Exhibit 2

Workplace design solutions

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

Preventing Falls through the Design of Roof Parapets

Summary

Workers are exposed to risks from falls during construction, operation, maintenance, and demolition of buildings. Parapets are the parts of the wall assembly that extend above the roof [Rajendran and Gambatese 2013] and can prevent falls from low-sloped (flat) roofs. Other design features that can prevent falls include using guardrail systems and permanent anchor points (for use with personal fall arrest systems and lifelines) [See NIOSH 2013 for more information].

Workers may be close to roof edges and exposed to fall hazards when accessing building roofs during construction and for operation and maintenance tasks after the building has been completed. Workers may be close to roof edges when transferring material to and from the roof, accessing rooftop equipment, and communicating with coworkers on the ground. To prevent falls, parapets can be built on the roof edges during building construction. The need for additional fall arrest roof anchors (and related personal fall arrest equipment), temporary barricades, or signs during operation and maintenance tasks would thus be minimized or even eliminated if parapets are more than 39 inches tall [29 CFR* 1926.502(b)(1)].

Description of Exposure

Construction is one of the most dangerous industries [Toole and Gambatese 2008], and falls are a frequent cause of fatal and nonfatal injuries. Of the 4,609 fatal work injuries that occurred in 2011, 541 (12%) were the result of falls to a lower level [BLS 2012]. Worker's compensation providers estimate that each fall from elevation (fatal or nonfatal) in construction costs between $50,000 and $106,000 [OSHA 2012].

The NIOSH Fatality Assessment and Control Evaluation (FACE) program (an activity of the NIOSH Division of Safety Research (DSR) investigates worker fatalities to determine causes, and recommends injury prevention measures. Behm [2005] analyzed 224 FACE case reports and found that 42% of fatalities might be linked to the building design, and 6 fatalities may have been prevented if the building designs had included parapets for fall protection.

Code of Federal Regulations. See CFR in References.

Prevention through Design (PtD)

PtD addresses worker exposure to hazards during the design stages of a project. When a building is designed, risks of fall-related injuries and fatalities can be minimized with a life-cycle approach to address fall hazards for the workers who construct, operate, maintain, and eventually demolish a building. This approach can include using a building's features to address fall hazards in construction plans, considering safety when buying equipment, and communicating risks to building owners and facilities personnel [Behm 2005].

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DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Case Study

A 32-year-old project engineer was fatally injured when he fell from a roof. Three engineers were examining a building and measuring the roof for an insulation cost estimate. The roof was completely flat all the way to the edges and did not have a parapet. Two of the engineers were measuring the roof with a tape measure. The third was writing down the measurements. As they were about to leave, they noticed that they had not measured one section of the roof. While two engineers and the maintenance person waited by the door, the victim, carrying a flashlight, pulled out the tape measure while quickly walking backward from the door. He walked over the edge and fell. The distance from the penthouse door to the edge of the roof was approximately 38 feet. The victim fell approximately 29 feet to the sidewalk below. Emergency medical services were called and arrived on the scene. The victim was transported to a nearby local hospital where he was pronounced dead on arrival [NIOSH 1997].

Although a fall protection system is not be required by law (29 CFR 1926.500) when performing site evaluations for bids, controls for fall hazards are still necessary, such as a safety monitoring system [NIOSH 1997]. Parapets would have ensured that fall protection was already designed into the building. In the above case, the parapet was not required by law but might have saved the worker.

Design Solutions

The decision to add parapets or to extend the height of a planned parapet is made during the conceptual design of a building. Since workers need to access the roof during construction of a building, they can be exposed to fall hazards before parapets can be completed. During this time, the following interim measures may be needed to protect workers from falls:

- Job-built or commercially available guardrails that meet OSHA height and strength requirements [Bobick et al. 2010]
- Properly designed anchor points with appropriate personal fall arrest systems and lifelines
- Other forms of fall protection, such as safety netting

In addition, some parapet designs require that building columns extend above the roofline of the building, so the parapets can tie into the columns. While these parapets are being constructed, the extended columns can provide temporary lifeline anchor points. Such columns also provide a visual reference point for the roofing crew, which has been suggested as an important component for maintaining balance [Hsaio and Simeonov 2001]. After parapets are finished, they can serve as fall protection for the remainder of the building construction.

