Addressing Facility Personnel Safety in BUILDING OPERATIONS, MAINTENANCE & REPAIR

By Nicholas Tymvios, Jake Smithwick and Glenda Mayo

THE LIFE CYCLE OF A BUILDING consists of relatively short planning, design and construction phases, compared to the occupancy phase, which accounts for more than 95% of the life cycle (Gallaher et al., 2004). During this phase, the building must function correctly and efficiently in occupants' day-to-day operations; therefore, regular maintenance, repairs and renovations are required. These activities are referred to as operations, maintenance and repair (OM&R) needs (Tymvios et al., 2020).

OM&R needs are undertaken by facility managers who oversee a building's occupancy after the construction phase ends. When occupants move in, they often ask facility managers to make changes and improvements to address issues not identified during the design and construction phases due to, among other things, new equipment installation (Okada et al., 2017) or modifications to address maintenance safety concerns (Christensen, 2007). Facility managers address these requests by assigning tasks to support staff or by subcontracting work to third-party entities (Mayo & Tymvios, 2017).

Maintenance employees can be exposed to safety hazards that have been inadequately addressed during the previous phases of the facility. The types of hazards associated with OM&R have not been investigated in the U.S., and researchers in other countries have limited the investigations to characteristics that link OM&R operations and injuries. The results of one such study conducted in Hong Kong indicate that 62% of the fatalities that occur in repair, maintenance, minor alteration and addition projects are the result of falls (Hon & Chan, 2013).

As Szymberski (1997) suggests, the sooner that safety is addressed in a project's schedule, the greater the ability to influence safety performance. Addressing safety concerns during the design phase of a project is one principle in the concept of prevention through design (Lorent, 1987) that was proposed to address hazards during construction; this principle can also be applied to address OM&R hazards. Alternative project delivery methods allow designers to contribute to construction safety and maintenance safety because, with these methods, more conversations occur between project partners as part of constructability review meetings (Tymvios & Gambatese, 2015). Additionally, owners are becoming more vested in their project designs and are often involved much earlier in the design and construction process.

KEY TAKEAWAYS

- **The occupancy phase of a building accounts for a significant portion of a building's life cycle; during that time, operation, maintenance and repair (OM&R) activities expose facility technicians to varying levels of hazards.**
- **Information on incidents involving OM&R activities can be difficult to quantify. This article aims to identify which building systems pose the greatest concern to facility management personnel and the types of modifications made to address hazards that exist after the building is turned over for occupancy.**
- **A survey tool was used, and 240 facility professionals responded. The results provide a different perspective in terms of categorically looking at safety concerns during OM&R and the demographics of those who represent the industry. Two important findings: 65.8% of respondents made changes to address safety hazards in facilities after occupancy; and less than 15% of respondents had received OSHA training, indicating that more facility professionals need training on how to identify safety hazards.**

Background

Facilities Management

Facilities management (FM) includes all activities involved in managing a structure after the construction phase ends (Cotts et al., 2009). Activities during the OM&R phase of a facility can include maintaining and monitoring electrical, mechanical and plumbing systems; repairing and renovating cladding and curtain wall systems; making minor modifications to internal walls and layouts (Gallaher et al., 2004); and completing many other tasks. Facility managers perform managerial tasks and may undertake tasks as skilled technicians in various trades.

Maintenance includes "all work relating to the economical preservation of facilities, equipment and systems at a level satisfactory to perform their designed functions" (Payant & Lewis, 2007). These functions can include preventive and predictive maintenance, routine maintenance, reactive maintenance, major repairs, emergency repairs, alternations and upgrades. Historically, OM&R was considered a business cost center because these activities do not generate revenue for the organization.

In 2018, the 5.9 million buildings in the U.S. contained 97 billion square feet (EIA, 2020) and had total annual maintenance expenditures of more than $260 billion (IFMA, 2017). As owners become more involved in the earlier phases of the project, it is advantageous for them to better understand safety risks and provide input during the design phase. Maintenance and repair technicians are typically included in the repairer occupations category, as described in CPWR (2018); this category includes individuals involved in installation, maintenance and repair work for existing facilities. According to the Bureau of

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Labor Statistics (BLS, 2018a), the types of occupations associated with this category include radio, cellular, and tower equipment installers and repairers; telecommunications equipment installers and repairers; electrical and electronics installers and repairers; and heating, air conditioning, and refrigeration mechanics and installers. With such a broad variety of occupations included in this category, it is difficult to determine statistics for incidents (injuries and fatalities) directly connected to OM&R operations.

