The goal of the present study is to develop a tool for assessing and enhancing workforce sustainability (i.e., a tool to assess social sustainability in construction at the workforce level).

4.3 Conceptual Model for Workforce Sustainability

The concept of workforce sustainability is new to most industries but especially to construction. Kossek et al (2014) stated that workforce sustainability can be “created and nurtured via employment practices, [policies, and procedures] that link employee work-life balance and well-being to employment experiences over the course of employees’ working lives, enabling them to perform well over time while also thriving in their personal and family lives.” Achieving workforce sustainability includes the process of creating an environment that supports a coherent, motivated, and healthy individuals who are highly skilled and competent, and then nurturing and maintaining the requisite skills and competencies constantly using multiple strategies. Workforce sustainability is defined by the researchers as *a property of a workforce that reflects the extent to which the workforce can perform its desired functions over a selected period of time*. Workforce sustainability reflects the extent to which members of the workforce feel a part of a nurtured, diverse, equal, safe, connected, valued, and mature community at work. A workforce may exhibit a high or low level of sustainability depending on the acquired input (e.g., education and training) or developed qualities and skills (e.g., maturity and competence). A workforce may be self-sustaining or require external inputs to maintain its presence and ability to perform its desired functions. For the purpose of this study, the workforce consists of all members of a construction-related organization who are involved, directly or indirectly, in the construction process including laborers, engineers, supervisors, and managers.

Prior to performing the research activities needed for this study, the authors desired to establish a conceptual model for workforce sustainability to serve as a framework for the intended assessment tool. A mixed-methods approach was then carried out to construct the workforce sustainability conceptual model. Semi-structured interviews and informal discussions with industry professionals and academics in different fields of study related to workforce development were conducted. This process involved interviewing experts from both industry (e.g., workforce development trainers) and academia (e.g., human sciences scholars). The main purpose of the interviews was to create a framework for the intended assessment tool for construction workforce sustainability. First, a description of the scope of the study and the intended use of the framework was provided. Then, the interviewees were asked to propose a framework that could work best for the proposed study. The researchers described existing frameworks and tools used for sustainability assessment that are currently available to construction stakeholders. The sustainability assessment frameworks and tools described primarily included the JUST label (https://living-future.org/just), the Leadership in Energy and Environmental Design (LEED) rating system (https://new.usgbc.org), the Safety Climate Assessment Tool (S-CAT) (https://safetyclimateassessment.com), and the B Corporation certificate program (https://bcorporation.net). After considering and examining the available assessment tools, it was concluded that the conceptual workforce sustainability model should include three levels of components organized in a hierarchy, from the most general to the most specific, as shown in Figure 4.2. This conceptual model relied, in part, on the structure of the JUST label and S-CAT. The three levels of components of the conceptual model are attributes, indicators, and metrics, respectively. Each of the levels is briefly described below:

- Attributes: Foundational qualities and characteristics of workforce sustainability;
- Indicators: Practices, procedures, and policies that reveal the presence of each attribute within the workforce, and which can be used to assess and improve each attribute and, as a result, the overall level of workforce sustainability; and
- Metrics: Measurement units and scales used to assess the extent to which the practices, procedures, and policies (i.e., indicators) are actually implemented in practice within an organization to cultivate the workforce.

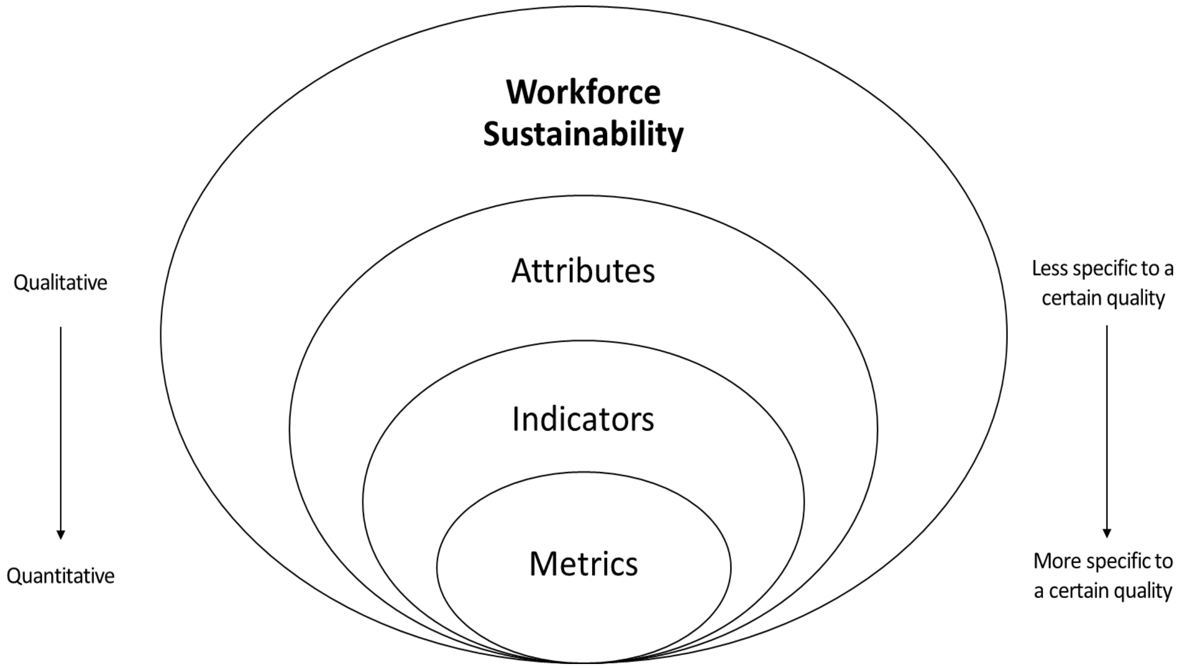

Figure 4.2: Conceptual Model for Workforce Sustainability

To identify the essential attributes of workforce sustainability, a literature review was carried out that involved reviewing both industry and academic sources. The results of the literature review provided support for eight essential attributes of workforce sustainability illustrated in Figure 4.3. The attributes are: nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity. The definition of each attribute is provided in Table 4.1. More detail about the literature review process is provided below.

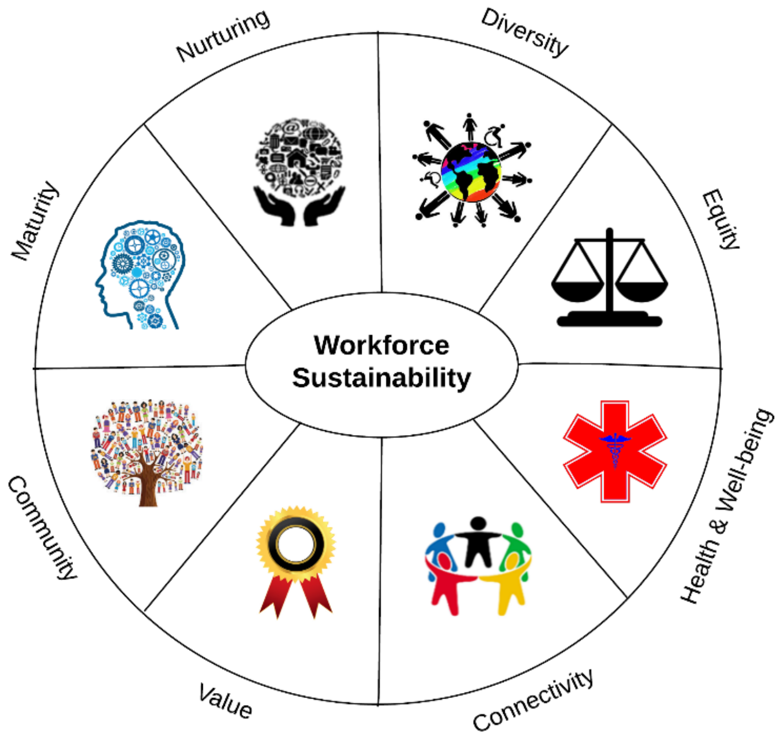

Figure 4.3: Attributes of Workforce Sustainability

Table 4.1: Definition of Workforce Sustainability Attributes

Attribute	Definition
Nurturing	The extent to which employees feel supported, educated, and trained in their work
Diversity	The extent to which the workforce is diversified, and members of the workforce feel welcome and accepted
Equity	The extent to which employees feel that they are treated and evaluated fairly without any discrimination
Health and well-being	The level of health, safety, and contentment that employees feel and experience in their work
Connectivity	The degree to which employees feel connected to peers, fellow employees, and management through open channels and two-way communication
Value	The extent to which employees feel respected and appreciated by peers and by their employer for their work performance, contributions, and loyalty
Community	The extent to which employees feel camaraderie and see themselves as part of a supportive and productive team
Maturity	The extent to which employees are proactive, competent, responsible toward each other, and share accountability in decision-making and problem-solving

4.3.1 Literature Review

As mentioned above, the literature review involved searching for both academic and industry resources relevant to the topic of workforce sustainability. For the review of industry resources, the researchers examined existing industry tools, reports, and certification programs about topics related to workforce sustainability. The review results are summarized in Table 4.2. It is evident that there is support in the resources for the existence of all eight attributes as important constructs of workforce sustainability. For example, the JUST label (https://living-future.org/just), a disclosure program administered by the International Living Future Institute to demonstrate social equity and enhance employee performance in the workplace, recognizes the importance of education (nurturing), diversity, equity, and safety and health in the workplace and implements metrics to quantify each of these components. Similarly, the World Happiness Report (2017), a landmark survey used to rank people's happiness and well-being across different countries, acknowledges the role of employment practices and the significance of work environment on individuals' level of sustainability, including their happiness with respect to their working and non-working careers. According to the World Happiness Report, education (nurturing), diversity, equity, health and well-being, and sharing (connectivity and community), are key contributors to influence job satisfaction and employee happiness. In 2017, Gallup, Inc., a well-known research-based, global performance-management consulting company that conducts public opinion polls to identify issues and propose solutions with respect to workforce and organizational sustainability, released its latest report titled "State of the American Workplace," also known as the Gallup report (Gallup 2017). The Gallup report describes what workers need and summarizes, from the perspective of workers, methods to improve employee engagement (connectivity) and performance at work (maturity). The report includes numerous practices and policies to improve worker engagement and performance at work, including providing career development opportunities, fair payment, job stability, work-life balance, and family support to improve and sustain workers in the workplace (Gallup 2017). Each of the aforementioned practices can be easily classified under one or more of the eight workforce sustainability attributes shown in Figure 4.3. For brevity purposes, other industry sources are not discussed in this report but are summarized in Table 4.2.

Table 4.2: Key Workforce Sustainability Attributes — Industry Sources Search

Source		Workforce Sustainability Attributes							
		Nurturing	Diversity	Equity	Health & well-being	Connectivity	Value	Community	Maturity
Industry Tools and Reports	Just Label	X (educat-ion)	X	X	X	X	X (benefit)	—	—
	World Happiness Report	X	X	X	X	X (sharing)	—	X	—
	Gallup Report	X	—	—	—	X (engage-ment)	X	—	X
	United Nations ISD	X	X	X	X		X	—	—
	Workforce Happiness Index	X	X	—	X	X (engage-ment)	X	—	—
	Corporate Social Responsibility (CSR) Report	X	X	—	X	—	—	X	X (compet-ence & ethics)
	Social Accountability (SA) 8000 Standard	X (training)	X	X	X	—	X (wages & welfare)	—	—

In the same way, the researchers identified and reviewed academic publications and relevant research articles. Similar to that found in the industry sources, there was overwhelming support in the academic literature for the inclusion of the eight workforce sustainability attributes. Kossek et al. (2014) studied workforce sustainability and identified multiple organizational strategies used to promote work-life balance and foster workforce sustainability. The strategies identified provide support for seven attributes, namely nurturing (e.g., professional development), diversity, health and well-being, connectivity (e.g., strong connections among employees), value (e.g., compensation and benefits), community, and maturity. For instance, knowledge sharing (a form of maturity) was identified as an effective strategy for promoting a sustainable workforce. Likewise, Raheem and Ramsbottom (2016) identified key contributors of social sustainability in highway construction. The study conducted by Raheem and Ramsbottom found that employee awareness (nurturing), diversity, equity and respect, health and safety, quality of living (value), and responsibility (a form of maturity) are vital attributes of social sustainability and important factors of a positive work community. A summary of the findings from the academic literature review is provided in Table 4.3.

Table 4.3: Key Workforce Sustainability Attributes — Academic Search

Source		Workforce Sustainability Attributes							
		Nurturing	Diversity	Equity	Health & well-being	Connectivity	Value	Community	Maturity
Academic Articles	Kossek et al. (2014)	X	X	—	X	X	X (compe-nsation & benefits)	X	X (knowle-dge sharing)
	Raheem and Ramsbottom (2016)	X (aware-ness)	X	X	X	—	X	X	X (leader-ship & response-bility)
	Sing et al. 2018	X	X	—	X	—	X	—	X
	Jafari et al. (2018)	X	—	X	X	X (stakeho-lder enhance-ment)	X	X	—
	Chang et al. (2016)	X	—	X	X	—	X (wages & welfare)	X	—
	Woodcraft et al. (2013)	—	X	X	—	X (engage-ment)	X	X	—
	Bacon et al. (2012)	X	X	X	X	X	X	—	—
	Torjman (2000)	X	—	—	X	—	—	X	X (skills develop-ment)
	Zarrabi and Fallahi (2014)	X	X	X	X	—	X	—	—
	Haralson (2010)	X	—	—	—	X (engage-ment)	—	—	X
	Mani et al. (2014)	X	—	X	X	—	X	—	X (ethics)

4.4 Research Objective

As stated previously, the goal of this study is to develop an assessment tool for workforce sustainability. The research questions are: (1) what are the important attributes of workforce sustainability and what is their level of influence on achieving workforce sustainability, and (2) what are the indicators and metrics that can be used to assess each of the identified workforce sustainability attributes. To attain the study goal and answer the research questions, three objectives were identified as follow:

1. Quantify and verify the level of influence of the identified workforce sustainability attributes shown in Figure 4.3;
2. Identify and quantify potential indicators of each workforce sustainability attribute; and
3. Identify metrics to assess the extent to which indicators are actually implemented in practice within an organization.

Once these objectives are achieved and the questions are answered, a practical assessment tool for workforce sustainability will have been developed. The intended tool will include an evaluation procedure to assess workforce sustainability in construction. This evaluation can be performed at the team, division, company, or industry levels.

4.5 Research Methodology

To achieve the objectives of the study described in the previous section, the authors elected to rely on a multi-round subject matter expert survey using the Delphi process. The Delphi process is an interactive, structured, data-collection protocol used to obtain insights from a group of experts on specific subject matter. The group of experts plays a substantial role in the Delphi process and, therefore, the selection of its members is paramount to the success of the process (Hallowell and Gambatese 2010; Sierra et al. 2016). Numerous research studies in construction, including Jafari et al. (2018) and Leon et al. (2018), have relied on the Delphi technique as a reliable research method. Once selected, the Delphi panel would be asked to identify, verify, and quantify the three levels of components of workforce sustainability (attributes, indicators, and metrics). The three primary tasks of this research along with the methods used and outputs obtained are illustrated in Figure 4.4. The selection and qualification of expert panel as well as the Delphi process will be described subsequently.

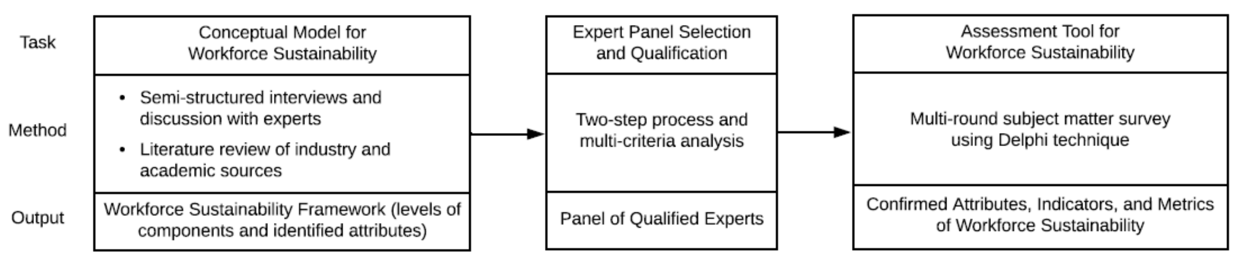

Figure 4.4: Research Tasks, Methods, and Outputs

4.5.1 Expert Panel Selection

In any survey, the level of expertise of the participants is paramount to the usefulness of, and confidence in, the collected responses. To ensure that the Delphi panel members possess practical and scientific perspectives, participants from both industry and academia were considered for participation on the panel.

The inclusion of both industry professionals and academics provides assurance that the study findings have practical and theoretical implication. Moreover, the research team desired to employ experts from different fields of study to minimize potential biases toward one or more of the attributes.

To identify and select qualified experts, a two-step process was carried out. In the first step, potential experts were selected based on their education, experience, position, publication, and/or prior work related to workforce sustainability. In the second step, a quantitative evaluation of the selected experts based on predetermined criteria was carried out similar to previous research in construction (Jafari et al. 2018; Hallowell and Gambatese 2010; and Leon et al. 2018). Following this two-step process, potential industry experts were selected based on their position and experience within their organizations, and whether they had played a direct role in workforce development and human resource management. In a similar manner, the selection of potential experts from academia relied on authorship of research articles related to workforce development. After this initial selection process, 67 potential experts (22 academics and 45 industry professionals) were identified from online publications and resources along with the personal contact lists of the researchers. Academics were selected based on authorship of publications related to workforce development and social sustainability, while industry professionals were identified based on the connections of the researchers with industry partners. It should be mentioned that only individuals located in the US were considered for potential inclusion in the expert panel. The authors contacted and invited the potential experts, via telephone and/or email, to participate in the study. Nineteen potential experts, from both industry and academic, positively responded indicating their willingness to participate in the study. However, only 16 experts (11 from industry and five from academia) eventually provided the requested information and participated in the initial survey round.

The second step of the selection process relied on previous research that attempted to quantify the profile of the panelists. For construction research, Hallowell and Gambatese (2010) identified predetermined criteria that can be used to qualify whether a participant is an expert in a particular field of study. The criteria along with their weightings, adapted from Hallowell and Gambatese (2010), are summarized below.

- Professional registration → 3 points for each valid registration
- Years of professional experience → 1 point for every year
- Publications → Book: 4 points; journal article: 2 points; conference paper: 1 point
- Member of a committee → 3 points for each membership
- Advanced degrees → BS: 4 points; MS: 6 points; PhD: 10 points
- Leading positions → 3 points for every leading position

According to Hallowell and Gambatese (2010), a minimum score of 11 points is needed in order to confidently label a participant as an expert and include him/her in a Delphi study. The results of the qualification process are presented in Table 4.4 for the 16 identified participants. Based on the table, it is evident that all participants received a score that is higher than 11 and were, therefore, considered qualified experts for inclusion on the Delphi panel. It should be mentioned that the number of points the panelists scored were significantly higher than the 11-point threshold. That is, all panelists except a single panelist obtained more than 20 points, with the majority of the panelists scoring 40 points or more. The high number of points scored provides high confidence that the selected panelists are experts in their field. Although there is a high variation between academics and industry professionals in terms of academic publications and practical experience, such a variation is well-explained. The nature and expectations of an academic job are different from those of an industry job, and, hence, the variation is expected. In fact, the researchers believe the different levels of research and industry experience of the panelists is one of the strengths of the present study and its Delphi panel.

