PREVENTION THROUGH DESIGN AND GREEN BUILDINGS: A US PERSPECTIVE ON COLLABORATION

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ABSTRACT

Current green design and building practices are primarily aimed at minimizing environmental and resource impacts and improving the safety, health, and productivity of a building's final occupants and the public. Rating systems, such as the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) put little, if any, focus on the safety and health of the temporary occupants, i.e., the construction workers. Yet such systems and their proponents represent a largely untapped opportunity for safety and health practitioners to enlist in efforts to promote designing for safer workplaces during their construction and maintenance.

In the United States, the likelihood of governmental regulations that would broadly specify Prevention through Design (PtD) efforts in upstream construction activities is remote. Because PtD has seen international support in enhancing construction worker safety, innovative and creative ways to diffuse the concept in the U.S. must be developed. This paper focuses on the congruencies between the green building effort as a sustainable holistic system and the safety and health of construction workers who build and maintain these buildings. NIOSH Construction Sector goals will be described as they relate to green building elements and ideologies and efforts to collaborate with the USGBC will be reported.

No entity that presides over avoidable workplace deaths, injuries, or illnesses can ever claim to be sustainable. For green construction to be considered sustainable, construction safety and health concepts must be integrated into upstream considerations.

Keywords: Sustainability, Green buildings, Prevention through design

INTRODUCTION

Current green design and construction practices are primarily aimed at minimizing environmental and resource impacts and improving the safety, health, and productivity of a building's final occupants and the public. Rating systems, such as the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) put little, if any, focus on the safety and health of the initial occupants, the construction workers, or those that maintain these buildings. Yet such rating systems and their proponents represent a largely untapped opportunity for safety and health practitioners to enlist in efforts to promote designing for safer workplaces during the building's construction and maintenance. In the United States, the likelihood of governmental regulations that would broadly specify Prevention through Design (PtD) efforts in upstream construction activities is remote. Because PtD has seen international support in enhancing construction worker safety and health, innovative and creative ways to diffuse the concept in the United States must be developed. This paper focuses on the congruencies between the green building effort as a sustainable holistic system and the safety and health of workers who build and maintain these buildings. National Occupational Research Agenda (NORA) Construction Sector

goals, whose formulation was facilitated by the National Institute for Occupational Safety and Health (NIOSH) in collaboration with external stakeholders, are described as they relate to green building elements and ideologies. Motivations and methods for design professionals to participate within NIOSH PtD and a new NIOSH program, Safe Green Jobs, are described. The basic premise of the paper is summed up by Gilding et al. (2002) who wrote "no entity that presides over construction projects or green buildings that experience avoidable workplace deaths, injuries, or illnesses can ever claim to be sustainable." For green buildings to be considered sustainable, construction safety and health concepts must be integrated into upstream considerations.

WHY SHOULD GREEN BUILDINGS BE CONSTRUCTED SAFER?

Green's eventual purpose is to benefit people

Green buildings are built by and occupied by people. As cited by Abbaszadeh et al. (2006), the USGBC defines green buildings as structures that have significantly reduced or eliminated negative impacts on the environment and the occupants. Construction workers are the earliest occupants in the initial lifecycle stage of a green building. Construction workers will also maintain, remodel, and decommission a green building throughout its lifecycle. Green design and construction are founded on the concept of promoting environmental sustainability and consequently perceived as doing the right thing for the ultimate benefit of the health and well-being of people. However, the construction industry is a highly hazardous industry. In the United States, over the past few years, the following statistics have remained fairly constant – the construction industry employs roughly 7.5% of the nation's workforce yet accounts for over 20% of the nation's occupational related deaths. See Table 1. The safety record in the construction industry is improving. The fatality rate decreased from 14.7 per 100,000 workers in 1995 (Toscano and Windau, 1996) to 10.5 per 100,000 workers in 2007 (BLS, 2008). However, each year more than 1000 workers are killed in the construction industry, and there is still a large disparity between the percentage working in construction and the percentage of construction fatalities in relation to all industries.

