

Life Cycle Safety: How it supports Social Equity Goals

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Learning Objectives

Understand the links between worker safety and health, social equity, and green and sustainable development.

Become familiar with “Life Cycle Safety” and “Prevention through Design” (PtD) as practical approaches for understanding and addressing safety and health in the built environment.

Become familiar with construction and maintenance safety and health hazards and benefits associated with specific LEED credits.

Gain working knowledge of Life Cycle Safety and PtD through case studies.

Agenda

- 1. Rationale for including Safety & Health in sustainable green building and maintenance**
 - Seven questions about Social Equity and Safety
- 2. Life Cycle Safety and LEED credits of interest**
- 3. Vegetated Roofs as a case study**
- 4. Take home messages, questions and discussion**

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

1. Rationale for Safety and Health



“A 46-year-old electrical worker died when he fell through a skylight on a roof while installing solar panels”

Photo: California FACE Case 09CA003

Environment and Safety are sister disciplines: so why did this happen?



Have you seen our interviews in High Definition?


City Center Las Vegas: 6 LEED Gold certifications

25 FEB 2010

By David Basulto — Filed under: Hotels and Restaurants , City Center, Daniel Libeskind, KPF, Las Vegas, LEED, Norman Foster, Pelli Clarke Pelli Architects, Rafael Vinoly Architects, Rockwell Group, USA



CityCenter Crystals Veer Aria and Harmon



NEWS A&E OPINION SPORTS BUSINESS GUIDES BLOGS


History Fighting UNLV Sports Elvis NASCAR Gaming Ralston Showcase Today

5 COMMENTS PRINT E-MAIL SHARE

WORKER SAFETY:

After 6 die, OSHA finds violations

Summer sweep by federal, state agencies uncovered dozens of serious problems

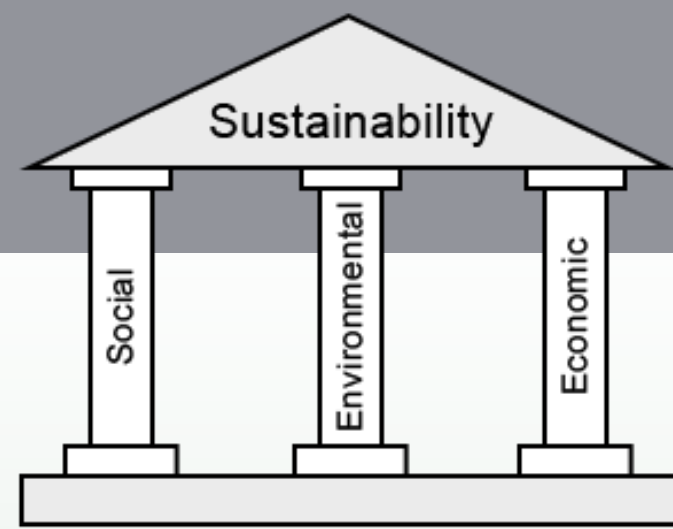


IMPORTANT: No indication that LEED credits were directly connected to poor safety record on this project

2009 wake-up call

Seven questions about social equity and safety

Why is social equity important?



- USGBC @20 years → Looking ahead to evolve “Green” towards true “Sustainability”
- Sustainability → **Raises the bar**
 - More comprehensive than green
 - Encompasses **Social Equity**
- Fostering Social Equity is one of 7 USGBC guiding principles

Is safety and health of buildings a social equity issue?

YES

Buildings connect to work...and work connects to safety

Buildings serve as workplaces

Building occupants are also workers

Health and Safety at work are among the fundamental pillars of decent work; these are also essential for a green economy

World Health Organization: Health in the Green Economy
(http://www.who.int/hia/green_economy/hgebrief_occ.pdf)

How does LEED currently address safety and health?

LEED prerequisites and credits do address HEALTH and WELL-BEING ... but not SAFETY

Primary focus → general building occupants
(e.g. indoor air quality for office workers)

Other types of occupants are a secondary focus
(e.g. construction workers, operations and maintenance (O&M) workers, and custodial workers)

“Other” occupants face higher risks:

Construction, operations, and maintenance involves hazards and exposures for these workers

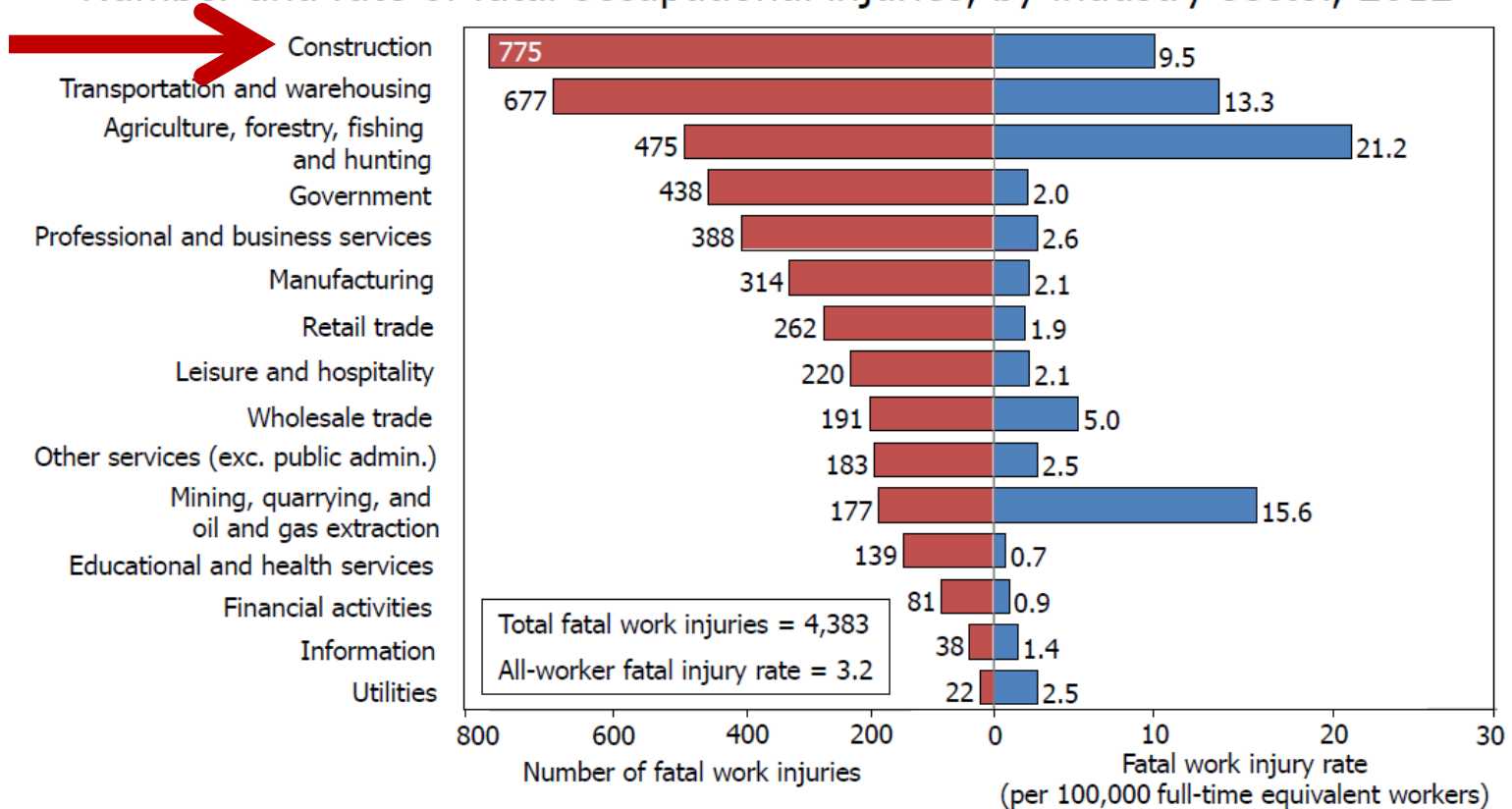


Fall exposures during Atrium Maintenance work. Photo: Mike Behm

Sustainable buildings need to address their needs

What is the extent of the problem?