According to CPWR (2018), 232,000 repairers were employed in the U.S. construction industry in 2017. This number equates to 2.3% of the construction worker population but does not include many FM technicians involved with maintenance and repair (e.g., electricians, painters, plumbers, heat and air conditioning technicians, elevator technicians, roofers). Until recently, the occupation of facility manager was not recognized as a profession by BLS. When the occupation classification was created in 2017, it only included managers, building cleaning and pest control workers, and ground maintenance workers, and therefore does not encompass the vast majority of trades and technicians performing OM&R work (BLS, 2018b; IFMA, n.d.).

Furthermore, reports of incidents (fatalities and injuries) do not capture the true nature of the hazards that relate to OM&R activities since incidents are categorized according to the employer's North American Industry Classification System code, not according to the type of work performed. For example, suppose that a roof repair worker is employed by a contractor hired by a manufacturing facility manager. If this worker is killed by a fall from that roof, then the fatality would be categorized as a construction incident (OSHA, 2019). However, if the worker is employed directly by the owner of the facility, then the incident would be categorized according to the employer, which in this case is manufacturing (OSHA, 2015).

FM & Safety

The limited scholarly work on safety in FM highlights the need to determine the concerns that FM personnel have during OM&R activities. Research is needed on current OM&R practices and how they relate to the safety and health of OM&R personnel. It is imperative to identify the building elements or systems that pose the greatest concern to FM personnel, as well as what modifications are currently performed after the construction phase to address safety.

Hierarchy of Controls & Facilities

As in other industries, improvements that address safety and health can be categorized into the hierarchy of controls (NSC, 2009). Injuries and fatalities can be reduced by using the higher-level controls (elimination, substitution, engineering), and often require that the designer (architect and engineer) be involved to modify systems, processes and other building elements. Lower-level controls (warnings, administration, PPE) are less effective in reducing hazards and the probability of incidents because they rely on workers' interactions and compliance with safety guidelines (NSC, 2009). According to Szymberski (1997), safety decisions such as higher levels of safety controls can be more efficiently and effectively implemented during the early stages (conception and design) of a structure's life cycle. For this reason, considering maintenance safety during the design phase is financially beneficial.

Research Objectives

The aims of the study presented in this article include:

- Classify the hazards that different types of facilities encounter during OM&R.
- Identify the types of improvements made to address safety hazards after facility occupancy.
- Evaluate how the identified improvements are categorized with respect to the hierarchy of controls.

Methodology

To gather facility managers' concerns regarding building OM&R activities, an online survey was distributed to members of two FM organizations: International Facility Management Association (IFMA) and the Association of Physical Plant Administrators (APPA). IFMA (2019) consists of 24,000 members in a variety of industries, and APPA (n.d.) consists of 18,000 facility professionals focusing on educational facilities such as university buildings, K-12 school buildings, museums and libraries. These organizations represent the two most prominent owner organizations assisting facility managers in the U.S., while IFMA also includes international members. Survey participants were asked to respond to four categories of questions:

1. demographics: role, experience, education and credentials;
2. hazards: the facility elements that pose the major safety concerns and the hazards that FM crews encounter;
3. safety improvements: improvements made to the facilities to address OM&R safety needs; and
4. facility description: the facility's name, primary use, type, industry, ownership, age, location, occupancy level and size.

[The facility types, industry sectors and ownership classification categories were based on IFMA's (2017) "Operations and Maintenance Benchmarks" report.]