Table 1. U.S. Construction safety statistics, 1995, 2005-2007

Year	Construction Employment (thousands)	Total Employment (thousands)	% Construction employment	Construction Fatalities	Total Fatalities	% Construction Fatalities	Fatality Rate
2007	11,416	147,215	7.8%	1,204	5,657	21.3%	10.5
2006	11,312	145,501	7.8%	1,239	5,840	21.2%	10.9
2005	10,739	142,894	7.5%	1,192	5,734	20.8%	11.1
1995	7,153	126,248	5.6%	1,048	6,210	16.8%	14.7

Fatality rate = (N / W) x 100,000; N = the number of worker fatalities, age 16 and older; W = the annual average number of employed workers, age 16 and older.
Sources: Toscano and Windau (1996); BLS (2006 – 2008)

Green buildings are constructed with green materials and specific elements that are designed to improve a building's sustainability and hopefully earn the green or sustainable design designation; yet the processes used during construction have not incorporated elements to account for sustainability (i.e., safety and health) of the construction workforce. Construction literature and practice are filled with proven methods for constructors to work safely and remain healthy. The causes of injuries and illnesses in construction have long been recognized and their persistence continues to frustrate construction safety and health practitioners and researchers (Hill, 2003). Research has identified best practices which improve the safety and health performance of construction workers (for example: CII 2003; Jaselskis et al. 2006). Individual companies have reached incredible milestones of zero injuries and no accidents throughout their projects. In other words, in general, it is known how to work safely and how to manage construction safety and health to eliminate and reduce recognizable risks and hazards. These established best practices ultimately have a positive effect on people – the construction workers and their families. In his text on a contractor's guide to green construction, Glavinich (2008) addresses construction safety in one page but does not make the link that worker safety and health should be connected to green

building design. Another text on green project planning and estimating (Greene, 2006) does not mention worker safety or health.

One example of a green building where construction safety failures occurred is at the Las Vegas, NV Mirage City Center which was striving for USGBC LEED certification at the Silver level. During this construction project, scheduled to be completed near the end of 2009, six construction workers died on the job in an 18 month period (CPWR, 2008). Regarding the safety and green link on this project, Ivanovich (2008a) posed the question "how many construction site deaths should there be to make a building 'not green' regardless of the environmental benefits?" Ivanovich (2008b) went on to suggest awarding one credit if a project is completed without a serious injury or death. He also proposed that green certifications should be revocable where accidental injuries or deaths occurred during construction and were proved to be complicit with negligence after the certification was awarded. While these comments are thought-provoking, proving such negligence or corruption is difficult. Rather, a more proactive suggestion would specify the incorporation of leading indicators of H&S performance in obtaining LEED certification rather than revoking it for occupational fatalities. Examples include fall protection anchor points (for both construction and maintenance activities), the inclusion of roof parapets where appropriate, recommendations for safe design of atria windows and skylights to facilitate building and maintenance, organization of the building site to facilitate the safe handling of building materials, etc, and other design suggestions (See Gambatese, et al., 1997).

Green concepts are evolving to sustainable concepts

The USGBC LEED Rating System measures how well a building or community performs across a spectrum of environmental and public health metrics: energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. Yet these are predominantly environmental issues, and construction worker safety and health issues are not included among the metrics. With the LEED focus on the environment as an end goal, worker safety and health is only incidentally linked to the environment by the fact that many professionals in both fields have responsibilities in the other. As an example, professionals often have job titles that encompass both fields, such as Environment, Safety, and Health (ESH) Manager. The term 'green' is not synonymous with the term "sustainable." However, these two terms have been used interchangeably in the construction industry (Kibert, 2008; Kopec, 2009). The main contention of this paper is that construction worker safety and health and green construction development have linkages and opportunities for integration.