Number and rate of fatal occupational injuries, by industry sector, 2012*



Construction experiences a disproportionate share of fatalities

(Source: US Bureau of Labor Statistics)

It's not just "NEW" construction "O&M" and repair work are important

Fully **1/3** of those who died while employed in construction were contracted to another industry such as government or real estate when the fatal injury occurred.

These are the workers that help operate, maintain, repair, and refurbish **existing** buildings and structures.

If these fatalities were grouped with those other industries, it would cause noticeable increases in fatality numbers.

- Education and Health services → would increase **12%**
- Government → would increase **34%**
- Financial activities → would increase **59%**

How does the US compare internationally?

The United States is NOT the leader in safe building

Lower fatality rates in UK, Australia, some EU nations
and Canadian provinces.

Construction fatality rates		(rates are per 100,000 workers)
US =	9.5	(2012)
UK =	1.9	(2012-13)
Singapore =	5.0	(2012)

Don't existing codes and regulations already address these safety issues?

Building codes

- Do address general occupant safety issues
- Do not address construction or O&M issues

OSHA regulations

- Address “employer” responsibilities
- Silent on owner and designer responsibilities
- Leaves gaps in duties

Safety is important for contractors, but how is it an issue for architects, designers, and LEED APs?

Eliminating hazards by **DESIGN** is the preferred approach to preventing work place risks using the “**Hierarchy of Controls**”

Designer
Reduce Major Risk

End user
Reduce Residual Risk

Inherently
Safe Design
Measures

Safeguarding
and
engineering
controls

Provide Use
information,
warnings,
instructions

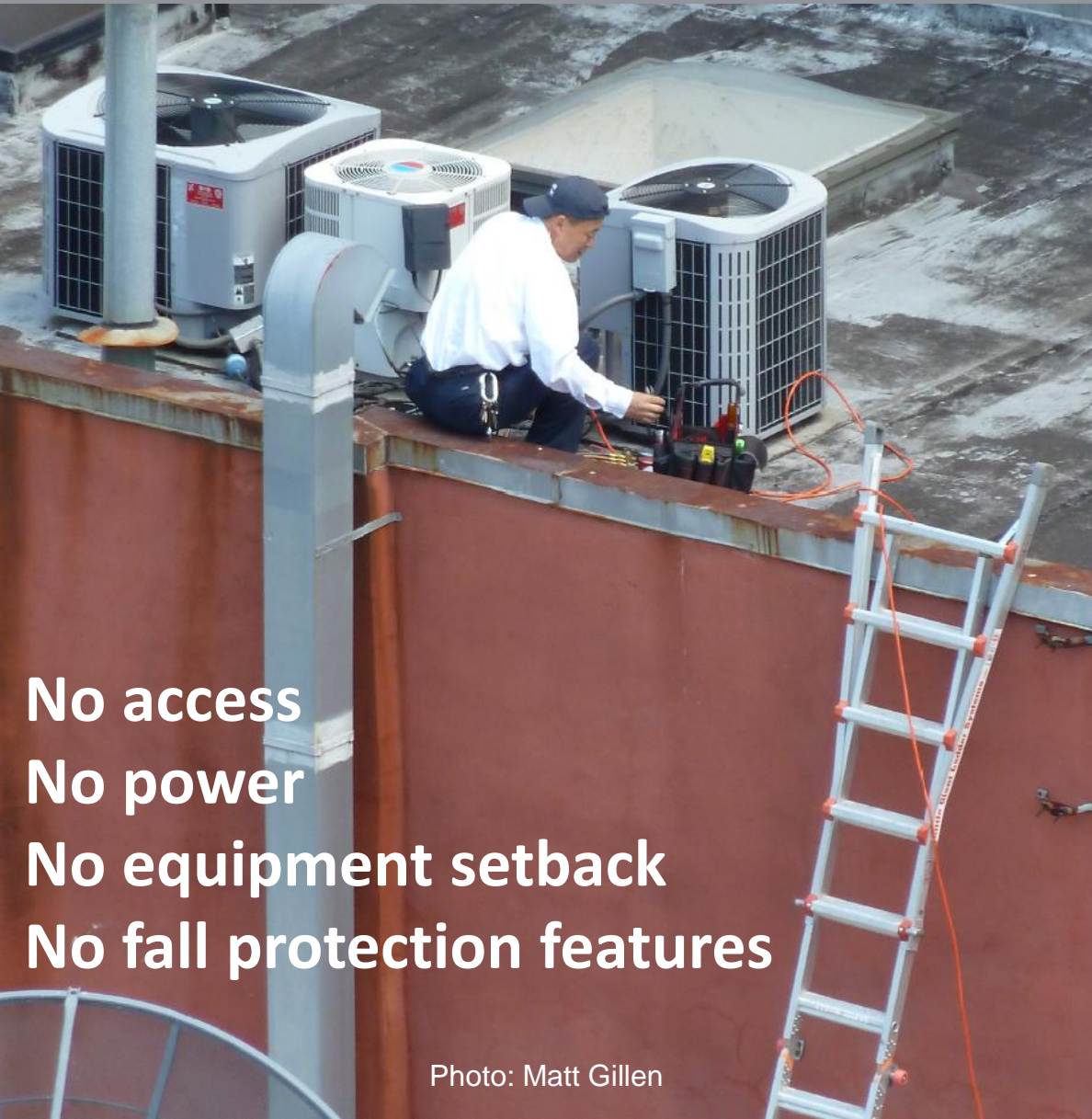
Administrative
controls,
Procedures

Training

PPE

Order of Preference and Effectiveness from high to low →

The design of this installation directly affects safety for this O&M worker



**Servicing rooftop
HVAC equipment**

Is this well-designed?

This is an “error trap”

**No access
No power
No equipment setback
No fall protection features**

Photo: Matt Gillen

Other countries make use of design to address workplace safety and health

- Safety duties assigned by law to **owners** and **designers**
- Safety is part of integrated planning.
- Design process used to
 - 1) reduce major risks, and
 - 2) communicate residual risks to contractors and owners

These laws and policies reflect research findings

Example: 42% of 224 construction fatalities included some link to design (US 1990-2003). [Behm, 2005]

COLLABORATION NEEDED

Design is at the top of the Hierarchy of Controls....

but safety and health professionals do not have design skills.

Design is done by architects and engineers....

yet they do not currently recognize or appreciate the need, do not have safety and health expertise, or may be concerned about liability.

→ → Need collaborative effort for a “Safety Design Review”

NIOSH Perspectives

“A sustainable product, process or technology should not only protect the environment and the consumer but also the worker.

Green jobs must be safe jobs”

