# 墜落災害の防止と防護に関する
# ワークショップ

日時：平成 25 年 10 月 24 日(木)　13:00～17:10

場所：独立行政法人労働安全衛生総合研究所

本部棟 2 階 講堂

JNIOSH

# ワークショップ　プログラム

1. 13:00～13:05　開会挨拶

2. 13:05～16:40　基調講演

(1) 13:05～13:30

講演名：A TOTAL WORKER SAFETY APPROACH FOR PREVENTING SLIPS, TRIPS, AND FALLS　1

講演者：Hongwei Hsiao

（米国, National Institute for Occupational Safety and Health(NIOSH)）

(2) 13:30～13:55

講演名：STUDY TREND OF SLIP, TRIP, FALL(STF) IN KOREA　9

講演者：Woonchul Shin

（韓国, Occupational Safety and Health Research Institute for Safety）

(3) 13:55～14:20

講演名：A HOLISTIC APPROACH ON FALL PREVENTION AND PROTECTION IN HK　13

講演者：Alan Chan

（香港, Occupational Safety and Health Council）

(4) 14:20～14:45

講演名：ADDRESSING FATALITIES AND INJURIES AT WORK DUE TO FALLS - THE SINGAPORE JOURNEY　19

講演者：Suresh Navaratnam

（シンガポール, Ministry of Manpower Singapore, Occupational Safety and Health Division, Policy, Information and Corporate Services Department）

（14:45～15:00　休憩）

# A TOTAL WORKER SAFETY APPROACH FOR PREVENTING SLIPS, TRIPS, AND FALLS

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Slips, trips, and falls (STF) represent a serious hazard to workers and occupants in many industries, homes, and communities. Often, the cause of a STF incident is multifactorial, encompassing human, environmental, and task risk factors. A STF-related disability can greatly diminish the occupational capability and quality of life of individuals in both the home and the workplace. Countering STF hazards and risks both on and off the job is a "total worker safety" matter, a challenging yet tangible undertaking. As the federal organization responsible for conducting research for the prevention of work-related injuries in the United States, NIOSH has been conducting research on STF controls for some decades. Many NIOSH research outcomes have been utilized for STF prevention in workplaces, with potential for prevention in homes as well. This paper summarizes the concept of total worker safety for STF control, NIOSH priority research goals and activities, and some emerging issues on STF.

## Introduction

The most recent report on fatal occupational injuries showed that there were 681slip-trip-and-fall (STF) related fatalities in 2011 in the United States (U.S. BLS, 2013a), which accounted for 14.5% of the overall occupational fatality cases. In addition, there were 299,090 STF-related nonfatal occupational injuries resulting in days away from work in 2011, which accounted for about 25.3% of all occupational injuries in that year (U.S. BLS, 2012). The construction industry continued to have the highest count of STF-related fatalities (U.S. BLS, 2013), and food servers, healthcare support workers, highway maintenance workers, housekeeping cleaners, and telecommunications line installers experienced the highest rates of nonfatal STF injuries (U.S. BLS, 2011). Many countries are facing the same challenges as the United States with STF injury problems in the workplace (NIOSH, 2011a). Aside from workplace incidents, STFs are the second-leading cause of unintentional death in homes and communities, resulting in more than 25,000 fatalities in 2009 (NSC, 2011). Often, inhabitants fall from ladders, stairs, uneven surfaces, or wet areas at home. Elderly individuals are particularly at risk. In 2011, more than 3.3 million nonfatal fall injuries among older adults (55 ~ 85+ years old) were recorded in emergency departments (NCIPC, 2013). Similar concerns are seen worldwide (WHO, 2007).

Given the prevalence of STF problems, an organized global research/intervention effort is warranted. This paper describes a concept for total worker safety for preventing global STFs, which improves occupational capability and quality of life at both workplaces and homes. The paper also presents NIOSH research goals on STF prevention, selected NIOSH research activities relevant to the concept of total worker safety for STF control, and some emerging issues on STF.

## A Concept of Total Worker Safety for Slip, Trip, and Fall Prevention

STFs occur as a result of a complex interaction of risk factors which can be organized into three categories: personal, environmental, and task-related factors (Hsiao and Simeonov, 2001). The personal factors include individual differences (e.g., age, gender, race, and body size), work experience, chronic illness, physical strength, substance use, cognitive capacities, constraints of personal protective equipment (PPE), visual acuity, contrast sensitivity, discrepant vision between the eyes, and expiratory flow rate (Hsiao and Simeonov, 2001; WHO, 2007; Knudtson, Klein, & Klein, 2009). The environmental factors concern the information available from visual and physical interactions with environments, including elevation perception, moving visual scenes, depth perception, visual ambiguity, visual detection of obstacles and their properties, restricted support surfaces, support surfaces inclination, lighting, building design, and material properties of support surfaces (e.g., friction, contaminants, evenness, loose fixtures, and firmness). The task-related factors include load handling, physical exertion and fatigue, footwear, complexity of tasks, social interactions, and community resources (Hsiao and Simeonov, 2001; WHO, 2007).

National and global research efforts on STF are vary among government agencies, healthcare institutes, professional societies, and individual safety and health research organizations. Many of the entities have focused on certain aspects of research topics and applications, such as occupational issues, biomarkers, forensics, and elderly falls. As national and global communities are moving to better workplace safety and quality of life as a whole, countering fall hazards and risks faced by workers and community-dwellers on and off the job becomes even more inseparable. Workers use ladders at work; they also use ladders in their homes for household chores. Community members access building floors through stairways at home as well as at workplaces and public facilities. Moreover, a STF injury typically affects a person's ability in handling tasks at the workplace and the home; it may diminish a person's social capacity in the community as well. The settings may differ, but the scientific basis, risk assessment tools, and control strategies for STF remain the same. The concept of total worker safety for STF prevention considers integration of current knowledge and research efforts among all aspects to: (1) publicize the importance of STF prevention, (2) advance the identification of risk factors and innovations for STF control, and (3) transfer/implement realistic and effective STF interventions.

## NIOSH Research Goals for Slip, Trip, and Fall Prevention

While NIOSH research on STF prevention has been occupational in nature, many of the NIOSH research findings, methods, and recommendations for safe practices are equally applicable to non-occupational settings. We are increasing our communication and collaboration with industries, stakeholders, and global partners to advance research efforts on STF control, which would facilitate the implementation of a total worker safety strategy to prevent STFs in the workplace, home, and community. Recently, NIOSH has undertaken a concerted effort to update four of its research goals to address the national STF burden.

Three NIOSH goals for STF prevention research are industry specific, emphasizing program activities and directions that are likely to have the greatest impact on preventing fall injuries and deaths in high risk workplaces. They include goals of reducing fall injuries in the construction industry, wholesale and retail trades (WRT), and public safety, services, manufacturing, and other high-risk industries. These efforts emphasize implementing effective, evidence-based STF prevention and protection designs, technologies, programs, and communications materials for: (1) structure design, worksite implementation, and vulnerable group (e.g., Hispanic workers) protection in the construction industry; (2) the handling, storage, and retrieval of goods in WRT settings; and (3) ambulance, fire truck, and heavy truck apparatus improvements in the public safety sector to reduce falls from these vehicles and implementation of comprehensive STF prevention programs in

the food services industry.

The fourth goal addresses human characteristics, social-organizational characteristics, and biotechnology-based fall control measures which offer fundamental knowledge and practical solutions for STF prevention in the workplace, home, and community. Research organizations can identify human biomarkers, social-organizational characteristics, and human-system interface traits that are common precursors to fall incidents, and use them to design out fall risk or craft engineering solutions and organizational interventions to reduce STF incidences. Accordingly, manufacturers can produce improved fall protection devices and systems that effectively reduce the forces on the human body during fall arrest and fall impact. Furthermore, safety professionals and researchers can develop and use comprehensive digital models of human fall dynamics to evaluate new fall prevention and protection technologies, products, and methods as well as to conduct fall injury investigations and verify solutions.

NIOSH has proposed retiring the goal to reduce STF injuries in the health services industry, given productive research that has been conducted as well as industry adoption of recommended protective measures (NIOSH, 2013). For example, NIOSH has published a user-friendly STF prevention toolkit targeted toward staff in the healthcare sector that is being adopted by many hospitals nationwide (NIOSH, 2011b).

## Activities and Accomplishments

Selected research projects associated with the four NIOSH overarching research goals are presented to illustrate our efforts and accomplishments. These projects target high fall-risk industrial sectors and leading sources of fall incidents which coincide with national workplace and community fall injury data.

### *Ladder Safety Research and Innovations*

Ladders are one of the most widely-used means of access to elevated surfaces at home and in the workplace in multiple industries (e.g., construction, wholesale and retail, and public safety sectors). On average more than 164,000 emergency room-treated injuries in the U.S. each year are related to ladders (U.S. CPSC, 2011). What are the current regulations, practice guidelines, and measures to control falls from ladders? What are risk factors, critical knowledge gaps, and emerging issues and technologies to address ladder safety? Partnering with ladder manufacturers, a national ladder safety standards committee, technology research organizations, and other U.S. Government agencies, NIOSH has published literature on solutions and knowledge gaps on extension ladder safety (Hsiao, Simeonov, & Pizatella et al., 2008), identified factors affecting extension ladder angular positioning (Simeonov, Hsiao, Powers, & Kim et al., 2013), and developed and patented a ladder safety software application for mobile devices which features a multimodal indicator and a graphic-oriented guide for ladder selection, inspection, positioning, accessorizing, and safe use (Simeonov, Hsiao, & Powers, 2013). The literature, scientific study outcomes, and the mobile device safety application provide both a scientific basis and practical tools to reduce the risk of fall injury for millions of ladder users across many industries, homes, and communities.