FIGURE 1
FACILITY USE TYPE

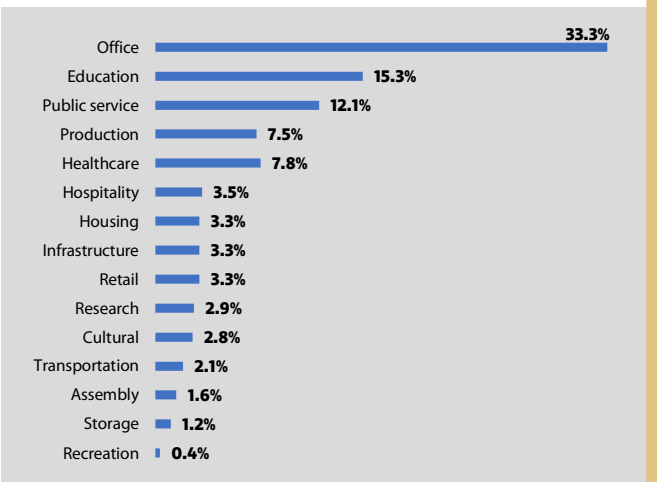


TABLE 1
FACILITY OWNERSHIP TYPES

Type of ownership	No. of respondents	Percentage
Space within a building	30	12.5
Facility is a single building	65	27.1
Multiple buildings in one location	58	24.2
Multiple buildings in multiple locations	87	36.3

Potential participants' email addresses were identified through online searches and through the authors' professional connections with IFMA and APPA members, since a complete list of APPA and IFMA members was not available. The authors have collected contacts through past interactions, research activities, presentations and webinars conducted by the researchers. Emails were sent to potential participants with an invitation to complete the study survey. A reminder email was sent 2 weeks after initial contact. A total of 2,546 individuals were contacted, and 240 individuals completed the survey.

Results

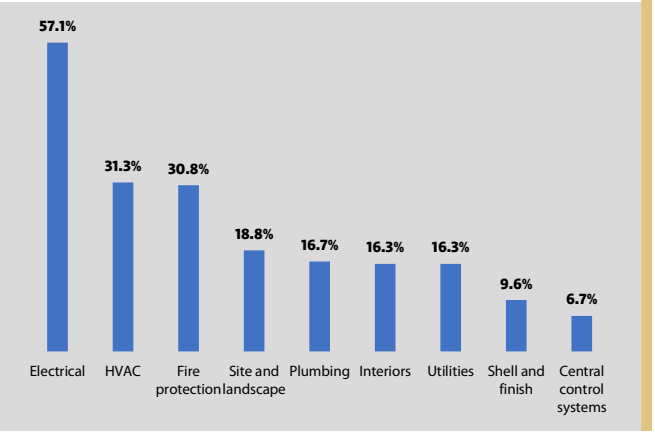
Participant Demographics

The study participants were demographically diverse. Of the 240 participants, 164 (68.3%) lived in the U.S. (including Washington, DC, and Puerto Rico); 21 (8.7%) lived in Canada; and the remaining 55 (22.9%) were spread across 23 other countries. The participants' years of experience in FM ranged from 6 months to 57 years; the average was 17.2 years.

The participants' job titles included administrator (n = 17, 7.1%), director (n = 51, 21.3%), manager (n = 139, 57.9%), technician (n = 10, 4.2%), and other (n = 23, 9.6%). The "other" category includes, among others, facilities consultants, facility preservation managers, service providers, specialists, contractors and accountants.

Many of the respondents stated that they held FM-focused credentials, including Certified Facility Manager (17.1%), Facility Management Professional (22.1%) and Sustainability Facility Professional (4.2%). In addition, some respondents held credentials that relate to safety and hazard recognition, such as the OSHA 10-hour certificate (14.6%) and the OSHA 30-hour certificate (11.7%). Three (1.3%) participants stated that they possess the ASP or CSP certification.

FIGURE 2
SYSTEMS/ELEMENTS OF CONCERN IN DAY-TO-DAY OPERATIONS



Types of Facilities

As shown in Figure 1, the participants managed a variety of facilities; the largest percentage (33.3%) of participants managed office facilities.

Participants also identified their facilities' type of ownership, according to the following categories: space within a building; facility encompassing a single building; multiple buildings in one location; and multiple buildings in multiple locations. As shown in Table 1, the largest percentage of participants (36.3%) reported having multiple buildings in multiple locations, suggesting that many OM&R employees may have diverse safety requirements depending on their facilities' OM&R needs.