It is a misperception that including construction worker safety and health will dilute the green effort; on the contrary, sustainable design and green buildings must account for both environmental and human resources throughout their lifecycles. Sustainability is a broader concept which, in addition to the environmental aspect, addresses the continuity of economic considerations, resource conservation, and social aspects of human society. Sustainability raises the "green" discussion from materials and processes to include marketing, distribution, disposal and human labor (Evans, 2006). For a green building to be sustainable, consideration must be given to more than just protecting the environment. Worker safety and health are key issues within the social dimension of sustainability (for example: Holcim, 2009; Epstein and Roy, 2003; Gilding et al., 2002). Montoya (2009) references Trevor Hancock, a public health physician and first leader of the Green Party of Canada, whom he calls a pioneer of the "healthy communities" movement, and credits him with a definition of socially sustainable development that includes, among other items, safe working conditions. The USGBC is founded on a similar set of guiding principles, expressed in its Mission Statement "To transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life (USGBC, 2009)." Moreover, the USGBC Strategic Plan (2009) states that "the meaning of 'green' is evolving, to more fully include human and social relationships to the built environment." The USGBC is deeply rooted within six guiding principles that are incorporated into all aspects of their organization, consistent with promoting the triple bottom line (i.e., economic, social, and environmental responsibility).

The six principles are: (1) Promote the triple bottom line; (2) Establish leadership; (3) Reconcile humanity with nature; (4) Maintain integrity; (5) Ensure inclusiveness; and (6) exhibit transparency. However, no mention of construction worker safety and health, or construction workers at all for that matter is included in the USGBC Strategic Plan or other materials available on the USGBC website. The absence of construction worker safety and health under the context of sustainable construction is evident in other publications. Kibert's (2008) text on sustainable construction mentions the health and safety plan, however, the focus of that one-page section is to ensure that the completed building's final indoor air quality (IAQ) is not compromised by the construction process. Kopec's (2009) text on health, sustainability and the built environment discusses safety and ergonomic considerations for a sustainable building's occupants, but does not mention construction workers at all. The Holcim Foundation for sustainable construction is committed to the "triple bottom line" concept, which asserts that long-term and sustainable progress requires the balanced achievement of economic growth, ecological balance and social progress. Within their social equity framework, workers' safety and health is not mentioned. Kibert (2008) further states that sustainable construction is defined most comprehensively by addressing the ecological, social, and economic issues of a building in the context of its community, but construction worker safety and health is not mentioned as a social issue. Moreover, Kibert (2008 p.5), Lützkendorf (2003), and Sarja (2002) agree that sustainable construction must encompass the entire life cycle of the building. The entire life cycle includes the construction process itself as well as the maintenance of the building and building systems. Construction worker safety and health, as well as the safety and health of all workers, falls under the umbrella of the social dimension of sustainability, and that the construction safety process, by its current safety record, is unsustainable. In other words, green and sustainable buildings are built by an unsustainable process. Gilding et al. (2002) summed up this contention by stating "no corporate regime that presides over avoidable deaths, injuries and illnesses in the workplace can ever claim to be sustainable or even to understand what the concept requires of their business."

Is green construction safer or less safe than conventional construction?
Green buildings are not constructed with additional safety and health measures within the design and planning process. Construction firms selected to construct green buildings are not required to have special safety management systems or evidence of a particular safety performance. Therefore, a null hypothesis would state that the construction safety and health record used to construct green building is no different than conventional construction. Those statistics have been discussed previously and are included in Table 1. As yet, there are no records or published studies which describe the safety record of green construction. Gambatese et al. (2004) performed case study research to answer the following questions:

- "Do LEED buildings (i.e., green design and construction) impact construction worker safety and health?"
- "What is the impact, positive or negative, of LEED on safety and health on construction sites?"