Table 4.4: Profiles and qualifications of the Delphi panel members (*n* = 16)

Expert Panelists	Qualification						Total Points
	A	B	C	D	E	F	
A-1	6	18	12	6	10	3	55
A-2	0	14	14	3	10	0	41
A-3	`3	31	307	15	10	6	372
A-4	3	14	59	3	10	3	92
A-5	0	28	244	6	10	9	297
I-1	3	15	0	0	4	0	22
I-2	6	8	0	6	4	3	27
I-3	3	20	0	3	8	6	40
I-4	3	16	0	0	4	0	23
I-5	3	37	2	0	8	6	56
I-6	0	5	2	0	8	0	15
I-7	3	40	0	9	8	0	60
I-8	3	35	0	0	8	3	49
I-9	0	30	0	6	4	3	43
I-10	3	15	0	0	8	3	29
I-11	0	40	12	6	4	0	62

Note: A: professional registration; B: years of experience; C: publication;
D: membership of committees; E: advanced degrees; F: leading positions

With respect to the panel size, different researchers have recommended different expert panel sizes to optimize the Delphi process. Hallowell and Gambatese (2010) stated that a panel size of as low as eight panelists is considered adequate for a Delphi study if the panel members are carefully selected. As a result, the panel size of 16 for this study was considered adequate to optimize the Delphi process.

4.5.2 Survey Development and Dissemination

In parallel with the expert panel selection, three questionnaires were developed by the research team. The aim of the questionnaires was to obtain feedback from the Delphi panel members regarding the content and structure of the intended assessment tool for workforce sustainability. Thereafter, the three questionnaires were distributed to the expert panelists via email in three subsequent rounds (one questionnaire per each round). A copy of the questionnaires is available in Appendix I.

The initial questionnaire was pilot tested with multiple experts not selected for inclusion on the Delphi panel, and suggested revisions were incorporated into the questionnaire prior to dissemination. The Delphi process provides the opportunity for each panelist to revise and re-assess his/her responses in light of the responses made by other members of the panel. The researchers managed the process independently and maintained confidentiality amongst the panel members. The protocol created a collaborative effort, yet ensured anonymity, providing a desired environment to develop the intended assessment tool. The output of this process is expected to capture and incorporate different perspectives about assessing workforce sustainability in construction. Variability in the participant responses is expected in the initial rounds, but consensus is commonly reached in later rounds of the Delphi process. To reiterate, the primary goal of the Delphi process was to identify/verify and quantify workforce sustainability attributes, indicators, and metrics prior to developing a practical tool for assessing workforce sustainability. Each round of the Delphi process is described in more detail below.

4.6 Result of Delphi Process

This section of the manuscript presents and discusses the results of the Delphi rounds. Each round will be discussed individually.

4.6.1 Round 1: Verify and Quantify Workforce Sustainability Attributes

The objective of this survey round was to verify and quantify the attributes of workforce sustainability. The questionnaire for this round included two parts. The first part solicited information about the qualification of the participants; while, the second part asked the expert panelists to evaluate the conceptual model as a framework for the development of the intended assessment tool and to indicate the level of influence that each of the eight attributes should have on workforce sustainability.

Sixteen responses were received and analyzed in this round. The majority of the Delphi panel members – 14 out of 16 (87.5%) – indicated that the conceptual model is a solid framework for the intended workforce sustainability assessment tool, and the eight attributes (nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity) are important foundational qualities and characteristics to assess workforce sustainability. These 14 members – although they agreed that the conceptual model was suitable – provided suggestions to include additional qualities and characteristics in the description of the attributes. For example, one participant put forward that “accountability” is an essential characteristic of a sustainable workforce and, therefore, should be included in one of the attributes. Accordingly, accountability was incorporated into the maturity attribute. Accountability in decision-making and problem-solving is a sign of maturity of a worker or a workforce.

Contrary to the majority, two members of the panel expressed concerns about the developed conceptual model for workforce sustainability. These two panelists indicated that priorities in the construction industry continually shift and, therefore, it is challenging to develop a framework that corresponds to this continued shift all the time. The research team carefully examined the assessment that the two dissenting participants provided and incorporated changes into the framework to respond to such concerns. The definitions of the attributes shown in Table 4.1 were accordingly updated multiple times according to the panelists’ feedback.

To quantify the level of influence of each attribute of workforce sustainability, the expert panelists were asked to provide a rating, based on a 5-point Likert scale. The rating scale ranged from 1 to 5 where “1” indicates “low influence” and “5” indicates “extreme influence.” Responses for this part were collected, analyzed, aggregated, and then returned back to the panelists for re-assessment and confirmation in Round #2. This refinement process provided additional reliability of the findings and ensured that a high level of consensus was achieved.

4.6.2 Round 2: Finalize Workforce Sustainability Attributes and Identify Potential Indicators

The objectives of this survey round were to: (1) reach consensus about the level of influence that each attribute should have on workforce sustainability (obtained in Round #1); and (2) identify applicable indicators of each attribute that can be used to assess workforce sustainability in construction.

As suggested by previous studies (Mitchell 1991; Hallowell and Gambatese 2010), the median value was used in this study to determine the level of influence of each attribute on workforce sustainability. The median is less likely to be influenced by outliers and, therefore, is more appropriate to measure central tendency. To measure consensus amongst the panelists, standard deviation (SD) is typically used due to its ability to quantify variation from central tendency (Hallowell and Gambatese 2010). The researchers established that, for the present study, consensus is reached for 5-point Likert scale whenever the standard deviation is below 1.64 as suggested by Rogers and Lopez (2002).

Based on this analysis protocol, the responses were collected and analyzed. Table 4.5 provides a summary of Round #2 responses regarding the level of influence of the attributes. Fifteen experts participated in this round and provided responses; only one person did not complete the survey and was therefore removed from the panel in subsequent rounds. Of the 15 responding panelists, four participants (27%) updated one or more of their prior responses from Round #1. Based on Table 4.5, the standard deviation was below 1.64, and therefore consensus was reached, for all attributes.

Table 4.5: Descriptive Statistics of Round Two Responses (*n* = 15)

Measure	Influence of Workforce Sustainability Attributes (1 = Low Influence, 5 = Extreme Influence)							
	Nurturing	Diversity	Equity	Health & well-being	Connectivity	Value	Comm-unity	Maturity
Median	4.00	3.00	5.00	4.00	3.00	4.00	3.00	3.00
Mean	4.00	2.87	4.33	4.00	3.20	4.00	3.27	3.20
Mode	4.00	3.00	5.00	4.00	3.00	5.00	3.00	3.00
SD	0.53	1.25	1.05	0.85	0.94	1.07	1.03	0.94
Min. Value	3.00	1.00	1.00	3.00	1.00	2.00	2.00	1.00
Max. Value	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

To achieve the second objective of this round, the Delphi panelists were asked to suggest applicable indicators that can be used to assess and improve certain qualities and characteristics of the workforce sustainability attributes. Indicators can take the form of practices, policies, procedures, or other means implemented by an organization/employer or the workforce itself to sustain a high level of nurturing, diversity, equity, and so forth. Achieving high levels of nurturing, diversity, equity, etc. eventually leads to improved workforce sustainability at the team, division, company, and industry levels.

Identifying indicators for each attribute is an indispensable component of the study to ensure practical feasibility of implementation of the intended assessment tool. Applicable indicators to the health and well-being attribute, for example, can be practices, procedures, and policies that the employer provides to ensure members of the workforce are safe and healthy. Such practices, procedures, and policies can include regular toolbox meetings, annual safety training, and periodic health check-ups. These practices, procedures, and policies are expected to help workers foster, advance, and sustain their physical and mental health and, therefore, are considered applicable indicators to assess and improve this attribute of workforce sustainability.

After receiving and analyzing responses in Round #2, it was found that 282 indicators were suggested by the panel, which is too many for all to be included and create an assessment tool that is feasible to implement in practice. To shorten the list of indicators, similar indicators were grouped together, and the wording of some suggested indicators was modified to improve clarity and maintain consistency with industry terms. Indicators suggested by less than three experts were re-evaluated and compared with literature to determine inclusion or exclusion in the final list of indicators. That is, if the indicator is reported in literature as an important practice, policy, or procedure to assess the attribute, then the indicator was retained. Otherwise, the indicator was removed from the list of indicators. This analysis protocol led to a shorter list that included 54 indicators. It should be mentioned that while comparing with literature, the researchers also identified seven additional potential indicators not suggested by the panel. The seven indicators are: company newsletter (Vecchio-Sadus and Griffiths 2004), employee happiness (JUST 2017), local community at work (JUST 2017; Valdes-Vasques and Klotz 2013), safety policy (Corporate Social Responsibility Report 2017), union-friendly workplace (JUST 2017; Ho 2017), workload trade-off (Kossek et al. 2013), and workforce integration in industry (JUST 2017; Kossek et al. 2013; Valdes-Vasquez and Klotz 2013). These seven indicators were added to the list, producing a final list of 61 indicators (54 plus 7). This final list was then returned to the expert panelists in Round #3 for re-assessment and confirmation using the same methodology used in Round #2.

4.6.3 Round 3: Finalize Indicators, Assign a Weighting, and Identify Possible Metrics

The objectives of this survey round were to: (1) finalize applicable indicators for each attribute; (2) assign a weighting that indicates the level of influence of each indicator on its applicable attribute; and (3) solicit insights from the expert panel regarding appropriate metrics to assess the identified indicators. To achieve the objectives of this round, the Delphi panel members were asked to provide two evaluations. First, the panelists were asked to provide a rating, on a 5-point Likert scale where 1 indicates low influence and 5 indicates extreme influence, of the level of influence of the indicator. Second, the researchers requested a recommendation from the panelists on what indicators to include or exclude in the final assessment tool.

Out of the 15 panelists who participated in Round #2, 13 experts completed the survey and provided responses in Round #3. After receiving the responses, a two-step process was implemented to determine inclusion or exclusion of the suggested indicators in the assessment tool. In the first step, indicators that were suggested or supported by a clear majority of the panelists were retained. Unfortunately, there is no specific rule to determine what a clear majority is. Some studies relied on “a weak majority” which is defined as the agreement/disagreement of more than 50% of the participants on a particular matter, while other studies utilized the concept of “infinite majority” (a.k.a., overwhelming majority) to measure agreement or disagreement (Pacuit and Salame 2006). Infinite majority occurs when an agreement or disagreement is reached by 90% or more of the participants on a particular matter. The researchers felt that both rules are extreme but in different directions. A percentage that is reasonable, rather than extreme, was needed. Accordingly, 70% (the mid-point between 50% and 90%) was selected as a threshold to determine clear majority. That is, all indicators that were suggested by or received support from 70% or more of the panelists were retained.

In the second step, the level of suggested influence for those indicators that received less than 70% consensus was examined. If the level of influence was rated as being high or extreme – 4 or 5 on a 5-point Likert scale – based on the aggregated group median, the indicator was included in the final assessment tool. Otherwise, the indicator was removed from the list and excluded from inclusion in the final tool. Following this process, 19 indicators that received low consensus (less than 70%) and low rating (3 or less) were removed or combined with similar indicators (13 indicators were removed and 6 indicators were combined), leaving a list of 42 indicators for inclusion in the assessment tool. A complete list of the indicators along with their level of influence is provided in Table 4.6.

Table 4.6: Workforce Sustainability Indicators and their Level of Influence

Attribute	Indicator	Level of Influence (1-5)		
		Median	**Mean**	**SD**
1. Nurturing	1.1 Productive performance appraisals	4.00	3.69	0.72
	2.2 Professional development/continuing education	4.00	3.66	0.98
	3.3 Onboarding process	4.00	4.23	0.72
	4.4 Technical skill training	4.00	4.00	0.58
2. Diversity	2.1 Corporate statement/policy on diversity and inclusion	4.00	3.60	1.06
	2.2 Ethnic and racial diversity	3.00	3.20	0.83
	2.3 Gender diversity and inclusiveness at labor force level	4.00	3.50	0.87
	2.4 Gender/ethnic diversity in leadership/management positions	5.00	4.33	1.03
	2.5 Knowledge and skill diversity	3.00	2.80	0.83
3. Equity	3.1 Equality, social justice, and non-discrimination	4.00	3.70	1.04
	3.2 Pay structure transparency	4.00	4.00	0.82
	3.3 Equitable pay/compensation within organization	4.00	3.77	1.37
	3.4 Equitable pay/compensation at industry level	4.00	3.77	0.55
	3.5 Merit-based recruitment and promotion process/plan	4.00	4.00	0.60
4. Health and well-being	4.1 Safety policy and zero injury goal	4.00	3.75	0.94
	4.2 Safety and health program	4.00	4.00	0.58
	4.3. Safety toolbox meetings and training	4.00	3.77	0.58
	4.4 Breaks and social interactions during workdays	4.00	3.92	0.86
	4.5 Annual physical/medical check-up	4.00	3.64	0.48
5. Connectivity	5.1 Worker involvement in decision-making	4.00	4.10	0.62
	5.2 Regular meetings with supervisor (one-on-ones)	4.00	3.70	0.75
	5.3 Employee stock ownership plan/program (ESOP)	4.00	3.30	1.07
	5.4 Social pleasure and connecting activities during workdays	3.00	3.20	0.77
	5.5 Teamwork approach within organization	3.00	3.50	0.89
6. Value	6.1 Full-time employment and long-term commitment policy	4.00	4.00	0.71
	6.2 Health insurance and retirement plan	4.00	4.50	0.50
	6.3 Family resources	4.00	3.60	0.89
	6.4 Work-life/family balance	4.00	4.10	1.00
	6.5 Job stability and retention	4.00	4.10	0.67
	6.6 Employee benefit program	4.00	4.00	0.58
	6.7 Performance feedback and appreciation	4.00	4.20	0.37
	6.8 Fair compensation	4.00	3.90	0.77
7. Community	7.1 Company social events	3.00	3.20	1.05
	7.2 Workforce integration in industry	3.00	3.00	0.90
	7.3 Local community at work	3.00	3.10	0.75
	7.4 Workload trade-off	3.00	2.60	0.92
8. Maturity	8.1 Leadership and communication skills	5.00	4.40	0.74
	8.2 Accountability (set performance standards)	4.00	3.40	0.74
	8.3 Competence-based education	4.00	3.90	0.73
	8.4 Competence-based training	3.00	3.20	0.70
	8.5 Multiskilling	3.00	3.50	0.90
	8.6 Volunteering	3.00	3.20	0.57

Finally, in Round #3, the Delphi panel was consulted regarding the metrics that should be used to assess the extent of implementation of each indicator in practice. Seven out of the identified 42 indicators received limited or incomplete feedback from the Delphi panel regarding what metrics should be used to quantify the indicators. In such cases, the authors relied on information available in literature and their judgment to complement the information received from the panel. Rooting judgement to information available in literature improves reliability and minimizes bias of the findings. Suhr (1999) pointed out that any decision-making involves some level of subjectivity but stated that basing decision-making on relevant data (i.e., the feedback received from the Delphi panel or information available in literature) yields objective findings. To better illustrate the idea, an example is provided. For the diversity attribute, the expert panel suggested "the extent to which work crews match demographic of population in their local area" as a metric to assess "ethnic and racial diversity." However, the expert panel did not specify limits or levels to quantify this indicator of diversity. In this case, the JUST label, a disclosure program for socially just and equitable organizations, was used as a reference available in literature to describe the metric levels for this indicator. That is, the percentage of deviation from the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics was used to quantify the extent to which ethnic and racial diversity is implemented in a construction organization. To be exact, an organization using the workforce sustainability tool will receive the lowest score for this indicator if it has a workforce with more than 25% deviation from the current state census data on Caucasian and non-Caucasian ethnicity and racial demographics. Contrariwise, the organization will receive the highest possible score for this indicator if the deviation from the current state census data is 10% or less.

4.7 Development of Assessment Tool for Workforce Sustainability

Based on the Delphi process, the three levels of components of workforce sustainability (attributes, indicators, and metrics) were finalized. The researchers used the conceptual model shown in Figure 4.2 and the results from the Delphi process to develop a practical assessment tool for workforce sustainability. The developed workforce sustainability tool includes eight attributes (shown in Figure 4.3), 42 indicators (shown in Appendix II), and one metric for each indicator. The metrics are used to quantitatively evaluate the indicators, and the quantities obtained for the indicators are in turn used to evaluate the attributes. This bottom-up approach eventually provides an individual score for each attribute and an overall score representing the level of workforce sustainability. The workforce sustainability assessment tool is shown in Appendix II. Two examples are provided below to describe the process of evaluating the indicators of workforce sustainability using the assessment tool.

4.7.1 Example 1 – Annual Physical/Medical Check-up

An annual physical check-up is one of the five indicators suggested by the Delphi expert panel to evaluate the "health and well-being" attribute of workforce sustainability. The result from the Delphi process revealed that this indicator can help assess the level of health, safety, and contentment that workers feel and experience in their work environment. An annual physical check-up is a preventive measure to reduce the risk of physical and emotional health problems. Organizations providing annual health check-ups for their employees can gain several benefits such as enhanced employee morale, reduced employee absenteeism, improved productivity, and lower risk of undesirable behaviors resulting from physical and emotional health problems (e.g., stress, fatigue, and emotional exhaustion). The availability of and participation in an annual physical check-up program is used as the metric for this indicator. Basically, an organization can earn from 1 to 4 points for this indicator depending on the availability of the program and level of employee participation in the program. Table 4.7 explains the metric for this indicator and its four levels.

Table 4.7: Indicator Metric for Annual Physical Check-up

Levels	Measurement Unit: Availability of and Participation in Annual Physical Check-up Program Description of Thresholds
1 point	Organization does not provide annual physical/medical check-ups for its employees.
2 points	Organization provides annual physical/medical check-ups for all full-time employees at no cost.
3 points	Organization provides annual physical/medical check-ups for all full-time employees at no cost, and more than 50% of the employees have had a medical check-up in the preceding calendar year.
4 points	Organization provides annual physical/medical check-ups for all full-time employees at no cost, and more than 75% of the employees have had a medical check-up in the preceding calendar year.

4.7.2 Example 2 – Work-Life/Family Balance

Work-life/family balance is one of the eight indicators of the "value" attribute of workforce sustainability. This term is used to describe the balance employees need between time allocated for work and for personal life in order to stay healthy and productive while leaving time for family and personal interests. Friendly workplaces that provide a work-life/family balance, from both policy and practice perspectives, lead to improved employee satisfaction, lower turnover rates, higher productivity, and other positive outcomes (Holden and Sunindijo 2018; Lingard et al. 2010; JUST 2017). According to the Delphi expert panel, work-life/family balance can help assess the extent to which workers are valued, respected, and appreciated in their work environment by their employer. The metric suggested to assess this indicator consists of four levels organized in a hierarchy for a total of four possible points. The indicator is assessed according to whether there are policies and practices in place to ensure work-life/family balance in a workplace and, if so, the extent of these policies and practices. In this regard, the JUST label suggested the use of employment-protected maternity, paternity, and parental leaves to measure the extent to which a workplace or an organization is family-friendly. These measures from the JUST label were adopted for this study and incorporated into the workforce sustainability assessment tool accordingly. Table 4.8 illustrates the metric used for this indicator along with its four possible levels. According to this metric, a workplace or an organization can score up to 4 points for this indicator.