Building Hazards

Participants were asked to indicate which building systems or elements were of greatest concern in day-to-day OM&R activities (Figure 2). The most frequently identified area of concern was electrical systems (57.1%), followed by HVAC (31.3%) and fire protection systems (30.8%). The survey inquired about systems or elements as well as the types of hazards; one overlapping category was electrical (electrical systems and electrical hazards) and in both questions, they had the highest ranking.

In addition, participants described some of the hazards that maintenance and repair crews experienced when performing work activities. The research team reviewed the hazards, then categorized them (Figure 3). Many participants clearly and concisely identified hazards (e.g., electrical, fall, chemical). When the responses were less definitive, the research team deduced which category to assign the hazard to. Following are two examples of a participant's description and the categories the research team assigned:

Example 1

•Participant response: "Cars speeding in the parking lot"

•Category assigned: Moving objects (vehicles and equipment)

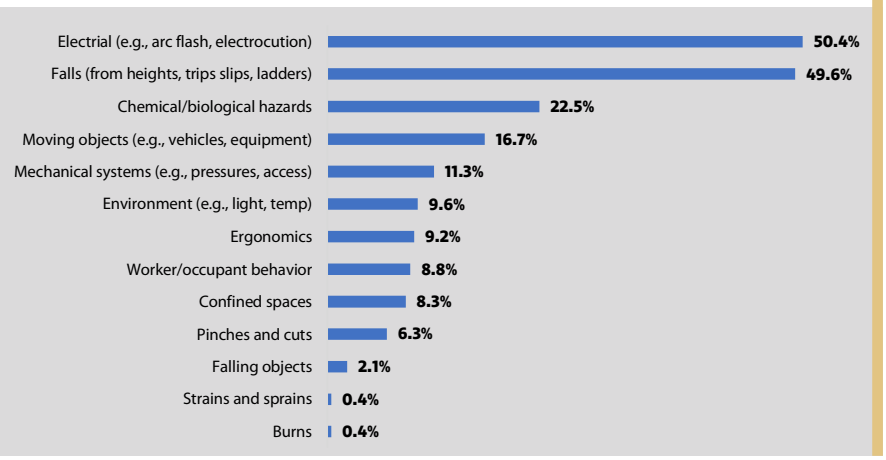
Example 2

•Participant response: "Debris in corridors left by rental tenants, entering high-risk communities to undertake repair works, working in dirty surroundings and dealing with irate residents"

•Category assigned: Trip hazard, fall hazard and worker/occupant behaviors

The categories shown in Figure 3 are defined as follows (Levy et al., 2005; Toscano et al., 1996): The results shown in Figure 3 are similar to the top four construction hazards identified by OSHA: falls, struck by, caught in/between and electrocutions (Compacion Foundation, 2008). Because OM&R crews need to perform work in functioning facilities (e.g., hospitals), chemical and biological hazards were identified more frequently than were traditional construction operations.

FIGURE 3
HAZARDS IDENTIFIED BY PARTICIPANTS



Analysis

Type of Building Ownership & Hazards of Concern

The data regarding the participants' types of space provide insights into facility managers' ability to implement new practices (Dodd et al., 2019). Individuals who are responsible for a portion of space in a building are likely leasing the space and have a limited scope of responsibilities. Equally, facility managers who oversee multiple buildings in multiple locations typically oversee many personnel, and these personnel are likely exposed to more frequent and diverse hazards than are personnel working in a portion of only one building. Table 2 (p. 28) summarizes the frequency of hazards reported across the four facility-ownership types.

Implementation of Safety Controls

Survey participants were asked to describe their improvements to address safety concerns and the researchers categorized these improvements according to their level in the hierarchy of controls. In this article, the lower levels in the hierarchy of controls—warnings, administration and PPE—were combined into one category termed "administrative controls," since administrators need to be involved in effectively implementing warnings and ensuring the availability and proper use of PPE (NSC, 2009). The majority (65.8%, $n = 158$) of participants indicated that their organizations had undertaken measures to reduce the risk of incidents while personnel complete OM&R tasks; these participants were asked to describe their organizations' efforts.