They found that some features of green buildings designed and constructed to meet the LEED Rating System, such as the construction material recycling programs, may negatively impact the safety of construction workers, while others, such as the use of low VOC materials, may help to eliminate construction site health hazards. This study prompted further study by the same authors, and they recently had an article on this issue accepted for publication in the October issue of *Journal of Construction Engineering and Management* (Rajendran et al., 2009). The research surveyed construction companies on their safety records during green and conventional construction projects. Based on their research study, they found no statistical difference between green and non-green projects in terms of construction worker safety and health. With both green and non-green buildings having the same safety and health performance, a question arises as to whether LEED buildings should be labelled as sustainable buildings. Because no difference in safety and health performance is experienced, LEED projects are perhaps sustainable environmentally but not sustainable in terms of worker safety and health.

PREVENTION THROUGH DESIGN CONGRUENCIES

Overview of NIOSH PtD in Relation to Green

To organize efforts to explore and promote the role of design in the broad field of occupational safety and health, NIOSH and its partners convened the first PtD Workshop in Washington, DC in July 2007. The intent was to launch a National Initiative aimed at eliminating occupational hazards and controlling risks to workers "at the source" or as early as possible in the life cycle of items or workplaces. PtD includes the design of work premises, structures, tools, plants, equipment, machinery, substances, work methods, and systems of work. The workshop attracted approximately 225 participants from diverse industry sectors and disciplines. Initial partners included the American Industrial Hygiene Association, the American Society of Safety Engineers, the Center to Protect Workers' Rights, Kaiser Permanente, Liberty Mutual, the National Safety Council, the Occupational Safety and Health Administration, ORC Worldwide, and the Regenstrief Center for Healthcare Engineering. Others have joined and continue to do so since.

The central tenet of this initiative is expressed as follows:

> PtD addresses occupational safety and health needs by eliminating hazards and minimizing risks to workers throughout the life cycle of work premises, tools, equipment, machinery, substances, and work processes including their construction, manufacture, use, maintenance, and ultimate disposal or re-use.

The PtD National Initiative is framed by industry sector and within four functional areas: **Research, Education, Practice, and Policy**. Goals for each of these areas, and an additional focus area of small businesses, were established at a subsequent meeting of the NORA PtD Council in September 2008. More information on the initiative is available at: http://www.cdc.gov/niosh/programs/PtDesign/. Because the role of design is so closely linked to safety and health in so many applications identified through this initiative, the incorporation or adaptation of PtD into green building projects warrants consideration to ensure such projects are consistent with the concepts of sustainability proposed here.

The following PtD policy intermediate goal was established to move the PtD concept forward through sustainable construction practices: IG4.4: *Worker health and safety principles are included in sustainable design and construction practices*. Additionally, a comprehensive description of the PtD initiative is documented in an issue of the *Journal of Safety Research* (Volume 39, Number 2, 2008) dedicated to the proceedings of the 2007 PtD National Workshop. As a further step to recognize the potential linkages between environmental sustainability and worker safety and health, NIOSH launched an effort in June 2009 focusing on *Going Green: Safe and Healthy Jobs* (http://www.cdc.gov/niosh/topics/greenjobs/). A December 2009 workshop is planned to launch the effort.

Opportunities for collaboration – PtD and Green

Incorporating worker safety and health in to a system such as LEED would move safety into the design effort (Silins, 2009) and thus presents collaborative opportunities for the NIOSH PtD initiative and the green building movement. While the use of low VOC-materials will enhance construction worker health (Gambatese et al., 2004; Montoya, 2009), certain green features have documented risks associated with their construction and maintenance. Atria and skylights are often specified to increase the amount of natural light and heating, thereby reducing electricity usage. The construction and maintenance of atria present fall hazards which can be overcome with proper design and planning. A significant number of injuries and fatalities result from workers falling through skylights (NIOSH, 2004). In 2008, the American Society for Testing and Materials (ASTM) assembled a committee to evaluate skylight specifications and testing (eGlass Weekly, 2008). The standard will increase the required force from the 1984 OSHA standard, which specified that skylights be designed to withstand a load of at least 200 pounds. Dr. Nigel Ellis, lead for the ASTM skylight test committee, calls the 200 pound requirement woefully inadequate (eGlass Weekly, 2008). Alternatively, a specification could be included that the skylight be surrounded by a permanent protective guardrail. The literature associated with construction PtD has established over 400 additional specific methods where design professionals could positively impact