### *Slips, Trips, and Falls Control in Food Services*

Food preparation workers and non-restaurant food servers are among the groups with high fall-on-the-same-level incident rates, with rates of 61.2 and 65 per 10,000 full-time workers, respectively (U.S. BLS, 2012). Partnering with one of the largest food service companies in the US, NIOSH is evaluating the effectiveness of slip-resistant shoes as part of multi-factor prevention programs in reducing STF injuries in the food services industry. This study is a randomized controlled trial with the participation of approximately 4,000 employees for a four year period (Bell, 2009). The research will impact worker safety by providing scientific evidence and business case support for a

comprehensive STF prevention program to reduce STF injuries among food service workers. Food service companies, initially hesitant to expend time and money on prevention programs with unknown effectiveness, could use these findings to help justify implementing prevention strategies. The information will be equally useful for food handling persons at schools and food courts.

*Safe Fire Truck Aerial System*

A turntable telescopic ladder is perhaps the best-known form of specialized aerial firefighting apparatus, and is used to gain access to fires occurring at heights or areas inaccessible to conventional ground-based ladders. Ascending and descending aerial apparatus present a significant source of fall risk due to apparatus space constraints and challenges in firefighter-apparatus-interface design in accommodating the uses at various ladder heights and angles, from almost vertical to almost horizontal settings. The environmental constraints of firefighting scenes and the increased physical and mental loads of bunker gear on firefighters often worsen the fall risk. NIOSH is conducting a series of research projects on the ergonomic design of aerial ladder systems (Simeonov and Hsiao, 2013). Among the objectives are: (1) determination of optimal rung spacing, (2) identification of range of optimal angles for aerial ladder use, and (3) development of an automated dynamic rung profile that presents a stable horizontal footing surface independent of aerial ladder slope angle.

*Fall-Arrest Harness System Safety*

The Occupational Safety and Health Administration (OSHA) mandated a construction standard in 1998 that full-body harnesses replace waist belts for fall arrest in personal fall arrest systems (U.S. DOL, 2011). This provided improved protection against falls from height for 6.3 million construction workers. Some knowledge gaps remain on suspension trauma risk and how harness fit affects dynamic loading to the head and neck during fall arrests as well as information about optimal harness sizing and design to accommodate diverse worker populations. Partnering with harness manufacturers, national safety standards committees, and research organizations, NIOSH has published improved sizing systems and suggested specification ranges for harness straps (Hsiao, Friess, & Bradtmiller et al., 2009; Hsiao, Whitestone, & Taylor et al., 2009) and has identified factors that affect harness-body fit and interface (Hsiao, Whitestone, & Kau, 2007). In addition, NIOSH has reported the effects of body characteristics and harness fit on human suspension tolerance time (Hsiao, Turner, & Whisler et al., 2012) and the merits and risks of fall-arrest system use for operators of mechanized access platforms (Pan, Powers, & Hartsell et al., 2012 ).

*Scaffolding Safety in Fall Injury Prevention*

Dismantling of frame scaffolds was reported as one of the most hazardous tasks for the carpenter trade in the construction industry due to overexertion and fall hazards (National Constructors Association, 1985). A significant portion of these hazards are associated with scaffold-end-frame (23 kg) dismantling tasks which require both muscle strength and postural balance skills. Most workers tend to place their hands at the below-hip locations to generate greater lifting power. They, however, face a fall risk once they lift up the end frame; the center of mass of the end frame is far above their hands and thus difficult to manipulate. NIOSH studies demonstrated that hand location between elbow height and chest height with a hand separation distance of 46 cm would allow workers to generate sufficient isometric strength to disassemble typical 23 kg scaffolds while concurrently allowing them to mitigate the likelihood of postural imbalance (Cutlip, Hsiao, & Garcia et al., 2002). As scaffolding technology has advanced, mast climbing work platforms (a new elevating system that can lift construction workers to extreme elevations) are increasingly being used in major construction projects in the U.S. with some 4,200 operations daily (Pan, 2010). Increasing numbers of high-visibility incidents (i.e., multiple fatalities) have occurred in recent years in public settings, which concern OSHA and many construction safety officials. NIOSH is conducting research to identify fall protection strategies and effective intervention programs for

workers who are at risk of injury from work at elevation on mast climbing work platforms, using both computer modeling and field testing approaches. The end products will include recommendations and informational literature associated with mast climbing work platform fall protection systems for use by standards committees, manufacturers, employers, and workers.

*Human Characteristics and Biomarkers in Fall Injury Controls*

The majority of human falls can be regarded as loss-of-balance incidents. Factors that may lead to disruption of balance include lack of adequate visual cues, inadequate lighting or visual information in the work environment, narrow and inclined support surfaces, unexpected changes in surface properties, load handling, physical exertion, fatigue, task complexity that diverts workers' attention, individual differences, lack of work experience and training, and the physiological and mental load imposed by personal protective equipment (Hsiao and Simeonov, 2001). NIOSH has conducted a series of studies on human characteristics and biomarkers with practical implications to advance fall injury controls. For instance, a simple vertical structure, e.g., a narrow bar, available in line of sight can serve as a visual cue to assist workers' balance (Simeonov, Hsiao, & Hendricks, 2009). The finding may be useful in modifying elevated work environments and construction procedures to improve workers' postural balance during construction or structure repair jobs. In addition, at elevation, workers depend heavily on sensory information from their feet to maintain balance. Sensory suppression associated with elevated vibration levels at a work site may increase the risk of losing balance. Mechanical vibration transmitted to walking/working surfaces through supporting structures needs to be controlled when workers are performing tasks at elevation (Simeonov, Hsiao, & Powers et al., 2011). Moreover, NIOSH studies showed that shoes with characteristics of tight fit, good motion control of the rear, high flexibility of the front, moderate torsional stiffness, and a very flexible high-cut upper can minimise the risk of loss of balance, making them a better choice than casual shoes for work on elevated and narrow surfaces (Simeonov, Hsiao, & Powers et al., 2008).

## Emerging Issues - For Total Worker Safety for Slip, Trip, and Fall Control

First, populations of a given age, gender, ethnicity, and occupation permutation may have unique body size and shape compositions. Workplaces, community environments, and PPE need to be adequately designed to accommodate diverse populations. Through anthropometric research, NIOSH has provided both scientific theories and practical manufacturing information to advance harness design for protecting workers from fall injury in the construction sector. Developing improved protective gear, better home and community environments, and user-friendly assist devices for fall prevention that fit diverse population groups is a significant agenda for the community. Second, in this new era of changing technology, there are unique issues in the booming green energy and digital communication businesses in which safety professionals can make a significant contribution (e.g., safe erection of wind turbines and communication towers). Third, workers of specific age, social, and economic characteristics may have unique vulnerabilities for fall injury. It is important to focus on these populations, particularly as they have been largely underserved in the past. One example is the study of the constraints of aging workforces in coping with injury risks; injury data systems have shown that 42% of fatal STF victims in 2011 were age 55 and above (U.S. BLS, 2013b).

Finally, innovation and implementation should be an important chapter in total worker safety in STF control. Current design paradigms provide a framework to build upon, but may limit design creativity. It took 20 years for airbags to become a standard safety device for reducing vehicle-crash-related injuries. While skeptics will always exist with the introduction of new technologies (e.g., the concept of wearable airbags) to combat falls, with advancements in durability and reduction of cost, wearable airbags to reduce fall-related injuries may become an integral part of worker fall protection systems in the near future. The notion is equally valuable in protecting

inhabitants during household-chore activities (e.g., window cleaning) and reducing resident fall injury risk in healthcare or homecare settings during daily activities. Furthermore, smart phone based safety software/applications (apps) represent an emerging area of total worker safety for STF control; many STF risk exposure assessment tools and safety guidelines can be developed into mobile apps for STF prevention in workplaces and homes. The NIOSH ladder safety mobile app mentioned in the "Ladder Safety Research and Innovations" subsection is a successful example.

## Summary

STF research has long been recognized as one of the most important and needed areas of occupational and non-occupational injury prevention research. The complex and multifactorial nature of STFs in workplaces, homes, and communities demands a proactive and systematic approach to prevention. A total worker safety strategy for STF prevention offers an opportunity to integrate science-based information to publicize the importance of fall prevention and further STF risk factor identification and control. It also facilitates practical and effective STF innovations and implementation in the community. To maximize the benefits of the opportunity, collaborations should be actively implemented among national and international government entities, medical institutes, technology firms, STF control assist-device developers, and research centers to develop global research agendas, promote knowledge exchange, and conduct joint research.

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# STUDY TREND OF SLIP, TRIP, FALL(STF) IN KOREA

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Now a day, the accident rate shows 0.6% in Korea. The fatal injuries are of 461 cases from construction industry and 336 cases from manufacturing industry. Our goal of accident rate is 0.5% and that of fatality rate per 10,000 persons is 0.7 in 2014. There are many accidents caused by human errors as can be seen in slip accidents. We will also focus on the research for the prevention of falls caused by human errors especially in the construction industry. Unless one commit suicide, falls are results of accidents. The primary cause of a fall can be a slip, trip or misstep. So far, construction industry has implemented the accident prevention plan only for misstep as a primary cause. There were no analysis items and no analyzed data about fall by the slip and trip accidents in the construction. We will analyze construction accidents by primary causes and endeavor to prevent accidents in future.

## Introduction

The number of occupational injuries in Korea was 92,256 in 2012. Among these, occupational diseases were 7,472 cases and injuries were 84,784 cases. The accident rate shows 0.6%. The accident rate has been stagnant around 0.7% for recent 10 years. However, it reduced to 0.65% in 2012. Also, the fatal injuries have exceeded 2100 cases every year. The deaths of illnesses were 730 and fatal injuries were 1.435 in 2012. The fatal injuries are of 461 cases from construction industry and 336 cases from manufacturing industry.

