Green Design & Construction

Understanding the effects on construction worker safety and health

By John A. Gambatese, Sathyanarayanan Rajendran and Michael G. Behm

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. The goal of these practices is to create facilities that are sustainable. Designing and constructing buildings using current sustainability practices may—or may not—benefit construction worker safety and health. A negative impact on construction worker safety and health is of concern since, in terms of the aggregate number of fatalities, no industry experiences more fatalities than construction (BLS, 2006).

If an injury or fatality occurs during the construction of a green building, is the project sustainable? Green building design focuses its attention to a large extent on the sustainability of the end users and the end use, while the process by which the building is constructed is somewhat ignored and may not necessarily be a truly sustainable process. Gilding, Humphries and Hogarth (2002) argue that many sustainability agendas are too narrowly focused on environmental issues and ignore occupational safety. The authors of this article propose that a more holistic view of green construction is needed—one that addresses safety and health over the entire life cycle of a constructed building—in order for the green process to be truly categorized as sustainable.

Entities responsible for sustainable processes are seeking to evaluate and even take responsibility for their supply chain to ensure that inputs are as sustainable as outputs (Kjaerheim, 2005; Lewis, 2005). The construction process is the key supply chain component for green buildings. Therefore, if green construction is to be sustainable and safety is a key component of sustainability, evaluating and considering worker safety within the construction supply chain is a reasonable expectation. Construction worker safety and health is as important as that of the end-user.

This article focuses on the impact of green design and construction practices on the safety and health of construction workers. It presents the concept of sustainability and the current drive toward green buildings, and describes the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) rating system. Rating systems such as LEED are designed to evaluate how "green" and, therefore, how sustainable, a project is.

However, these systems typically have little, if any, focus on the safety and health of those who construct the facilities. This issue is covered to support the stance that buildings should not be deemed "sustainable" without considering the construction safety and health element. The article also reviews a pilot study of an LEED-rated project to provide insight to the industry's perspective on the proposed concept and highlights several green design features which affect construction site safety and health. Finally, modifications to the LEED rating system that would enhance the safety and health of construction workers are discussed.

Sustainable Building Design & Construction

Sustainable development can be defined as development that meets the needs of the present without compromising the ability of future generations to

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Abstract: *This article discusses the impact of green design and construction on the safety and health of construction workers. It examines the concept of sustainability and the current drive toward green buildings, and describes the U.S. Green Building Council's Leadership in Energy and Environmental Design rating system. The authors present the results of a pilot study conducted on a green construction project and propose several modifications to this system that would enhance the safety and health of construction workers.*

meet their own needs (World Commission, 1987). The concept of sustainable development is further exhibited in the following definitions:

- "Improving the quality of human life while living within the carrying capacity of supporting ecosystems" (IUCN/UNEP/WWF, 1991).
- "Development that delivers basic environmental, social and economic services to all residences of a community without threatening the viability of natural, built and social systems upon which the delivery of those systems depends" (ICLEI, 1996).

Sustainable buildings are considered by many to be those whose design and construction employ "green" techniques that minimize environmental and resource impacts, and contribute to the safety, health and productivity of their occupants. USGBC recognizes buildings designed and constructed using green techniques by means of its LEED rating system, which was released in 2000. The system is a voluntary, consensus-based national standard for developing high-performance green buildings. Based on well-founded scientific standards, LEED emphasizes state-of-the-art strategies for sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality (USGBC, 2005a).

Buildings that satisfy or exceed the green requirements posed by the LEED system are formally certified by USGBC as sustainable. The system has four levels of certification based on the extent to which green features are incorporated: Certified, Silver, Gold and Platinum. The primary purpose of LEED certification is to promote greener buildings—that is, to reduce the environmental impacts of the building's life cycle, which can be significant (USGBC, 2005a).

LEED recognition is leading to changes in the way owners, designers and contractors approach building design, construction and operation. This change, and the motivation to attain LEED certification, can be attributed to several factors, including an enhanced public image for owners; the presence of more environmentally friendly owners; use as a marketing tool for contractors; reduced operation and maintenance costs; and improved health of building occupants.