construction and maintenance worker safety and health without interfering with constructor's choice of means and methods (Gambatese et al., 1997). The relationship between designer and constructor can be complicated by construction contracts, and the relationship between design decisions and construction safety and health is complex and multi-faceted (Behm, 2005). Therefore, sustainable PtD efforts are more about considering the safety and health of workers in relation to design and providing an opportunity for construction workers to work safely than about dictating means and methods. Success in PtD hinges on the relationship and communication between designer and constructor with both parties knowing their roles and responsibilities. The texts by Montoya (2009), Kopec (2009), and Glavinich (2008) go into detail on the specifications, environmental benefits, and construction aspects of specific green elements. It is recommended that revisions of these or future textbooks also include the safe design, planning, and construction of green elements. A suggested future research endeavour would be to find congruencies with these textbooks and construction PtD suggestions and establish specific design measures within the context of green and sustainable construction.

NORA CONSTRUCTION SECTOR GOALS

The NORA Construction Sector Council was formed in 2006 facilitated by NIOSH in collaboration with external stakeholders; the Council is comprised of invited stakeholders and subject matter experts from government, academia, industry groups, organized labour, and private consulting. During initial face-to-face meetings, the Construction Sector Council identified priority topic areas through a series of discussions and multi-voting processes. Among the resulting topic areas identified, safety by design, later renamed Construction Hazards Prevention through Design (CHPtD) for harmonization and consistency with the broader PtD initiative, was determined to be a priority area for assessing research needs as well as the translation and dissemination of best practices for preventing hazards in construction through design and engineering solutions. A core CHPtD workgroup was formed from volunteers on the Sector Council with interest and experience in this topic area. Additional corresponding members were recruited through the Sector Council in February 2008.

To apply the concept of designing for safety to the construction industry the NORA Construction CHPtD workgroup was given the task of providing leadership to develop goals and priorities. The main idea was to utilize engineering strategies in the design phase of projects to reduce accident producing situations. This is to be accomplished by the formation of partnerships, coordination of efforts, and facilitating networking between the construction industry and associated groups of design organizations. These activities were performed through a series of facilitated discussions, face-to-face meetings, and multiple teleconferences throughout a three-year period (2006-2008).

The following strategic goal (Goal 13) was established for the CHPtD topic:

> ***Strategic Goal 13 –*** Increase the use of "prevention through design (PtD)" approaches to prevent or reduce safety and health hazards in construction.
> ***Performance Measure –*** Increase the use of CHPtD by 33% over the next 10 years.

The intermediate goals (IGs) and associated performance measures were established to support the strategic goal and describe specific research or research-to-practice (r2p) activities identified as priority activities for this topic area. The draft goals, first disseminated in February 2008, were later revised in July 2008 as they appear below.

IG 13.1 – Characterize the current use of CHPtD and coordinate efforts to promote its use. (5 subgoals)

Performance Measures: Provide a baseline report within 2 years describing key measures of current national use of CHPtD within construction, along with a repository of currently available materials, current construction organization activities and contacts, and current training. Use findings to inform and begin at least three promotion activities. Collect data from at least eight (8) design/construction firms and other organizations actively involved in this process. Compile cost

comparison assessments and business case models to characterize costs of CHPtD approaches. Develop a repository for large and medium size AE firms which deal with electrical, mechanical, civil, and commercial projects. For target audiences (i.e., engineers, architects, construction managers, and safety and health professionals), develop the following training programs to disseminate the principles and benefits of CHPtD:

- Full semester undergraduate course, and
- One week modules which can be incorporated into existing college courses 8-hour continuing education course.

IG 13.2 – Confirm the most prevalent obstacles to acceptance and implementation of CHPtD: *(3 sub goals)*

- Fear of liability;
- Lack of expertise in safety and in designing for safety; and,
- Increased costs associated with CHPtD.