In order to reduce the stagnating industrial accidents in Korea, Ministry of Employment and Labor and KOSHA had tried various approaches. The goal of the KOSHA is reducing 5% both for the accident rate and fatality rate for every year. Our goal of accident rate is 0.5% and that of fatality rate per 10,000 persons is 0.7 in 2014. (fatality rate, OECD 0.4 in 2008, Korea 0.96 in 2011, 0.4 in 2030)

## Measure

The major measures for reduction of accident rate are encouraging risk assessment, OSHAS 18001 safety management system, etc., mainly to motivate implementation of self-regulating system at workplaces. This means that the essential philosophy for accident prevention was changed from regulation to autonomy. The autonomy can achieve more than simply keeping rules but regulation has a certain limitation. The measures against fatalities are rare in Korea. The fatality rate per 10,000 persons of Korea ranked 27th among 27 member countries of the OECD. We set a goal of reducing of fatality rate from 2012 and try a lot of the efforts.

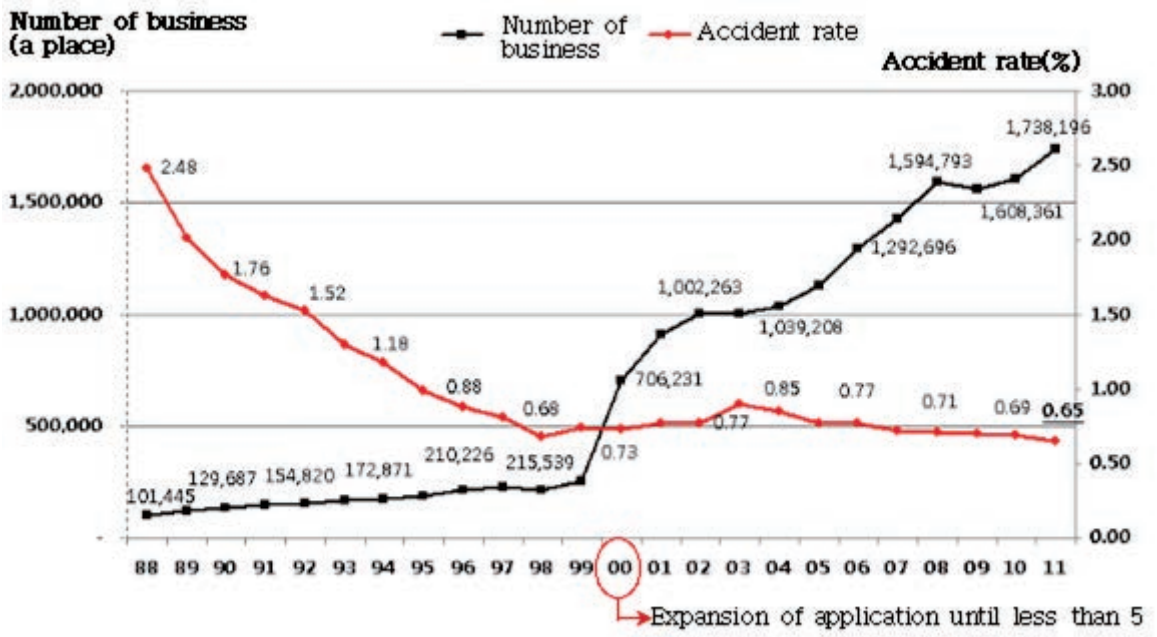


**Figure 1. Accident rate and number of businesses by years**

Existing researches for the reduction of accident rate were hardware-oriented such as protection devices of machines. There are many accidents caused by human errors as can be seen in slip accidents. We will research more for human error in the future. The type of accidents are classified into STF, caught-in or between, and fall from higher level, etc. Investigation of individual case of STF accidents shows that prevention measures targeting to human factors need more attention. The unsafe act with its counterpart unsafe condition can be seen everywhere in accidents causation analysis. However, it could not be used as a concrete prevention measure because of lack of detailed items. In the future, we will use the Fool proof(P) or Fail safe(S) to supplement unsafe act relating to human factor. The analysis for fatality injuries about 1100 cases in 2011 shows that P could be solution for 80% cases, S for 20% cases. The main causes relating to human factors appear to be visibility or communication problem. STF accidents reaches around 30% of all occupational accidents. We have studied STF for recent seven years. STF accidents are consist of about 50% by slip, 20% by trip, 30% by fall from same level. Main factors causing STF accidents are floor materials, contaminants, shoes, and human as treated in biomechanics. These four main factors can be combined into lots of different factors. So, biomechanics has difficulties to take role of main measure of controlling industrial accidents. In my humble opinion, the history of individual can be regarded as variable. Because the study targeting human reflects the whole history of human beings who have lived since three million years ago. The results of these studies have contributed to the accident prevention to a certain degree, but not remarkably.

Some of the researches performed by our center are as follows.

1. The suggestion of technique of risk assessment for STF accidents at workplaces.
- The evaluation factors were floor materials, contaminants, floor conditions, type of shoes, worker's postures of work.
- Shows the most dangerous part of the whole floor area.

2. The draft of Korean governmental notification "criteria of slip characteristics of safety shoes"
- development of measuring tool
- Suggestion of standard for frictional resistance of floors; Less than 0.5 : risky floor0.5~0.6 : normal floor, More than 0.6 : safe floor

3. Development of measuring tools of various friction factors.
- Reflects human factors

- Drag-type tool containing load cell is easy to use and make measurements.
- The measuring tools about slip developed such as portable push-type, robot, tool of trip and fall, etc.

We are going to study for prevention of the caught-in or between type accidents focusing on the human error. Similar to the this year's study of prevention for the woods and veneer manufacturing industry focusing on human behavior's characteristic. We are going to pay more attention to ergonomics for accident prevention similar to the studies of STF in Korea. We want to share and exchange of papers, opinions, and other informations with Japan in this field too.

# A HOLISTIC APPROACH ON FALL PREVENTION AND PROTECTION IN HONG KONG

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Fall of person from height continues to be one of the leading causes of work-related injury and deaths among all occupations in Hong Kong, especially construction industry. As the major organization with statutory responsibilities in Hong Kong, the Hong Kong Occupational Safety and Health Council (OSHC) has made enormous efforts to protect the safety and health of the working population. OSHC has adopted a holistic approach to promote fall prevention and protection in the workplace, which involves scientific research, partnership with industries, promotional campaigns and education and training. By adopted this holistic approach, the number of fall of person from height accident decreased significantly in recent 15 years.

## Introduction

In Hong Kong, fall of person from height continues to be one of the leading causes of work-related injury and deaths among all occupations in recent years. According to the accident statistics by the Hong Kong Labour Department, construction industry was the major industry that contributed to the accidents. As the major organization with statutory responsibilities, the Hong Kong Occupational Safety and Health Council (OSHC) has made enormous efforts to protect the safety and health of the working population. In order to prevent fall from height accidents, OSHC has adopted a holistic approach, as the major strategies to protect those workers need to work at height in Hong Kong.

## Strategies on promoting fall prevention and protection – a holistic approach

The holistic approach for promoting fall prevention and protection includes four aspects – scientific research, partnership with industries, promotional campaigns and education and training (Figure 1). Each aspect in the holistic approach is related with the other aspects, in order to create an all-round and effective influence for fall prevention and protection.

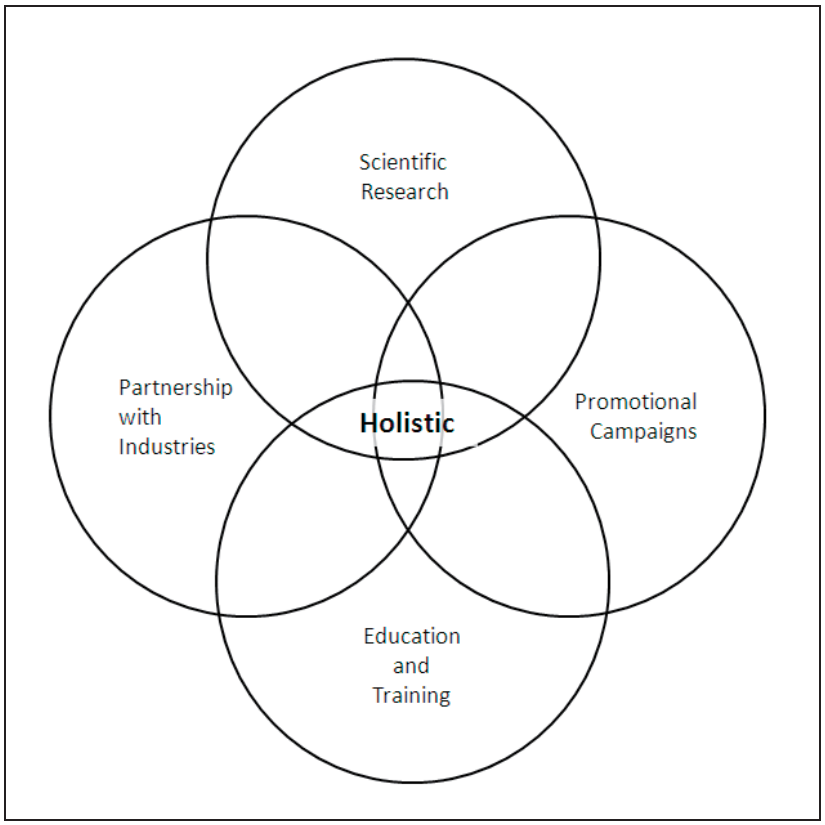


**Figure 1. Holistic approach for promoting fall prevention and protection**

## Scientific Research

Scientific research is a key aspect to create knowledge for fall prevention and protection. Since the early 2000s, OSHC has been conducting research on working at height safety. Major research topics are listed in Table 1 below:

**Table 1. Major research works on working at height safety**

| Year | Topics | Remarks |
|---|---|---|
| 2000 | Safety Attitudes, Safety Climate, and Employee Health Among Older and Younger Workers Working at Height in Construction Industry: A Facet Approach | |
| 2002 | An Engineering Study for Improving Safety and Reliability of Bamboo Scaffoldings | Joint research with university |
| 2006 | An Engineering Study for Safety & Reliability of Truss-out Metal Bracket Bamboo Scaffolding | Joint research with university |
| 2010 | Evaluating OSH Awareness amongst RMAA Contractors and Workers and in General Public | Evaluation also focused on safety knowledge and attitude of workers for working at height |
| 2012 | Follow up evaluation of OSH Awareness amongst RMAA Contractors and Workers and in General Public | Evaluation also focused on safety knowledge and attitude of workers for working at height |

Findings of these researches were applied to partnership program, education and training, and promotional campaigns for fall prevention and protection. For example, the study on truss-out metal bracket bamboo scaffoldings at 2006, found out that the use of T-metal bracket has several advantages over the conventional I-metal bracket, including the ease for installation and better supporting to the scaffold (HK Occupational Safety and Health Council, 2006). Therefore OSHC has develop a sponsorship scheme to subsidy small and medium size construction companies to purchase T-metal bracket, and promote the advantages of T-metal bracket in the industry. What's more, the evaluation of safety knowledge and attitude of workers for working at height from 2010 to 2012, has identified the needs of these workers and help OSHC to determine the focus and most appropriate methods for working at height safety promotion.

## Partnership with small and medium size enterprises

Partnership with Small and Medium size Enterprises (SMEs) is another important approach for fall prevention. Most SMEs suffered from financial constraints to improve work safety, therefore OSHC has formed strategic partners with SMEs to improve their safety performance by offering financial assistance and professional guidance. In 2005, OSHC launched sponsorship scheme for SMEs in construction industry to purchase safety harness, Transportable Temporary Anchorage Device (TTAD) and other fall arresting equipment (T-metal bracket as well started from 2006). The scheme not only provides safety devices, but also training for working at height safety and proper use of these devices. Up to mid 2013, there are more than 300 SMEs in Hong Kong participated the scheme. In 2013, OSHC also launched the sponsorship scheme for SMEs to purchase mobile working platform, and initiate a safety campaign on working at height to advocate the proper use of safe working platforms

Workers involved in Renovation, Maintenance, Alteration and Addition (RMAA) works are those exposing in high risk of fall from height, reflected by the fall from height accident case information issued by the Hong Kong Labour Department (Hong Kong Labour Department, 2013). In 2012, an "OSH Star Enterprise - Pilot Scheme on Safety Accreditation for the Renovation, Maintenance, Alteration and Addition (RMAA) Industry" was launched to augment supports on safety training, safety devices, as well as safety audit to improve the RMAA contractors' safety performance, and to offer premium discounts to the enterprises by the insurance companies.

The above partnership schemes not only offer financial assistance to purchase safety devices, but also promote the use of safety devices for fall prevention in the industry. Participating enterprises are required to assist OSHC to promote fall prevention and protection, by sharing their successful experience for using safety devices among other practitioners.

## Promotional campaigns

OSHC has also launched many promotional campaigns to promote fall prevention. These campaigns focus on practitioners and promote the importance of safe working at height, the use of safe working platform, safety harness and other safety devices, and the latest technology for fall prevention. For example, the Construction Safety Promotional Campaign is a large scale annual promotional activity to promote fall prevention and workplace safety. The campaign includes competitions of "Outstanding Scaffolder in OSH" and "Best Fall Arresting Safety Enhancement Program" to recognize safe scaffolders and enterprises that implemented effective program for safe working at height. In addition, the Hong Kong OSH Award includes the "Safe Enhancement Program Award" to recognize outstanding fall protection and accident prevention innovations from the industries. All finalists of these awards are required to present their accident

prevention programs / innovations in front of other practitioners, so that effective fall protection measures can be promoted and benchmarked.

In 2010, OSHC and the Hong Kong Labour Department launched a two-year large scale promotional campaign on RMAA and working at height safety. This program involves a launching ceremony, site visits, seminars, exhibitions, television and radio programs, advertisements, posters and leaflets, etc., in order to promote RMAA and working at height safety by an all-round approach. According to the evaluation results of this campaign, more than 80% interviewees, which are all RMAA workers, agreed that this campaign has a positive effective on their safety attitude and behaviour at work (HK Occupational Safety and Health Council, 2013).

## Education and training

OSHC pays attention to education and training in workplace safety and fall prevention through various training courses and workshops. Apartment mock-up with truss-out scaffold is set up at OSH Academy of OSHC, in order to demonstrate safe truss-out scaffold and the use of fall arresting devices such as TTAD. The OSH Academy also provides safe working platforms, ladders and fall arresting systems, which enable course and workshop participants to have practical experience for using these devices and systems.

To educate the workers for the safety measures in working at height, various publications such as posters, leaflets, bulletins and articles are published. OSHC also conduct the education in several interactive means, including the "Life on the Line" exhibit in OSH Gallery in Hong Kong Science Museum which shows the consequence of falling from height without safety harness; the "Construction Industry Accident Analysis" interactive software which enable users to learn the causes of fall from height accidents by participating the accident investigation; and the OSH e-learning system which provide on-line learning opportunity for the use of personal protective equipment including safety harness.

The education of the importance of fall prevention not only focuses on industrial practitioners, but also extends to youths. OSHC provides OSH workshop for secondary school students and designed tailor-made training kit to equip students with safe working at height and other OSH knowledge, in order to well prepare them to work safely in their future careers.

## Achievement

Through the holistic approach on the fall prevention in the workplace which incorporates with research, industries partnership, promotional campaigns and education and training, the number of fall from height accident has been decreased in recent years. According to the statistics provided by the Hong Kong Labour Department, the number of fall from height accident has reduced 55% from 1998 to 2012 (Figure 2), and the number of fatal cases has reduced 35% in the same period. It is encouraging to see that the promotion of safe working at height and the provision of safe working equipment and training to the SMEs, have effectively reinforce the adoption of safe working methods among front-line workers and to enhance the safety awareness of both the enterprises and employees. According to the evaluation results of OSH awareness amongst RMAA contractors and workers, the percentage of RMAA workers those have heard about and used TTAD, has increased 40.4% from 2010 to 2012; and the Safety Climate Index on "perception of safety rules and procedures" has increased 4.4 in the same period (HK Occupational Safety and Health Council, 2013).

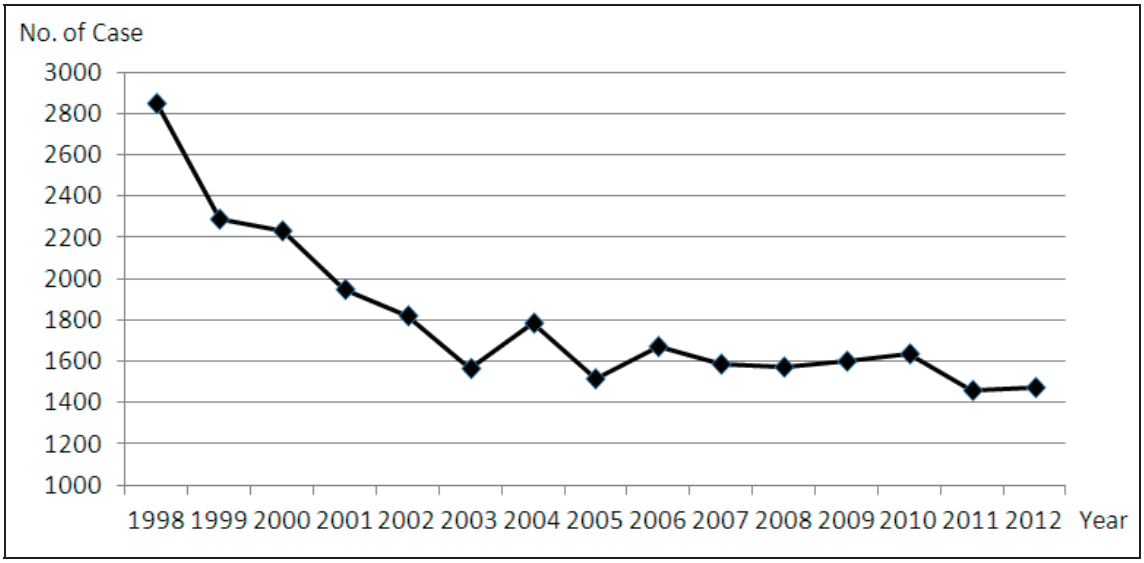


**Figure 2**. **Number of fall from height accidents in Hong Kong (data source: Hong Kong Labour Department)**

## Conclusion

Proofed by the accident statistics and evaluation results of OSH awareness amongst RMAA contractors and workers, the holistic approach used by OSHC for the fall prevention and protection can effectively reduce the number of fall from height accident cases and improve the OSH awareness of workers in Hong Kong. With the joint efforts of employers, employees, the government and insurance industry on fall prevention, we believe the fall accidents will continue to be reduced in the future.