Green Buildings & Sustainability

The primary purpose of LEED certification is to make buildings "greener." By doing so, USGBC aims to reduce the environmental impacts of a building's life cycle and protect the health of the building's occupants.

However, the terms *green* and *sustainable* are not necessarily synonymous although these two terms have been used interchangeably within the construction industry. *Green* is a term used to refer to primarily the design and construction practices that impact the environment (e.g., the soil, water, air, plants and animals). *Sustainability* is a broader concept that, in addition to the environmental aspect, addresses the continuity of economic, resource and social aspects of human society. For a green building to be sustainable, consideration must be given to more than just protecting the environment.

In addition, a building can be called sustainable only if sustainability principles are applied throughout its life cycle, which includes all phases from planning and construction through the building's end-of-life stage. Since control of performance outcomes typically exists only until the penultimate (maintenance and operations) stage of a building and no knowledge about its end-of-life stage or its life span is available, a building cannot be truly labeled as sustainable in the early stages of its life cycle. A building can only be identified as more or less sustainable than another building, similar to the different levels of LEED certification. For each sustainable design and construction feature added during the early stages (design, construction and operation) of a building, another step is taken toward sustainability, but the facility is not necessarily fully sustainable.

Safety & Health Impact of Green Buildings: A Pilot Study

Green buildings are designed to incorporate environmentally friendly practices in the project development process with the help of the LEED rating system. Currently in all 50 states and in 13 countries worldwide, 2,069 new construction projects have been registered with USGBC and 289 new construction projects have received LEED certification (USGBC, 2005b). This amounts to approximately 235 million gross square feet of building space (USGBC, 2005b).

Analysts predict that the number of registered projects will grow to 5,000 by the end of 2007 with more than 1,000 LEED-certified projects during the same time. This is more than a 10-fold increase in the

Table 1

Interview Questionnaire

Question	Response
1) What type of work do you perform on this project (e.g., masonry, concrete, steel)?	
2) How long have you worked on this project?	_____ days/months/years
3) Did you know that this building is being commissioned as a green building?	❑ Yes ❑ No
4) Have you worked on other green building projects in the past?	❑ Yes ❑ No
5) Do you know of any particular aspects of this construction project that are being implemented as part of the green building process? If so, describe.	❑ Yes ❑ No
6) Do the aspects listed in Question 5 affect construction site safety or health in any way? If so, how?	❑ Yes ❑ No
7) With regard to construction site safety and health, green building construction when compared to conventional construction is:	❑ Much safer ❑ A little safer ❑ Same ❑ Less safe ❑ Much less safe
8) Do you think that green designed buildings should consider construction worker safety and health as part of the LEED accreditation process? Why or why not?	❑ Yes ❑ No
9) Has the fact that the building is a green building impacted your work in any way? If so, describe.	❑ Yes ❑ No

number of certified projects over year-end 2003 (Yudelson, 2004). This intense movement toward sustainable design and construction represents a major portion of the building industry's activity, and it might have major impacts on the safety and health of the workers who construct the buildings.

As noted, the LEED rating system has only minimal focus on construction worker safety and health. Only one element—indoor air quality (IAQ) management during construction—addresses this facet. The intent of this element is to protect the workers and building occupants from potential air quality problems during the construction or renovation process.

For example, the plan might include protection against dust formation in the heating, ventilation and air conditioning (HVAC) duct systems that could trigger the growth of mold during construction. On successful implementation of the plan, the project will receive one LEED credit. Considering that the maximum number of possible credits for a project is 69, one credit is almost negligible and underscores the minimal consideration given to construction worker safety and health in the LEED system.

This fact and the potential significant effect of increased LEED presence in the industry leads to the question, Do LEED buildings impact construction worker safety and health? In addition, What is the impact, positive or negative, of LEED on safety and health on construction sites? Answering these questions will provide SH&E professionals in the construction industry with knowledge to develop necessary actions to prevent hazards associated with sustainable design and construction practices.