Performance Measures: Conduct a survey or other quantitative research method of owners, AEs and professional liability insurance carriers to empirically confirm the factors hindering their adoption of PtD processes.

IG 13.3 – Develop tangible products and methods to address identified CHPtD obstacles and challenges. (*11 sub goals)*

Performance Measures: Develop tools, policies, sources of information, training courses and other formal mechanisms as described in the following goals to circumvent barriers to the acceptance and implementation of CHPtD.

IG 13.4 – Expand the use and evaluation of CHPtD practices. *(5 sub goals)*

IG 13.5 – Develop incentives for architects and engineers to include the following in facility design plans and specifications:

- Methods for safer project erection;
- Methods for safe operation;
- Methods for safe service and maintenance; and
- Methods for safety of the public.

Within each of these intermediate goals there are multiple research and r2p subgoals providing further detail activities for meeting the broader objectives. The CHPtD goals are found within the NORA Construction Sector Agenda, which can be accessed at http://www.cdc.gov/niosh/nora/comment/agendas/construction/. As NIOSH and the construction industry works on meeting these performance measures and goals, the incentives for designers to participate in construction PtD have the opportunity to evolve absent formal governmental regulation. Just as the design community has embraced green building design and the environmental pillar of sustainable construction, NIOSH provides the opportunity for architects and design engineers to embrace the PtD concept, construction worker safety and health, and that part of the social pillar of sustainability.

MOTIVATIONS FOR DESIGNERS TO PARTICIPATE IN PtD

As a new focus is revealed on the safety – sustainability link by NIOSH, safety researchers, and reporters such as Ivanovich, design professionals on the leading edge of new innovations as early adopters would likely choose to participate. As any new idea grows, it is the early adopters who will shape that idea. These early adopters would desire to influence the amount and type of safety through design modifications in such a safety – sustainability expansion, rather than having the other aforementioned groups dictate that amount upon them through such means as public outcry or regulation. As green and sustainable construction evolves, eventually the construction safety and health link will become obvious to all. Moreover, owners will start to see the link between

safety and sustainability, and therefore will be interested in sustainable construction models that include safety and health. NIOSH's initiative on safety and green is kicking off with workshop entitled "*Making Green Jobs Safe: Integrating Occupational Safety and Health into Green and Sustainability*", and is scheduled for December 14-16, 2009. The NIOSH PtD initiative is a venue for design professionals to be involved. Additionally, NIOSH is planning a PtD conference in 2010.

SUMMARY

The crux of this paper is summed up by Gilding et al. (2002) when they stated "no corporate regime that presides over avoidable deaths, injuries and illnesses in the workplace can ever claim to be sustainable or even to understand what the concept requires of their business." Through this paper, this notion is applied to construction workers, the initial occupant of a green building, by contending that no entity (includes design professionals and project owners) that presides over construction projects or green buildings that experience avoidable workplace deaths, injuries, or illnesses can ever claim to be sustainable. Green and sustainable construction should have a better safety record than conventional construction. Rajendran et al. (2009) have shown that it currently does not.

The following future research activities are recommended:

- Determine the effect of specific green building elements on construction worker safety and health.
- Sustainable and green construction textbooks should consider construction worker safety and health as an element of importance, and should consider including previous research that has highlighted construction PtD efforts. NIOSH and their collaborators are ready to provide assistance.

Green and sustainable construction is predicted to evolve and grow over the next few decades (Yudelson, 2008). Perhaps what is labeled green construction today will simply be conventional construction in the future. The innovation and creativity that has and will positively affect the environment will be substantial. If construction worker safety and health is not part of this arrangement, any additional improvements in construction safety and health may lag behind environmental improvements. Green and sustainable buildings will continue to be built by a process that employs 8% of the nation's workforce yet experiences over 20% of its deaths. Green and sustainable construction should incorporate recognized construction safety best practices, including PtD, in order to truly have a positive impact on the dismal safety record and ensure a sustainable building life cycle.

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