Many participants (52.1%, $n = 125$) described administrative controls similar to those practiced in construction, such as:

- implementing OSHA safety training for all personnel as a minimum
- implementing toolbox talks before every shift
- closing off areas that are undergoing repair or maintenance
- implementing lockout/tagout for all electrical repair operations

These administrative controls implemented after occupancy are important for worker safety during day-to-day operations but do not remove hazards that affect the work performed by OM&R crews. Thus, higher levels in the hierarchy of controls (engineering, elimination, substitution) are required to effectively address these hazards. Fifty-four (22.5%) participants indicated that their organizations implemented engineering controls. Examples include:

- installing improved ventilation, extractor fans, and air-conditioning systems for improved air circulation and quality and for quick extraction of contaminants
- installing ventilation hoods in labs
- installing stair access to roofs
- installing guardrails and other barriers
- installing retractable netting in loading docks
- grounding all electrical circuits

Participants provided fewer examples of the substitution and elimination levels of control. Eleven (4.6%) participants presented examples of substitution, and two (0.8%) participants presented examples of elimination.

The substitution examples included:

- installing antislip flooring
- installing speed bumps to reduce vehicle speed
- using lifting equipment instead of ladders
- reducing voltage levels in areas that workers have access to
- lowering equipment and meters to heights accessible to workers
- installing work platforms to provide access to work areas
- replacing higher-toxicity chemicals with lower-toxicity chemicals

Two examples of elimination are:

- eliminating all toxic chemicals, and
- replacing workstations and equipment to address ergonomics issues.

To gain a better understanding of the hierarchy of controls in the participants' organizations, the data were examined by facility use (Table 3, p. 28). As Table 3 shows, the hierarchy of controls solutions that require designer input (engineering, elimination and substitution) were less common in the participants' organizations, suggesting that these controls cannot be readily implemented or that the costs are too great for the controls to be implemented. Solutions that are lower in the hierarchy (PPE, administrative and warning systems) were numerous, but they shift the risk of injury to the workers or to management personnel. A more effective approach would be to address possible hazards during the design phase; addressing hazards during this phase will enable the implementation of permanent solutions that rely less on individual workers' skills, knowledge and behavior. Szymbersky (1997) suggested this idea for the construction phase, but it was not effectively proven until Lingard et al. (2015) investigated real construction projects. The extension of the idea of prevention can be encompassed within the OM&R activities but should be investigated with further research.

Conclusion

It is evident that many facility managers need to modify their facilities after occupancy to address safety hazards and thereby improve working conditions for OM&R personnel and occupants. In total, 65.8% of the respondents made changes to address safety hazards after initial occupancy. The two main categories that participants identified as concerns are electrical hazards and falls.

Safety Measures After Occupancy

The largest percentage of participants said their organizations implemented administrative controls to address safety concerns, and fewer stated that they implemented higher-level controls to improve worker safety in their facilities after occupancy. Changes to improve safety are less likely to occur after a project is completed and the space is occupied because changes during occupancy are typically time consuming and more expensive than during the design phase (Szymberski, 1997). Unfortunately, many safety measures are not implemented proactively during the design phase. In 2017, facility managers reported that 36.76%

TABLE 2

IDENTIFIED HAZARDS PER FACILITY-OWNERSHIP TYPE

Hazard category	Space within a building (*n* = 30)		Single building (*n* = 65)		Multiple buildings, one location (*n* = 58)		Multiple buildings, multiple locations (*n* = 87)	
Electrical	4	13.3%	34	52.3%	25	43.1%	53	60.9%
Falls	14	46.8%	36	55.4%	28	48.3%	41	47.1%
Chemical/biological	10	33.3%	9	13.8%	15	25.9%	20	23.0%
Moving objects	2	6.7%	11	16.9%	11	19.0%	16	18.4%
Mechanical systems	4	13.3%	4	6.2%	6	10.3%	13	14.9%
Environment	1	3.3%	6	9.2%	6	10.3%	10	11.5%
Ergonomics	2	6.7%	3	4.6%	9	15.5%	8	9.2%
Worker/occupant behavior	1	3.3%	5	7.7%	10	17.2%	5	5.7%
Confined spaces	4	13.3%	3	4.6%	4	6.9%	9	10.3%
Pinches and cuts	1	3.3%	1	1.5%	6	10.3%	7	8.0%