A pilot study was conducted to serve as a preliminary investigation of the relationship between green design and construction and construction worker safety and health. The study aimed to address the following questions:

- Does green building design and construction (LEED buildings) affect the safety and health of construction workers?
- If so, what green design and construction practices affect worker safety and health, either positively or negatively?
- What are the project members' perspectives on the relationship between green building design and construction practices and construction worker safety and health?

A preliminary literature search found no documents discussing the effects of green design and construction on the safety and health of construction workers. This may be attributed to the fact that the LEED rating system is relatively new (having been introduced in 2000), and studies of its effect on construction safety have yet to be completed and published. However, the inclusion of safety and health in sustainability concepts is recognized within the occupational safety and health community as imperative in order for sustainability to be addressed and achieved. Occupational safety and health issues are a part of the social dimension in sustainability agendas. No entity that presides over avoidable workplace deaths, injuries or illnesses can ever claim to be sustainable (Gilding, Humphries & Hogarth, 2002).

Project Description

A construction project on the Oregon State University campus was used as the focus of the pilot study. The project involved the construction of a new, four-story, 146,000 square ft electrical engineering/computer science building. The building was designed and constructed to the LEED Gold specifications for sustainability. Green features of the building include the following:

- Natural ventilation is achieved by providing interior spaces with fresh air.
- IAQ is managed during construction to ensure clean air for the workers.
- Materials used emit no or low amounts of unpleasant or harmful vapors.
- Building systems are designed to require 35% less energy than in typical buildings.
- Classrooms, labs and offices are supplied with natural light, cutting energy costs by as much as 40%.
- Earth-friendly concrete reduces CO_2 emissions.
- Bio-planters "recycle" water runoff and provide outdoor seating.

•Bicycle parking and on-site showers encourage alternative modes of transportation.

•Use of local construction materials reduces transportation costs.

•Use of low-toxicity finishes, fiberboard and flooring minimizes volatile organic compound (VOC) off-gassing.

•More than 90% of original materials on site were recycled.

Data Collection & Analysis

Data used for the pilot study were collected in two ways: focus-group interviews of project personnel and reviews of project documentation. Participants in focus-group interviews (typically four to six per group) included on-site representatives, both management and labor, from the general contracting and subcontracting firms working on the project. These interviews were conducted periodically during the course of construction (approximately once every 3 to 4 months) to obtain the participants' perspectives and input on the impact of the project's green building design and construction features on worker safety and health.

Five rounds of interviews were conducted throughout the entire construction phase to obtain the views of different subcontractors who worked on the project at different times. Overall, 24 participants were interviewed in the pilot study, some participating in more than one focus group.

To conduct the interviews, the researchers used a written questionnaire composed of questions that solicited information regarding the following: 1) the participant's awareness, knowledge and experience with constructing LEED buildings; 2) the participant's knowledge of the green features included on the pilot building project; 3) the perceived positive and/or negative impacts of green features on construction worker safety and health; 4) the relative safety and health performance between conventional and green buildings; and 5) any impacts of the green building on their regular tasks. Table 1 shows the specific questions included in the questionnaire.

The researchers conducted the focus-group interviews in the general contractor's office trailer on the jobsite. Hard copies of the questionnaire were handed out to the participants at the start of the interview, allowing them time to read through the questions. The researchers then asked each question to the group and solicited responses. Participants were also asked to record their answers on the questionnaire forms where appropriate to ensure that their responses were recorded. Furthermore, the participants were individually given a chance to answer each question verbally. Respondents were asked to provide their responses based on their experience on this project and, where relevant, the projects they have worked on in the past. The researchers recorded all responses to the questions.

In addition to the focus-group interviews, project documentation was obtained from the general contractor and reviewed to find any evidence of a connection between green features and construction site hazards. Documentation reviewed included job hazard analyses (JHAs) prepared by the subcontractors; an LEED matrix showing the categories in which each LEED point is obtained; and OSHA recordable and lost-time injury/illness data.