Table 4.8: Indicator Metric for Work-life/Family Balance

Levels	Measurement Unit: Policies and Practices in Place to Ensure Work-Life/Family Balance
	Description of Thresholds
1 point	Organization provided less than 12 weeks of employment-protected maternity leave, 2 weeks of employment-protected paternity leave, and/or 10 weeks of employment-protected parental leave.
2 points	Organization provides a minimum of 12 weeks of employment-protected maternity leave, 2 weeks of employment-protected paternity leave, and 10 weeks of employment-protected parental leave.
3 points	Organization provides a minimum of 12 weeks of paid maternity leave, 3 weeks of employment-protected paternity leave, and 12 weeks of employment-protected parental leave.
4 points	Organization provides a minimum of 24 weeks of paid maternity leave, 4 weeks of employment-protected paternity leave, and 12 weeks of employment-protected parental leave.

4.7.3 Example 3 – Ethnic and Racial Diversity

"Ethnic and racial diversity" is one of the five indicators suggested by the expert panelists for evaluating the "Diversity" attribute of workforce sustainability. Ethnic and racial diversity at work is an important element to improve work and team dynamics, and to support the presence of a supportive and healthy work environment. The objective of integrating this indicator into the developed assessment tool is to be able to better assess diversity within a construction organization and to encourage the organization to establish a workforce that is as ethnically and racially diverse as the surrounding community. The results from the Delphi process suggested using "ethnic and racial diversity attainment" as a metric to measure the extent to which work crews in an organization match demographics of population in the surrounding, local area. Although the Delphi process did not reveal specific limits or levels to quantify this indicator, information available in literature particularly from the JUST label, a disclosure program for socially just and equitable organizations, was utilized to create a 3-point hierarchy system for this indicator as the median weighting received from the expert panel for this indicator was 3. That is, the percentage of deviation from the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics was used to quantify the extent to which ethnic and racial diversity is implemented in a construction organization. To be exact, an organization using the workforce sustainability tool will receive the lowest score (i.e., one point) for this indicator if it has a workforce with more than 25% deviation from the current state census data on Caucasian and non-Caucasian ethnicity and racial demographics. Contrariwise, the organization will receive the highest possible score for this indicator (i.e., three points) if the deviation from the current state census data is 10% or less. Finally, an organization with 10-25% deviation from the current state census data on Caucasian and non-Caucasian ethnicity and racial demographics will receive two points. Table 4.9 below illustrates the hierarchy system used for this indicator.

Table 4.9: Indicator Metric for Ethnic and Racial Diversity

Levels	Measurement Unit: Ethnic and Racial Diversity Attainment within Organization Description of Thresholds
1 point	Organization has a workforce with more than 25% deviation from current census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.
2 points	Organization emphasizes the importance of ethnic and racial diversity in hiring and promotion within, and has a workforce with a maximum of 25% deviation from current census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.
3 points	Organization emphasizes the importance of ethnic and racial diversity in hiring and promotion, and has a workforce with a maximum of 10% deviation from current census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.

4.8 Workforce Sustainability Score

Based on the structure of the developed tool, the maximum possible score is 29 and the minimum possible score is 7.5. The maximum score was calculated by summing the median values of the eight workforce sustainability attributes shown in Table 4.5, assuming that an organization would receive a perfect score for all eight attributes. It should be mentioned that the standard deviation (σ) of the median values was found to be 2.76. The standard deviation was calculated using Equation 4.1 below using the standard deviations of the eight attributes provided in Table 4.5.

$$\text{Standard Deviation } (\sigma) = \sqrt{\begin{matrix}[(SD\ nurturing + SD\ diversity + SD\ equity \\ +SD\ health\ and\ wellbeing\ + SD\ connectiviety \\ +SD\ value + SD\ community + SD\ maturity)\hat{}2]/8\end{matrix}} \quad \ldots\ldots\ldots \text{ Equation 4.1}$$

However, recognizing that a perfect score is not always possible, three workforce sustainability levels (low, Intermediate, and high) were created. The range of values for the highest level was determined as deviating up to three standard deviations (3σ) from the maximum possible score (29). Accordingly, the lower limit for the "high" level of workforce sustainability is determined to be 21 [29- 3*2.76 = 20.72 (rounded to 21)]. This means that any value ranging from 21 to 20 would indicate a high level of workforce sustainability.

Using the same notion, the "intermediate" level of workforce sustainability was established. It was found that values ranging from 13 to 21, inclusive, would indicate an "intermediate" level of workforce sustainability. The lower limit for this level was determined based on subtracting three standard deviations (3σ) from the low limit for the "high" level of workforce sustainability [21- 3*2.76 = 12.72 (rounded to 13)].

Lastly, the level of workforce sustainability was considered "low" if the final score is less than 13 (the low limit for the intermediate level of workforce sustainability) or more than six standard deviations (6σ) away from the maximum possible score (29). The three levels of workforce sustainability are illustrated in Figure 4.5. For each level, a different action is required to maintain and improve the workforce. The required action for each level is summarized in Table 4.10.

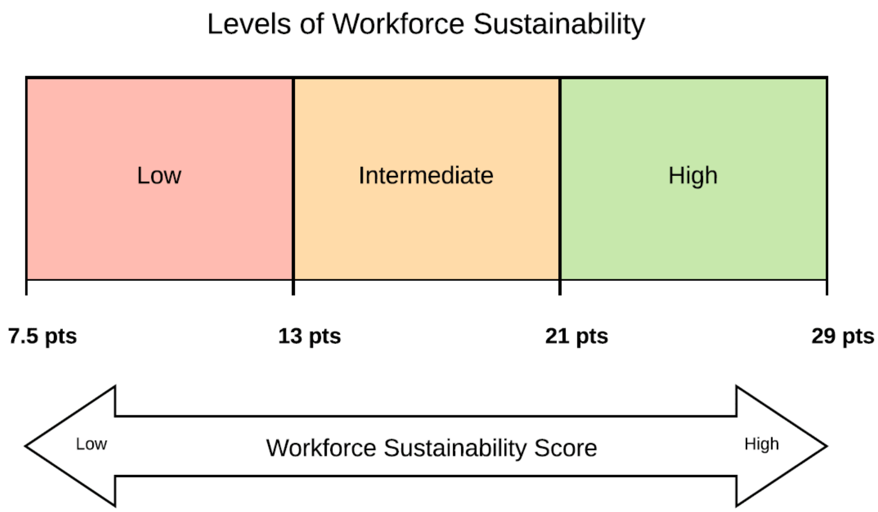

Figure 4.5: Workforce Sustainability Levels and Scores

Table 4.10: Workforce Sustainability Levels, Scores, and Actions

Score	Level	Description of Required Action
Above 21	High	Desirable level for sustaining the workforce; monitor and adjust as needed
13 - 21	Intermediate	Acceptable level but improvements are needed to some or all attributes
Below 13	Low	Insufficient practices, policies, and procedures in place to sustain a productive workforce; corrective actions are required

4.9 Conclusions and Recommendations

Workforce sustainability is the property of a workforce that reflects the extent to which members of the workforce can perform their desired functions over a period of time. Sustaining the workforce requires continued workforce development and cultivation. The continued development and cultivation process includes facilitating an environment that supports coherent, motivated, and healthy individuals that are highly skilled and competent, and then nurturing and maintaining the requisite skills and competencies. This research was intended to develop a practical tool for assessing and improving workforce sustainability in construction. To this end, a mixed-methods research approach was carried out. First, a conceptual model that served as a framework for the intended assessment tool was constructed using a combination of semi-structured interviews and discussions with experts in different fields of study. The conceptual model included three levels of components (attributes, indicators, and metrics) to characterize a workforce and assess its level of sustainability. Next, a review of literature was performed to identify key attributes of workforce sustainability. After that, a subject matter expert panel consisting of 16 panelists was utilized using multi-round survey to identify, verify, and/or quantify the attributes, indicators, and metrics of workforce sustainability. Eventually, a practical tool for assessing, and ultimately improving, workforce sustainability was developed.

The developed tool consists of eight attributes, 42 indicators, and one metric for each indicator as well as evaluation procedure to assess workforce sustainability in construction. The assessment process yields a final aggregated score that describes the level of sustainability within a workforce. The score is calculated based on the aggregated values and weights of the attributes, indicators, and metrics. The possible scores range from 7.5 to 29 – a score greater than 21 indicates high level of sustainability, a score between 13 and 21 indicates an intermediate level of sustainability, and a score lower than 13 indicates a low level of sustainability. For each level, different actions are required to maintain and improve the sustainability of the workforce.

The development of the workforce sustainability assessment tool is expected to be the foundation for subsequent and future workforce development studies in the field of construction engineering as this tool is the first of its kind to identify and assess workforce sustainability attributes, indicators, and metrics. It should be noted that the application, implementation, and validation of the developed workforce sustainability assessment tool is beyond the scope of this study. Future studies are needed to apply, assess, and validate the developed tool within construction projects and organizations. Such a validation study would confirm the accuracy and utility of the tool, and identify potential areas for improvement in the tool. In addition, a supporting study is needed to examine the correlation between the level of workforce sustainability and key performance indicators, such as work quality, safety performance, and worker productivity. It is expected that such an additional study would help to justify the importance of workforce sustainability and generate interest in, and diffusion of, the workforce sustainability assessment tool in the construction industry.

5.0 Conclusions, Limitations, Contributions, and Recommendations

5.1 Chapter Outline

In this chapter, the key conclusions and limitations from each manuscript are presented. After that, the overall conclusions and contributions of the entire research are discussed. Finally, recommendations for future research directions are provided. This dissertation successfully led to a new understanding of social sustainability in construction and the attributes, indicators, and metrics associated with social sustainability in construction. Importantly as well, the research also successfully resulted in the development of a practical tool to assess and improve social sustainability in construction at the workforce level.

5.2 Conclusions and Limitations

In this section, the overall objective along with conclusions and limitations of each manuscript will be summarized. The logical links between the three manuscripts are also briefly discussed.

5.2.1 Manuscript #1: Identification, Quantification, and Classification of Potential Safety Risk for Sustainable Construction in the United States

The main objective of Manuscript #1 was to evaluate social sustainability in the construction industry using occupational health and safety (OHS) as an indicator of social sustainability. The study focused on green design and construction, namely LEED certified projects, as claimed in the literature to be environmental, economically, and socially sustainable.

5.2.1.1 Manuscript #1 Limitations

As mentioned in Chapter 2, a random sample of 41 LEED projects was selected for the analysis. It should be mentioned that the random sample only included new construction commercial building projects (LEED-NC buildings) and did not include other types of projects. Another limitation relates to the fact that the analysis only included the main LEED credits, excluding the pilot credit library (i.e., elective LEED credits). Finally, it was assumed that the selected projects did not use innovative methods, such as prevention through design (PtD), to eliminate OHS hazards on construction projects. This assumption stemmed from the fact that PtD strategies are infrequently implemented in the US construction industry because they require designer involvement in safety during the design phase (Gambatese 2000). Given that designers are typically not required legally and contractually to address construction worker health and safety (Toole 2005), this assumption seems reasonable. In addition, there are multiple barriers that inhibit the implementation of PtD in the US construction industry including liability concerns, lack of PtD training and education, and increased costs of designs (Tymvios and Gambatese 2015). That being said, the limitations do not impact the main conclusions of the study in a direct manner. Not including credits from the LEED pilot credit library in the analysis and assuming that most project did not incorporate innovative practices such as PtD seem reasonable. That is, the credits in the LEED pilot credit library are experimental and could be removed from the list by the USGBC at any time. Relatedly, multiple studies have found that, at this point in time, there are significant challenges to implement innovative safety practices such as PtD (Gambatese 2000; Tymvios and Gambatese 2015).

5.2.1.2 Findings and Conclusions from Manuscript #1

After collecting data and undertaking the analysis, the findings revealed that the requirements for the majority of the LEED credits for new construction commercial building projects, excluding the LEED pilot credit library, focus on environmental and economic sustainability with limited emphasis on social sustainability. Even for those credits that partially address social sustainability, either corporate social sustainability or the social features of the end product (i.e., the building) are addressed in the LEED requirements, rather than the building process and construction workforce. Out of the 54 credits available in the LEED-NC v3 (2009) main categories, 12 credits were found to increase worker exposure to OHS risks when compared with traditional non-LEED projects. Four credits were found to have mixed impact (both positive and negative) on OHS in sustainable design and construction. Only four credits were identified to reduce worker exposure to OHS risks compared with conventional construction. Finally, the majority of the credits (to be exact 34 credits) do not impact the health and safety of construction workers, and expose construction workers to the same level of health and safety risks encountered on traditional construction projects (i.e., non-LEED projects). Previous research (Fortunato et al. 2012; Dewlaney et al. 2012; and Omar et al. 2013) has reached similar conclusions that, overall, the LEED certificate system does not seem to enhance worker health and safety in construction. This study confirms the findings reached by prior research mentioned above and includes in the analysis other significant components of the risk associated with green design and construction that were not addressed by prior research. These components include analyzing the requirements of the new version of the LEED rating system (LEED v3 2009), including LEED projects from different regions throughout the US, and acquiring information in the risk analysis about the extent to which each credit is actually attained in practice by construction companies. The next phase of the research will explore the impact of a new safety credit from the LEED pilot credit library, titled PtD LEED pilot credit, on worker health and safety.

5.2.2 Manuscript #2: Integrating Worker Health and Safety into Sustainable Design and Construction

Findings from Manuscript #1 provide indication that social sustainability of the construction workforce on green projects may be lacking at least with respect to the health and safety of workers. Prior to conducting a literature review to examine other aspects of social sustainability for the construction workforce such as diversity and equity, a new safety LEED credit referred to as the Prevention through Design (PtD) pilot credit was released by the USGBC as part of the LEED pilot credit library. Manuscript #2 examined the PtD LEED pilot credit as a potential solution to the generated OHS risks associated with the implementation of the LEED rating system in sustainable design and construction. The new pilot credit includes requirements that specifically address the health and safety of the construction workforce through the project life-cycle. To examine the level of viability and extent of implementation of the new PtD pilot credit, a survey questionnaire was distributed to two construction industry groups (designers and constructors) involved in the design and building of construction projects. The subsequent subsections below discuss the limitations and conclusions of the study.

5.2.2.1 Manuscript #2 Limitations

Given that a survey questionnaire was the main instrument to collect data for Manuscript #2, the study has a few limitations that should be acknowledged. First, the study results cannot be generalized with high confidence beyond the sample studied given that the sample was not randomly selected. Second, the response rate is relatively low (about 10%) which raises concerns about whether the group of individuals who did not participate in the study would share the same perception about the new PtD LEED pilot credit compared with the group of individuals who participated in the study. Third, the study is perception-based and is not based on empirical data from construction projects that involved safety data. That being said, the researcher believes that the main conclusions are not directly influenced by the limitations discussed above although caution should be practiced when interpreting the results. While the response rate is relatively low, the number of individuals participated in the study is adequate for empirical and statistical analysis. Low response rate is a typical challenge in construction research (Abowitz and Toole 2005; Fellows and Liu 2015) and was totally expected as the population were neither motivated by their employers nor offered any tangible incentive to participate in the survey. Finally, despite the fact that perception-based research, such as Manuscript #2, is less effective than experimental-based research in many instances (Fellows and Liu 2015), the implementation of the PtD LEED pilot credit itself on a project (i.e., the decision to pursue this pilot credit or not) is dependent on the perception of the management team undertaking the project. Accordingly, collecting perception-based data for this research is well-justified.

5.2.2.2 Findings and Conclusions from Manuscript #2

Findings from the survey indicate that, although the PtD pilot credit may be a viable solution to mitigate worker exposure to health and safety risks on construction projects, the implementation of the PtD pilot credit across the construction industry is currently non-existent and is expected to remain limited in the near future. A large percentage of industry professionals who participated in the survey, especially designers, are resistant to the implementation of PtD practices on green projects. The survey respondents reported multiple barriers that inhibit the implementation of PtD practices in the US construction industry. These barriers include, but are not limited to, fear of liability, segmentation of the construction industry, and lack of PtD knowledge among industry professionals in the US. Based on the findings from Manuscript #2, it can be claimed that the new PtD LEED pilot credit may not be a practically viable solution to mitigate OHS risks on construction projects given the unawareness and resistance of industry professionals especially designers to its existence. Although results from Manuscript #2 indicate that it is unlikely for the PtD pilot credit to be implemented in high numbers in the future, only time can confirm or refute this conclusion. A similar research study carried out subsequently by Behm and Pearce (2017) reached the same conclusions of Manuscript #2. Behm and Pearce found that the design community is not motivated to implement the PtD pilot credit and most designers and architects who participated in the study believe that PtD is not a "viable" concept for mitigating worker health and safety risks. The study found that although several projects have registered for the PtD pilot credit, none of the projects was able to achieve the credit requirements and earn the certificate yet (Behm and Pearce 2017). The study of Behm and Pearce (2017) provides additional confidence in the findings from Manuscript #2 and validates its conclusions.

To determine the next phase of the research, a literature review about the social aspects of sustainability as they relate to the workforce was carried out. Results from the literature review, outlined in Section 3.11, indicated an apparent lack of social sustainability among workers in the US construction industry. The apparent lack of social sustainability necessitates the development of a tool for assessing and improving social sustainability of the construction workforce. The third manuscript aimed to develop a model and practical tool for assessing social sustainability of the construction workforce and provide an evaluation procedure to conduct such an assessment.

5.2.3 Manuscript #3: Development of Assessment Tool for Workforce Sustainability

The primary objective of Manuscript #3 was to identify, quantify, and classify the attributes, indicators, and metrics of social sustainability as it related to the construction workforce. The identification, quantification, and classification of these components of social sustainability was used to develop a model of social sustainability and a practical tool to enable assessing and improving social sustainability of the construction workforce. The two subsequent subsections highlight the limitations and conclusions of this study.

5.2.3.1 Manuscript #3 Limitations

Given the study is perception-based, the study has a few limitations that should be acknowledged. First, the study relied on feedback collected from a panel of experts. Although the expert panelists have highly qualified profiles as shown in Table 4.4, the workers in the field may have a different opinion about important practices, procedures, and policies (i.e., indicators) that should be used to assess the social sustainability of the workforce. To minimize potential discrepancy, the expert panelists were asked to think from the perspective of the construction workers. Another limitation is that findings from Manuscript #3 were not validated with empirical data. Future studies should validate the study findings by collecting empirical data from construction projects. Finally, seven out of the identified 42 indicators received limited or incomplete feedback from the Delphi panel regarding what metrics should be used to quantify the indicators. In those cases, the author relied on information available in literature to complement the information received from the panel. Relying on information available in literature is a reliable way to ensure that the author is unbiased and that the study is objective. Despite of the limitations reported above, the methodology itself is not impacted directly by the limitations and those limitations are inherent within the Delphi process. Proactive measures were utilized to overcome or at least minimize the limitations. For example, the expert panelists were asked to think from the perspective of the construction workers to ensure that the study findings represent the views of the construction workforce.

5.2.3.2 Findings and Conclusions from Manuscript #3

Using a mixed-methods research, the attributes, indicators, and metrics of construction workforce sustainability were identified. The results from Manuscript #3 indicated that there are eight attributes (namely, nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity), and 42 indicators (multiple indicators for each attributes – see Table 4.6) to assess and improve social sustainability of the construction workforce. Each attribute was assigned a value that indicates the level of influence of the attribute on social sustainability. In turn, each indicator has a numerical value, ranging from 3 (moderate) to 5 (extreme), that represents the level of the influence of the indicator on its applicable attribute. The indicators are practices, procedures, and policies used to advance social sustainability of the construction workforce. To quantify the actual level of influence obtained in practice by an organization for its workforce, measurement units/scales referred to as metrics were utilized as illustrated in Sections 4.7.1 and 4.7.2.