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# ADDRESSING FATALITIES AND INJURIES AT WORK DUE TO FALLS- THE SINGAPORE JOURNEY

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Falls (including Slips, Trips and Falls) continued to be the leading incident type in Singapore for fatalities and injuries in 2012 as well as previous years. Recognizing the need for holistic intervention against perennial cause for injuries and deaths at work, Singapore has embarked on a journey against Falls at a national level through concerted efforts involving the government, Workplace Safety and Health Council, industry and business associations. This paper discusses Singapore's journey, key milestone as well as key challenges in the national efforts to stamp out workplace accidents due to Falls.

## Introduction

Falls is a key area of concern for workplace safety as a top contributor for workplace deaths in Singapore. In the last decade, Falls from Heights accounted for about one third of total work fatalities every year (Workplace Safety and Health Council, 2010). Concrete steps had been taken to address the problem of Falls. Both engagement and enforcement efforts saw some initial success in the gradual decline in fatalities due to falls from 25 in 2006 to 17 in 2012, a 30% reduction. (Workplace Safety and Health Institute, 2013) In this paper, we will be touching on the journey taken by Singapore to address the Falls issue; more specifically we will focus on falling from heights.

Falls at work have always been a priority area for intervention by the Ministry of Manpower, Singapore. But the Ministry of Manpower does not work alone. The Workplace Safety and Health Council (WSH Council) was established on 1 April 2008, comprising of 18 leaders from the major industry sectors (including construction, manufacturing, marine industries, petrochemicals and logistics), the government, unions and professionals from the legal, insurance and academic fields. The WSH Council works closely with the Ministry of Manpower, other Government agencies, the industry, unions and professional associations to develop strategies to raise WSH standards in Singapore and to realize the national Workplace Safety and Health 2018 strategy. One of the key initiatives led by the WSH Council was the formation of the National Work at Height Safety Taskforce.

The National Work at Height Safety Taskforce formed in Dec 2009 heralded the beginning of our concerted national effort to address Work at Heights (WAH) safety by all key stakeholders and not just the government alone. The Taskforce is led by Mr. Wong Weng Sun, President and CEO, Sembcorp Marine Ltd, with members from the Ministry of Manpower, the Workplace Safety and Health Council (WSH Council), various industry representatives and training providers.

The WAH Taskforce also established the national strategic framework consisting of a three-pronged plan to improve WAH safety across workplaces namely building strong capabilities, promoting the benefits of WAH safety, and enhancing the intervention framework for WAH. This national strategic framework thus became the guiding beacon for our journey towards safer work at heights over the years. This is the story of our work at heights journey with its key milestones and challenges.

**Building Strong Capabilities**

The WAH Taskforce, together with the Ministry of Manpower, Singapore, analysed the contributory factors for 126 works at heights (WAH) incidents. Key contributory factors including the lack of safe work procedures and inadequate fall prevention measures highlighted gaps in our industry practices and competency standards for WAH. Efforts to build strong WAH capabilities were thus made to develop industry guidelines, standards for practical implementation as well as a national competency framework for WAH training.

*Enhancing Industry Standards for WAH Practices*

In 2009, the WSH Council issued the Approved Code of Practice (ACOP) for Working Safely at Heights, which illustrated a variety of control measures, work practices and fall prevention measures that address the risk of falls. The ACOP also highlighted the Fall Prevention Plan which provided a systemic approach to eliminate or mitigate the risk of falls. The WSH council revised this ACOP regularly to update according to current developments. The latest revision was dated Mar 13.

The WSH Council also developed the WAH Compendium comprising of 3 Guides on key WAH issues namely Guide for Working Safely on Roof, Guide on Anchorage, Lifelines and Temporary Edge Protection Systems, Guide on Personal Protective Equipment for Work at Heights. These guides aim to provide practical instruction to implement safe work practices for working at heights to compliment the ACOP for Working Safely at Heights.

*Developing National WAH Competency Framework*

To address industry gaps in competency to work safely at heights, a new national competency framework was launched earlier in 2013 this year. Co-developed by the WSH Council and Ministry of Manpower, this is the first safety and health competency framework developed in Singapore for a specific area of work. It will address the concerns raised by the industry on competencies and raise capabilities of all stakeholders involved in addressing WAH risks, from professionals down to workers. The WAH Competency Framework will be the foundation in building capabilities and competencies to equip all levels of staff with the necessary skills to work safely at heights. It will focus on training four different levels of vocation – workers, supervisors, assessors and managers.

*Other Assistance to build WAH Capabilities*

Recognizing that companies may lack capabilities or resource to properly adopt safe WAH practices within their workplaces, the Ministry of Manpower Singapore came up with various financial assistance schemes to encourage more companies to take on a more proactive role in ensuring a safer environment for the workers. Acknowledging that small and medium enterprises (SMEs) may lack capabilities or resources to implement good WAH safety practices, various financial assistance programmes were setup to help these companies. This includes financial assistance schemes like Risk Management Assistance Fund and WSH Assist which helps defray the cost the companies might need to bear to engage consultants to help them identify any gaps, formulate action plans and to build in-house capabilities.

## Promoting the Benefits of WAH Safety

One of the key strategies under the National WAH Taskforce framework was to get all stakeholders to recognise the importance of adopting good WAH practices. However, it was also noted that there were a few barriers that might hinder companies from practicing good WAH or rather WSH practice in general, namely the lack of capability and resources to adopt these practices and the lack of safety culture within companies.

*Raising Industry Awareness on WAH Safety*

To reach out to diverse industry stakeholders to raise awareness on key WAH issues and safe work practices, the WSH Council, supported by the Ministry of Manpower organized various one-off and recurrent free seminars, forums and workshops to educate various industry sectors on work at height hazards and safe work at height practices. These outreach events were also often organized in collaboration with industry partners including the Singapore Contractors Association Limited (SCAL) of construction sector and Association of Singapore Marine Industries (ASMI) of marine sector.

In efforts to bring in international WAH expertise to enrich the WAH awareness of local industries, the inaugural WAH Conference 2012-Scaling New Heights in Fall Protection was conducted as a satellite event under the WSH Conference 2012, with support of the Ministry of Manpower and the Workplace Safety and Health Council. The event also aims to promote Singapore as a centre of WSH excellence in Asia Pacific in particular for working at heights.

The inaugural WAH Conference 2012-Scaling New Heights in Fall Protection was hosted on 14 Sep 12 by the International Society for Fall Protection (ISFP) and Access and Scaffold Industry Association (ASIA) of Singapore. The Conference attended by more than 500 industry members, brought together the best minds, thought leaders, regulators, safety professionals, WAH practitioners, and other industry stakeholders in WAH to discuss and deliberate on the real challenges and complex issues facing the WAH community at the workplace. Esteemed conference speakers include Mr. Jordan Barab, Deputy Assistant Secretary for Occupational Safety and Health Occupational Safety and Health Administration, United States Department of Labor and Mr. Kevin Myers, Deputy Chief Executive, Health and Safety Executive (HSE), United Kingdom. Day 2 of the Conference also include an interactive workshop featuring hands-on practical WAH solutions in key areas of concern.

*Safety Compliance Assistance Visit (SCAV)*

To reach out to workers who have not attended our forums and seminars, a new mode of engagement channel was developed in the form of the Safety Compliance Assistance Visits or SCAV to bring WAH awareness directly to site personnel in their workplaces.

The SCAV was a new, innovative capability building and intervention tool initiated by the National Work at Heights Taskforce in Mar 10. The objectives of SCAV were to provide on-site safety educational training to supervisors and workers, create awareness of WAH safety by disseminating educational materials, and site demonstration. Lastly, SCAV strived to enhance the standards of the safety conditions and practices by identifying safety lapses and offering professional advice. SCAV is fully funded by the Singapore government and without charges to the recipient companies.

SCAV involved workplace safety and health professionals who will visit smaller workplaces across the island in special safety vans to reach, engage and educate industry players on workplace safety and health issues. The vans showcase the latest equipment and solutions for WAH as part of the on-site awareness education. Such workplaces will benefit most from practical assistance to build capability for better WSH management. Workplaces found to have WAH concerns will be given time to make improvements before a second visit by the Ministry of Manpower inspectors.

*WAH outreach Tools and Collaterals*

Various educational and promotional materials have also been developed by the WSH Council to support these outreach efforts on WAH safety. These include the Work at Height Kit, comprising the CEO Guide to WAH, Supervisor's Guidebook, Worker's Handbook, WAH Posters and Stickers. To highlight special WAH issues, customized collaterals such as the ladder safety pack was developed in 2011 to raise awareness on safe ladder usage against fatal falls from ladders. We were heartened when OSHA adopted the content for their ladder safety guidance published this year.

*Culture Building*

A national, strategic and long-term approach is vital for Singapore to achieve sustained and continuous improvement in WSH standards. In attaining this objective, the WSH 2018 was co-drafted by the WSHC and the Ministry of Manpower (MOM). WSH 2018 spells out our national vision, the strategic outcomes and the strategies required to achieve the 2018 vision. And to sustain and improve WSH standard, there is a need to inculcate the right WSH mindset among the workforce and each to take accountability and responsibility for WSH outcomes. The WSH2018 national strategy thus addressed such concern by identifying and fostering of a progressive and pervasive WSH culture as one of the key outcome.

To achieve this outcome, WSHC has developed the CultureSAFE programme, a one-stop platform for organizations to embark on a WSH culture building journey beyond WSH infrastructure and competency that focuses on cultivating the right WSH mindset and attitudes in every employee – from top management down to the last worker. The CultureSAFE Model is a representation of the characteristic attributes of an organized group as established by its leaders. These attributes can dictate the WSH values and practices of its members which can in turn shape their psycho-social programming of deep seated WSH attitudes and perceptions.