The researchers analyzed the data collected in the study using both quantitative and qualitative methods. Quantitative analysis involved simple statistical analyses. Since most of the questions were closed-ended, frequency statistics were used to evaluate the responses. Open-ended questions were analyzed qualitatively to assess the participants' perspectives of the construction worker safety and health differences between LEED and non-LEED building projects.

Table 2

Distribution of Participants by Trade

Trade/profession	Frequency	% of participants
General contractor	7	29.2
Mechanical	4	16.7
Concrete	4	16.7
Drywall	2	8.3
Electrical	2	8.3
Excavator	1	4.2
Structural steel	1	4.2
Window	1	4.2
HVAC controls	1	4.2
Carpenter	1	4.2
Total	**24**	**100**

Note. n = 24.

Table 3

Green Building Awareness, Experience

Survey question	"Yes" response	"No" response
Did you know that this building is being commissioned as a green building?	20 (83.3%)	4 (16.7%)
Have you worked on other green buildings before?	8 (33.3%)	16 (66.7%)

Note. n = 24.

Table 4

Safety & Health of Green Building Construction

Response	Frequency	% of participants
Much safer than conventional buildings	7	29.2
A little safer than conventional buildings	12	50.0
The same as conventional buildings	5	20.8
Less safe than conventional buildings	0	0.0
Much less safe than conventional buildings	0	0.0

Note. n = 24.

Limitations

One limitation of the methods used for this study is the presence of confounding variables that might affect worker safety and health even in the absence of the building being LEED registered. The two most significant variables are described here.

First, the general contractor managing the project is certified to the ISO 14001 standard. This requires the contractor to implement environmentally friendly practices not only on LEED projects, but on all of its jobsites. Second, the general contractor is one of the safest in the U.S. The company's established safety program contains many different elements that are intended to identify and eliminate hazards regardless of the green design objectives. These two variables could influence the impact of LEED and the green design and construction practices on construction worker safety and health on the project studied.

Results

Focus-group participants had varied backgrounds representing various trade specialties (Table 2, p. 31). Of those interviewed, the majority represented the general contractor (29.2%), followed by mechanical and concrete subcontractors (16.7% each). The length of time spent on the project of those interviewed ranged from 1 to 24 months (mean = 7.3 months; median = 5.5 months).

General knowledge of LEED and experience constructing LEED projects among the focus group participants was evaluated using the responses to three different questions. In the initial stage of the interview, participants were given the opportunity to state their understanding of the green concept and the LEED rating system. Table 3 (p. 31) lists the additional specific questions and provides a summary of the responses.

Most of those interviewed had knowledge of LEED. Twenty respondents (83%) indicated that they knew that the current project was being built to be an LEED-certified building. Eight respondents (33%) stated that they had previous experience working on a LEED-certified building, with one of these eight reporting that he had previously worked on several LEED buildings.

The focus-group interviews solicited input from the participants regarding the specific green design and construction features actually implemented on the project as part of its design. The following features were recognized by participants as being part of the building's green features:

- **Recycling program.** All of the recyclable waste materials (e.g., plastic, wood and metal) from the construction activities are separated and accumulated in containers on site for delivery to a recycling facility.
- **Rainwater collection system.** Rainwater from the roof is collected and stored in the basement for use in flushing toilets, cooling and irrigation.
- **Low VOC-emitting paint.** Paint that does not emit unpleasant and noxious fumes after its application was used throughout the building.
- **Energy efficiency.** High-efficiency electrical fixtures and mechanical systems were used to minimize energy use.
- **Window heaters.** Individually controlled thermostats were installed in each office to allow for use-specific temperature control. The windows were designed to be opened to allow for natural temperature control.
- **Natural lighting.** The large atrium in the center of the building allows light to penetrate into the building's interior areas and reduces the amount of artificial lighting required.
- **Solar panels.** Solar panels for generating electricity were installed on the roof. Electricity is stored in batteries and used to help power the building's electrical needs.
- **Regional materials.** Construction materials were procured from suppliers within the local region to minimize environmental and energy impacts of hauling heavy materials over long distances.
- **Waste diversion.** When possible, waste materials from construction work were saved and used elsewhere on the project or on another project rather than simply discarded.
- **Permeable paving.** Paved areas surrounding the building were designed to allow water to penetrate through the paving. This helped to eliminate the need for an extensive site stormwater system and to minimize the amount of additional runoff into the city's stormwater system.
- **Reflective roof coating.** A coating was applied to the roof to reflect the sunlight and minimize the heat absorbed by the roof on hot days. This helps to prevent a heat island effect.
- **IAQ plan.** A plan was created to ensure a clean source of air for the workers during construction.

Two questions were aimed directly at the effects of green design and construction practices on construction worker safety and health (Table 1, p. 30,

questions 6 and 7). Impact was considered to be either positive (improving safety and health) or negative (making work more hazardous). The individuals interviewed reported both positive and negative aspects, which are summarized below.

Table 5

Project Injury Data & Safety Performance

Metric	Pilot project	Construction industry
Total workhours worked on the project	265,000 hours	---
Number of minor incidents (nonrecordable)	6	---
Number of OSHA recordable injuries	3	---
OSHA recordable rate (number of recordable injuries per 100 workers per year)	2.3	6.3
Number of lost-time injuries	0	---
Lost-time rate (number of lost-time injuries per 100 workers per year)	0.0	3.4

Positive Aspects

•Good housekeeping leads to less chance for trips, slips and falls. The recycling program resulted in a cleaner project site. Respondents felt that this was one of the cleanest projects on which they had worked.

•Low VOC materials. Cleaner air provides a reduced health hazard to workers.

•Painting. More consideration is given to the time and location of painting in order to minimize the impact of the paint odor.

Negative Aspects

•Increased material handling. Waste materials from the construction process are gathered on the ground and manually separated according to type of material (e.g., wood, steel, plastics, glass). In some cases, material assemblies must be dismantled piece-by-piece before separation. Once separated, the materials are loaded into different containers. Recycling makes workers handle material two to three more times than usual. Workers spend more time separating and moving materials than in a normal project, which creates the potential for strains, sprains and punctures.

•More dumpsters. The presence of multiple recycling dumpsters creates congestion on the jobsite near the material laydown and entry/exit areas.

•Atrium design. While the atrium provides natural light to interior areas of the building, it increased the duration of the work because scaffolding had to be erected to the top of the four-story atrium. This presented an increased risk of worker falls from the extensive scaffolding system.

Comparisons to Conventional Construction

One question solicited the participant's judgment as to how green buildings compared to conventionally designed buildings in terms of construction site safety and health. Table 4 presents a summary of the responses. Of those interviewed, 12 (50%) felt that green buildings were a little safer; 7 (29.2%) stated that they were much safer; and 5 (20.8%) reported that they were the same as conventional buildings in terms of construction safety. None of the respondents felt that green buildings were less or much less safe to construct than conventional buildings.

Another question elicited their opinion of incorporating construction worker safety and health into the LEED rating system. Nineteen participants (79.2%) felt that construction worker safety and health should be considered; 4 (16.7%) responded "no"; and one participant did not answer the question. Responses to this question are dependent on the participant's knowledge of sustainability concepts, and the LEED rating system and certification process.

One survey question asked, "Has the fact that the building is a green building impacted your work in any way?" Most of the responses received were directed at the extra effort needed to separate and recycle the waste materials generated on the project. Comments received include:

•Yes, separating recyclable materials takes time.

•Yes, shop for different sources of materials, intangible value to owner, LEED documentation required and more awareness.

•Yes, more cleaning required like vacuuming.

•Yes, cleaner and safer, which means more production.

•Yes, longer to clean up and separate material.