The study findings are significant for multiple reasons. First, the study results provide a new understanding the social sustainability aspects affecting the construction workforce, and its growth and sustainability. Second, the study identifies, quantifies, and classifies the attributes, indicators, and metrics of the social aspects of workforce sustainability. This identification, qualification, and classification provides important information about what practices, procedures, and policies should be used to enhance a certain attribute of workforce sustainability, and what practices, procedures, and policies are the most influential in terms of enhancing a certain attribute of workforce sustainability.

5.3 Overall Research Conclusions and Contribution

A key finding from this dissertation, based on results from the first two manuscripts and the literature review, is that social sustainability of the construction workforce is lacking. Social sustainability of the construction workforce was assessed based on the level of worker health and safety, diversity of the construction workforce, opportunities for career development across the industry, amount of training and support provided to construction employees, job stability and security across the industry, etc. The health and safety aspect of social sustainability was thoroughly studied in the first two manuscripts. However, the present study included evaluation of multiple aspects of social sustainability that are beyond just worker health and safety. To be specific, a review of literature (see Section 3.11) was used to evaluated other aspects of social sustainability such as diversity and equity. Based on the finding that social sustainability of the workforce is lacking, it was concluded that it is essential to develop a model and practical tool to assess and improve social sustainability of the construction workforce. Such a tool is currently not available to construction industry stakeholders. Existing social sustainability tools in the construction industry primarily focus on the organization, the end users (i.e., occupants), or the final product (i.e., the building), rather than the construction workforce. The JUST label, DOI Sustainable Building Assessment and Compliance tool, and the LEED rating system are used to assess the sustainability of organizations, occupants' health, and buildings, respectively.

To fill in the identified gap, a practical tool that provides an evaluation procedure for assessing the social sustainability of the construction workforce was developed. The author utilized the identified eight attributes of workforce sustainability from Manuscript #3 to develop the intended tool. To evaluate the extent to which the attributes are satisfied within a workforce, multiple indicators (practices, procedures, and policies) along with metrics are integrated into an evaluation procedure to quantify each attribute of workforce sustainability within the developed tool and its evaluation procedure. The indicators and metrics were also identified in Manuscript #3 using a panel of experts and a review of available literature on the topic. The developed evaluation procedure yields a final aggregated score that describes the level of social sustainability of a workforce. The possible scores range from 7.5 to 29 where a score greater than 21 indicates a high level of sustainability, a score between 13 and 21 indicates an intermediate level of sustainability, and a score lower than 13 indicates a low level of sustainability. The developed tool is referred to as the workforce sustainability assessment tool (see Appendix II).

The specific contributions of this research are summarized below. For one part, the present study defines the social sustainability of the construction workforce and provides a new understanding the social sustainability as it relates to the construction workforce. The concept of social sustainability of the construction workforce (i.e., workforce sustainability) is considered a new and innovative direction to both enhance and maintain skill development, work-life balance, and the safety and well-being of construction personnel. Relatedly, the present study contributes to the body of knowledge by identifying, quantifying, and classifying relevant attributes, indicators, and metrics for assessing the social sustainability of the construction workforce. This identification, qualification, and classification provides important information about what indicators should be used to assess a certain attribute of workforce sustainability, and what practice, procedure, and policy is the most influential in terms of enhancing a certain attribute of workforce sustainability. For the other part, by developing a practical tool for workforce sustainability, the present study will enable the assessment and improvement of social sustainability of the workforce in practice across the construction industry and make it easy for practitioners to conduct the assessment. Without such a tool, social sustainability of the construction workforce cannot be comprehensively and holistically assessed and improved.

The contribution of this study especially enabling the assessment of social sustainability of the construction workforce is essential for two primary reasons. First, assessing social sustainability of the construction workforce will identify the current level of workforce sustainability and required actions that employers and employees should undertake to maintain or improve the sustainability of the workforce. Higher levels of workforce sustainability are expected to be associated with low turnover rates, high productivity, improved safety, and other short- and long-term benefits. When workforce sustainability level is low, there is an opportunity for the employer to take required actions to improve social sustainability of the workforce before encountering undesired outcomes. Identifying this opportunity and the attributes on which the employer should focus the effort is enabled by using the developed assessment tool of workforce sustainability. The focus area to improve social sustainability of the workforce can include one, multiple, or all attributes of workforce sustainability. The use of the assessment tool will indicate which attributes are not adequately addressed by the organization and provide suggested practices, procedures, and policies to nurture and improve the attributes. Implementing the suggested practices, procedures, and policies promotes a sustainable career for construction workers and a sustainable workforce for the construction industry. It is also expected that by doing so will enhance an organization’s safety culture and worksite’s safety climate. Industry best practices and strategies identified by both previous research and the expert panel are incorporated into the developed assessment tool of workforce sustainability in the form of indicators under each applicable attribute.

Second, the development of the tool will complement the LEED rating system and provide a holistic assessment of sustainable development for a project or a company. That is, while the LEED rating system focuses on assessing the environmental and economic dimensions of sustainability in construction as well as the occupants’ health and prosperity (Gambatese et al. 2007; Hinze et al. 2013), the developed assessment tool focuses on assessing the social dimension of sustainability as it relates to the workforce. Assessing the three dimensions (environmental, economic, and social) in a holistic manner while considering both the building occupants and construction workers enables accurate evaluation of sustainable development in construction.

The present research is in line with the OSU strategic plan for achieving "*The Three Signature Areas of Distinction*: *advancing the science of sustainable earth ecosystems, improving human health and well-being, and promoting economic growth and social progress."* In particular, the output from this dissertation contributes to promoting economic growth and social progress of the construction workforce.

5.4 Recommendations for Future Research

The development of the workforce sustainability assessment tool is expected to be the foundation for subsequent and future workforce development studies in the field of construction engineering as this tool is the first of its kind to identify and assess workforce sustainability attributes, indicators, and metrics. It should be noted, however, that application, implementation, and validation of the developed tool is needed to ensure that the tool can be easily used by different types of constructions organizations and that it accurately represents workforce sustainability. Future studies are needed to apply, assess, and validate the developed tool within construction projects and organizations. Such a validation study would confirm the accuracy and utility of the tool, and identify potential areas for improvement in the tool.

In addition, a supporting study is needed to examine the correlation between the level of workforce sustainability and key performance indicators, such as work quality, safety performance, and worker productivity. It is expected that such an additional study would help to justify the importance of workforce sustainability and generate interest in, and diffusion of, the developed assessment tool for workforce sustainability across the construction industry.

Finally, to ensure that the tool will be used by a large number of construction organizations, a user-friendly website, similar to the SCSH rating system (http://sustainablesafetyandhealth.org), Safety Climate Assessment Tool (S-CAT) (https://safetyclimateassessment.com), and Construction Solutions tool (www.cpwrconstructionsolutions.org), should be developed. Such a website will minimize the time and paperwork required to perform the assessment, as well as increase awareness of the availability of the tool, all of which help the tool penetrate the market and reach a high level of diffusion in the AEC industry.

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7.0 Appendices

7.1 Appendix I – Delphi Survey Questionnaire – Identifying Workforce Sustainability Attributes, Indicators and Metrics

This appendix shows the three sets of questionnaires that were used as part of the Delphi survey. Each section along with the invitation email is shown below.

Dear Participant,

We would like to thank you for taking the time to participate in these multiple rounds of survey and be part of the expert panel for our research study.

Your responses to this survey and personal information provided will be kept confidential. All identifiable information connecting respondents to their responses will be removed as part of the data collection process. Publications generated from the research study will not include any information that can be used to identify respondents.

If you have any questions about the survey, please contact the researchers listed below. If you have questions about your rights or welfare as a survey participant, please contact the Oregon State University Institutional Review Board (IRB) Office at 541-737-8008, or by email at IRB@oregonstate.edu

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Round One
Part I: Demographic Information

Q1 What is your gender?

- Male
- Female
- Prefer not to say

Q2 What is your race/ethnicity origin?

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or other Pacific Islander
- White
- Other, please specify ____________________
- Prefer not to say

Q3 What type(s) of organization(s) do you represent or work for? Please select all that apply.

- University
- Research Institute
- Architecture, Engineering, or Construction Association
- Design Firm
- Construction Firm
- Design and Construction Firm
- Owner
- Regulatory Agency
- Workforce Development Organization
- Other, please specify: ____________________

Q4 What is your job title?

- Faculty Member (please specify rank) ________________
- Independent Researcher (please specify) ________________
- Project Manager
- Sustainability/Environmental, Health, and/or Safety (SHS/EHS) Manager
- Human Resources/Workforce Development Manager or Director
- Corporate Social Responsibility Manager or Director
- Other, please specify: _____________________

Q5 Where is your work located currently?

- List of states

Q6 What degree(s) have you earned and in what area(s)? Please list only those degrees that relate to the focus of the study (e.g., civil/construction engineering, workforce development-related degree, human factor, sociology, health and well-being, safety, sustainability, etc.).

- BSc (or equivalent degree) _____________________
- MSc (or equivalent degree) _____________________
- PhD (or equivalent degree) _____________________
- Other, please explain: _________________________

Q7 How many years of professional experience do you have working for the following entities? Please select all that apply.

- University ____________
- Research Institute ____________
- Architecture, Engineering, or Construction Association ____________
- Design Firm ____________
- Construction Firm ____________
- Design and Construction Firm ____________
- Owner ____________
- Regulatory Agency ____________
- Workforce Development Organization ____________
- Other, please specify: ____________

Q8 Please lists the professional committee(s) that you are/were the chair or a member of. Please, specify only the committees that relate to the focus of the study (e.g., workforce training and development, safety, and sustainability), and whether you are/were a member or the chair of the committee.

- ☐ ______________________
- ☐ ______________________
- ☐ ______________________

Q9 Please list the leading position(s) or role(s) that you have filled within your current or previous organization with respect to workforce training and development, safety, and sustainability effort (e.g., Human Resources/Workforce Development Manager).

- ☐ ______________________
- ☐ ______________________
- ☐ ______________________

Q10 How many workers/students/employees/etc. have you supervised throughout your working career?

☐ List of numbers. Please specify type (e.g., students) ______________________

Q11 How many published works (e.g., papers, articles, reports, etc.) have you authored or co-authored on topics related to the construction workforce, workforce development, workforce diversity, employee training, human factors, sociology, safety, health and well-being, social sustainability, work-life balance, etc.? Please select all that apply and specify the number of published works for each

- ☐ Academic/Scientific Journal article ______________________
- ☐ Book or book chapter ______________________
- ☐ Conference paper ______________________
- ☐ Invited conference paper ______________________
- ☐ Industry publication (technical article, technical report, etc.) ______________________
- ☐ Other, please explain: ______________________

Q12 How many academic or industry presentation(s) have you given, either nationally or internationally, with respect to the construction workforce, workforce development, workforce diversity, employee training, human factors, sociology, safety, health and well-being, social sustainability, work-life balance, etc.? Please specify the type and number for each.

- ☐ ______________________
- ☐ ______________________
- ☐ ______________________

Q13 What professional registrations and certifications do you have with respect to civil/construction engineering, workforce development, safety, sustainability, etc.? Please, select all that apply.

- ☐ Professional Engineer (PE)
- ☐ LEED Accredited Professional (LEED AP)
- ☐ Certified Safety Professional (CSP)
- ☐ Associate Safety Professional (ASP)
- ☐ Certified Workforce Development Professional (CWDP)
- ☐ Other, please explain: ____________________

Q14 Please list in the space provided below all types of experience that you have had, positions you occupied, and so forth with respect to workforce development and human resource management.

____
____
____

Round One
Part II: Confirming and Quantifying Workforce Sustainability Attributes

A detailed description of the developed conceptual workforce sustainability model was provided to the participants for their review before they can answer this part of survey round. The description included the purpose of the study, definition of the concept, structure of the intended final model, and detailed definitions and illustrations of suggested attributes of workforce sustainability. After that, the participants were asked to answer the following questions to the best of their knowledge.

Q15 To what extent have you been involved with or contributed to the following area of workforce development throughout your working career as a researcher, educator, or industry professional

1. Nurturing (i.e., worker support, encouragement, and training)

   Use graphic slider with "not involved at all" to "extremely involved"
   Use another graphic slider to indicate years of involvement

2. Diversity (i.e., workforce diversity)

   Use graphic slider with "not involved at all" to "extremely involved"
   Use another graphic slider to indicate years of involvement

3. Equity (i.e., social equity in the workplace)

   Use graphic slider with "not involved at all" to "extremely involved"
   Use another graphic slider to indicate years of involvement

4. Health and well-being (i.e., occupational health and safety)

   Use graphic slider with "not involved at all" to "extremely involved"
   Use another graphic slider to indicate years of involvement

5. Connectivity (i.e., worker communication, interaction, and integration in the workplace)

   Use graphic slider with something "not involved at all" to "extremely involved"
   Use another graphic slider to indicate years of involvement

6. Value (i.e., respect, appreciation, and recognition of workforce)

   Use graphic slider with "not involved at all" to "extremely involved"
   Use another graphic slider to indicate years of involvement

7. Community (i.e., community at work; camaraderie and cohesiveness in the workplace)

   Use graphic slider with "not involved at all" to "extremely involved"
   Use another graphic slider to indicate years of involvement

8. Maturity (i.e., employee maturity)

   Use graphic slider with "not involved at all" to "extremely involved"
   Use another graphic slider to indicate years of involvement

Q16 Please indicate your agreement with the following statement: Overall, the proposed conceptual workforce sustainability model is an accurate method to reflect workforce sustainability, and its eight attributes (nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity) are important qualities and characteristics to assess and evaluate the level of workforce sustainability (i.e., the identified eight attributes capture essential qualities and characteristics of workforce sustainability).

- 5: Strongly agree (i.e., inclusive and comprehensive model)
- 4: Agree (i.e., representative and comprehensive model)
- 3: Somewhat agree (i.e., comprehensive but inconclusive model)
- 2: Disagree (i.e., inconclusive and selective model)
- 1: Strongly disagree (i.e., faulty and misleading model)

Suggestions, thoughts, comments, criticisms, etc. ____________________

Q17 Please indicate the level of influence that each attribute should have on workforce sustainability:

Nurturing: the extent to which workers feel supported, encouraged, educated, and trained in their work and as individuals

- 5: Extreme influence
- 4: High influence
- 3: Moderate influence
- 2: Minor influence
- 1: Low influence
- 0: I do not know

Diversity: the extent to which the workforce is diversified with respect to personal characteristics (e.g., gender, experience, race, social status, education, etc.) and to which diversity is integrated into and promoted within the workplace

- 5: Extreme influence
- 4: High influence
- 3: Moderate influence
- 2: Minor influence
- 1: Low influence
- 0: I do not know

Equity: the extent to which workers feel treated fairly, evaluated equally, and respected without discrimination in terms of personal characteristics, employment level, payment, work load and responsibilities, promotion, work opportunities, and so forth

- 5: Extreme influence
- 4: High influence
- 3: Moderate influence
- 2: Minor influence
- 1: Low influence
- 0: I do not know

Health and well-being: the level of workplace health, safety, and contentment that workers feel and experience physically, mentally, and socially, during and after work operations within their work career and beyond

- 5: Extreme influence
- 4: High influence
- 3: Moderate influence
- 2: Minor influence
- 1: Low influence
- 0: I do not know

Connectivity: the degree to which workers feel connected to peers and fellow employees, integrated into the work community, and engaged in the operations, leadership, and decision-making process

- 5: Extreme influence
- 4: High influence
- 3: Moderate influence
- 2: Minor influence
- 1: Low influence
- 0: I do not know

Value: the extent to which workers feel that they and their families are valued, appreciated, and recognized by others in the organization for their work performance, contributions, and loyalty

- 5: Extreme influence
- 4: High influence
- 3: Moderate influence
- 2: Minor influence
- 1: Low influence
- 0: I do not know

Community: the extent to which workers feel they are accepted by, share similar interests with, and have camaraderie and cohesiveness in growth and achievement together with others in the workforce and with the organization as a whole

- 5: Extreme influence
- 4: High influence
- 3: Moderate influence
- 2: Minor influence
- 1: Low influence
- 0: I do not know

Maturity: a reflection of the extent to which workers have or gain competence in social, technical, environmental, and economic terms with respect to performance, problem-solving, collaboration, idea-generation and innovation, and work involvement and integration. A mature workforce should be able to gain, develop, and carry on the aforementioned competences effectively and efficiently as a group and as individuals throughout their working and non-working life.

- 5: Extreme influence
- 4: High influence
- 3: Moderate influence
- 2: Minor influence
- 1: Low influence
- 0: I do not know

If you have any additional comment or suggestion, please feel free to write them in the space provided below:

___

___

___

The first round of the survey is complete. Thank you for taking the time to complete this survey. Your input is very much appreciated.

If you have any questions or want to learn more about our research, please feel free to reach us at karakhaa@oregonstate.edu, john.gambatese@oregonstate.edu, or densimm@vt.edu.

Round Two

Part I: Confirming Influence of Workforce Sustainability Attributes

In this part, the participants were asked whether they wanted to retain or update their responses for round #1 based on the aggregated group response (i.e., the median value) using the 5-point Likert scale used before. The question asked about the level of influence that each of the eight attributes should have on workforce sustainability. When the updated, or retained, response was two or more units away from the aggregated group response, the participants were asked to explain their responses and why they chose to keep their response distant from the group median. The following table was used to collect the responses for this round.

Attribute	Previous response	Group aggregated response	Retain response? (Y/N)	If No, updated response	If final response is two units away from group response, please justify
Nurturing					
Diversity					
Equity					
Health and well-being					
Connectivity					
Value					
Community					
Maturity					

Rating Scale:

5 = Extreme influence
4 = High influence
3 = Moderate influence
2 = Minor influence
1 = Low influence
0 = I do not know

Round Two
Part II: Identifying Workforce Sustainability Indicators

In this part, the participants were asked to suggest and identify potential indicators that can be used to assess and improve each of the identified eight workforce sustainability attributes (nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity). Before presenting the question, a full description of what constitutes an indicator with multiple examples was provided. Along with each suggested indicator, the participants were asked to provide a weighting to indicate the relative level of influence that the suggested indicators should have on their applicable attributes. The question of interest is shown below.

Q1 Please list all potential indicators that can be used to assess and improve each of the eight workforce sustainability attributes along with a weighting indicating the level of influence that each suggested indicator should have on its applicable attribute(s) using the same scale shown above.

Example: Indicating "OSHA 10 hour training (3)" as a response means that you suggest "OSHA 10 hour training" as an indicator with "moderate influence" (3) on the qualities and characteristics of the attribute.

1- Nurturing: the extent to which workers feel supported, encouraged, educated, and trained in their work and as individuals

- ☐ Indicator 1: ______________________________
- ☐ Indicator 2: ______________________________
- ☐ Indicator 3: ______________________________

2- Diversity: The extent to which the workforce is diversified and inclusive with respect to personal characteristics (e.g., gender, experience, race, social status, education, etc.) and to which diversity is integrated into and promoted within the workplace

- ☐ Indicator 1: ______________________________
- ☐ Indicator 2: ______________________________
- ☐ Indicator 3: ______________________________

3- Equity: The extent to which workers feel treated and compensated fairly compared to other workers, and evaluated fairly without discrimination with respect to personal characteristics, employment level, payment, work load and responsibilities, promotion, work opportunities, and so forth.