*Leveraging on Technology for Mass Outreach*

Understanding that with the advancement of technology these days, it is vital to tap on technology to further reach out to the public. One of the mediums to reach out to the general public and keep them updated on the latest WSH related news that was employed was the WSH bulletin. The WSH Bulletin is a free electronic newsletter published by the WSH Council. Emailed to subscribers 2 to 3 times weekly, the WSH Bulletin keeps WSH professionals and interested stakeholders updated on local and international WSH-related matters and developments. The subscribers of WSH Bulletin will receive email alerts on WSH alerts, Safety and Health articles, announcements and lastly OwLinks. Through these email alerts, the subscribers are kept updated with the latest WSH incidents and causal factors and at the same time kept abreast of the latest WSH developments and trends from around the world.

Another technology used is the smartphone application, SNAP@MOM. This application is a free and simple to use mobile application offered by the Ministry of Manpower Singapore to encourage and drive industry and community ownership in managing WSH. Using the latest mobile phone technology platform for iPhones and Android phones, members of the public or the workforce can take photographs of unsafe workplace practices and immediately send them to the occupiers of the workplace registered on the application. Occupiers can use this channel to be better aware of WSH concerns within their premises so that they can take immediate corrective actions. Public and the workforce can also send photographs of good works practices for purpose of sharing.In efforts to reach out to the masses, the mass media were also leveraged in safety promotional efforts including the ladder safety campaign media clip, a dedicated WAH portal and various WAH video clips.

## Enhancing the Intervention Framework for WAH

The third recommendation that was made by the taskforce was the need to establish and maintain an effective regulatory framework for better WAH standards. Based on this recommendation, 2 approaches was developed, namely coming up with a strategic intervention through a Programme-Based Engagement and lastly through the legislation review of the current regulations in Singapore.

*Programme-Based Engagement (ProBE)*
ProBE is a key initiative of the strategic occupational safety and health engagement framework. The aim of ProBE is to engage the industries in partnership, for the purpose of raising Workplace Safety and Health competencies and awareness. Coupled with firm and fair enforcement activities, ProBE strives to help reduce the national occupational fatality rate, especially in the priority or high-risk areas that contribute to the bulk of deaths and injuries.

WAH remains one of the featured priority areas in ProBE, coming up with various engagement initiatives to raise awareness of the importance of working safely at heights. For instance in 2012, based on the statistics of 2011, ProBE targeted 4 key accident agencies that had the highest contribution to total the fatality of the year, namely roof, ladders, scaffolds and structures. Efforts were made to increase awareness of the safety working with these 4 accident agencies, these include but not limiting to a yearlong engagement effort through targeted industry workshops and forums, WAH clinics and pilot trail on Fragile Roof Program. It is heartening to note that a significant improvement of more than 50% in the reduction of fatalities in the focus areas for the year of 2012. (Workplace Safety and Health Institute, 2013)

*Legislation Review*
Singapore being a relatively inexperienced nation in the aspect of WSH, understands the need to benchmark with other countries that are established in WSH and seek to learn from their successful examples. For example, in 2006 the International Advisory Panel (IAP) for Workplace Safety and Health was formed to allow Singapore to tap on the expertise and advice on international experts on strategies to reduce the national workplace fatality and injury rates. The roles of the IAP include advising on significant trends and developments in industrial practices that would impact WSH in Singapore, sharing of approaches to WSH challenges in other countries that might guide Singapore's WSH development and critiquing WSH standards, practices and the regulatory regime in Singapore and provide advice on possible improvements to bring WSH standards in Singapore to the level of leading edge country leaders.

In the aspect of WAH, Singapore noted that established countries like UK and USA have a dedicated set of regulations for WAH. While having a set of regulations that governs work at heights is important, it was not the top priority for Singapore. Singapore believes that it is more important to properly engage all the relevant stakeholders on the importance of safely working at heights and build up the capability of the workforce. After close to years of engagement efforts, the Ministry of Manpower believes it was timely to address the issues by consolidating all the relevant regulations and coming up with a set of regulations dedicated for WAH. However, to ensure that the regulations are fair and applicable, close to year worth of consultations was conducted spanning across all industries and the public before the enactment of the regulations in 2013.

## Conclusion

While some progress has been made in Singapore's journey, the story has yet to reach our goal of "Vision Zero" – zero injury, zero accident, and zero harm. While the ground work has been laid in terms of the enhanced regulations, technical standards and competency for working at

heights, the quantum leap will only be possible through the change of industry mindset and company culture. We have already begun to take infant steps towards culture building which will open another chapter for Singapore's own work at heights journey.

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# PREVENTION OF OSTFA (OCCUPATIONAL SLIPS TRIPS AND FALLS ACCIDENTS): THE ACTIVITIES AND PERSPECTIVES OF THE INRS

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The prevention of occupational accidents (OA) is one of the missions of the INRS (French National Research and Safety Institute). The importance of the challenge of preventing OSTFA is first emphasised by the statistical data of OAs occurring in French companies. The INRS targets different groups of OSTFA in its activities in view to taking into account both the real diversity of OSTFA and the need to set up priority and/or specific prevention actions in certain cases of accident. The specific characteristics of each group of OSTFA are presented first, followed by a description of the INRS's different activities and medium term perspectives dedicated to preventing them.

## Introduction

The INRS's mission is to prevent occupational accidents and occupational diseases from occurring in French companies. This article presents the stakes for these companies in terms of preventing occupational accidents commonly known as OSTFA, the different groups of accidents targeted and all the works and perspectives associated with them.

## The stakes in terms of statistical occupational accident (OA) data

In 2010, occupational accidents designated by the acronym OSTFA represented about 37% of the 658,847 OAs with time off work, 32% of the 41,176 OAs with permanent disability, 43% of the 37,194,643 days lost by temporary incapacity and 13% of the 529 fatal OAs (CNAMTS, 2011). These accidents are most often caused by a disturbance of walking or more generally by a disturbance of movement while working. This disturbance can upset bodily balance and lead to a fall from height if the employee is exposed to such a fall. In the latter case, the accident is particularly serious and often fatal.

## Groups of OAs targeted by INRS's activities and falling within the framework of OSTFA

Work situations can be affected by a diversity of movement disturbances: slipping and tripping, but also collisions (a wrench which slips, an employee that knocks themselves, etc.), jamming (of hand when opening a door or window, etc.), stepping on an uneven surface, etc. Furthermore, priority or specific measures must be taken for certain types of accidents. For

example, when an employee is exposed to the risk of falling from height, the regulations demand that protection against such falls in particular be implemented. Moreover, the installation of an anti-slip floor coating is necessary in certain workshops where the floor is almost always greasy. To take into account both the diversity of movement disturbances and the priority and/or specific actions to be implemented, the works performed by the INRS target the prevention of four generic types of event encountered recurrently for all OSTFA. Extracts of accounts of accidents grouped as a function of type are presented in table 1. Four subgroups of OSTFA are thus considered:

- Falls from heights;
- Balance disturbed by a sudden external force;
- Slipping on wet and/or greasy floors;
- Movement disturbances that are neither generated by a sudden external force, nor by slipping on a wet and/or greasy floor, and which do not lead to a fall from height.

It should be specified that these recurrent types of event are close to the injury in the genesis of the accident. The contributing factors and root causes upstream in the accident genesis are not mentioned but are obviously taken into account in the framework of prevention. What is more, the subgroups defined in this way are not absolutely exclusive, meaning that the prevention of accidents at the intersection of two subsets benefits from works performed on each of these two subsets.

**Table 1. Different sets of OSTFA targeted by the INRS's activities**

| Generic event | Extracts of accounts of accidents |
|---|---|
| Fall from height | … not having seen that the safety rail had been removed, the apprentice stepped back and fell 5 m onto the lawn of the house …<br>… a roofer climbed up a ladder to a height of 6 metres and held the console (of the scaffolding). He fell …<br>… the employee was working on the gangway at a height of 8 metres. … The victim took hold of a plate that had not been fastened well enough …. The plate detached, causing the victim to fall from a height of 7.50 m …. |
| balance disturbance due to a sudden, external force | … the employee, who was moving in a train, was thrown off-balance when the train went over the switchgear …<br>… the victim was standing on a travelling crane that collided with another travelling crane. Surprised, the victim was thrown off-balance. …<br>… The wedge was ejected, … the fitter was thrown backwards and his head hit the floor … |
| Slipping on a wet and/or greasy floor | … During this displacement, the employee slipped then fell to the floor in the kitchen. …<br>… The operator (of the automatic press) wanted to straighten it (the metal strip) and, simultaneously, slipped on an oily metal plate placed on the floor … |
| movement disturbance not due to a sudden, external force, or to slipping on a wet and/or greasy floor, and not occurring in a working situation at height | … the employee tripped over the forks of the forklift truck and fell to the floor …<br>… when climbing down from the truck, the employee hit his head against the low point of the hatch …<br>… when the truck was leaving, the two handlers climbed onto the running board. One of them slipped and fell …<br>… The wrench slipped when the victim was unscrewing a bolt and he fell to the floor … |

## The INRS' Activities and Perspectives relating to preventing OSTFA

*Preventing falls from heights*

These accidents occur when the person is going to, or during, work at height. They are particularly serious and subject to many regulations. They occur in all sectors of activity, though the highest proportion occurs in the construction sector - 26% in 2010 - with the severest consequences: 57% of deaths.

The INRS's activities in these issues essentially include **consulting assistance**, providing information, training and standardisation. Regarding the first point, the INRS responds to a large number of direct requests from companies seeking advice on prevention in the framework of specific work situations, or clarifications regarding regulatory provisions. This activity is provided by its Technical Expertise and Consulting Department (ECT). The same experts also work with the manufacturers of materials and equipment used to gain access to, and work at, heights, that want to obtain the recommendations of INRS's experts on innovative equipment, and integrate the principles of ergonomic design and prevention. Collaboration from the INRS is also sought by professional organisations. Mention can be made of its regular collaboration with companies specialised in scaffolding engineering (design and installation of structures) in the framework of the Technical Commission which has led to making progress with safety in professional rules.