Project Documentation

The researchers also reviewed project documentation as part of the data collection process. JHAs prepared by the subcontractors describe the hazards recognized by the subcontractors and how they plan to mitigate those dangers. JHAs for the following work were reviewed as part of the pilot study:

•concrete forming and placement;

•erection of tower crane;

•placement of underground utilities (steam, firewater, waste and vent piping);

•construction of interior partition walls;

•HVAC duct installation;

•waterproofing;

•generator placement.

While the JHAs identified hazards associated with the work, none of the identified hazards could be attributed specifically to the project's green design and construction features. For example, no JHA was prepared to address the safety and health hazards associated with the material recycling program. Other JHAs did not address the potential haz-

Considering the safety and health of the workers who are part of a building's life cycle would take green buildings one step closer to sustainability.

ards when applying the reflective coating on the roof or installing the solar panels. There was no evidence that hazards associated specifically with these green features were recognized in the JHAs. While not confirmed, it is unlikely that those who prepared the JHAs participated in the focus group interviews as part of the study. Therefore, it is not known whether those who prepared the JHAs were aware that the building was designed as a green building.

The researchers obtained project safety performance data from the general contractor at the end of the project. These data included the number of OSHA recordable and lost-time injuries on the project and the details of each incident. The total number of worker hours was also obtained in order to calculate the recordable and lost-time injury rates. Table 5 (p. 33) summarizes the project's safety performance data and presents the national injury rates for the construction industry as a whole for comparison (BLS, 2006). This comparison shows that safety performance on this project was better than the industry's national average.

The researchers gathered information on the three recordable injuries that occurred during the project in order to evaluate those injuries in terms of their relation to the green building design and construction features. The three recordable injuries were as follows:

- Hand scalded. A pipe fitting was not put on tightly enough and came off with the flow of hot water.
- Slip on concrete roof. Slippery surface was caused by morning dew on the roof (not by the reflective roof coating).
- Foot punctured by nail. Worker was breaking down (taking apart) wood pallets for separation of waste materials into different recycling bins.

The puncture injury reinforces the concern about increased material handling raised during the focus-group interviews. The added effort required for the recycling process increases the amount of material handling, creating a hazard that would not be present on construction sites which do not have recycling programs.

Pilot Study Conclusions

The pilot study provided a preliminary view of the effects of green design and construction practices on construction worker safety and health. The following findings can be drawn from the study:

- Current literature does not provide evidence of the impact of green design and construction on the safety and health of construction workers.
- Some features of green buildings designed and constructed to meet the LEED rating system, such as the construction material recycling programs, may negatively affect the safety of construction workers, while others, such as the use of low VOC materials, may help to eliminate construction site health hazards. It should be noted, however, that these hazards may occur on any project, not just on an LEED project.
- Project personnel predominantly felt that green building projects were a little safer than conventional building projects.
- One of the OSHA recordable injuries experienced on the project (foot punctured by nail) was related to a green feature (material recycling). Again, this type of injury may occur on any project, not just on an LEED project.

The results of the pilot study provide indications that green buildings may have some negative effects on construction worker safety and health. However, 19 of 24 interviewees (79%) felt that in general the construction of green buildings was either a little or much safer than construction of conventional buildings. These findings warrant additional investigation. As a result of this pilot study, the authors are in the process of conducting a detailed research study on many LEED-rated projects nationwide to understand these effects and provide more evidence on the subject. The results of this additional study are forthcoming.

Analyzing the Rating System

Another approach is to analyze the LEED rating system thoroughly and look for ways to change it in order to incorporate safety and health. When reviewing the system and its various green features, two questions come to mind:

1) If green design and construction practices cause negative impacts on construction worker safety and health, how can these impacts be countered?

2) How can LEED-certified buildings be taken one step closer to sustainability?