Eliminating hazards is the first priority in the hierarchy of controls, and takes precedence over the use of personal protective equipment [Gambatese et al. 2005]. Elimination of a hazard is best accomplished in the concept and design phase of a project [ANSI/ASSE 2011]. Once complete, parapets eliminate the fall hazard. They are considered to be a passive fall protection system, meaning workers are protected without the need for additional action. Passive systems are preferred over active systems that depend on specific action by the worker [NISOH 2000].

Standards

OSHA construction regulations require guardrails for elevated work (6 feet or more above the ground) to be a height of 42 inches (1.1 m) plus or minus 3 inches (8 cm) [29 CFR 1926.502(b)(1) www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10758&p_table=STANDARDS].

Roof designs that included 42-inch high parapets would meet the minimum OSHA requirements for guardrail fall protection [Gambatese et al. 1997] (See Figure 1).

Cost Savings/ Advantages

Since Federal OSHA regulations state that employee safety is the responsibility of the employer, hazards are not always considered by architects or design engineers during the design phase of a construction project. Issues might include the cost and time to construct the parapet; designs are meant to be completed on schedule and cost effective for the owner [Gambatese et al. 1997; Gambatese et al. 2005; Toole and Gambatese 2008]. With a large roof, the increased cost that comes with guarding the perimeter may be significant [Rajendran and Gambatese 2013].

But these increased costs of safe design (for labor, materials, including parapets etc) can be offset by long term savings over the life cycle of the building that begin to accrue soon after construction of the parapet. When parapets are designed in and fall hazards reduced through design, temporary guardrails and other types of fall protection may not be needed during most roof maintenance operations [Gambatese et al. 1997].

The use of parapets can save costs in additional ways. It is recommended that equipment, vents, access points, etc., be placed 15 feet back from the roof edge to reduce the risk of falling during servicing and maintenance. This would no longer be necessary with parapets. More of the roof can be used, making work more efficient [OSHA Alliance Program 2010; Rajendran and Gambatese 2013]. If properly designed (39-inch or taller) parapets are in place, fall restraint systems would no longer be needed for maintenance work within the perimeter of the parapet. However, fall protection would still be required for work on roof-top equipment/design features at heights greater than 6 feet, over the edge of the parapet, on the face of the building, and for work near unguarded roof openings and skylights.

Including parapets of sufficient height is also advantageous when green features such as vegetated roofs or rooftop photovoltaic solar panels are being considered, as these features do involve regular maintenance activities. Additional advantages include the following [Pupkin 2013]: (1) Parapets reduce wind flow over the roof so that wind uplift resistance is evenly distributed. (2) Parapets can help prevent rainwater damage on the exterior of buildings.