NIOSH Science Blog: *Going Green: Safe and Healthy Jobs*, 1/4/2010

<http://blogs.cdc.gov/niosh-science-blog/2010/01/green-2/>

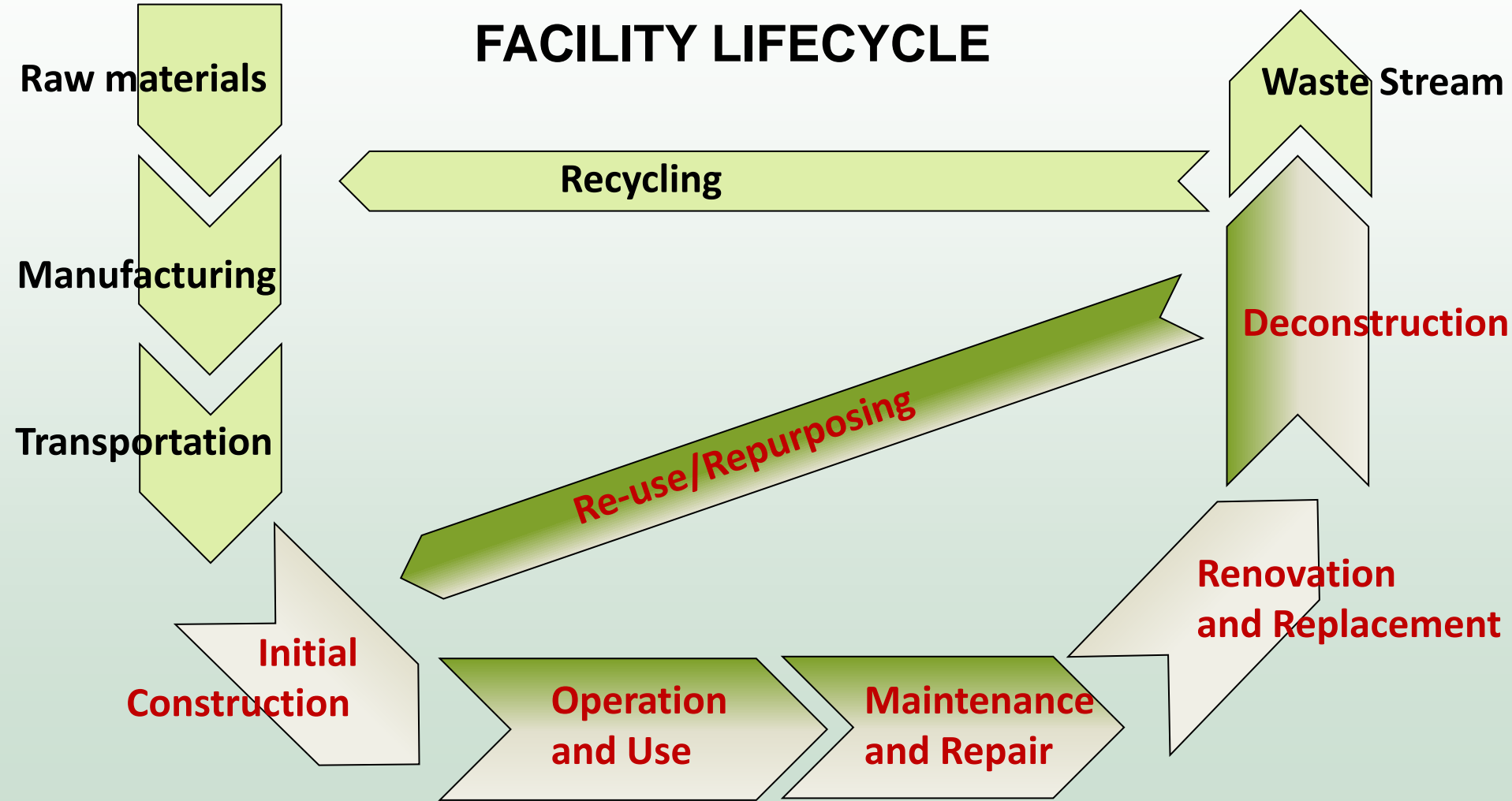
LEED uses DESIGN as its primary intervention

It already addresses worker health in an important way.

It provides an opportunity, in the name of sustainability, to further address safety design issues relevant for construction, operations, maintenance, and custodial workers

OPPORTUNITY

2. Life Cycle Safety and LEED Credits of Interest



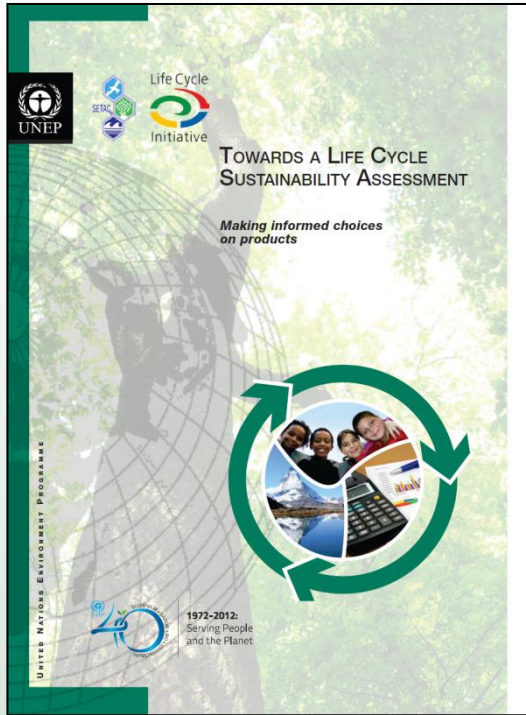
....Looking beyond initial construction

Every building roof needs maintenance

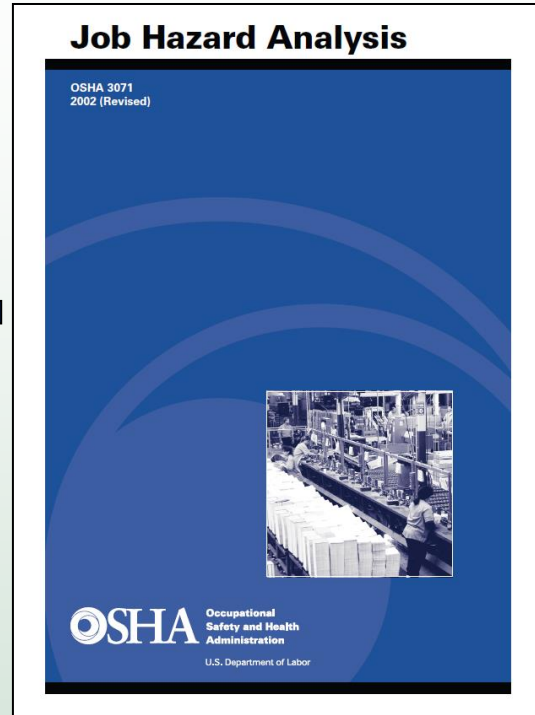
Roof work involves fall hazards

How are O&M workers to be protected?

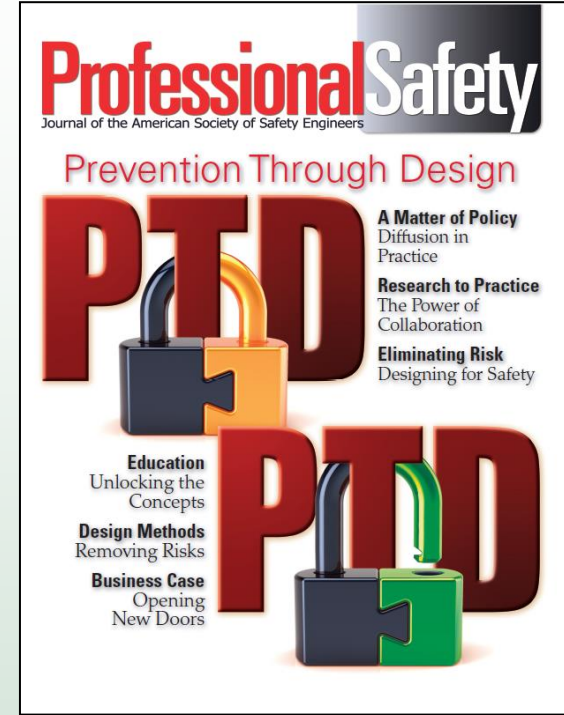
Life Cycle Safety =



Life Cycle Assessment
Thinking



Job Hazard Analysis
Thinking



Prevention through
Design Thinking

Looking comprehensively at all risks affecting all building stages

RISK = HAZARD X EXPOSURE

HAZARD:

potential source of harm and its severity.

EXPOSURE:

-Health hazard:

→ dose X time

-Safety hazard:

→ proximity to a hazard X time



Thinking Green? Consider Coal Tar Pitch

By Joe Mellott

Coal tar remains a desired and strong source of technology within the roofing

Coal Tars and Coal Tar Pitches*

Known to be human carcinogens

First Listed in the *First Annual Report on Carcinogens* (1980)

Carcinogenicity

Coal tars and coal tar pitches are *known to be human carcinogens* based on sufficient evidence of carcinogenicity in humans. Numerous studies, mostly case reports, have found that occupational exposure to coal tars or coal-tar pitches (coal-tar distillates) is associated with skin cancer, including scrotal cancer; workers in these studies have included patent-



Life Cycle Safety: Basic Steps

1) Screen: What green features/practices deserve review?

Credit for Public Transportation Access??? → **No**

Credit for Vegetated Roofs??? → **Yes**

2) Scope: What Life Cycle Stages are relevant?

- Construction**
- Operations and Use**
- Maintenance and repair**
- Renovation and replacement
- Deconstruction or repurposing

3) Identify tasks: What tasks/jobs are done at each stage by what groups?