Sustainable Construction Safety & Health

One way to enhance construction safety and health within the context of sustainability is to consider construction worker safety and health in addition to the health of the final occupants. Since sustainable concepts address the environmental, economic and social well-being of human society, considering the safety and health of the workers who are part of a building's life cycle would take green buildings one step closer to sustainability. This concept can be thought of as "sustainable construction safety and health." Apart from serving as a strategy to reach sustainable construction safety and health, this concept will also help to mitigate any negative impacts created by LEED buildings.

Worker safety and health plays a major role in achieving sustainable socioeconomic development in the construction industry. The sustainable safety and health concept, which considers the social and economic well-being of construction workers, is a new approach to boosting their safety and health performance. This concept aims to sustain the construction worker's safety and health 1) from start to finish of a single project; 2) for each future project in which the worker is involved; and 3) during the worker's remaining lifetime after retirement, without any injuries or illnesses as a result of the construction work.

For example, the work lives of many construction workers have been shortened by repeated physical hazards posed by exposure to lead, silica, asbestos and many other chemical and environmental hazards (Hill, 2003). The condition persists even after the exposure ends (as in when the worker quits the

job or is reassigned). The worker's health could have been sustained had s/he been properly protected from the exposure or had the hazard been eliminated in the first place. Several elements, if properly implemented in a project development process, can help sustain worker safety and health. The sustainable safety and health concept approaches the consideration and implementation of safety and health measures from a different perspective.

A New Rating System

To implement this concept in the construction industry, the authors are developing a sustainable construction safety and health rating system. This rating will incorporate the safety and health elements to be implemented to sustain worker safety and health from project to project. The rating system will provide an opportunity to rate projects based on the importance given to and implementation of those elements that promote worker safety and health. Publication and presentation of the rating system are forthcoming.

Many parties are involved in the construction process: the owner, contractors, subcontractors, suppliers, sureties, financial agencies, architects, engineers and others. The foundation of the rating system is the combination of the safety and health initiatives typically implemented by the major parties (owners, designers, contractors and subcontractors).

The system will be categorized into several sustainable safety and health elements that will carry credits based on the frequency and severity of the issue they address. The credits under these categories will be combined to derive a total credit score for the project. A project that incorporates more initiatives would receive more credits. The premise of the rating system is that a higher number of total points received by a project would indicate a lower potential for incidents. The sustainable safety and health elements that are part of the rating system will come from two sources: literature and industry experts.

The rating system can be used as a tool to help sustain the safety and health of construction workers. It will unite and coordinate the efforts of the different parties on a project. In the past, safety has primarily rested on the constructor's shoulders. Many construction companies have developed positive safety cultures and are committed to creating an injury-free work environment on each project. However, no recognition, such as a gold or platinum safety certification, exists for those constructors who stand out in their commitment to reduce workplace fatalities and injuries.

This rating system can be used (in a manner similar to LEED) to rate projects based on the safety commitment of its team members. Recognition for using the rating system will be an added incentive to the project team to improve the project's safety and health performance. Since the rating system would require the joint efforts of all involved, a team effort would be another benefit that will help set in motion the sustainable safety and health drive in the construction industry.

Conclusion

Construction workers are exposed to many hazards and face significant risk of work-related fatality or injury/illness. Construction safety and health research over the past several decades has helped to improve the safety and health performance of workers. The advent of green design and construction in the U.S. has changed the way buildings are designed and constructed. The pilot study described in this article provides suggestive evidence of both positive and negative impacts of green practices on worker safety and health. Further research is needed to document all such effects associated with green buildings. While the positive effects can be appreciated, the negative effects should be eliminated.

If current green design and construction practices have negative effects on worker safety and health, those concerns can be mitigated through the integration of the sustainable construction safety and health concept within green design and construction practices. This combination will result in an integrated environment, safety and health rating system. This system is envisioned to provide a new perspective on the way industry practitioners view safety and health. Attaining injury-free environments and sustaining the effort in the construction industry will require a team effort. This rating system will fulfill the purpose of "building toward sustainable safety and health" by uniting the safety and health initiatives of all major parties in a project. ■

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