- ☐ Indicator 1: ______________________________
- ☐ Indicator 2: ______________________________
- ☐ Indicator 3: ______________________________

4- Health and well-being: The level of workplace health, safety, and contentment that workers feel and experience physically, mentally, and socially during and after work operations within their work career and beyond

- ☐ Indicator 1: ______________________________
- ☐ Indicator 2: ______________________________
- ☐ Indicator 3: ______________________________

5- Connectivity: The degree to which workers feel connected, and willingly desire to connect, to peers, fellow employees, and management through open channels and two-way communication, and feel engaged in the operations, leadership, planning, and decision-making process

- Indicator 1: ________________________________
- Indicator 2: ________________________________
- Indicator 3: ________________________________

6- Value: The extent to which workers feel that they and their families are valued, respected, appreciated, and recognized by others in the workforce and the organization, financially and emotionally, for their work performance, contributions, and loyalty

- Indicator 1: ________________________________
- Indicator 2: ________________________________
- Indicator 3: ________________________________

7- Community: The extent to which workers feel they are accepted by, share similar interests with, and have camaraderie and cohesiveness in growth and achievement together with others in the workforce, with the organization, and with the industry as a whole

- Indicator 1: ________________________________
- Indicator 2: ________________________________
- Indicator 3: ________________________________

8- Maturity: A reflection of the extent to which workers have and/or gain leadership, responsibility, accountability, and competence in social, technical, environmental, and economic terms with respect to work performance, cooperation, problem-solving, collaboration, idea-generation and innovation, and work involvement and integration. A mature workforce should be able to gain, develop, and carry on the aforementioned competencies effectively and efficiently as a group and as individuals throughout their working and non-working life and be responsible/accountable towards self and others

- Indicator 1: ________________________________
- Indicator 2: ________________________________
- Indicator 3: ________________________________

The second round of the survey is complete. Thank you for your continued commitment to this study. Your input is highly appreciated.

Thank you!

Round Three
Confirming Indicators and Identifying Metrics of Workforce Sustainability

In this round of the survey, the participants were asked to suggest whether each indicator should be retained or removed from the list of indicators compiled from the previous round. In addition, the participants were asked to provide, in light of the aggregated group response (i.e., the median), a weighting to indicate the level of influence that each identified indicator should have on desired qualities and characteristics of its applicable workforce sustainability attributes. Moreover, the participants were asked to suggest whether the indicator should be listed in the final model as essential or auxiliary. Essential indicators refer to those that are required practices/procedures/ policies to assess and improve workforce sustainability, while auxiliary indicators are preferred but not essential practices/procedures/policies to assess and improve workforce sustainability. Finally, the participants were asked to suggest one or more metrics to measure each indicator.

Metrics were defined as “scales used to measure or quantify the extent or degree of implementation to which practices, procedures, or policies (i.e., indicators) are actually implemented by a company or an organization in practice to enhance workforce sustainability.” We also provided the following examples to ensure that the participants understand what a metric is.

> *Examples: A self-assessment of employee happiness in the workplace is an example of a metric to measure the "Employee Happiness" indicator of the "Value" attribute. A survey can be utilized to obtain information related to self-assessment of employee happiness. However, the survey in this case is NOT a metric; the self-assessment of employee happiness is the metric, and the survey is just a data collection tool used to obtain information about the metric. To provide one more example, the number of annual training hours could be used as a metric to measure the "Leadership and Communication Training" indicator of the "Maturity" attribute.*

Then, the indicators were presented to the expert panelists in the following format and the panelists were asked to answer the four questions shown in the table below. Only the nurturing attribute is shown below but for the actual survey, the participants were given similar table to each of the other seven attributes.

Nurturing: The extent to which workers feel supported, encouraged, educated, and trained in their work and as individuals

Nurturing attribute (suggested indicators)	**Group response**	**Retain indicator? (Y/N)**	**Level of influence, if retained**	**Essential or Auxiliary**	**Suggested metrics to assess indicator**
Productive performance appraisals	4				
Professional development/continuing education	3				
Employee onboarding and mentoring process	4				
Technical skill training	4				
360 degree evaluation by peers	4				
Non-work related skill development	3				

Note: The group response is basically the level of suggested influence of the indicator that was provided by the panel in the previous round of the survey (Round #2).

The third round of the survey is complete. Thank you for your continued commitment to this study. Your input is highly appreciated.

Thank you!

7.2 Appendix II – Workforce Sustainability Assessment Tool (W-SAT)

This appendix contains the workforce sustainability assessment tool created. The tool is written in anticipation that it will be used as a standalone document independent of this dissertation. This tool was developed as a part of small grant (#17-8-PS) awarded by the Center for Construction Research and Training (CPWR) through cooperative agreement #U60-OH009762 from the National Institute for Occupational Safety and Health (NIOSH). The researcher deeply appreciates the support and funding provided by CPWR and NIOSH.

Workforce Sustainability Assessment Tool (W-SAT)

WORKFORCE SUSTAINABILITY ASSESSMENT TOOL (W-SAT)

Executive Summary

The construction workforce has experienced high turnover rates over the last decades. The high turnover rates make it challenging to attract, develop, and retain a young, skilled, and competent workforce in the industry. These high turnover rates have been caused by many factors including among others the negatively perceived work values of many positions, the high number of fatalities in the industry each year, the high exposure to health hazards in a typical construction environment, and the lack of opportunities for career progression and development in the industry. Little research has been conducted on workforce development in construction. Similarly, there are no industry tools readily available to develop and sustain the workforce in the construction industry. Existing tools are solely focused on one or a few elements (e.g., training) rather than implementing a holistic and concrete approach to develop and sustain the construction workforce.

The Center for Construction Research and Training (CPWR) funded as a part of its Small Study Program a research study led by researchers from Oregon State University and University of Florida to explore the topic of workforce sustainability in construction. Workforce sustainability is more evolved and reaching than workforce development. Achieving workforce sustainability includes the process of hiring and facilitating an environment for a coherent, viable, and healthy individuals who are highly skilled and competent, and then nurturing and maintaining the requisite skills and competences constantly. The workforce sustainability concept is a big step forward that The Center for Construction Research and Training (CPWR) funds and supports to foster and advance the life of construction employees.

The goal of the research study was to develop a practical assessment tool (a model and evaluation process) for assessing and improving workforce sustainability in construction. This document is intended to describe this practical assessment tool, both the model and the evaluation process. The developed assessment tool is voluntary and can be used by any organization (profit or non-profit whether public or private) within the Architecture, Engineering, and Construction (AEC) industry to assess and/or improve workforce sustainability. The assessment and/or improvement can be made at the individual, team, division, organization, or even entire industry level. Improved workforce sustainability demonstrates healthy and diverse work communities where each member of the workforce is accepted, respect, protected, and treated fairly and equally regardless of race, ethnicity, nationality, etc. In order to create and nurture a high level of workforce sustainability, members of the workforce should feel safe and valued, be engaged in the decision-making and connected to peers and fellow employees, and have access to training and professional development opportunities throughout their career. Such opportunities can enable them to progress and mature over the years.

The workforce sustainability assessment tool consists of a total of eight attributes and forty-two indicators as described below. For each indicator, a metric is used to evaluate the extent of application of the indicator in practice and assign a quantified value to the indicator.

What is Workforce Sustainability?

Workforce Sustainability is defined as a property of a workforce that reflects the extent to which the workforce can perform its desired function over a selected period of time, be adaptable to workplace environment and market demands, and be resilient to internal and external work- and personal-related challenges. This property can be influenced by several attributes (i.e., qualities or characteristics) described below in more detail. A workforce may exhibit a high or low level of sustainability based on the extent to which it safely, skillfully, and collaboratively performs its function with respect to certain attributes.

The workforce sustainable assessment tool was developed based on an academically rigorous study performed by researchers at Oregon State University and University of Florida. The workforce sustainability model on which the assessment tool is founded is based on the perspectives of the employees (i.e., the workforce) and how they feel about their sustainability as a group and as individuals, as opposed to the viewpoint of the organization. Employees, or the workforce in this regard, are any members of a construction-related organization who are involved, directly or indirectly, in the construction process, whether laborers, managers, supervisors, engineers, or other individuals. Given its applicability throughout the workforce and connection to work quality, it is expected that orgnizations will benefit from creating a sustainable workforce.

How to Improve, Nurture, and Sustain Workforce Sustainability

Workforce sustainability can be nurtured, improved, and sustained via employment practices, procedures, and policies that an organization (the employer) or the workforce itself (the employees) implement in the workplace to provide support, encouragement, education, and training to employees whether as a group or as individuals.

Structure of the Workforce Sustainability Assessment Tool

The workforce sustainability assessment tool consists of three levels of components organized in a hierarchy, from the most general to the most specific as shown in the diagram below. These three levels of components are attributes, indicators, and metrics, respectively. Each of the levels is briefly described below.

- Attributes are foundational qualities and characteristics of workforce sustainability. There are eight attributes that characterize a workforce and disclose its level of sustainability, as shown in the figure below. These attributes are: nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity.
- Indicators are practices, procedures, and policies that reveal the presence and level of each attribute within a workforce, and which can be used to assess and improve each attribute and, as a result, the overall level of workforce sustainability.
- Metrics are measurement units and scales used to measure the extent or degree to which the practices, procedures, and policies (i.e., indicators) are actually

implemented in practice within an organization to maintain and/or improve workforce sustainability.

Within the assessment tool, indicators are either essential or auxiliary for assessing the level of workforce sustainability. Among the 42 indicators of workforce sustainability, 32 indicators are considered *essential* and 10 are considered *auxiliary*. Essential and auxiliary in this context refer to the role of the indicator in providing a full and accurate assessment of the level of workforce sustainability within an organization, and do not indicate the level of influence of the indicator on overall workforce sustainability. For example, the leadership and communication skills indicator is widely acknowledged as a fundamental measure of maturity and, therefore, is considered essential for complete assessment of maturity. Correspondingly, outreach and volunteering are preferred features of maturity meaning that if they are not evaluated, maturity can still be assessed with adequate accuracy. However, to acquire a more accurate and comprehensive assessment of workforce sustainability, it is recommended that all indicators, both essential and auxiliary, be evaluated. Assessing solely the auxiliary indicators would not provide an accurate level of workforce sustainability. The designations “E” and “A” associated with each indicator are used to indicate whether the indicator is essential or auxiliary, respectively.

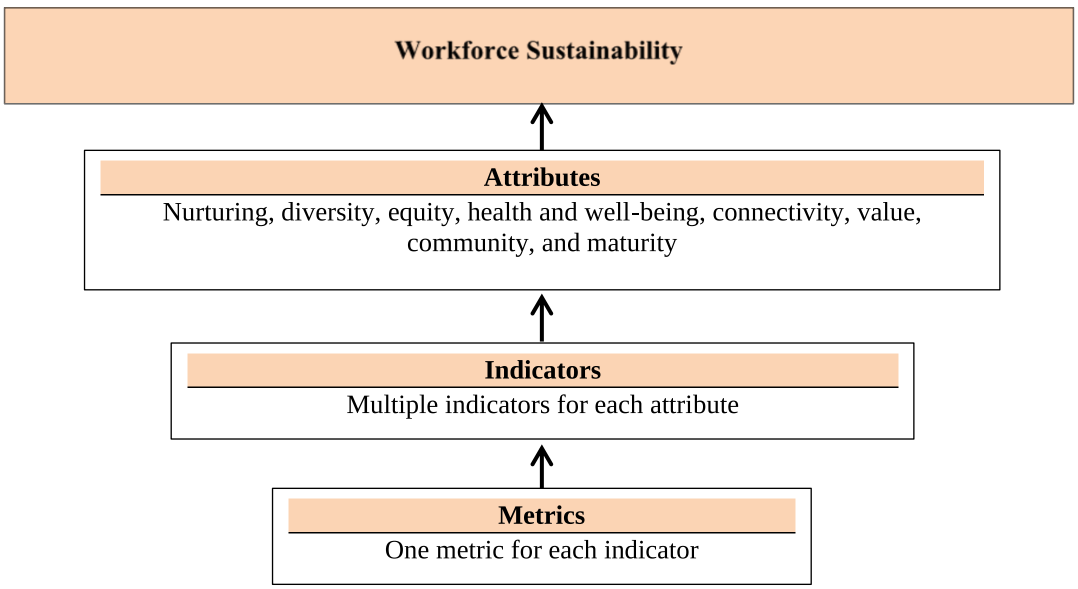


Figure 7.1: Three Levels of Components of Workforce Sustainability

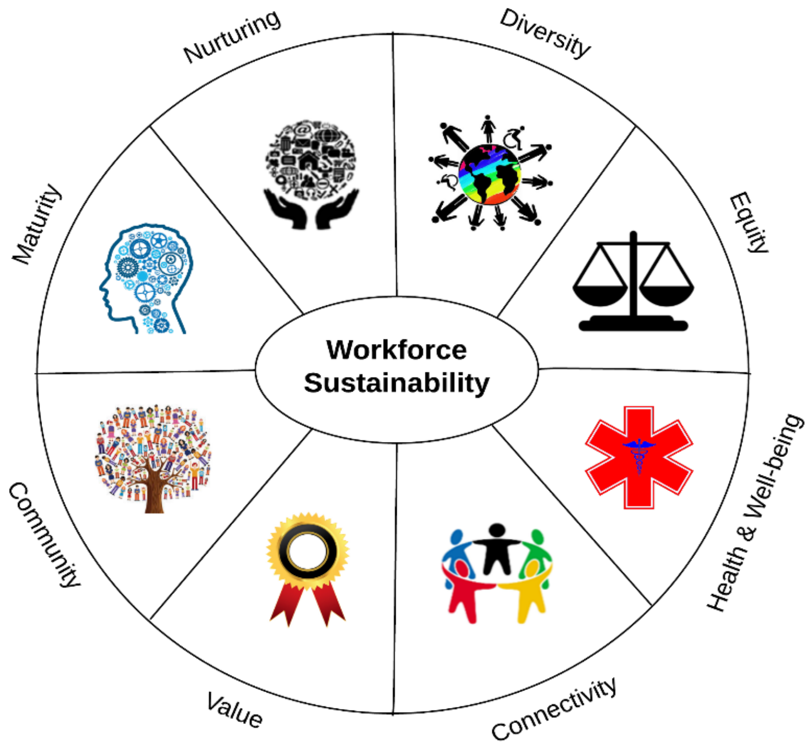


Figure 7.2: Workforce Sustainability Attributes

Possible Score and Levels of Workforce Sustainability

The maximum possible score for workforce sustainability is 29. This score is calculated based on the aggregated and weighted values of the eight workforce sustainability attributes and their 42 indicators. The score is divided into three major levels of workforce sustainability. Any score above 21 may be considered an indication of a *high* level of workforce sustainability. A score falling from 13 to 21 may be an indication of an *intermediate* level of workforce sustainability. An intermediate level of workforce sustainability indicates that additional or modifications to practices, policies, and/or procedures would be required for all or some attributes. Lastly, if the score is below 13, then this is considered an indication of a *low* level of workforce sustainability. In this case, current practices, policies, and procedures are insufficient to sustain a productive workforce and corrective actions are required. The scores and levels are not arbitrary; they were carefully determined, in part, by relying on a statistics theory. The calculation sheet on the next page summarizes the scores and levels of workforce sustainability, and how they are determined using the developed assessment tool.

Following the summary calculation sheet, a detailed description of each indicator and the metrics used to measure each attribute is then provided.

WORKFROCE SUSTAINABILITY ASSESSMENT

Workforce Sustainability Score – Summary Calculations

	Attribute Weighted Scored		Possible Weighted Score
Nurturing	_____	(from page #120)	4
Diversity	_____	(from page #127)	3
Equity	_____	(from page #134)	5
Health and well-being	_____	(from page #141)	4
Connectivity	_____	(from page #148)	3
Value	_____	(from page #158)	4
Community	_____	(from page #164)	3
Maturity	_____	(from page #172)	3

Workforce Sustainability Score = _____ out of 29 (total possible score)

Workforce Sustainability Level (check one):

_____ High (workforce sustainability score above 21)
_____ Intermediate (workforce sustainability score from 13 to 21)
_____ Low (workforce sustainability score below 13)

Description of workforce sustainability levels

- *High* means the level of workforce sustainability is desirable for sustaining the workforce, and practices, policies, and procedures should be monitored and adjusted as needed
- *Intermediate* means the level of workforce sustainability is acceptable, but improvements are needed to some or all attributes
- *Low* means the practices, policies, and procedures in place are insufficient to sustain a productive workforce and corrective actions are required

1.0 NURTURING

Attribute: Nurturing

The extent to which workers feel supported, encouraged, educated, and trained in their work and as individuals.

Attribute weight: 4

Attribute Indicators:

There are four indicators of the nurturing attribute:

1. (E) Productive performance appraisals
2. (E) Professional development/continuing education
3. (E) Technical skill training
4. (E) Onboarding process

1.0 NURTURING (cont'd)

Indicator 1: **Productive Performance Appraisals**

A productive performance appraisal is the process of documenting and evaluating employees for past performance on a regular basis, and providing critical feedback on what they did well and what should be improved. This feedback loop is an essential part of an employee's career development and can lead to a motivating work environment and continuous improvement process.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Frequency of implementation

Scales:

1 point

Organization does not have a specific plan for and never implements productive performance appraisals in a systematic manner.

2 points

Organization has a plan co-developed by employer and employees with specific performance goals. The organization formally implements the plan with at least two face-to-face meetings each year.

3 points

Organization has a plan co-developed by employer and employees with specific performance goals. The organization formally implements the plan with regular face-to-face meetings (three- to four-times a year).

4 points

Organization has a plan co-developed by employer and employees with specific performance goals. The organization formally implements the plan with frequent face-to-face meetings and evaluates the progress during semi-annual performance reviews.

Indicator Points Earned = _____

1.0 NURTURING (cont'd)

Indicator 2: **Professional Development/Continuing Education**

Professional development (also referred to as continuing education) programs are education opportunities relevant to construction that are provided for employees in the form of lectures, courses, webinars, or other types of educational activities. Professional development programs are delivered either to provide the knowledge required for a profession or to update employees' existing knowledge as opposed to providing the skills needed to perform a specific task. Successful organizations provide work-time support, access, and financial support for their employees to attend and engage in these education programs.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Annual funds dedicated to support employee continuing education programs

Scales:

1 point

Organization has no annual dedicated fund for continuing education and no policy to allow employees to attend professional development and education programs.

2 points

Organization dedicates an annual fund of 0.5% of payroll for professional development purposes, allows employees to attend approved programs during paid work time, and pays 50%, or more, of associated costs.

3 points

Organization dedicates an annual fund of 1.0% of payroll for professional development purposes, allows employees to attend approved programs during paid work time, and pays 50%, or more, of associated costs.

4 points

Organization dedicates an annual fund of 1.5% of payroll for professional development purposes, allows employees to attend approved programs during paid work time, and pays 50%, or more, of associated costs.

Note: Education programs, and participation in the programs, need to be approved by the organization.