Example: LEED Reference Guide on Reflective (cool) roofs:

“Materials with high reflectivity must be **cleaned** to maintain their heat island reduction properties.
... at least every 2 years to maintain good reflectance.

4) Evaluate risks: What are the potential risks?

- A) Identify key hazards
- B) Identify key exposures

- Slip and trip** from wet slippery surface
- Fall from roof** when working within 15 feet of edge

	Low Exposure Probability	Medium Exposure Probability	High Exposure Probability
Low Hazard Severity			
Medium Hazard Severity			Slip & Trip
High Hazard Severity			Fall from roof

5) Apply Hierarchy of Controls:

A) Upstream: Architect/design team

B) Downstream: Building owners and contractors

A) Upstream: Design phase review by architects/engineers

☑ Eliminate or reduce major risks

- *Design out hazards... or design in engineering control safeguards*

☑ Communicate residual risks downstream

B) Downstream: Work phase review by contractors and building owners

☑ Address communicated residual risks

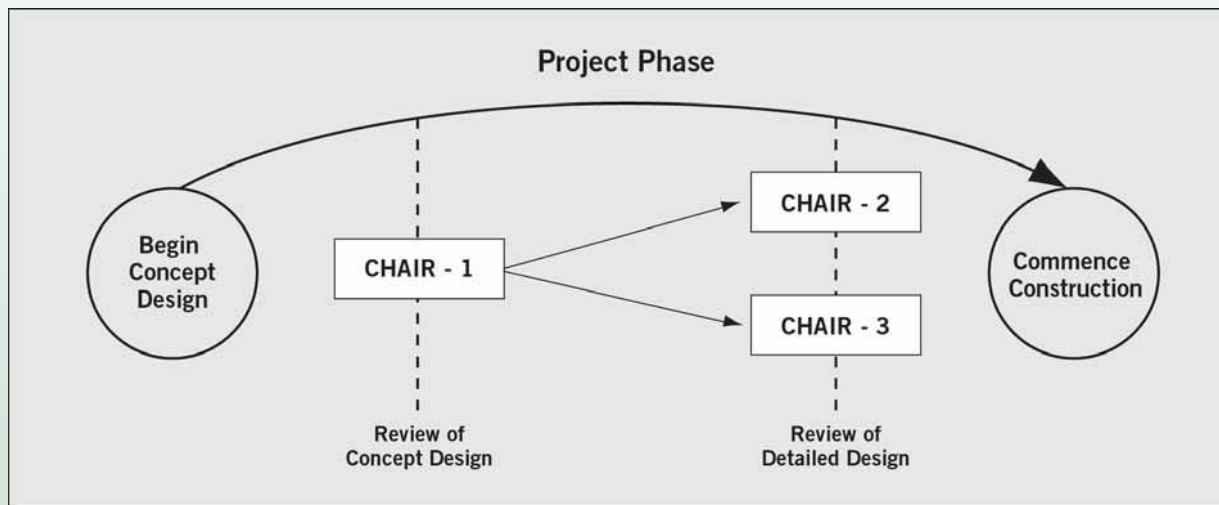
- *Use additional controls and administrative measures (supervision, training, pre-task planning, standardized procedures) and PPE to manage remaining risks*

Safety Design Review

Example: CHAIR

Construction **H**azard **A**ssessment **I**mplication **R**eview

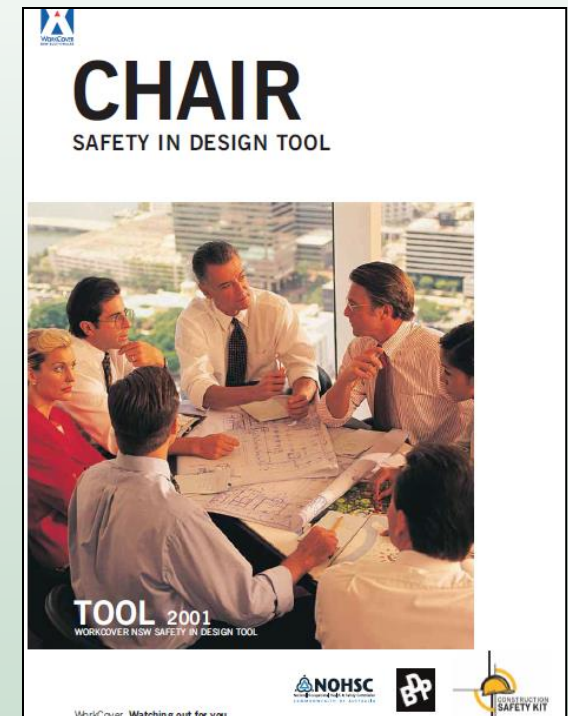
Used in Australia → Integrates 3 **Safety Design** reviews



CHAIR 1: General Review

CHAIR 2: Construction Review

CHAIR 3: Maintenance and Repair Review



http://www.workcover.nsw.gov.au/formspublications/publications/Documents/chair_safety_in_design_tool_0976.pdf

Life Cycle Safety: value proposition

- ✓ Helps designers include ALL building “occupants”
- ✓ Takes a Total Cost approach (vs. first cost only)
- ✓ Aligns with owner interests to improve long term operational efficiency
- ✓ Safer and more cost-effective O&M and renovation
- ✓ Increases reliability and safety of green features

“Reduced Operating Costs” cited as top (77%) reason for client interest in Green design.

McGraw Hill. [2012] Construction Industry Workforce shortages: Role of Certification, Training, and Green jobs in Filling the Gaps. SmartMarket Repo

“Plan methods for cleaning windows and atrium glass, it should not be an afterthought”

“Consider equipment replacement process when locating mechanical and emergency generator rooms”

Veterans Administration Design Alerts

<http://www.cfm.va.gov/til/Alert.asp>

Example: Lurie Children's Hospital, Chicago

Designers engaged facility O&M personnel in designing a large mechanical floor for a new 23 story hospital. They used BIM to explore tasks and designs.

"...The designer or engineer may think they need this type of fan, but the facilities person is thinking – to service this piece of equipment I have to pull it out a certain way and it weighs 150 pounds, so how do I get it out and down safely?"

These are the kinds of exercises the team can do on the front end that can make the difference between 50 years of a bad design or a design that is efficient, easy, and safe."

From Barista, D. 2013. World's tallest children's hospital pushes BIM to the extreme.
Building Design + Construction <http://www.bdcnetwork.com/world%E2%80%99s-tallest-children%E2%80%99s-hospital-pushes-bim-extreme>

Research findings

Safe design of skyrise greenery in Singapore

Michael Behm

Occupational Safety Program, East Carolina University, Greenville, North Carolina, USA, and

Poh Choon Hock

CUGE Research, Centre for Urban Greenery and Ecology, Singapore, Singapore

Abstract

Purpose – Singapore is transforming from a “garden city” to a “city-in-a-garden”. Designing for safety is recognized by researchers and some governments as a best practice in facilitating eventual worker safety within the built environment. The purpose of undertaking this research was to understand

Safety Risk Quantification for High Performance Sustainable Building Construction

Katherine S. Dewlaney, S.M.ASCE¹; Matthew R. Hallowell, A.M.ASCE²; and Bernard R. Fortunato III³

Abstract: A recent study found that Leadership in Energy and Environmental Design (LEED) certified buildings have a recordable injury rate that is 9% higher than traditional, non-LEED buildings. A follow-up study showed that there are distinct aspects of the design elements and means and methods of construction used to achieve LEED certification that have negative impacts on worker safety. The research

Technical Note

Safe Design Suggestions for Vegetated Roofs

Michael Behm¹

Abstract: Rooftop vegetation is becoming increasingly popular because of its environmental benefits and its ability to earn green-building certification credits. With the exception of one international guideline, there is little mention of worker safety and health in vegetated-roof codes and literature. Observations and field investigations of 19 vegetated roofs in the United States revealed unsafe access for workers and equipment, a lack of fall-protection measures, and other site-specific hazards. Design for safety strategies and the integration of life-cycle safety thinking with green-building credits systems are the preferred methods to reduce risk to workers on vegetated roofs. Design suggestions have been developed to add to the body of knowledge. The findings complement several National Institute for Occupational Safety and Health (NIOSH) construction and prevention through design (PtD) goals and are congruent with NIOSH's Safe Green Jobs initiative. Organizations that install and maintain vegetated roofs can utilize the findings to understand hazards, take precautions, and incorporate safety into their bids. DOI: 10.1061/(ASCE)CO.1943-7862.0000500. © 2012 American Society of Civil Engineers.