Regarding **information**, the INRS publishes specific documents and brochures with information on risks and the means of preventing them, organisational resources and equipment. The INRS issues publications (INRS, 2007; 2010 and 2012) on the subject of falls from height of which the last bore the title *Prevention of risks of falls from height*. It is a synthesis intended for actors in companies and which provides them with elements for organising an approach to prevention based on applying the principles of prevention, good understanding of regulations, and knowledge of the types of equipment used for reaching and working at heights, their characteristics and their limitations.

The INRS also relies on **French, European and international standards** in view to making progress in ensuring conformity with prevention by drafting texts on certain items of equipment. Regarding this, mention can be made:

- in the scope of French standardisation, a standard on steel shoring towers (pr NF 93-551) focused on the materials assessment and a standard on overhanging work platforms (pr NF 93-351). These two standards are scheduled for publication in the next few months.
- in the scope of European standardisation, a standard on Structural Protection Systems based on elements of scaffolding systems (pr EN 16508) and the revision of the standard on rolling scaffolds (EN 1004).
- in the scope of international standardisation, the revision of standards relating to permanent access to machines (EN ISO 14122, parts 1 to 4).

Lastly, regarding **training**, it is noteworthy that the CNAMTS (French National Health Insurance Fund for Salaried Workers) has given the INRS the task of establishing the reference framework for training dedicated to the assembly, dismantling, and utilisation of scaffolding, as part of its National Training Plan for 2013. This approach is aimed at standardising the certification procedures of training organisations and improving the quality of their services.

*Prevention of loss of balance in situations where balance disturbance is caused by a sudden, external force or a movement of the floor*

The INRS carries out **research** in this area in cooperation with the "*laboratoire d'intégration des systèmes et des technologies (CEA/LIST)*". A **human balance control model** has been developed (Collette et al., 2007a; 2007b; 2008) that is capable of predicting the dynamics of a humanoid model subjected to external disturbances such as a thrust at torso level, a floor movement, etc. Its originality stems from an approach using forward mechanics and the management of multiple non-coplanar contacts. This model has been modified to predict and simulate situations of changes of foothold, such as taking a step in the case of push recovery

(Mansour et al., 2011a; 2011b). A stability criterion has been established that allows predicting the need to change foothold as a function of the magnitude of the disturbance. The digital "Virtual Human" model, capable of simulating the behaviour of operators subjected to sudden, strong disturbances, could be enhanced by simulating more complex situations. In the long term, this approach will **improve tools for computer-aided design,** taking account of Man-Machine interactions (for example to design elevator platforms or to secure hold-to-run controls). The content of the training to prevent risks linked to physical activity could also benefit from the results obtained from these works.

*Prevention of slips occurring on wet and/or greasy industrial floors*

The INRS has **developed a measurement method** for evaluating the slip resistance of floor coatings in the laboratory. This method uses the LabINRS device developed previously to evaluate the slip resistance of safety shoes (Tisserand, 1985) and it provides a dynamic friction index for characterising the anti-slip performance of floor coatings (Leclercq et al., 1991). To measure this performance in companies, the INRS is equipped with a Portable Friction Tester (PFT) that measures friction indexes correlated with laboratory measurements (Leclercq et al., 1994). This portable device is used by 5 regional prevention departments (French Regional Health Insurance Fund) in different parts of France. In addition, the methods developed have allowed the CNAMTS (French National Health Insurance Fund for Salaried Workers) to first issue a recommendation on floor coatings intended for food production premises: the dynamic friction coefficient required to ensure good safety for pedestrians must be equal to or higher than 0.30 and, second, to manage a list of floor coatings for such premises corresponding in particular to this criterion.

A technical specification (CEN/TS 16165, 2012) established by the European Standards Organisation (CEN) proposes two methods for evaluating floor slip resistance that use the Inclinable Plane Friction Tester and the Pendulum Skid Resistance Tester (SRT). The INRS has **compared its own methods with those proposed by the CEN**. To this end, it has developed a method for the psychophysical evaluation of the perceived slipperiness of floor coatings (Marchal & Jacques, 2013) that has led to the reference classification of a panel of 15 floor coatings, ranging from the least to the most slippery. This panel was then measured using the different methods studied. The inclinable plane friction tester gave results that are well-correlated with the reference classification, but it requires test samples and does not permit measurements on site. Conversely, the pendulum SRT is adapted for measurements on site, but correlation with the psychophysical method is poor. As for the PFT, the results were well-correlated with the reference classification and it can be used for measurements in the laboratory and on site.

Furthermore, the deterioration of floor coatings due to mechanical, chemical and heat damage can cause changes in their slip resistance. A study by the INRS (Saulnier & Jacques, 2010) led to the development of a **method to accelerate the aging of floor coatings** when they are subjected to mechanical aggression by rolling and skidding, inherent to company activities. The classification according to the friction coefficient measured of five floor coatings commonly used in the agro-foodstuff industry was the same for both coatings subjected to aggressions in the laboratory and those subject to real wear in companies.

It is important to continue the promotion of anti-slip floor coatings. The outlook for the future includes **increasing the number of slip resistance measurements on site** performed by regional prevention departments, and **improving their selection criteria,** especially by taking into account their sustained performance through time.

Slipping is very frequent in agro-foodstuff production premises, and this sector is specifically targeted by the INRS's current works. It will be necessary to set up actions in other sectors in which there is also a high risk of slipping.

*The prevention of collisions, tripping, slipping and other disturbances of movement that are neither caused by a sudden, external force, nor by a wet and/or greasy floor, and which do not lead to a fall from height.*

These accidents occur in every sector of activity and every trade is affected. The INRS's activities in this area mainly include two modes of action: training/providing information and research. **Making actors of prevention aware** is a vital prerequisite for ensuring progress. Video DV 0331 (INRS, 2005), documents ED 140 (INRS, 2011) and ED 840 (INRS, 2013) that use the results of the research carried out contribute to this awareness in work groups, training activities, seminaries and conferences. The aim is to get **perceptions** to change towards a group of situations that conforms to the real diversity of accidents due to movement disturbance (Leclercq et al, 2010) and to the seriousness of many of them. It is also to include their genesis in the functioning of a **socio-technical system** and demonstrate that prevention cannot be limited to neutralising accident factors present visibly and permanently in the working environment. Along with other European organisations, the INRS has also contributed to the production of a video film DV 0399 (AUVA, DGUV, HSE, INAIL, SUVA & the European Agency for Safety and Health at Work, 2013) intended to promote good practices in the prevention of slips and trips.

**Recent research works** carried out in companies and in the laboratory, including some in the framework of cooperations with university laboratories ("*Université de la Méditerrannée, Laboratoire Mouvement et Perception - UMR 6152*" and "*Université de Paris 8, Laboratoire Paragraphe*") have led to the identification of accident factors of different nature (linked in particular to the physical environment, the task done, work organisation, the operator, etc.) and the recurrent combinations they form (**recurrent scenarios**) in work situations and which cause movement disturbance (Leclercq et al., 2007 ; Derosier et al, 2008; Sicre et al., 2008; Abdat et al., 2013). These works, whose starting point is accidental situations, will be completed by analyses focused on the activities performed and which take greater account of the context of companies.

With the aid of X. Cuny (honorary professor of Health and Safety) the INRS has proposed a **model** representing the final sequence of any accident caused by movement disturbance (Monteau et al., 2009; Leclercq et al., 2013). This model highlights similarities and differences between this type of accident and an OA in which injury is caused directly by an element with which any contact will cause an injury (high voltage source, corrosive chemical product, moving parts of a machine, etc.). This has led to underlining the difficulties/impossibilities of implementing certain prevention actions in the case of accidents with movement disturbance. Developing a method dedicated to the analysis of this type of accident would contribute to taking better account of them in current approaches applied within companies.

In parallel, **research** has highlighted **characteristics shared by all the risks manifesting themselves in movements at work** (musculoskeletal disorders (MSDs) and accidents with movement disturbance). These are diffuse and emerging risks, affecting every sector of activity for which the injury is not directly caused by an element with which any contact leads to an injury. The consequences of these proximities in the field of prevention were described by Leclercq et al. (2013) who showed that the prevention of accidents with movement disturbance, which deserves more attention given the magnitude of the risk involved, should benefit from progress made in the field of MSD prevention. In particular, the interest of studying the application of controls in occupational situations to perform an activity while preserving safety is emphasised. These controls are applied at different levels: movement in the work activity, the activity as a whole, the work situation, and the company.

## Conclusion

OSTFA make up a third of occupational accidents with time-off and form a heterogeneous group of accidents that require numerous actions to ensure prevention. The INRS dedicates

much of its actions (training, providing information, assistance, standardisation, studies and research) to this end.

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# THE STATE OF SCIENCE ON OCCUPATIONAL SLIPS, TRIPS AND FALLS ON THE SAME LEVEL

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This paper summarizes the state of science on occupational slips, trips and falls on the same level. The paper is divided by the subject areas in epidemiology, biomechanics, human-centered approaches, tribology and injury prevention and practices. The summary reveals that slips, trips and falls on the same level are complex problems that require multi-disciplinary approaches. Despite the current progress in recent decades in understanding the mechanisms involved, research and prevention practices remain insufficient given the risk. We urgently need to develop systematic approaches to understanding the mechanisms involved, and to evaluate and implement preventive interventions in the field.