TABLE 3

HIERARCHY OF CONTROLS MODIFICATION PER FACILITY-USE TYPE

Control category	Office (*n* = 80)		Education (*n* = 38)		Public service (*n* = 29)		Production (*n* = 18)		Healthcare (*n* = 17)	
No modifications	30	37.5%	11	28.9%	9	31.0%	3	16.7%	8	47.1%
Administrative	39	48.8%	20	52.6%	16	55.2%	14	77.8%	8	47.1%
Engineering	16	20.0%	9	23.7%	5	17.2%	8	44.4%	1	5.9%
Substitution	3	3.8%	2	5.3%	1	3.4%	2	11.1%	0	0.0%
Elimination	1	1.3%	1	2.6%	0	0.0%	0	0.0%	0	0.0%

of all maintenance projects were reactive, meaning that the repairs were made after an asset failed (IFMA, 2017). This reactive approach may put employees at greater risk due to the nature and need for expedited corrective measures.

FM Education & Training in Safety Hazard Identification

Facility managers must be able to recognize hazards that are present in their facilities, whether the hazards involve maintenance, repair or day-to-day operations. As a minimum requirement, managers and crews should have OSHA 10-hour or 30-hour certifications, or any other industry-specific professional training that relates to the safety of employees and the expected tasks they perform. With hazard recognition training, facility managers will have a better understanding of safety improvement needs in their facilities and may also address potential hazards more quickly in OM&R operations. Faculty who teach in university FM programs can help address hazards by introducing safety and health modules in their courses or by encouraging prospective FMs to obtain OSHA 30-hour certification at a minimum.

Facility Managers' Involvement in the Design Phase

One way to address hazards in OM&R operations is to remove the hazards during the design phase of a project (Laganà, 2000), during which facility managers are the most qualified and knowledgeable professionals to address safety hazards because of their close proximity to OM&R tasks (Hinze, 2000). Interaction between facility managers and design professionals during the design phase will enhance the performance of the building during occupancy (Arditi & Nawakorawit, 1999), reducing the need to retrofit during occupancy. Similar to constructability reviews, conversations and interactions between design professionals and FM technicians during design can identify OM&R hazards in a facility, and that interaction can lead to the creation of technical documents regarding safe maintenance. Designers would thus become more aware of maintenance needs, leading to improved designs for future facilities.

Various options are available for designers and facility managers to learn how to address FM safety needs during the design phase. The Construction Industry Research and Information Association in the U.K. published a set of design guidelines that address the safety of workers throughout the life of a structure (Iddon & Carpenter, 2009); these guidelines align with Construction (Design and Management) Regulations 2007, a set of guidelines developed for use in the U.K. (U.K. Government, 2007). A similar publication was produced for the Netherlands (Frijters & Suddle, 2013). Additionally, Yam et al. (2006) investigated the provisions for residential building repair in Hong Kong, and Foster (2011) investigated the implementation of tools such as building information modeling and virtual reality during the design phase to assist in identifying OM&R hazards.

Future Research

This article presents an initial investigation in hazards encountered by facility managers, their crews and technicians that relate to OM&R activities. The comparison used similar risks as outlined for the construction industry. For example, it was observed that electrical hazards and falls are of major concern to facility managers, and that they often perform modifications to facilities

to address these hazards, sometimes immediately after occupancy. There is a need to identify the nature of the falls for the FM profession. Future research is planned to investigate not only the taxonomy of FM safety, but also the methodology for incorporating FM input to address safety during OM&R operations. **PSJ**

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Cite this article

Tymvios, N., Smithwick, J. & Mayo, G. (2022, April). Addressing facility personnel safety and health during building operations, maintenance and repair activities. *Professional Safety, 67*(4), 24-29.

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