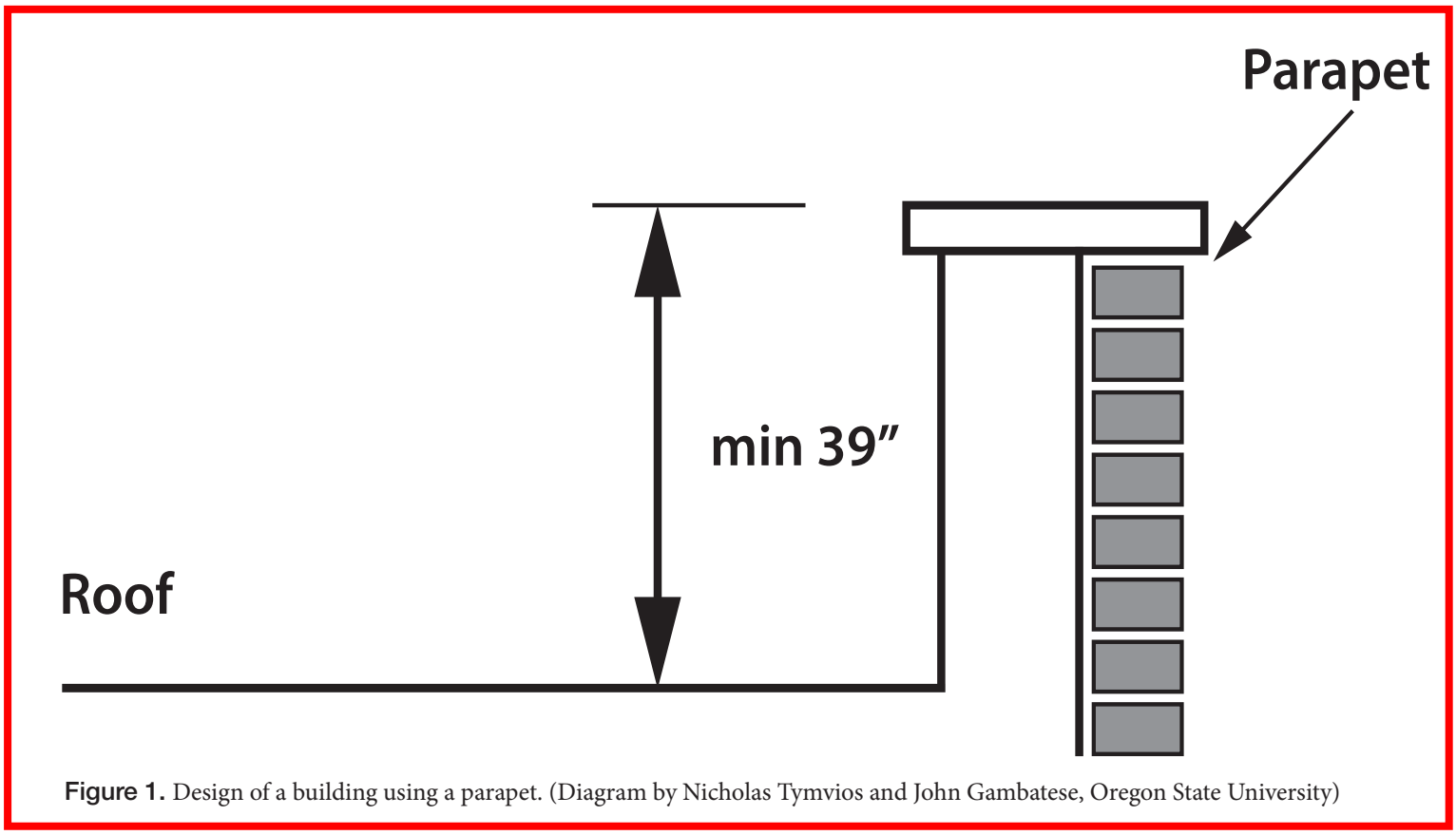

Figure 1. Design of a building using a parapet. (Diagram by Nicholas Tymvios and John Gambatese, Oregon State University)

(3) Parapets can hide roofing material or equipment that is unsightly or unattractive.

Recommendations

Designers should take the following steps to prevent falls from roofs during construction [Gambatese et al. 1997, 2005; OSHA Alliance Program 2010; ICC 2012]:

- Ensure that parapets meet the OSHA height requirement for guardrails of 42 inches (1.1 meters) plus or minus 3 inches (8cm) above the finished roof surface. An additional 6 inches may be necessary to account for subfloor depth, beams, columns, etc.
- Ensure that the parapet can withstand a force of at least 200 lbs (applied within 2 inches of the top edge in any outward or downward direction) [29 CFR 1926.502(b)(3) and (4)].
- Install a capstone over masonry parapet walls to prevent water from getting in and causing cracks.
- Consider the design of drainage systems, roof access, and insulation to accommodate parapets.
- Consider other uses for parapets during the design stage, such as anchorage for personal fall arrest systems and support for window-washing scaffolds (taking into account additional structural requirements that may be imposed by these other uses).
- Ensure that the parapet has the same fire rating as the wall below.
- Carefully evaluate additional snow loading and roof ponding loads when considering a parapet wall. The additional roof loading may require extensive modifications or re-design to the roof structure. Consult local building codes.