Indicator Points Earned = _____

1.0 NURTURING (cont'd)

Indicator 3: **Technical Skill Training**

Technical skills are the abilities required for employees to perform specific tasks relevant to their job positions. Technical skill training corresponds to providing the necessary performance skills and is different from professional development and continuing education. Professional development and continuing education programs aim at providing the knowledge required for a profession, whereas performance skills are associated with the ability to put the knowledge into practice.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Number of annual training hours

Scales:

1 point

Organization provides, on average, 0-10 hours of skill training annually for each full-time equivalent (FTE) employee.

2 points

Organization provides, on average, 10-20 hours of skill training annually for each full-time equivalent (FTE) employee.

3 points

Organization provides, on average, 20-30 hours of skill training annually for each full-time equivalent (FTE) employee.

4 points

Organization provides, on average, more than 40 hours of skill training annually for each full-time equivalent (FTE) employee.

Notes:

1. Attending an industry conference is a form of professional development, while an internship opportunity that focuses on specific sets of practical skills is considered a form of training.
2. The training hours should be job skills-related (e.g., roofing or bricklaying) and typically exclude safety and health, diversity, anti-harassment, and other similar types of training.

Indicator Points Earned = _____

1.0 NURTURING (cont'd)

Indicator 4: **Onboarding Process**

Onboarding is the process of integrating new employees in the workplace and getting them adjusted to the social and performance aspects of the organization smoothly and efficiently. The onboarding process can take the forms of formal meetings, lectures, videos, printed materials, and/or computer-based orientations designed to introduce new employees to the company culture and available resources.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Existence of a formal onboarding process

Scales:

1 point
: Organization has no formal onboarding process for new employees and only provides informal, quick orientation for new employees.

2 points
: Organization only provides a cursory, informal 1-day to 1-week orientation for all new employees.

3 points
: Organization has a formal onboarding process for new employees in which orientation is only one part of the process.

4 points
: Organization has a formal onboarding process for new employees in which orientation is only one part of the process. In addition, the onboarding process is directly supervised by upper management and human resource professionals and includes a mentorship plan that lasts for multiple weeks or months depending on the nature of the position.

Indicator Points Earned = _____

1.0 NURTURING (cont'd)

Attribute Weighted Score Calculation

	Points Earned	Possible Points
Indicator 1	______	4
Indicator 2	______	4
Indicator 3	______	4
Indicator 4	______	4

Total Points Earned = ______ out of 16 (total possible points)

Attribute Weighted Score = [(total points earned) ÷ (total possible points)] × (attribute weight)

= [______ ÷ (16)] × (4)

= ______

2.0 DIVERSITY

Attribute: Diversity

The extent to which the workforce is diversified and inclusive with respect to personal characteristics (e.g., gender, experience, race, social status, education, etc.) and to which diversity is integrated into and promoted within the workplace.

Attribute weight: 3

Attribute Indicators:

There are five indicators of the diversity attribute:

1. (E) Diversity and inclusion policy
2. (E) Ethnic and racial diversity
3. (E) Gender diversity and inclusiveness at labor force level
4. (E) Gender/ethnic diversity in leadership/management positions
5. (A) Knowledge and skill diversity

2.0 DIVERSITY (cont'd)

Indicator 1: **Diversity and Inclusion Policy**

Diversity and inclusion can bring numerous benefits to organizations and help them attract skilled and competent workforce. A diverse and inclusive workplace is an ideal place for community support, career progression, innovation, maturity, and so forth. Accordingly, organizations need to show that they are committed to creating and nurturing diversity and inclusion in the workplace.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Existence of a comprehensive diversity and inclusion policy

Scales:

1 point

Organization has no written statement or policy on diversity and inclusion.

2 points

Organization has a formal and written statement or policy on diversity and inclusion that is signed by the chief executive officer (CEO) and/or other senior corporate officers and publicly posted and available to every employee.

3 points

Organization has a formal and written statement or policy on diversity and inclusion that is signed by the chief executive officer (CEO) and/or other senior corporate officers, is publicly posted and available to every employee, and is verbally communicated from top management to employees on all jobsites.

4 points

Organization has a formal and written statement or policy on diversity and inclusion that is signed by the chief executive officer (CEO) and/or other senior corporate officers, is publicly posted and available to every employee, and is verbally communicated from top management to employees on all jobsites regularly. The statement/policy clearly states that ethnical/gender diversity and inclusion is one of the top core values of the organization and is directly monitored and evaluated by top management.

Indicator Points Earned = _____

2.0 DIVERSITY (cont'd)

Indicator 2: **Ethnic and Racial Diversity**

Ethnic and racial diversity at work is an important element to improve work and team dynamics, and to support the presence of a supportive and healthy work environment. The goal of this indicator is to assess ethnic and racial diversity within construction organizations and to encourage them to establish a workforce that is as ethnically and racially diverse as the community around them.

Type: Essential   Possible points: 3

Indicator Metric:

Measurement unit: Ethnic and racial diversity attainment within organization

Scales:

1 point

Organization has a workforce with more than 25% deviation from the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.

2 points

Organization emphasizes the importance of ethnic and racial diversity in hiring and promotion within, and has a workforce with a maximum of 25% deviation from the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.

3 points

Organization emphasizes the importance of ethnic and racial diversity in hiring and promotion, and has a workforce with a maximum of 10% deviation from the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics within each organizational unit.

Note: Statistics data used to show current census information regarding aggregated Caucasian and non-Caucasian ethnicity and racial demographics can be community-, region-, or state-related. The metric for this indicator is adapted from the JUST label.

Indicator Points Earned = _____

2.0 DIVERSITY (cont'd)

Indicator 3: **Gender Diversity and Inclusiveness at Labor Force Level**

Gender diversity at the labor force level refers to *representing* both genders in an organization with respect to its labor force, and gender inclusion at the labor force level means that the organization successfully *integrates* employees from both genders in the planning, decision-making, leadership, and other critical activities within the organization. A diverse and inclusive workplace will typically have low turnover rates, enabling the organization to strive for economic growth and success, and avoid substantial costs resulting from employee turnover.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Deviation from a gender-balanced labor force (50% men and 50% women)

Scales:

1 point

Organization has a workforce with more than 25% deviation from a gender-balanced workforce

2 points

Organization has a workforce with a maximum of 25% deviation from a gender-balanced labor force and has established and implements a clear plan of how to integrate women into planning, decision-making, leadership, other critical activities within the organization

3 points

Organization has a workforce with a maximum of 20% deviation from a gender-balanced labor force and has established and implements a clear plan of how to integrate women in the planning, decision-making, leadership other critical activities within the organization

4 points

Organization has a workforce with a maximum of 15% deviation from a gender-balanced labor force and has established and implements a clear plan of how to integrate women in the planning, decision-making, leadership other critical activities within the organization

Note: Ideally, a gender-balanced labor force is comprised of 50% men and 50% women. However, it was acknowledged during the development of this tool that the 50:50 goal may be overreaching given many industry circumstances and the low number of available female workers in construction, and, therefore, an alternative target limit (65:35) was established.

Indicator Points Earned = _____

2.0 DIVERSITY (cont'd)

Indicator 4: **Gender/Ethnic Diversity in Leadership/Management Positions**

Building a diverse workforce starts at the top with diversity at the leadership/management level. Diversity in leadership/management personnel ensures that the organization, and its culture, fosters acceptance, respect, and inclusion of all employees regardless of gender, race, and ethnicity.

Type: Essential Possible points: 5

Indicator Metric:

Measurement unit: Diversity attainment at leadership/management level

Scales:

1 point

Organization has a management and senior leadership staff with more than 30% deviation from a gender-balanced management/leadership and/or the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics.

2 points

Organization has a management and senior leadership staff with a maximum of 30% deviation from a gender-balanced management/leadership and/or the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics.

3 points

Organization has a management and senior leadership staff with a maximum of 25% deviation from a gender-balanced management/leadership and/or the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics.

4 points

Organization has a management and senior leadership staff with a maximum of 20% deviation from a gender-balanced management/leadership and/or the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics.

5 points

Organization has a management and senior leadership staff with a maximum of 15% deviation from a gender-balanced management/leadership and/or the current state census data on aggregated Caucasian and non-Caucasian ethnicity and racial demographics.

Indicator Points Earned = _____

2.0 DIVERSITY (cont’d)

Indicator 5: **Knowledge and Skill Diversity**

Knowledge and skill diversity is an important characteristic of a sustainable workforce. Knowledge diversity can sometimes be derived from gender and ethnic diversity but expanding it to include skill diversity is a critical step to enhancing the overall level of workforce sustainability within an organization.

Type: Auxiliary Possible points: 3

Indicator Metric:

Measurement unit: Existence of a policy to establish knowledge and skill diversity

Scales:

1 point

Organization does not have a formal and specific policy to establish work groups that are diverse with respect to knowledge and skills

2 points

Organization has a formal and specific policy to establish work groups that are diverse with respect to knowledge and skills. The organization can demonstrate that more than 50% of its work groups have knowledge and skill diversity with respect to the work they perform.

3 points

Organization has a formal and specific policy to establish work groups that are diverse with respect to knowledge and skills. The organization can demonstrate that more than 80% of its work groups have knowledge and skill diversity with respect to the work they perform.

Note: A work group with knowledge and skill diversity is a group where its members have adequate collective knowledge (e.g., education and experience) and set of skills that complement the group and enable its members to perform their work safely and effectively.

Indicator Points Earned = _____

2.0 DIVERSITY (cont'd)

Attribute Weighted Score Calculation

	Points Earned	Possible Points
Indicator 1	______	4
Indicator 2	______	3
Indicator 3	______	4
Indicator 4	______	5
Indicator 5	______	3

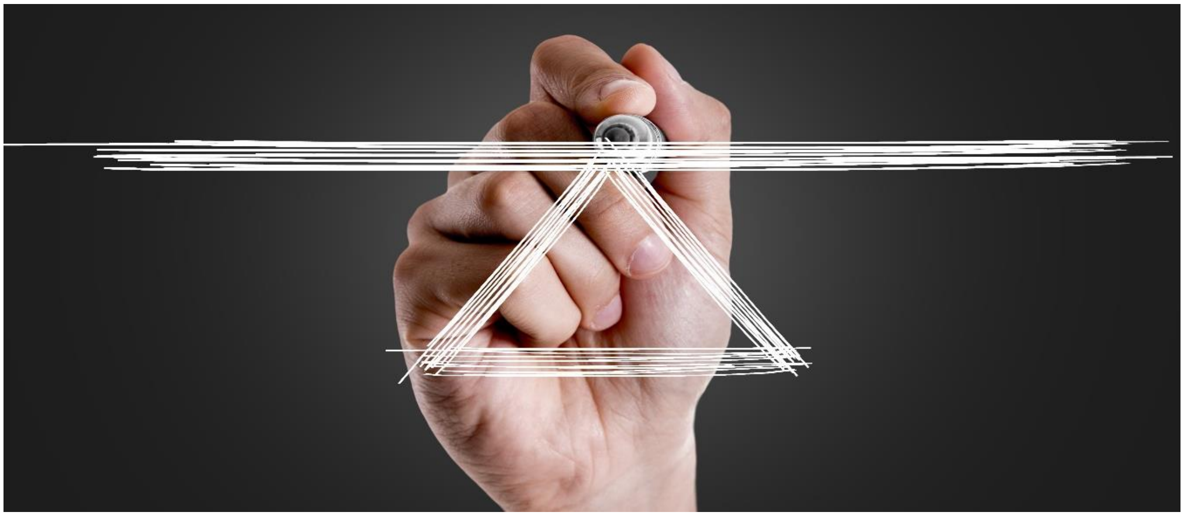
Total Points Earned = ______ out of 19 (total possible points)

Attribute Weighted Score = [(total points earned) ÷ (total possible points)] × (attribute weight)

= [______ ÷ (19)] × (3)

= ______

3.0 EQUITY



Attribute: Equity

The extent to which workers feel treated and compensated fairly compared to other workers, and evaluated fairly without discrimination with respect to personal characteristics, employment level, payment, work load and responsibilities, promotion, work opportunities, and so forth.

Attribute weight: 5

Attribute Indicators:

There are five indicators of the equity attribute:

1. (E) Equality, social justice, and non-discrimination
2. (E) Pay structure transparency
3. (E) Equitable pay/compensation within organization
4. (E) Equitable pay/compensation at the industry level
5. (E) Merit-based recruitment and promotion process/plan

3.0 EQUITY (cont'd)

Indicator 1: **Equality, Social Justice, and Non-discrimination**

All human beings are entitled to the right to be treated equally without discrimination of any kind. With respect to the workplace, organizations should demonstrate that they treat their employees fairly and respectfully without any form of discrimination and that there is a written policy to emphasis and regulate equality, justice, and non-discrimination in the workplace.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Demonstrated commitment to equality, justice, and non-discrimination

Scales:

1 point

Organization has no written statement or policy on equality, justice, and non-discrimination.

2 points

Organization has a formal, written equality, justice, and non-discrimination statement or policy, and there have been no complaints of any kind of discrimination against the organization in the past 12 months.

3 points

Organization has a formal, written equality, justice, and non-discrimination statement or policy signed by the chief executive officer (CEO) or other senior corporate officers, and there have been no complaints of any kind of discrimination against the organization in the past 24 months.

4 points

Organization has a formal, written equality, justice, and non-discrimination statement or policy signed by the chief executive officer (CEO) or other senior corporate officers, and there have been no complaints of any kind of discrimination against the organization in the past 36 months.

Indicator Points Earned = _____

3.0 EQUITY (cont'd)

Indicator 2: Pay Structure Transparency

Transparency within an organization means that the organization voluntarily formalizes a full-disclosure policy and provides ongoing open access on important information. Transparency establishes trust and confidence. Achieving transparency within an organization can help build a trusting relationship between employees and the organization (i.e., the employer). Transparency with regard to pay structure aims to encourage organizations to reveal the salaries of its employees. Transparency in pay structure can help establish trust between employees and their employer, and can promote equal pay and eventually minimize wage disparities.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Disclosure of pay structure within organization

Scales:

1 point

Organization does not disclose any current information regarding financial aspects and salaries of its employees.

2 points

Organization voluntarily and publicly discloses financial information regarding the range of salaries of its employees.

3 points

Organization voluntarily and publicly discloses current information regarding financial aspects and salaries of its employees.

4 points

Organization voluntarily and publicly discloses current information regarding financial aspects and salaries of all employees including management and senior leadership staff.

Indicator Points Earned = _____

3.0 EQUITY (cont'd)

Indicator 3: **Equitable Pay/Compensation within Organization**

An equitable pay/compensation program is essential to ensure social equity in the workplace. An indispensable part of such a program is to ensure that the organization provides equitable pay/compensation for employees who perform similar jobs (equitable pay within job classifications) and that wage disparity between senior executives and onsite laborers is reasonable (equitable pay across job classifications). A successful equitable pay/compensation program can provide assurance to employees that they are working in an equitable workplace.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Pay scale ratio within and across job classifications

Scales:

1 point

Organization has a pay scale ratio of more than 1:5 within job classifications and 1:30 across job classifications within the organization.

2 points

Organization has a maximum pay scale ratio of 1:5 within job classifications and 1:15 across job classifications within the organization.

3 points

Organization has a maximum pay scale ratio of 1:3 within job classifications and 1:20 across job classifications within the organization.

4 points

Organization has a maximum pay scale ratio of 1:2 within job classifications and 1:15 across job classifications within the organization.

Notes:

1. The pay scale ratio is a comparison between the amount of pay given to the lowest paid full-time employee and the amount given to the highest paid full-time employee in the organization.
2. Singular positions such as chief executive officer (CEO) are exempt from evaluation.
3. The ratios used in the metric scales were determined to allow different pay for differences in skills, education, experience, merit, and/or seniority.

Indicator Points Earned = _____

3.0 EQUITY (cont'd)

Indicator 4: **Equitable Pay/Compensation at Industry Level**

An equitable pay/compensation program is essential to ensure social equity in the workplace. In addition to providing equitable pay/compensation within and across job classifications, an organization needs to ensure that there is equitable pay/compensation for its employees compared to that in other organizations. Providing equitable pay/compensation for employees compared to the industry average can help the organization establish trust with its employees and attract skilled individuals.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Variation from annual mean wage for the industry

Scales:

1 point

Organization provides an annual mean wage that is 10% or more below the annual mean wage for the industry sector or occupation.

2 points

Organization provides an annual mean wage that is within 10% variation from the annual mean wage for the industry sector or occupation.

3 points

Organization provides an annual mean wage that is 10% or more above the annual mean wage for the industry sector or occupation.

4 points

Organization provides an annual mean wage that is 20% or more above the annual mean wage for the industry sector or occupation.

Notes:

1. Organizations can use federal, state, or regional statistics to satisfy the requirement for this indicator. For organizations located within the United States, it is recommended that wage statistics from the Bureau of Labor Statistics (https://www.bls.gov/bls/blswage.htm) be utilized for this purpose.
2. The comparison with the annual mean wage for the industry can be made with reference to either industry sector (e.g., residential construction and commercial building construction) or occupation (e.g., carpenters and roofers).

Indicator Points Earned = _____

3.0 EQUITY (cont'd)

Indicator 5: **Merit-based Recruitment and Promotion Process**

A merit-based transparent recruitment and promotion process is critical to attract and maintain competent employees. The criteria for recruiting and promoting employees should be merit-based. That is, the decision of whether to hire or promote an individual is solely made based on the individual's ability, skills, experience, and education qualifications, rather than being a result of favors, family or political relations, or friendship. The top five criteria desired to achieve the intended process are: (1) processes and requirements for appointments and promotions are accessible to every employee and shared in a guideline or policy document; (2) vacancies are advertised as openly as possible, and the advertisement lists the job descriptions and responsibilities and highlights the skills and qualifications required for the job; (3) the policy incorporates rewards for exceptional and above-average performance; (4) each appointment/promotion decision is made and reviewed by at least two people ("four-eyes principle"); and (5) recruitment, hiring, and promotions are made based on a standard application form that is accessible to everybody.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Comprehensiveness and transparency of recruitment/promotion process

Scales:

1 point

Organization has no formal, written process regarding recruitment and promotion of individuals.

2 points

Organization has a well-documented, formal process regarding recruitment and promotion of individuals, and the process includes three of the top five criteria mentioned above.

3 points

Organization has a well-documented, formal process regarding recruitment and promotion of individuals, and the process includes four of the top five criteria mentioned above.

4 points

Organization has a well-documented, formal process regarding recruitment and promotion of individuals, and the process includes all five of the top five criteria mentioned above.

Indicator Points Earned = _____

3.0 EQUITY (cont'd)

Attribute Weighted Score Calculation

	Points Earned	Possible Points
Indicator 1	______	4
Indicator 2	______	4
Indicator 3	______	4
Indicator 4	______	4
Indicator 5	______	4

Total Points Earned = ______ out of 20 (total possible points)

Attribute Weighted Score = [(total points earned) ÷ (total possible points)] × (attribute weight)

= [______ ÷ (20)] × (5)

= ______

4.0 HEALTH AND WELL-BEING

Attribute: Health and Well-being:

The level of workplace health, safety, and contentment that workers feel and experience physically, mentally, and socially during and after work operations within their work career and beyond.