CE Database subject headings: Vegetation; Roofs; Design; Safety.

Author keywords: Vegetated roof; Safe design.

Are Green Building Features Safe for Preventive Maintenance Workers? Examining the Evidence

Mohamed Shamun Omar, ScD,* Margaret M. Quinn, ScD, Bryan Buchholz, PhD, and Ken Geiser, PhD

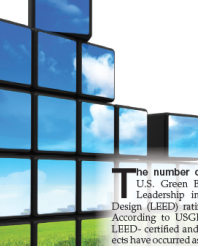
Background Many newly constructed green buildings (GB) are certified using the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) rating system for new construction and major renovation which focuses on architectural and mechanical design to conserve energy, reduce environmental harm, and enhance indoor quality for occupants. This study evaluated the preventive maintenance (PM) worker occupational safety and health (OS&H) risks related

to the design and operation of green buildings. The study used a method of JHA and results are presented in terms of mechanical building systems. KEY WORDS: preventive maintenance workers

Construction Safety

Peer-Reviewed

KEY WORDS: preventive maintenance workers



LEED Credits

How They Affect Construction Worker Safety
By John Gambatese and Nicholas Tynovits

IN BRIEF

There is a growing awareness that green design and construction practices may affect construction worker safety.

An in-depth review of the LEED-NC rating system for new construction found that many of the credits do not influence construction worker safety, while other credits may produce either a positive or a negative effect.

In some cases, attaining the LEED-NC credits may increase the amount of exposure to, or extent of, hazards that already exist on the construction site.

Suggested modifications to the LEED-NC credits have been developed to mitigate their effect on construction worker safety and aid in ensuring that green buildings are also safe to construct.

The number of buildings certified by the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) rating system continues to grow. According to USGBC (2010), more than 34,600 LEED-certified and -registered construction projects have occurred as of August 2010. An increasing number of federal, state and local agencies are augmenting their policies to mandate that the design and construction of public buildings in their jurisdiction be LEED certified or equivalent (Environment and Human Health Inc., 2010).

To achieve LEED credits, owners, designers and contractors incorporate green features into site selection and project design, and complete the construction work using green materials and practices. Examples of green elements are the use of alternative materials containing low levels of volatile organic compounds (VOC), the use of reclaimed materials from demolished buildings, the implementation of green roofs and the use of alternative sources of energy to power the facilities. For example, one site used temporary protection of HVAC ducts during construction as part of the LEED efforts

to eliminate contaminants within the HVAC system and improve indoor air quality. The intent is to reduce the project's energy and environmental impacts. As the number of LEED-certified projects grows, there has been increasing awareness and concern about the potential effect that green features have on occupational safety and health (OSH). Compared to traditional design and construction practices, green features may pose additional or new risks to worker safety and health through the introduction of alternate materials, as a result of different or additional work, or by creating an expanded or unintentionally hazardous work environment.

Based on practical experience, Walsh (2011), indicates that some aspects of buildings related to LEED, such as increased use of windows and skylights, installing photovoltaics on roofs, and recycling building materials that are heavy or contain protruding rebar or sharp edges, have the potential to increase safety hazards. Research corroborates this experience with regard to skylights and installing photovoltaic panels (Gerhold, 1999).

The potential for green features to create OSH hazards also came to light during the construction of the City Center project in Las Vegas, NV. While the project attained multiple LEED certifications for its design and construction efforts, it experienced numerous fatalities along with concerns about safety and health related to the construction methods designed to achieve LEED credits (Gittman, Halk, Stafford, et al., 2009; Silms, 2009). The extent to which green design and construction has expanded throughout the construction industry in-

John Gambatese, Ph.D., P.E., is a professor in the School of Civil and Construction Engineering at Oregon State University. He earned a B.S. and an M.S. in Civil Engineering from the University of California at Berkeley and a Ph.D. in Civil Engineering from the University of Washington. He has worked in industry as a structural engineer and as a project engineer for construction. He started his current position in 2000 after 3 years on the faculty at University of Nevada, Las Vegas, and 1 year as an acting assistant professor at the University of Washington. Gambatese has taught courses on construction contracts and specifications, construction safety and productivity improvement, planning and scheduling, structural analysis and design, temporary construction structures and engineering economics. He has performed research and published numerous articles on construction worker safety, sustainability,

constructability, innovation, construction contracting and life cycle properties of civil engineering facilities. He is a member of the American Society of Civil Engineers (ASCE) and ASSE, and actively participates on ASCE's Prevention through Design Committee, Construction Site Safety Committee, Constructability Committee, and Construction Research Council.

Nicholas Tynovits is a Ph.D. student in the School of Civil and Construction Engineering at Oregon State University. His educational background includes a B.S. and an M.S. in Civil Engineering from Purdue University with emphasis in structural engineering. After completing his M.S., he worked in industry at Tynovits Bros. Ltd., a steel fabrication company in Cyprus, for 4 years.

Evaluating LEED Credits

Designers and construction project managers interviewed about 6 LEED projects

Findings

- **Potential increase in risk: 13 credits**
- **Potential decrease in risk: 5 credits**
- No or negligible change **39 credits**
- Mixed impact **2 credits**

Identification of Safety Risks for High Performance Sustainable Construction Projects. Fortunato, Hallowell, Behm, Dewlaney JCEM April 2012

NIOSH and Construction safety & health pros reviewed 2009 LEED New Construction credits

Findings

- **Potential increase in risk: 11 credits**
- **Potential decrease in risk: 7 credits**
- No or negligible change **38 credits**
- Mixed impact **1 credit**

Integrating Occupational Safety and Health into the U.S. Green Building Council LEED New Construction Credits: A Preliminary Report. NORA/NIOSH 2011

About 2/3 of LEED credits are “NEUTRAL”

A smaller manageable number affect potential risks

Final safety and health impact depends on whether additional safety design and planning measures are taken

LEED credits – Potential to INCREASE risks

Prerequisite or Credit	Risk issue example
High Priority Site	Brownfield site hazardous materials
Rainwater management	Confined space hazard with cisterns and detention systems
Heat Island Reduction	Falls from vegetative or reflective roofs
Renewable Energy Production	Falls from roof-mounted solar and wind features
Waste Management Planning	Injuries and musculoskeletal disorders from material handling exposures
Building Reuse and Whole Building Life Cycle Assessment	Material handling injuries, collapse and struck by injuries
Construction and Demolition Waste Management	Injuries and musculoskeletal disorders from material handling exposures
Daylighting	Falls from and through skylights and atria

LEED credits – Potential to DECREASE risks

Prerequisite or Credit	Risk issue example
Integrated Project Planning and Design	(Healthcare) Opportunity to address safety during design.
Construction Activity Pollution Prevention	Reduction of dust exposures
Construction Indoor Air Quality Management Plan	Encouragement to control contaminant generation
Low-Emitting Interiors	Reduction of toxic chemical exposures
Prerequisite: Green Cleaning Policy	Reduction of toxic chemical exposures (EBOM)
PBT Source Reduction: Mercury, Lead, Cadmium	Reduction of toxic chemical exposures
Credit: Green Cleaning: Equipment	Reduction of musculoskeletal disorders (ergonomics), noise, fatigue

Life Cycle Safety Review example: Photovoltaic (PV) Panels



Photo: NIOSH Draft PtD Solar Panel Case Study

Summary of Steps 1- 3

STAGE	GROUP	KEY TASKS	HAZARDS/RISKS
Installation	Construction -Electricians	-Moving panels and supplies to roof -Installing panels and wiring	-Cranes/rigging -Falls from ladder -Falls from roof -Material handling -Electric shock
Maintenance	Maintenance -In house or electricians	-Replace/repair broken panels -Clean panels -Inspection	-Falls from roof -Electric shock
Recycle and replace	Construction -Electricians	-Removal of panels after 25 year life span -Moving new panels to roof -Installing new panels and wiring	-Cranes/rigging -Falls from ladder -Falls from roof -Material handling -Electric shock

O&M considerations for Onsite Renewable Energy Credit

*“Provide building operators with the manufacturer’s recommendations for operating and maintenance procedures. **Operators may need guidance on how to maximize efficiency, including information about cleaning method and frequency for solar panels**”* LEED Reference Guide

Apply the Hierarchy of Controls

Upstream: design options to reduce fall hazard:

Designer to provide for fall protection via:

Parapet
or Permanent guard rail
or anchors and horizontal lifeline
for fall restraint or fall arrest system



Another strategy: design to build sections on ground



Warehouse project Fatality

16,272 solar panels
were being installed on
a roof with
357 existing skylights

18 inch clearance
between skylight and PV
panels

**Need for safeguards
and safety planning**

“A 46-year-old electrical worker died when he fell through a skylight on a roof while installing solar panels. The victim was carrying solar panels and walking backwards because of the limited space around the skylight. As the victim was walking backwards, he tripped on the raised edge of the skylight frame and fell onto the skylight.”