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References

ANSI/ASSE [2011]. Prevention through Design guidelines for addressing occupational hazards and risks in design and redesign processes. Standard Z590.3.

Behm M [2005]. Linking construction fatalities to the design for construction safety concept. Safety Sci *43*:589–611. http://www.sciencedirect.com/science/article/pii/S0925753505000731

BLS [2012]. Census of Fatal Occupational Injuries Summary, 2011. Washington, DC: Bureau of Labor Statistics. http://www.bls.gov/news.release/cfoi.nr0.htm

Bobick TG, McKenzie, Jr, EA, Kau T-Y [2010]. Evaluation of guardrail systems for preventing falls through roof and floor holes. J Safety Res *41*:203–211.

CFR. Code of Federal regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10758&p_table=STANDARDS

Gambatese JA, Hinze JW, Haas CT [1997]. Tool to design for construction worker safety. J Arch Eng March:32–41.

Gambatese JA, Behm M, Hinze JW [2005]. Viability of designing for construction worker safety. J Constr Eng Manage September:1029–1036. http://faculty.kfupm.edu.sa/cem/jannadi/Viability-of-Designing-for-Construction-Worker-Safety.pdf

Hsaio H, Simeonov P [2001]. Preventing falls from roofs: a critical review. Ergonomics *44*(5):537–561.

ICC [2012]. International Building Code. International Code Council, Standard 714.1.

NIOSH [1997]. Project engineer dies in fall from roof in Massachusetts. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, MA FACE 97–MA–044–01. http://www.cdc.gov/niosh/face/stateface/ma/97ma044.html

NIOSH [2000]. Worker deaths by falls: a summary of surveillance findings and investigative case reports. By Braddee RW, Hause MG, Pratt S. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2000-116. http://www.cdc.gov/niosh/docs/2000-116/pdfs/2000-116.pdf

NIOSH [2013]. Architectural design and construction: instructor's manual. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2013-133. http://www.cdc.gov/niosh/docs/2013-133/.

OSHA [2012]. Workers' compensation costs of falls in construction. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration. http://www.osha.gov/dcsp/products/topics/businesscase/costs.html

OSHA Alliance Program [2010]. Construction workplace design solutions: specify sufficient wall height to allow parapets to function as fall prevention. OSHA Alliance Program Construction Roundtable http://www.designforconstructionsafety.org/Documents/Parapets_rev9.doc

Pupkin A [2013]. Parapet roofs. Ezine Articles. August 15. http://ezinearticles.com/?Parapet-Roofs&id=7937534

Rajendran S, Gambatese JA [2013]. Risk and financial impacts of prevention through design solutions. Pract Period Struct Des Constr *18*(1):67–72.

Toole TM, Gambatese J [2008]. The trajectories of Prevention through Design in construction. J Safety Research 39:225–230. http://www.cdc.gov/niosh/topics/ptd/pdfs/Toole.pdf

For More Information

The information in this document is based on research related to Prevention through Design (PtD) initiatives. More information about PtD is available on the NIOSH Web site at http://www.cdc.gov/niosh/topics/PtD/

More information about the NIOSH FACE Program can be found on the NIOSH Web site.

- http://www.cdc.gov/niosh/face/
- Click here for a list of NIOSH FACE Reports related to construction falls.
- Click here for a list of State FACE Reports related to construction falls.

To obtain information about other occupational safety and health topics, contact NIOSH at:

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TTY: 1–888–232–6348 • CDC INFO: www.cdc.gov/info

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