Attribute weight: 4

Attribute Indicators:

There are five indicators of the health and well-being attribute:

1. (E) Safety policy and zero injury goal
2. (E) Safety and health program
3. (E) Safety toolbox meetings and training
4. (A) Breaks and social interactions during workdays
5. (A) Annual physical/medical check-up

4.0 HEALTH AND WELL-BEING (cont'd)

Indicator 1: **Safety Policy and Zero Injury Goal**

Protecting employees and ensuring that the work environment is safe is the responsibility of employers, both legally and ethically. Accordingly, organizations should develop and implement an effective safety policy that fosters and advances the safety and health of employees. An effective safety policy should include an open-door policy for workers to report hazards and clear statements regarding compensation/benefits for work-related injuries. Establishing an effective policy can play a critical role in setting the safety culture for an organization. Once a positive safety culture is established, a zero injury goal becomes possible.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Effectiveness and formality of safety policy

Scales:

1 point

Organization has an informal, unwritten, and not publicly posted policy on occupational health and safety of its employees.

2 points

Organization has a formal, written, and publicly posted policy on occupational health and safety of its employees that is endorsed by the chief executive officer (CEO) or other senior corporate officers.

3 points

Organization has a formal, written, and publicly posted policy on occupational health and safety of its employees that is endorsed by the chief executive officer (CEO) or other senior corporate officers. In addition, the organization has received Merit recognition in OSHA's Voluntary Protection Program (VPP) or other equivalent program for organizations located outside the United States.

4 points

Organization has a formal, written, and publicly posted policy on occupational health and safety of its employees that is endorsed by the chief executive officer (CEO) or other senior corporate officers. In addition, the organization has received Star recognition in OSHA's Voluntary Protection Program (VPP) or other equivalent program for organizations located outside the United States.

Indicator Points Earned = _____

4.0 HEALTH AND WELL-BEING (cont'd)

Indicator 2: **Safety and Health Program**

Developing and implementing a comprehensive safety and health program can contribute to reducing the number of workplace injuries and illnesses. As the program becomes more comprehensive, its effectiveness increases. Comprehensive and effective programs ultimately lead to improved workplace safety performance. Some of the key components of a program that have shown to be associated with lower injury rates include: (1) management leadership, (2) employee involvement, (3) hazard identification and control, (4) incident reporting and investigation, (5) housekeeping plan, (6) drug and alcohol testing, (7) respiratory/hearing protection plan, (8) material safety data sheet (MSDS) or equivalent plan, (9) emergency action plan, and (10) ongoing program review. The availability of such a program ensures that employees are aware of acceptable and unacceptable behaviors, and that there is a framework in place for decision-making regarding workplace safety.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Comprehensiveness and effectiveness of safety and health program

Scales:

1 point

Organization may have a safety and health program that addresses some of the key elements listed above, but the organization has experienced one or more reportable fatal or non-fatal injuries in the preceding 12 months.

2 points

Organization has a safety and health program that addresses most of the key elements listed above, has been effectively implemented on projects, and has led to an absence of reportable fatal and non-fatal injuries in the preceding 12 months.

3 points

Organization has a safety and health program with annual reviews that addresses most of the key elements listed above, has been effectively implemented on projects, and has led to an absence of reportable fatal and non-fatal injuries in the preceding 24 months.

4 points

Organization has a safety and health program with annual reviews that addresses most of the key elements listed above, has been effectively implemented on projects, and has led to an absence of reportable fatal and non-fatal injuries in the preceding 36 months.

Indicator Points Earned = _____

4.0 HEALTH AND WELL-BEING (cont'd)

Indicator 3: **Safety Toolbox Meetings and Training**

Safety toolbox meetings and training can improve employee awareness about safety on the jobsite and ensure that employees can work safely and are alerted of potential hazards. Legal and ethical requirements necessitate that employers provide adequate training to their employees that are expected to work in hazardous situations. Accordingly, organizations need to provide formal safety training (typically annually) to their employees to ensure that they are safe. Furthermore, organizations should also provide 10-15 minute toolbox talks/meetings (informal safety training) daily, weekly, or monthly to ensure that the importance of safety is reinforced at work and employees are informed/updated regarding workplace safety concerns and challenges.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Frequency of safety training

Scales:

1 point

Organization provides OSHA 10- and 30-hour training (or other equivalent training) to selected field employees and supervisor, and/or periodic toolbox talks/meetings to selected field employees.

2 points

Organization provides OSHA 10-hour training (or other equivalent training) to all field employees and supervisors, and at least monthly toolbox talks/meetings to all field employees.

3 points

Organization provides OSHA 10-hour training (or other equivalent training) to all field employees, OSHA 30-hour training (or other equivalent training) to all field supervisors, and at least weekly toolbox talks/meetings to all field employees or before each major operation.

4 points

Organization provides OSHA 30-hour training (or other equivalent training) to all field employees, including supervisors, and toolbox talks/meetings to all field employees daily and before each major operation.

Indicator Points Earned = _____

4.0 HEALTH AND WELL-BEING (cont'd)

Indicator 4: **Breaks and Social Interactions during Workdays**

Breaks and affirming social interactions (e.g., friendly competitions, volunteering, and cooperation) at work can impact employee behaviors, physical/emotional health, and performance. These factors can influence workplace safety performance considerably. Accordingly, breaks and social interactions should be designed in a way that fosters and advances employees' physical and mental health, and minimizes undesired outcomes such as fatigue or conflict at work.

Type: Auxiliary Possible points: 4

Indicator Metric:

Measurement unit: Existence and length of breaks and social interactions at work

Scales:

1 point

Organization has no break policy or a maximum of a half-hour lunch break or rest time during a typical 8-hour shift schedule.

2 points

Organization has a policy that addresses overtime, night shifts, and work breaks. The policy provides at least a one-hour lunch break or rest time during a typical 8-hour shift schedule.

3 points

Organization has a policy that addresses overtime, night shifts, and work breaks. The policy provides at least one-hour breakfast and lunch breaks during a typical 8-hour shift schedule.

4 points

Organization has a policy that addresses overtime, night shifts, and work breaks. The policy provides at least one-hour breakfast and lunch breaks during a typical 8-hour shift schedule and includes plans to organize annual or bi-annual events during work hours to enhance social interactions among employees.

Note: A break is "a period of time during a shift in which employees are allowed to take time-off from work," while social interactions are activities in which employees interact with fellow employees.

Indicator Points Earned = _____

4.0 HEALTH AND WELL-BEING (cont'd)

Indicator 5: **Annual Physical/Medical Check-up**

An annual physical/medical check-up (also referred to as a wellness exam) is a preventive measure to reduce the risk of physical and emotional health problems. Organizations providing annual health check-ups for their employees can gain several benefits such as enhanced employee morale, reduced employee absenteeism, improved productivity, and lower risk of undesirable behaviors resulting from physical and emotional health problems (e.g., stress, fatigue, and emotional exhaustion).

Type: Auxiliary Possible points: 4

Indicator Metric:

Measurement unit: Availability of and participation in annual physical/medical check-up

Scales:

1 point
: Organization does not provide annual physical/medical check-ups for its employees.

2 points
: Organization provides annual physical/medical check-ups for all full-time employees at no cost.

3 points
: Organization provides annual physical/medical check-ups for all full-time employees at no cost, and more than 50% of the employees have had a physical/medical check-up in the preceding calendar year.

4 points
: Organization provides annual physical/medical check-ups for all full-time employees at no cost, and more than 75% of the employees have had a physical/medical check-up in the preceding calendar year.

Indicator Points Earned = _____

4.0 HEALTH AND WELL-BEING (cont'd)

Attribute Weighted Score Calculation

	Points Earned	Possible Points
Indicator 1	______	4
Indicator 2	______	4
Indicator 3	______	4
Indicator 4	______	4
Indicator 5	______	4

Total Points Earned = ______ out of 20 (total possible points)

Attribute Weighted Score = [(total points earned) ÷ (total possible points)] × (attribute weight)
= [______ ÷ (20)] × (4)
= ______

5.0 CONNECTIVITY

Attribute: Connectivity

The degree to which workers feel connected, and willingly desire to connect, to peers, fellow employees, and management through open channels and two-way communication, and feel engaged in the operations, leadership, planning, and decision-making process.

Attribute weight: 3

Attribute Indicators:

There are five indicators of the connectivity attribute:

1. (E) Worker involvement in decision-making
2. (E) Regular meetings with supervisor (one-on-ones)
3. (E) Employee stock ownership plan/program (ESOP)
4. (A) Social pleasure and connecting activities during workdays
5. (A) Teamwork approach within organization

5.0 CONNECTIVITY (cont'd)

Indicator 1: **Worker Involvement in Decision-making**

The most important asset of any organization is its workforce. Ensuring that workers are involved in decision-making improves employee morale and contributes to organizational success. Worker involvement in decision-making can be facilitated in many ways including roundtable events where employees can connect to peers and leadership, and provide insights before decisions are made. There are many ways to evaluate worker involvement in decision-making. For the purpose of this assessment, the employee survey question noted below is used to measure the perceived level of worker involvement in decision-making within an organization.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Perceived self-assessment of employee involvement in decision-making

Scales:

1 point

Organization does not evaluate worker involvement in decision-making or receives a score less than 6.0 on the annual aggregated worker involvement rating scale in the preceding calendar year using the survey question below.

2 points

Organization receives a minimum score of 6.0 on the annual aggregated worker involvement rating scale in the preceding calendar year using the survey question below.

3 points

Organization receives a minimum score of 7.0 on the annual aggregated worker involvement rating scale in the preceding calendar year using the survey question below.

4 points

Organization receives a minimum score of 8.0 on the annual aggregated worker involvement rating scale in the preceding calendar year using the survey question below.

Note: Worker involvement in an organization should be annually assessed, with at least 70% workforce participation, using the following survey question: On a scale from "1" (not involved at all) to "10" (extremely involved), how would you rate your level of involvement in decision-making within your organization?

Indicator Points Earned = _____

5.0 CONNECTIVITY (cont'd)

Indicator 2: **Regular Meetings with Supervisor (one-on-ones)**

Although it is the technology and digital era, research has shown that face-to-face, one-on-one, meetings are still the most effective communication method. These meetings encourage two-way communication, strengthen relationships between supervisors and team members, and improve teamwork.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: frequency of face-to-face meetings

Scales:

1 point

Organization has no policy on face-to-face meetings with respect to both frequency and implementation of meetings

2 points

Organization has specific policy on face-to-face meetings and the meetings are formally held at a specific time at least monthly.

3 points

Organization has specific policy on face-to-face meetings and the meetings are formally held at a specific time at least bi-weekly.

4 points

Organization has specific policy on face-to-face meetings and the meetings are formally held at a specific time at least *weekly*.

Note: Face-to-face meetings vary in duration. They can be as short as 10 minutes or as along as 2 hours or more; both are acceptable as long as they are held formally and scheduled regularly.

Indicator Points Earned = _____

5.0 CONNECTIVITY (cont'd)

Indicator 3: **Employee Stock Ownership Plan/Program (ESOP)**

Employee ownership and profit-sharing can benefit both the organization and the employees. Employee ownership can be accomplished in multiple ways, but one of the most common methods is to use an employee stock ownership plan/program (ESOP). An ESOP is an employee-owner program that provides an opportunity for the employees to share ownership interest in their organization. This ownership interest strengthens the degree of connectivity of the workforce to their organization and generates a feeling of increased bonding and belonging.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Existence of employee stock ownership plan/program (ESOP)

Scales:

1 point

Organization is large in size (i.e., more than 250 full-time employees) and has no employee stock ownership plan/program (ESOP).

2 points

Organization is small or medium in size (i.e., less than 250 full-time employees) and has no employee stock ownership plan/program (ESOP).

3 points

Organization has an employee stock ownership plan/program (ESOP) provided to employees with no up-front cost.

4 points

Organization has a successful employee stock ownership plan/program (ESOP) provided to employees with no up-front cost, and at least 50% of the organization's assets are owned by the employees.

Note: It is acknowledged in the scales described above that it is more challenging for a small- and medium-sized organizations to start and implement an employee stock ownership plan/program (ESOP).

Indicator Points Earned = _____

5.0 CONNECTIVITY (cont'd)

Indicator 4: **Social Pleasure and Connecting Activities during Workdays**

To ensure that employees are mentally and emotionally connected to their peers, fellow employees, and management personnel, social events for pleasure and connection purposes (e.g., eating off-site as a group, happy/free hour, planning a company-wide meeting where employees who do not usually work together can meet, and playing sports at work) are indispensable. These events can "break the ice" and facilitate high levels of connectivity among employees, improving both engagement and communication. High levels of employee connectivity positively influence work quality, work schedule, and productivity. Importantly, participation in these events should be voluntary.

Type: Auxiliary Possible points: 3

Indicator Metric:

Measurement unit: Availability of pleasure and connecting activities at work

Scales:

1 point

Organization does not have any planned social activities for pleasure and connecting purposes during workdays.

2 points

Organization has specific and planned social activities for pleasure and connecting purposes during workdays. These events must be scheduled at least once each month.

3 points

Organization has specific and planned social activities for pleasure and connecting purposes during workdays. These events must be scheduled daily or weekly.

Indicator Points Earned = _____

5.0 CONNECTIVITY (cont'd)

Indicator 5: **Teamwork Approach within Organization**

A typical construction project includes different trades, competing priorities, and pressing deadlines. Accordingly, a teamwork environment that promotes and fosters cooperation, friendship, and loyalty is highly desired in construction. Teamwork can facilitate higher degrees of connectivity and engagement within the workforce, enhancing problem-solving and motivating the workforce for better performance. An organization adopting a teamwork approach should typically reward employees with helping behaviors and support small unit sessions and discussions within teams.

Type: Auxiliary   Possible points: 3

Indicator Metric:

Measurement unit: Employee assessment of effectiveness of teamwork approach

Scales:

1 point

Organization does not formally implement a teamwork approach in its work aspects or receives an aggregated score of less than 6.0 in the preceding calendar year using the survey question shown below.

2 points

Organization formally implements a teamwork approach in all aspects of its work and receives an aggregated score from 6.0 to 8.0 in the preceding calendar year using the survey question shown below.

3 points

Organization formally implements a teamwork approach in all aspects of its work and receives an aggregated score of more than 8.0 in the preceding calendar year using the survey question shown below.

Note: Effectiveness of teamwork approach used in organization should be annually assessed, with at least 70% workforce participation, using the following survey question: On a scale from "1" (not effective at all) to "10" (extremely effective), how would you rate the effectiveness of the teamwork approach used in your organization?

Indicator Points Earned = _____

5.0 CONNECTIVITY (cont'd)

Attribute Weighted Score Calculation

	Points Earned	Possible Points
Indicator 1	______	4
Indicator 2	______	4
Indicator 3	______	4
Indicator 4	______	3
Indicator 5	______	3

Total Points Earned = ______ out of 18 (total possible points)

Attribute Weighted Score = [(total points earned) ÷ (total possible points)] × (attribute weight)

= [______ ÷ (18)] × (3)

= ______

6.0 VALUE

Attribute: Value

The extent to which workers feel that they and their families are valued, respected, appreciated, and recognized by others in the workforce and the organization, financially and emotionally, for their work performance, contributions, and loyalty.

Attribute weight: 4

Attribute Indicators:

There are eight indicators of the value attribute:

1. (E) Full-time employment and long-term commitment policy
2. (E) Health insurance and retirement plans
3. (E) Family resources
4. (E) Work-life/family balance
5. (E) Job stability and retention
6. (E) Employee benefit program
7. (E) Performance feedback and appreciation
8. (E) Fair compensation

6.0 VALUE (cont'd)

Indicator 1: **Full-time Employment and Long-term Commitment Policy**

Long-term, full-time employment can be fundamental to the value of the job from the employee's perspective. It can provide a sense of job security and motivate the workforce to develop and excel at work. Full-time employment demonstrates the organization's commitment to its employees and provides the feeling that they are valued members of the organization.

Type: Essential   Possible points: 4

Indicator Metric:

Measurement unit: Percent of full-time employment in organization

Scales:

1 point
: Organization maintains a minimum of 50% of its workforce on full-time employment with appropriate pay and benefits.

2 points
: Organization maintains a minimum of 70% of its workforce on full-time employment with appropriate pay and benefits.

3 points
: Organization maintains a minimum of 80% of its workforce on full-time employment with appropriate pay and benefits.

4 points
: Organization maintains a minimum of 90% of its workforce on full-time employment with appropriate pay and benefits.

Note: Full-time employment for an individual is defined by the Internal Revenue Service (IRS) as an individual who is, on average, required to work at least 30 hours per week.

Indicator Points Earned = _____

6.0 VALUE (cont'd)

Indicator 2: **Health Insurance and Retirement Plans**

In order to demonstrate value to the workforce, employers should provide employees with a comprehensive health insurance plan, as well as a retirement plan whenever possible. Providing a health insurance plan ensures that employees and their families have access to health care to assist them in remaining healthy.

Type: Essential   Possible points: 4

Indicator Metric:

Measurement unit: Comprehensiveness of insurance plan

Scales:

1 point

Organization does not provide a comprehensive health insurance plan (medical, dental, and vision) to employees, provides a plan to employees but not to their families, or provides a plan to employees and their families but requires the employees to pay more than 50% of the insurance premiums.

2 points

Organization provides a comprehensive health insurance plan (medical, dental, and vision) to employees and their families, and the employees pay a maximum of 50% of the insurance premiums.

3 points

Organization provides a comprehensive health insurance plan (medical, dental, and vision) to employees and their families, and the employees pay a maximum of 25% of the insurance premiums. In addition, the organization provides a retirement plan for its employees when they attain a certain age.

4 points

Organization provides a comprehensive health insurance plan (medical, dental, and vision) to employees and their families, and fully pays 100% of the insurance premiums. In addition, the organization provides a retirement plan (with employer match or contribution) for its employees when they attain a certain age.

Note: The metric for this indicator is adapted from the JUST label.

Indicator Points Earned = _____

6.0 VALUE (cont'd)

Indicator 3: **Family Resources**

In order to attack skilled employees, the work environment needs to be family-friendly with resources that employees and their families can utilize. Organizations seeking a high level of workforce sustainability should have a family resources program that provides multiple resources to employees and their families and ensures they are valued and supported. Such a program should typically allow for family medical/emergency leave whenever needed and provide flexible work arrangements for employees with families.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Existence and area of services of family resources program

Scales:

1 point

Organization has no family resources program to support employees and their families.

2 points

Organization has a family resources program to support employees and their families. The program includes at least one of the following components: access to child care, child care support/subsidy, family education support, family events, family-friendly spaces, and flexible work arrangements.

3 points

Organization has a family resources program to support employees and their families. The program includes at least two of the following components: access to child care, child care support/subsidy, family education support, family events, family-friendly spaces, and flexible work arrangements.

4 points

Organization has a family resources program to support employees and their families. The program includes at least three of the following components: access to child care, child care support/subsidy, family education support, family events, family-friendly spaces, and flexible work arrangements.

Note: A flexible work arrangement is when employees are allowed to work from home or in the non-standard hours when there is a family need or emergency.

Indicator Points Earned = _____

6.0 VALUE (cont'd)

Indicator 4: **Work-life/Family Balance**

Work-life/family balance is a term used to describe the balance employees need between time allocated for work and personal life in order to stay healthy and productive. Workplaces that provide a balanced, family-friendly work environment, from both policy and practice perspectives, experience higher levels of workforce sustainability. A balanced, family-friendly work environment enables members of the workforce to be healthier, more productive, and produce higher quality work.

Type: Essential   Possible points: 4

Indicator Metric:

Measurement unit: Policies and practices in place to ensure work-life balance

Scales:

1 point

Organization does not provide a minimum of 12 weeks of employment-protected maternity leave, a minimum of 2 weeks of employment-protected paternity leave, and a minimum of 10 weeks of employment-protected parental leave.