<http://www.cdc.gov/niosh/face/stateface/CA/09CA003.html>

Other emerging Life Cycle Safety issues for PV?

- Firefighter safety when roof access needed

Rooftop solar panels become new enemy of U.S. firefighters

Thu, Sep 5 2013

By Daniel Kelley

DELANCO, N.J., Sept 5 (Reuters) - Putrid air hung over a luncheon meats warehouse long after a blaze consumed the building where frustrated firefighters met their enemy: rooftop solar panels.

Loved by the green movement, solar panels pose a growing threat to firefighters, who may suffer electrical shocks from panels that typically cannot be turned off, said John Drengenberg, consumer safety director for Underwriters Laboratories.

Even when systems are equipped with shutoffs, any light can keep panels and their wires energized, Drengenberg said.

Gaining access to roofs gives firefighters advantages such as venting gases, and the panels get in the way, said Ken Willette, who manages the public fire protection division at the National Fire Protection Association.

- Recycling of old solar panels

[Trashing Old Solar Panels is a More Complicated Process Than You Think \(http://www.kcet.org/news/rewire/solar/photovoltaic-pv/state-rejects-loosening-toxic-waste-regs-on-old-solar-panels.html\)](http://www.kcet.org/news/rewire/solar/photovoltaic-pv/state-rejects-loosening-toxic-waste-regs-on-old-solar-panels.html)

by [Chris Clarke](#)

on October 17, 2013 3:33 PM

- Others?

Need for safety guidance



3. Vegetated Roofs as a Case Study

Potential relevant LEED credits

- **Site Development, Protect or Restore Habitat**
- **Site Development, Maximize Open Space**
- **Storm Water Design, Quantity Control**
- **Heat Island Effect, Roof**

From 2-9 points possible

http://www.greenrooftechnology.com/leed/leed_Greenroofs

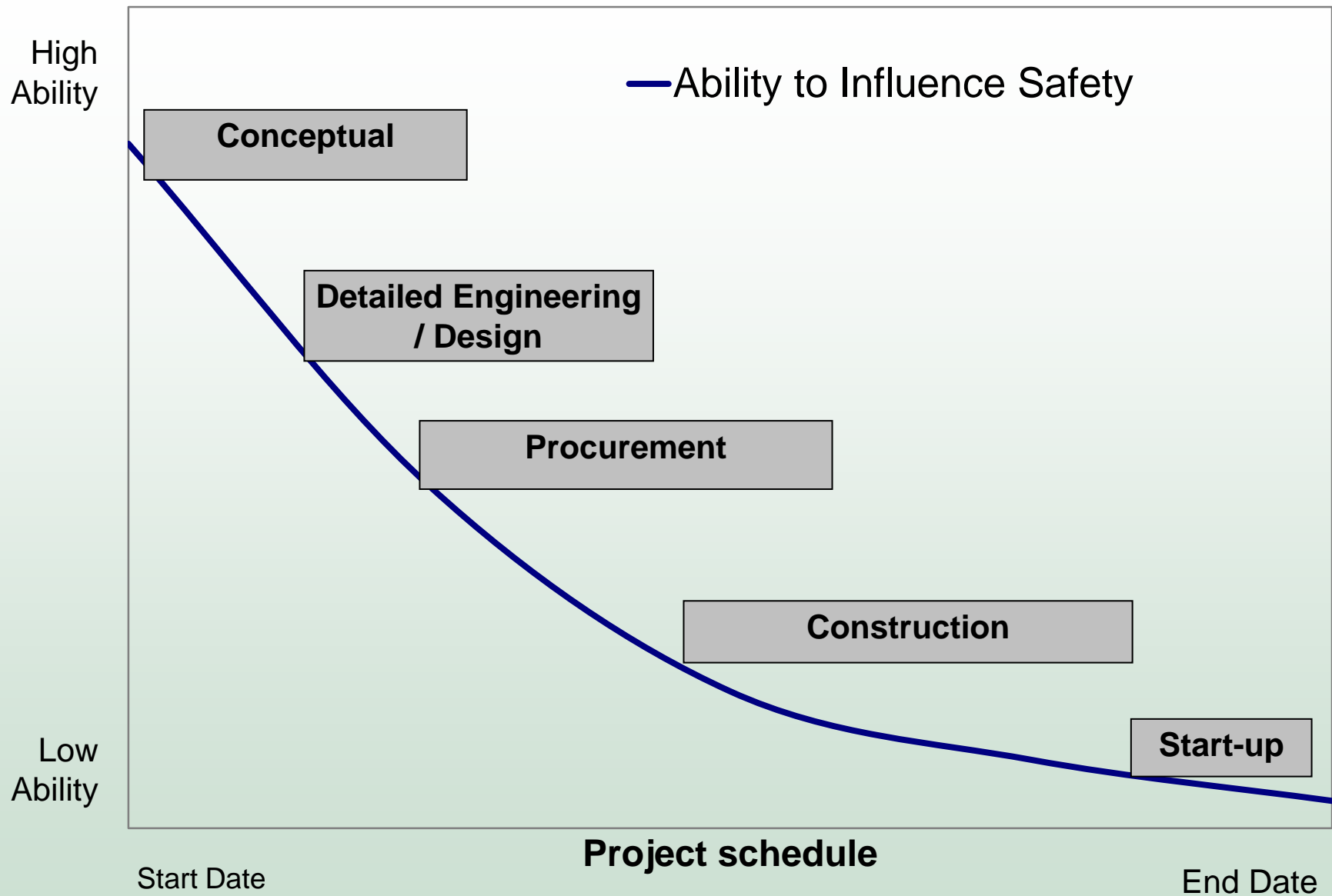




Photo: Mike Behm



Photo: Mike Behm



Photo: Mike Behm



When fall protection anchorage is not designed into the roof, workers use whatever they can to tie off....

.....even if it will not support a fall arrest

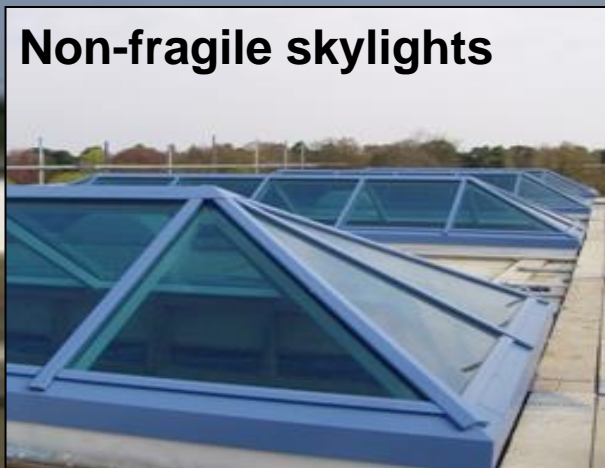
Yes



Photo: Mike Behm



Skylight guards



Non-fragile skylights





Photo: Mike Behm



Photos: Mike Behm

3001



Photo: Mike Behm



Centre for Urban Greenery & Ecology
CUGE Standards



GUIDELINES ON DESIGN FOR SAFETY ON ROOFTOP GREENERY

CS E02:2009

Guidelines on Skyrise Greenery



Photos: Mike Behm



Photo: Mike Behm



Photo: Mike Behm



Photo: Mike Behm



Photo: Mike Behm



Photo: Mike Behm

Comparing Singapore and the U.S. Safe **Access** to extensive Green Roofs

Rating	Singapore		US	
	N	%	N	%
Excellent	2	18.2	6	35.3
Good	9	81.8	3	17.6
Fair	0	0	3	17.6
Poor	0	0	5	29.4
Total	11	100.0	17	100.0

Comparing Singapore and the U.S.

Fall Protection on extensive Green Roofs

Rating	Singapore		US	
	N	%	N	%
Excellent	1	11.1	5	29.4
Good	3	33.3	1	5.9
Fair	5	55.6	2	11.8
Poor	0	0	9	52.9
Total	9	100.0	17	100.0



Green Walls

**Design...
or lack of design affects safety**



Front

Photos: Mike Behm



Rear
access



Green Wall with rear access
Good design is safe and efficient



Rotating Plant Column
Good design is safe and efficient

Using Life Cycle Safety and PtD for vegetated roofs

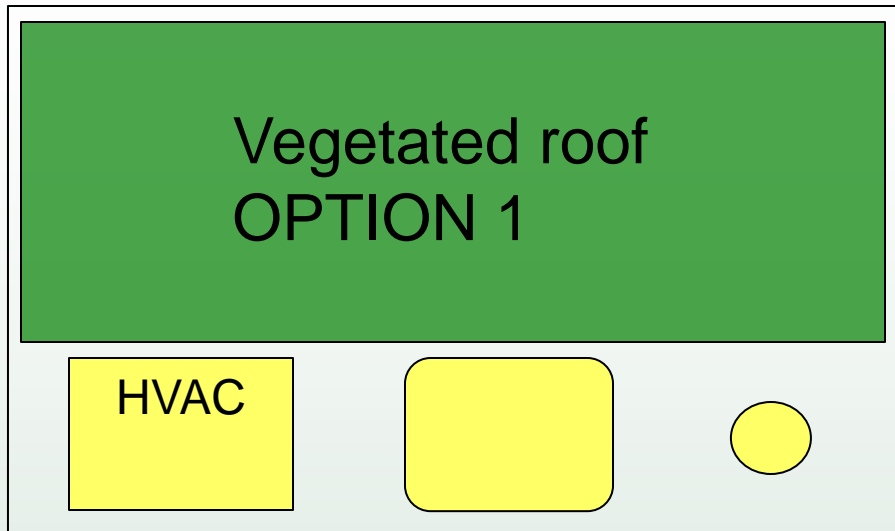
LIFE CYCLE STAGE	EMPLOYEE GROUP	KEY TASKS	HAZARDS/RISKS
Installation	Construction -Roofers -Landscapers	-Moving materials to roof -Installing materials and plants	-Crane and rigging -Material handling -Falls from roof
Maintenance	Maintenance -In house or landscapers	-Plant care -Irrigation -Inspection	-Roof access -Slips and trips -Falls from roof

Bottom line:

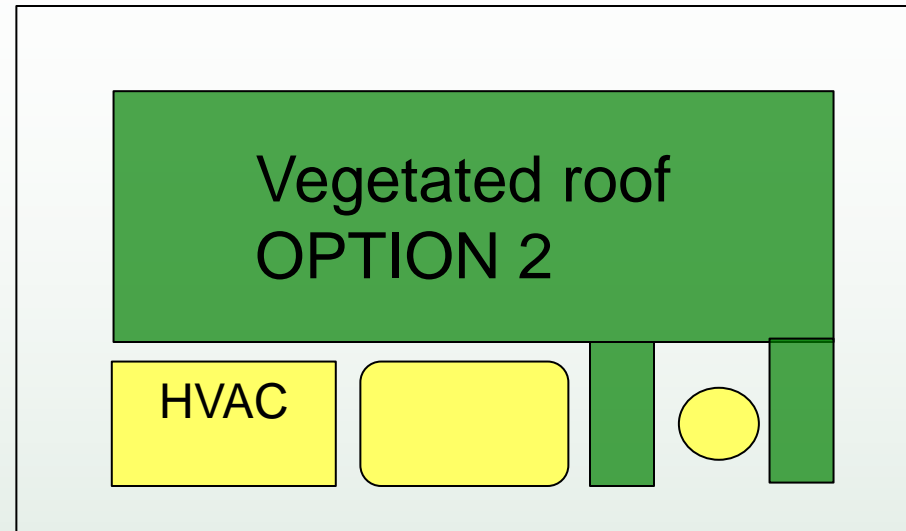
Vegetated roofs require regular roof access over their Life Cycle.

Safety Design Review and Options

Roof Plan view



Roof edge
↓



- ✓ **Plantings:** up to roof edge (Option 1) vs. safety buffer zone (Option 2) ?
- ✓ **Selection of plants:** consider maintenance needs
- ✓ **Safe access to roof:** for workers..... and for water and equipment
- ✓ **Fall Protection:**
 - Isolate fall hazards using parapet or permanent guardrail?
 - Secure the worker using fall restraint or fall arrest system with anchors?

Integrate safety into information transmitted to facility owner

LEED Reference Guide O&M considerations:

*The Project team should establish an **operations plan** for inspecting the roof membrane as well as maintaining drainage paths.*

This plan can also include information on fall protection features and measures to be used for inspection, maintenance, and replacement tasks



What really is Exemplary Performance?

LEED Reference Guide: 2009 Edition

Exemplary Performance

*Projects may earn an Innovation in Design credit for exemplary performance by demonstrating that **100% of the project's roof area** (excluding any mechanical equipment, photovoltaic panels, and skylights) consists of a vegetated roof system.*

This means that plantings would go right up to the roof edge

→ Increased exposure to falls during maintenance

→ Increased need for fall protection

Is it really exemplary if no fall protection is designed in?

4. Closing Comments

How are green and conventional building practices similar?