2 points

Organization provides a minimum of 12 weeks of employment-protected maternity leave, a minimum of 2 weeks of employment-protected paternity leave, and a minimum of 10 weeks of employment-protected parental leave.

3 points

Organization provides a minimum of 12 weeks of paid maternity leave, a minimum of 3 weeks of employment-protected paternity leave, and a minimum of 12 weeks of employment-protected parental leave.

4 points

Organization provides a minimum of 24 weeks of paid maternity leave, a minimum of 4 weeks of employment-protected paternity leave, and a minimum of 12 weeks of employment-protected parental leave.

Note: The metric for this indicator is adapted from the JUST label. More information about maternity, paternity, and parental leaves as well as the difference between them is available online at the following link: https://www.educaloi.qc.ca/en/capsules/maternity-paternity-and-parental-leave.

Indicator Points Earned = _____

6.0 VALUE (cont'd)

Indicator 5: **Job Stability and Retention**

Employee retention is critical for organizational success. Organizations maintaining high levels of employee retention are able to thrive, succeed, and achieve long-term results. Maintaining high levels of employee retention can be achieved if the organization provides long-term career objectives plans, a positive and supportive work environment, and enhanced job security to all employees.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Turnover rate at organization level

Scales:

1 point

Organization has an annual turnover rate that is equivalent (plus/minus three points) to the overall industry average turnover rate for the preceding calendar year.

2 points

Organization has an annual turnover rate that is at least *three* points *below* the overall industry average turnover rate for the preceding calendar year.

3 points

Organization has an annual turnover rate that is at least *five* points *below* the overall industry average turnover rate for the preceding calendar year.

4 points

Organization has an overall turnover rate that is at least *ten* points *below* the overall industry average turnover rate for the preceding calendar year.

Note: Statistics and reports published by the Bureau of Labor Statistics (BLS), or equivalent agencies, can be used to determine the overall industry average turnover rate.

Indicator Points Earned = ____

6.0 VALUE (cont'd)

Indicator 6: **Employee Benefit Program**

For the purpose of this assessment, an employee benefit program is defined as any intrinsic or extrinsic rewards/benefits that employees are entitled to other than training and development, health insurance, retirement plan, maternity/paternity/parental leave, and child care support. Offering a solid employee benefit program adds more value to employees and strengthens their desire to become a loyal member of the organization. Recognized elements of a solid employee benefit program may include such items as: company vehicles, scholarships, group life insurance plan, paid vacations and holidays, paid sick leave, paid cell-phone, gym reimbursement or fitness program, profit sharing, employer student loan contributions, employer paid or provided housing, disability income protection, and allowances for lunch.

Type: Essential   Possible points: 4

Indicator Metric:

Measurement unit: Elements of employee benefit package

Scales:

1 point
: Organization has an employee benefit package that includes two or fewer of the benefits mentioned above.

2 points
: Organization has an employee benefit package that includes a minimum of three of the benefits mentioned above.

3 points
: Organization has an employee benefit package that includes a minimum of four of the benefits mentioned above.

4 points
: Organization has an employee benefit package that includes a minimum of five of the benefits mentioned above.

Indicator Points Earned = _____

6.0 VALUE (cont'd)

Indicator 7: **Performance Feedback and Appreciation**

Performance feedback and appreciation are critical for employees to grow. They add more value to the work and can motivate employees for better performance. Performance feedback can be given formally (e.g., in one-on-ones meetings) and informally (e.g., in-the-moment development advice given to employees during work operations); both types are effective as long as they are critical and provided in a timely-manner on an ongoing basis.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Employee assessment of performance feedback in organization

Scales:

1 point
: Organization does not formally evaluate the effectiveness of employee performance feedback or receives an aggregated score of less than 6.0 in the preceding calendar year using the survey question shown below.

2 points
: Organization formally evaluates the effectiveness of employee performance feedback and receives an aggregated score from 6.0 to 7.0 in the preceding calendar year using the survey question shown below.

3 points
: Organization formally evaluates the effectiveness of employee performance feedback and receives an aggregated score from 7.0 to 8.0 in the preceding calendar year using the survey question shown below.

4 points
: Organization formally evaluates the effectiveness of employee performance feedback and receives an aggregated score of more than 8.0 in the preceding calendar year using the survey question shown below.

Note: Employee performance feedback should be annually assessed, with at least 70% workforce participation, using the following survey question: On a scale from "1" (extremely poor) to "10" (extremely high), how would you rate the quality of the performance feedback you received in your organization?

Indicator Points Earned = _____

6.0 VALUE (cont'd)

Indicator 8: **Fair Compensation**

Compensation is an essential component of any job. Providing fair compensation is imperative to recruit and retain skilled employees, maintain and increase employee morale, and encourage high performance. A skilled workforce, increased employee morale, and improved performance result in lower turnover rates, greater return-on-investment, and more job value, leading to higher levels of workforce sustainability. A fair amount of compensation complies with existing laws and regulations, reflects the nature and demands of the job, and provides what individuals need to support themselves and their families and live a decent life.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Percent of compensation exceeding minimum

Scales:

1 point

Organization provides wages and benefits that meet or exceed the prevailing wage determined by the Federal Davis-Bacon Act, or applicable state prevailing wage statutes, whichever is higher.

2 points

Organization provides wages and benefits that exceed the prevailing wage determined by the Federal Davis-Bacon Act, or applicable state prevailing wage statutes, whichever is higher, by at least 10%.

3 points

Organization provides wages and benefits that meet or exceed the wage determined for the two adults (one working) family category as identified by the living wage calculator (http://livingwage.mit.edu).

4 points

Organization provides wages and benefits that exceed the wage determined for the two adults (one working and one child) family category as identified by the living wage calculator (http://livingwage.mit.edu) by at least 10%.

Note: Temporary and newly-hired entry-level employees who are in their first year of employment may be excluded from evaluation.

Indicator Points Earned = _____

6.0 VALUE (cont'd)

Attribute Weighted Score Calculation

	Points Earned	Possible Points
Indicator 1	______	4
Indicator 2	______	4
Indicator 3	______	4
Indicator 4	______	4
Indicator 5	______	4
Indicator 6	______	4
Indicator 7	______	4
Indicator 8	______	4

Total Points Earned = ______ out of 32 (total possible points)

Attribute Weighted Score = [(total points earned) ÷ (total possible points)] × (attribute weight)

= [______ ÷ (32)] × (4)

= ______

7.0 COMMUNITY

Attribute: Community

The extent to which workers feel they are accepted by, share similar interests with, and have camaraderie and cohesiveness in growth and achievement together with others in the workforce, with the organization, and with the industry as a whole.

Attribute weight: 3

Attribute Indicators:

There are four indicators of the community attribute:

1. (E) Company social events
2. (E) Workforce integration in industry
3. (A) Local community at work
4. (A) Workload trade-off

7.0 COMMUNITY (cont'd)

Indicator 1: **Company Social Events**

To build camaraderie and cohesiveness within the workforce, company social events on non-working days or after working hours should be regularly organized. Company social events can be annual celebrations, parties, picnics, and other leisure activities on non-working days or after working hours such as sports, exercise, cultural, or other similar social activities. Companies organize or sponsor these social events to enable building a strong community at work. It must be mentioned that participation in these events should be voluntary but also acknowledged that low participation rates can diminish potential benefits of these events.

Type: Essential   Possible points: 3

Indicator Metric:

Measurement unit: Availability and frequency of company social events plus participation rate

Scales:

1 point

Organization arranged and/or sponsored less than two social events in the preceding calendar year and/or the overall participation rate in these social events was below 50%.

2 points

Organization arranged and/or sponsored a minimum of two social events in the preceding calendar year and the overall participation rate in these social events was above 50%.

3 points

Organization arranged and/or sponsored a minimum of four social events in the preceding calendar year and the overall participation rate in these social events was above 50%.

Indicator Points Earned = _____

7.0 COMMUNITY (cont'd)

Indicator 2: **Workforce Integration in Industry**

To ensure that employees are part of a larger community, workforce integration in the industry should be emphasized. Ensuring that the workforce is integrated in the industry can nurture employee growth and development, and enable a strong work community at the industry level, resulting in an enhanced the level of workforce sustainability across the industry.

Type: Essential Possible points: 3

Indicator Metric:

Measurement unit: Demonstrated involvement and engagement in professional organizations

Scales:

1 point

Organization cannot demonstrate active involvement and engagement in the industry with 25% of its workforce being members of professional organizations.

2 points

Organization demonstrates active involvement and engagement in the industry, and at least 25% of its full-time employees are members of and actively involved in local chapters of professional organizations.

3 points

Organization demonstrates active involvement and engagement in the industry, and at least 35% of its full-time employees are members of and actively involved in local chapters of professional organizations.

Indicator Points Earned = _____

7.0 COMMUNITY (cont'd)

Indicator 3: **Local Community at Work**

Establishing a local community at work ensures that an organization and its workforce are part of the larger community surrounding a business. Being part of the surrounding local community provides support to employees and enables business success. Employees are usually more productive and provide higher quality services when they serve their own community. Accordingly, ensuring that a local community at work is established enhances the overall level of workforce sustainability and organizational success.

Type: Auxiliary Possible points: 3

Indicator Metric:

Measurement unit: Demonstrated involvement and engagement in professional organizations

Scales:

1 point

Organization cannot demonstrate that at least 25% of its employees are from the local community and live within a maximum of 75 miles from where the workplace is located.

2 points

Organization can demonstrate that at least 25% of its employees are from the local community and live within a maximum of 100 miles from where the workplace is located.

3 points

Organization can demonstrate that at least 35% of its employees are from the local community and live within a maximum of 100 miles from where the workplace is located.

Note: To determine the distance between where employees live and work, the ZIP Codes for the employee's permanent home address and where the workplace is located can be used.

Indicator Points Earned = _____

7.0 COMMUNITY (cont'd)

Indicator 4: **Workload Trade-off**

Construction is a demanding occupation from physical and mental perspectives. Construction employees, including managers, laborers, superintendents, and engineers, usually work more than 40 hours per week in extreme environments. Long working hours impact employee health and prosperity, work-life/family balance, and growth causing potential physical and mental fatigue. A resilient work community should demonstrate the ability to overcome the abovementioned issues by allowing employees with a similar position and skill level to trade-off workload and hours (also referred to as job-sharing).

Type: Auxiliary Possible points: 3

Indicator Metric:

Measurement unit: Practices in place for workload trade-off

Scales:

1 point

Organization does not allow employees with a similar position and skill level to trade-off workload and hours.

2 points

Organization allows employees with a similar position and skill level to trade-off workload and hours but only in special circumstances.

3 points

Organization has a policy in place to allow employees with a similar position and skill level to trade-off workload and hours if possible and determined that such a workload trade-off will not be associated with negative outcomes in terms of safety and quality.

Note: Workload trade-offs need to be approved by the organization and the employees are not automatically entitled to these benefits. The employees should formally apply for workload trade-off in writing and await for a final decision from management.

Indicator Points Earned = _____

7.0 COMMUNITY (cont'd)

Attribute Weighted Score Calculation

	Points Earned	Possible Points
Indicator 1	______	3
Indicator 2	______	3
Indicator 3	______	3
Indicator 4	______	3

Total Points Earned = ______ out of 12 (total possible points)

Attribute Weighted Score = [(total points earned) ÷ (total possible points)] × (attribute weight)

= [______ ÷ (12)] × (3)

= ______

8.0 MATURITY

Attribute: Maturity

A reflection of the extent to which workers have and/or gain leadership, responsibility, accountability, and competence in social, technical, environmental, and economic terms with respect to work performance, cooperation, problem-solving, collaboration, idea-generation and innovation, and work involvement and integration. A mature workforce should be able to gain, develop, and carry on the aforementioned competencies effectively and efficiently as a group and as individuals throughout their working and non-working life and be responsible/accountable towards self and others.

Attribute weight: 3

Attribute Indicators:

There are six indicators of the maturity attribute:

1. (E) Leadership and communication skills
2. (E) Accountability (set-performance standards)
3. (E) Competence-based education
4. (A) Competence-based training
5. (A) Multiskilling
6. (A) Volunteering

8.0 MATURITY (cont'd)

Indicator 1: **Leadership and Communication Skills**

Leadership and communication skills are crucial in construction workplaces. Effective leadership and communication are signs of maturity; they can improve employee self-awareness of safety hazards, responsibility and accountability, cooperation, problem-solving, collaboration, and innovation in the work environment, resulting in higher levels of workforce sustainability.

Type: Essential Possible points: 5

Indicator Metric:

Measurement unit: Number of training hours for developing leadership and communication skills

Scales:

1 point

Organization provided *no* training in the preceding calendar year with respect to developing leadership and communication skills.

2 points

Organization provided a minimum of *two* hours of training in the preceding calendar year for each full-time equivalent (FTE) employee to develop leadership and communication skills.

3 points

Organization provided a minimum of *four* hours of training in the preceding calendar year for each full-time equivalent (FTE) employee to develop leadership and communication skills.

4 points

Organization provided a minimum of *six* hours of training in the preceding calendar year for each full-time equivalent (FTE) employee to develop leadership and communication skills.

5 points

Organization provided a minimum of *eight* hours of training in the preceding calendar year for each full-time equivalent (FTE) employee to develop leadership and communication skills.

Indicator Points Earned = _____

8.0 MATURITY (cont'd)

Indicator 2: **Accountability (Set-performance Standards)**

Establishing set-performance standards is important to both employees to understand expectations, obligations, and responsibilities of their job as well as to organizations to enable performance evaluation and accountability. Accountability for employee performance in a workplace empowers the employees to take ownership of their work and improves overall performance outcomes.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Policy in place to set clear expectations for positions

Scales:

1 point

Organization has no specific set-performance standards for positions to evaluate performance and hold employees accountable.

2 points

Organization sets clear expectations for positions and has specific set-performance standards related to quality and quantity of work expected from employees.

3 points

Organization sets clear expectations for positions and has specific set-performance standards related to quality and quantity of work expected from employees as well as the timeframe during which such standards should be achieved.

4 points

Organization sets clear expectations for positions and has specific set-performance standards related to quality and quantity of work expected from employees as well as the timeframe during which such standards should be achieved. The organization uses these performance standards to evaluate employee performance and, based on the evaluation results, provides specific training and coaching for performance improvement.

Indicator Points Earned = _____

8.0 MATURITY (cont'd)

Indicator 3: **Competence-based Education**

Competence is a set of defined knowledge, skills, abilities, and behaviors needed for employees to perform high-quality work in a professional manner. Sponsoring and providing educational opportunities to employees to obtain and maintain professional licensing and certification, such as a PE license and ASP, CSP, LEED AP, and PMI certifications, advances employee knowledge and professional creditability, leading to a higher level of maturity in the workplace.

Type: Essential Possible points: 4

Indicator Metric:

Measurement unit: Sponsored and provided opportunities to obtain and maintain professional licensing and certification

Scales:

1 point

Organization does not sponsor and provide opportunities to the workforce to obtain and maintain professional licensing and certification.

2 points

Organization has a policy in place to sponsor and provide opportunities to the workforce to obtain and maintain professional licensing and certification.

3 points

Organization has a policy in place to sponsor and provide opportunities to the workforce to obtain and maintain professional licensing and certification. Currently, at least 25% of the construction managers, engineers, supervisors, and other personnel within the organization have a valid professional license or certificate.

4 points

Organization has a policy in place to sponsor and provide opportunities to the workforce to obtain and maintain professional licensing and certification. Currently, at least 50% of the construction managers, engineers, supervisors, and other personnel within the organization have a valid professional license or certificate.

Note: A certificate of participation in a workshop or a conference is not considered a professional certificate.

Indicator Points Earned = _____

8.0 MATURITY (cont'd)

Indicator 4: **Competence-based Training**

As mentioned previously, competence is a set of defined knowledge, skills, abilities, and behaviors needed for employees to perform high-quality work in a professional manner. Sponsoring and providing training opportunities to employees related to business (to help employees understand how they fit within the company), computer and technology, problem-solving, time management, and work ethics develops the required skills and abilities. Developing these critical skills and abilities enhances the overall level of employee maturity as a group and as individuals.

Type: Auxiliary Possible points: 3

Indicator Metric:

Measurement unit: Annual training hours related to business, computer and technology, problem-solving, time management, and work ethics

Scales:

1 point

Organization did not sponsor or provide training related to business, computer and technology, problem-solving, time management, and work ethics in the preceding calendar year.

2 points

Organization sponsored or provided, on average, a minimum of three hours of training related to business, computer and technology, problem-solving, time management, and work ethics for each full-time equivalent (FTE) employee in the preceding calendar year.

3 points

Organization sponsored or provided, on average, a minimum of five hours of training related to at least two of the followings (business, computer and technology, problem-solving, time management, and work ethics) for each full-time equivalent (FTE) employee in the preceding calendar year.

Indicator Points Earned = _____

8.0 MATURITY (cont'd)

Indicator 5: **Multiskilling**

Multiskilling (also referred to as cross-training) is the practice of creating crews with multiple skill-sets and making use of these crews to perform more than one task safely and efficiently. Multiskilling is an indication of workforce maturity; it can enhance employee collaboration, increase flexibility, improve productivity, reduce employee boredom resulting from repetition, and help mitigate workforce shortages in the construction industry.

Type: Auxiliary Possible points: 3

Indicator Metric:

Measurement unit: Training and/or strategies in place related to multiskilling

Scales:

1 point

Organization has no specific training or strategies for creating crews with multiple skill-sets and making use of these crews.

2 points

Organization provides specific training and/or strategies for creating crews with multiple skill-sets and making use of these crews.

3 points

Organization provides specific training and/or strategies for creating crews with multiple skill-sets and making use of these crews. The organization purposely places employees in team assignments and gives the employees real-time feedback as to their performance in the team as well as rewarding employees for trying new positions/roles.

Indicator Points Earned = _____

8.0 MATURITY (cont’d)

Indicator 6: **Volunteering**

Volunteering comprises the services that individuals willingly provide to others and their community at no cost. Volunteering is an important measure of civic engagement and maturity. Volunteering, when administered or approved by the employer, provides mutual benefits to the work community (both employees and employers) and the broader community (e.g., industry or local community where work is located). With respect to the workforce, volunteering can help employees counteract stress and anxiety, increase self-actualization, and contribute to their community. Volunteering activities can include participation in outreach programs, providing services to vulnerable populations, and so forth.

Type: Auxiliary Possible points: 3

Indicator Metric:

Measurement unit: Policy in place to support volunteering

Scales:

1 point

Organization has no specific policy related to volunteering and does not provide paid time-off to employees to participate in volunteer activities.

2 points

Organization has a written policy that promotes volunteering and provides up to 8 hours of annual paid time-off work to participate in volunteer activities if desired by the employees.

3 points

Organization has a written policy that promotes volunteering and provides up to 16 hours of annual paid time-off work to participate in volunteer activities if desired by the employees.

Note: The metric for this indicator is adapted from the JUST label.

Indicator Points Earned = _____

8.0 MATURITY (cont'd)

Attribute Weighted Score Calculation

	Points Earned	Possible Points
Indicator 1	______	5
Indicator 2	______	4
Indicator 3	______	4
Indicator 4	______	3
Indicator 5	______	3
Indicator 6	______	3

Total Points Earned = ______ out of 22 (total possible points)

Attribute Weighted Score = [(total points earned) ÷ (total possible points)] × (attribute weight)

= [______ ÷ (22)] × (3)

= ______