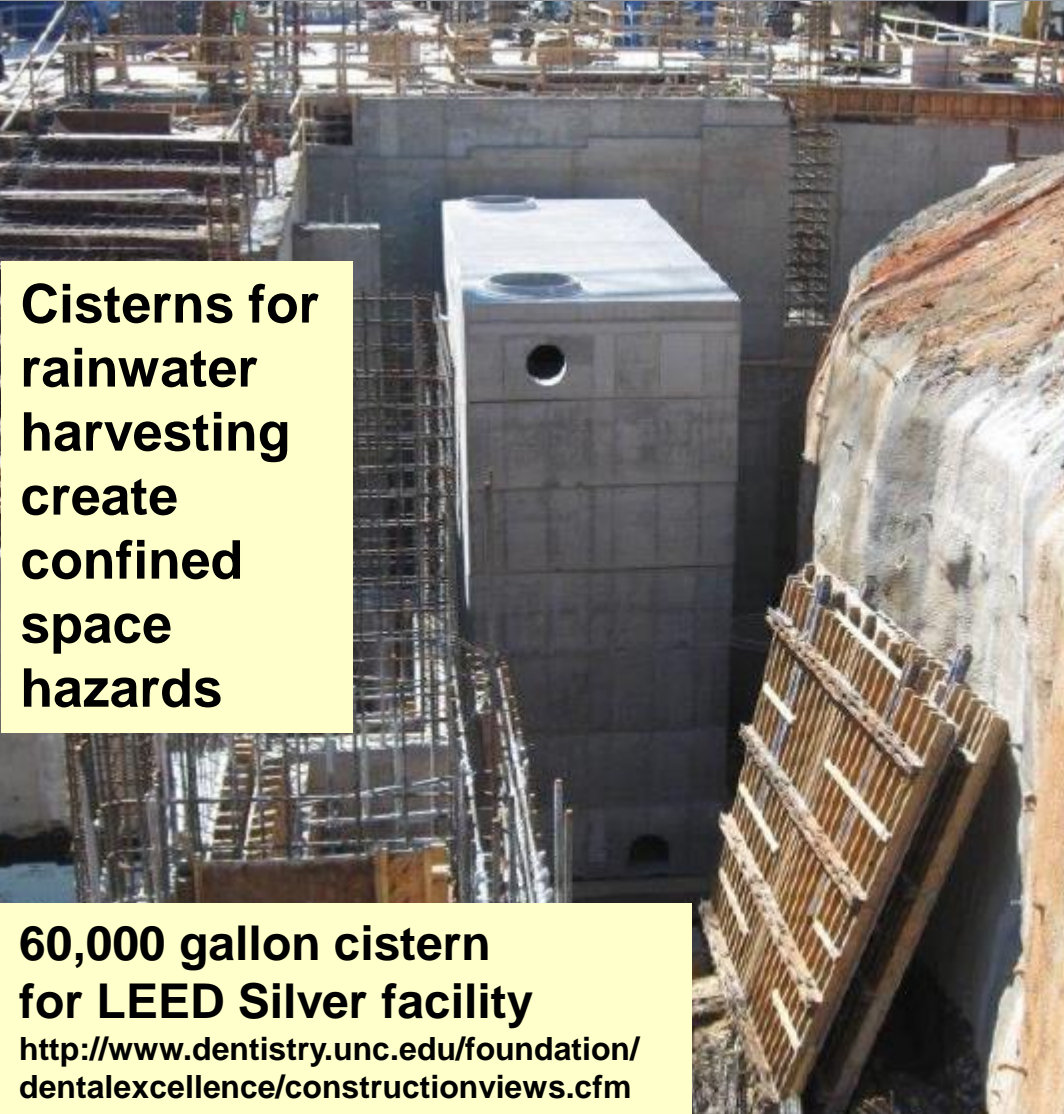


LEED Gold building under construction

Photo: Matt Gillen

- ✓ Underlying tasks are mostly similar
- ✓ PtD and Life Cycle Safety needed...but *NOT* typically done
- ✓ Safety viewed solely as:
 - a contractor responsibility
 - an OSHA compliance issue

How are green and conventional building practices different?



Cisterns for rainwater harvesting create confined space hazards

60,000 gallon cistern for LEED Silver facility

<http://www.dentistry.unc.edu/foundation/dentalexcellence/constructionviews.cfm>

FOR GREEN:

- ✓ Many **NEW** features and practices
- ✓ Emphasis on “**Best Practice**”...not compliance
- ✓ Some unique hazards and exposures, and gaps in establishing safety guidance
- ✓ Some changes in work sequencing

Why should LEED be different when it comes to Life Cycle Safety?

- ✓ LEED is about leadership, sustainability, and **“Best in Class building strategies”***
- ✓ Source of Innovation. LEED is about **“transforming the way we think about how our buildings and communities are designed, constructed, maintained and operated across the globe”**....* (* from <http://www.usgbc.org/leed>)
- ✓ LEED already provides health benefits for construction, O&M, and custodial workers → foundation for future efforts
- ✓ LEED already encourages integrated project planning and during design → foundation for adding safety perspectives

Good initial focus for collaboration: LEED features on roofs

- ☑ Falls → leading killer of construction workers
 - **Falls from roofs → top source of construction falls.**

- ☑ Several relevant LEED credits involve roof work
 - **Daylighting** (skylights)
 - **Heat Island reduction** (vegetative and reflective roofs)
 - **Energy production** (rooftop solar and wind installations)

Use a **“*Safe Roof Plan*”** to describe roof-related Life Cycle safety issues and resulting design and planning options.

Essence of a Safe Roof Plan = Think “Occupant-ready”

- 1) Group O&M workers with regular building occupants
- 2) Design the green roof feature for regular building occupant access and use



Publicly accessible green roofs are required to have fall protection features

Path Forward

The meaning of 'green' is evolving, to more fully include human and social relationships to the built environment.

USGBC Strategic Plan (2009)

Sustainability raises the "green" discussion from materials and processes to include marketing, distribution, disposal and human labor.

Evans (2006), San Francisco Chronicle



NIOSH initiatives underway

- Dialogue with USGBC
- Outreach to share ideas
- Concepts for:
 - pilot credits to address safety
 - safety guidance for existing credits
 - Webinars and education sessions
- Further development of Life Cycle Safety and PtD tools and approaches
- Concepts for case studies to evaluate PtD benefits on lifecycle cost of ownership and constructability
- Support for research and engagement

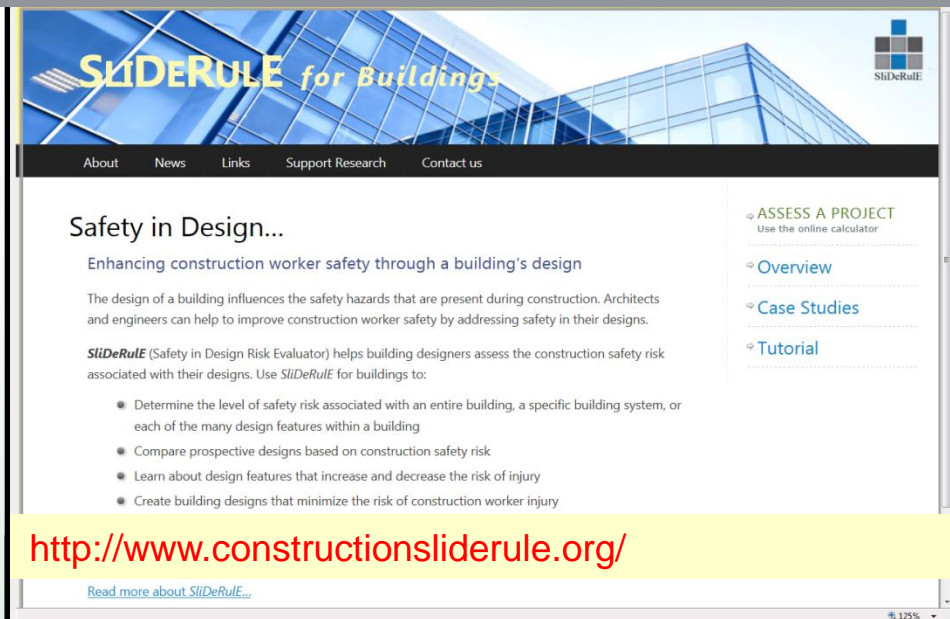
Examples of available Tools



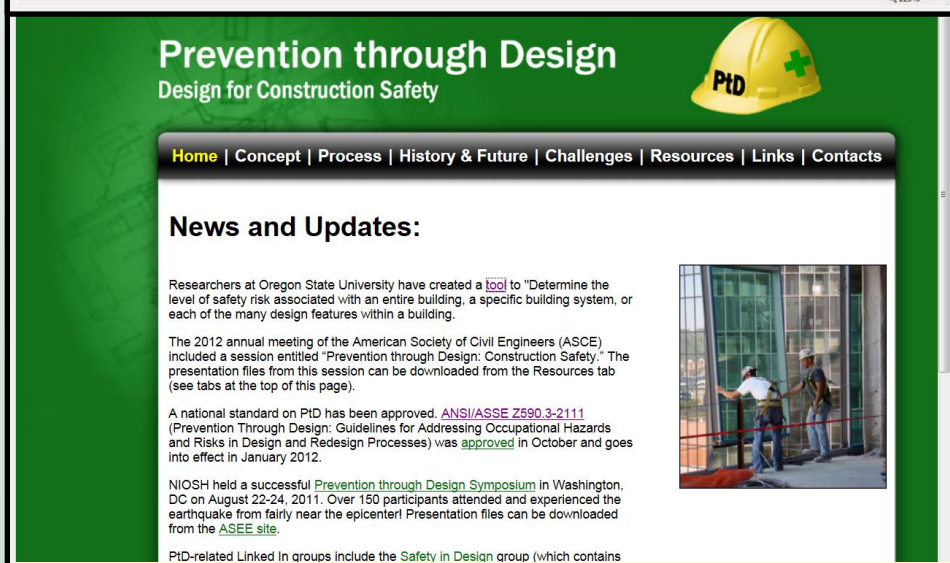
<http://sustainablesafetyandhealth.org/>



<http://www.constructioncoejobs.com/small-business-incubator/sustainability-resources-and-trainings/green-building-safety-curriculum>



<http://www.constructionsliderule.org/>



<http://www.designforconstructionsafety.org/>

**AUDIENCE QUESTIONS
and
DISCUSSION**

Thanks! and contact information

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<http://www.cdc.gov/niosh/topics/construction/>

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