## Introduction

Slips, trips and falls (STF) are a serious problem. Substantial losses due to slip, trip and fall injuries are reported worldwide, including Europe and the United States (Buck & Coleman, 1985; Kemmlert & Lundholm, 1998; Communauté Européenne, 2008; Liberty Mutual Research Institute for Safety, 2012; Nenonen, 2013). Data from the Liberty Mutual Workplace Safety Index (Liberty Mutual Research Institute for Safety, 2012) show that the costs for disabling workplace injuries in 2010 due to falls on the same level in the U.S. were estimated to be approximately 8.61 billion US dollars or 16.9% of the total cost burden. The same data also show that the cost of falls on the same level increased by 42.3% between 1998 and 2010 after adjusting for inflation, while the overall costs of disabling workplace injuries decreased 4.7% over the same period. Falls on the same level continue to be a serious problem in occupational injuries.

## Epidemiology

'Occupational Slips, Trips and Falls on the Same Level' (OSTF on SL) assumes that the accident genesis lies wholly within the operation of a socio-technical system. The accident process, starting with a slip or a trip, for example, is determined by accident factors related to safety management (Bentley & Haslam, 2001), equipment usage (Kines, 2003), work organisation (Leclercq & Thouy, 2004) or work system design (Derosier *et al*., 2008). Each factor revealed by analysis of an accident, notwithstanding its positioning in the accident genesis, is necessary to its occurrence and, therefore, represents a possible lever for its

prevention. Studies of OSTF on SL involve focusing analysis either on the accident process close to the injury event, without referring to the whole socio-technical system involved, or on factors more further upstream in the accident genesis. In the latter case, the identified accident factors are often specific to the activities or organisations, as revealed by the OSTF on SL studies conducted in specific areas of activity.

The notion of same level leads to at least excluding falls from heights. However, this notion is not operationally defined. This would suppose answering the question 'What set of accidents is it coherent to consider from the occupational safety standpoint?' Lortie and Rizzo (1999) proposed a categorisation for all loss of balance accidents. Based on a similar wish to embrace the diversity of occupational accidents, Leclercq *et al*. (2010) proposed an operational definition for a set of so-called 'accidents with movement disturbance'. While accurate distinction of 'slipping' or 'tripping' events is effectively necessary in the case of prevention that focuses on such events, it may be helpful to consider a larger set of accidents sharing explanatory factors within the framework of a systemic approach.

Whatever the set of accidents considered, the importance of the issue represented by OSTF on SL prevention is indisputable. The European Commission report (Communauté Européenne, 2008) effectively shows that 19% of the 3,983,881 non-fatal accidents at work, which led to more than 3 days lost in 2005, were either slips or trips with a fall on the same level or when walking heavily, or else slips or missteps with no fall. The data from Bureau of Labor Statistics (BLS, 2012) show that, among 1,181,290 non-fatal occupational accidents and diseases recorded at private companies and government agencies in the USA in 2011, 15.5% were falls on the same level and 4.1% were slips or trips with no fall, causing a median number of 10 days lost.

All workers are exposed to the risk of an OSTF on SL since this risk can manifest itself when walking at work. The floor characteristics and the movement disturbance energy are enough to cause an injury in the event of a fall on the floor. Walking is a feature of many accident-causing situations, but loss-of-balance occurrences are also very frequent during materials handling operations (Manning *et al*., 1984). While all employees are exposed to this risk, in-company activity sectors and their workers are not equally affected by these accidents (Buck & Coleman, 1985; Leclercq *et al*., 2004).

Findings of several studies investigating the relationship between age and OSTF on SL are sometimes contradictory (Buck & Coleman, 1985; Kemmlert & Lundholm, 1998; Bentley & Haslam, 1998; Leclercq *et al*., 2004). This could be explained notably by the scale of the study, i.e. the more or less integration of the variability in occupational situations.

Thus, knowledge of the activity sector, occupation or age can lead to formulating hypotheses concerning factors influencing OSTF on SL. However, they are insufficient for developing in-company operational prevention strategies. Conditions in which tasks or, more generally, movements, are performed at work, must be considered in order to explain the differences in OSTF on SL occurrence from one work situation to another.

## Biomechanics

Human bipedal locomotion (walking) provides a challenging balance task to the central nervous system (CNS). During a single support period which accounts for 80% of a gait cycle, the body is in a continuous state of falling down because the body's center of mass is outside the foot, the base of support (Perry, 1992). The only way that recovery is achieved is to position the swing limb so that during double support the CNS can make any re-balancing adjustments. As such, stability is lost and recovered in a gait cycle during normal walking. This recovery is a challenging balance task which requires complex interplay of neural and motor control mechanisms. Motor control is directly linked to the central nervous system's processing of sensory inputs (vision, vestibular and proprioceptive systems). The sensory systems send inputs to the CNS to make an adjustment in real time. In essence, we use the inverse pendulum model to modify our walking behavior. Additionally, the internal model is used to predict and adapt

into the next step. It is clear that 'EXPECTANCY' is required to walk safely. There will be a motion perturbation if expectation and reality do not match. If not controlled, this perturbation could grow into miss-steps, slips, trips, and falls. Extrinsic and intrinsic factors that can contribute to fall-related injuries are outlined by Gauchard *et al.* (2001).

*Slips*

Falls initiated by slips are the most prevalent level floor accidents (Courtney *et al.,* 2001). A slip occurs at the shoe and floor interface when the friction required to support human walking exceeds the friction available at the shoe and floor interface.

To reduce slip and fall incidents, steps can be taken to improve identification of individuals prone to have this type of incident and the related risk factors such as anticipation, available coefficient of friction, and human reaction to a slip event. Furthermore, fall prevention training programs using the 'kinetic learning' principle and a slip-simulator facilitated safety training and reduction of falls in the workplace (Lockhart, 2010).

Historically, most of the literature on the biomechanical aspects of slips has investigated human responses to unexpected contamination on floor surfaces. Some of the research focus was on kinematic measurements related to human slips before a slip incident and bodily responses to a slip event. Parameters measured included displacements, velocities and body part positions. For kinematics before a slip event, research focused on identifying parameters associated with the required friction coefficient measured (Kim *et al*., 2005) or slip outcomes (Moyer *et al*., 2006). More recently, accelerations and joint moments calculated from the kinematic measurements have been shown to be promising parameters (Beschorner & Cham, 2008). Whole body responses to a slip incident were summarized by Cham *et al*. (2007).

More recently, nonlinear dynamics was used to investigate walking stability measured with accelerometers on a treadmill (Liu & Lockhart, 2007). Body movements for several consecutive steps were analyzed to quantify variations in the temporal domain. The maximum Lyapunov exponent was identified as a measurement of stability.

*Trips*

Statistical distributions of the minimum foot clearance during mid-swing of repeated walking of the same participant were investigated by Begg *et al*. (2007) and the probability of a trip event at different obstacle heights could be calculated from the statistical distributions.

For trips that occurred in early swing and late swing phases, common responses were an elevating strategy of the swing limb to clear the obstacle and a lowering strategy to shorten the step length, respectively (Eng *et al.,* 1994). The results from Grabiner *et al*. (1993), Owings *et al.* (2001) and Pijnappels *et al.* (2005) indicate that a recovery from a trip depended on factors such as the lower extremity muscular power, ability to restore control of the flexing trunk, reaction time, step length and walking speed. Strength training for the lower limbs might help reduce fall risk.

## Human-centered approaches

Human-centered approaches include the psychophysical and organizational. Psychophysics involves perception of slipperiness with visual and tactile cues, while organizational approaches could include macroergonomics and safety climate.

*Perception of slipperiness*

Perceptions, based on factors such as visual cues and proprioceptive feedback, can be used to assess slipperiness and can supplement objective measurements of slipperiness. When potentially hazardous conditions are perceived through visual and tactile sensation, or are expected to exist in a walking person's perceptual field, walking gait is adjusted accordingly (Capellini *et al.,* 2010).

The visual field is an important psychophysiological parameter involved in gait regulation.

Studies of the human visual mechanism have indicated that only a small part of the effective visual field is attended to. Therefore, if a slippery condition is not detected within one's effective visual field (usually 10-15 feet ahead), the likelihood of fall accidents is significantly increased (Zohar, 1978). Visual control of locomotion has been classified into both avoidance and accommodation strategies (Patla, 1991).

Joh *et al*. (2006) reported that people rely on 'shine' information in forming judgments of slipperiness despite variations as a function of surface color, viewing distance, and lighting conditions. Lesch *et al.* (2008) found perceived 'reflectiveness' to be the strongest predictor of visually-based ratings of perceived slipperiness, but that visually-based judgments of texture and traction were also highly predictive of perceived slipperiness.

Perceived slipperiness can be quantified on a psychophysical scale using foot movement or postural instability as the physical stimulus. One is often not fully aware of the slip between the footwear and the floor on contaminated surfaces, and even on dry non-slippery surfaces, in the very beginning of the heel contact during walking (Perkins, 1978). The results reported by Leamon and Li (1990) indicated that any slip distance less than three cm would be detected in only 50% of the occasions, and that a slip distance in excess of three cm would be perceived as a slippery condition.

Objective measures of slipperiness include kinematic measurements of gait and may also include ground reaction forces obtained with force plates. Results of subjective rating or ranking have been correlated with the static or dynamic coefficient of friction (COF) and slip distance as summarized by Chang *et al.* (2008). The results from Cohen and Cohen (1994) showed that the sense of touch by bare feet, under the conditions of the study, agreed best with the measured ACOF compared with that of seeing the tiles and hearing fingernails dragging across them.

### *Organization approaches*

The roles of macroergonomics in reducing slip, trip and fall incidents were outlined by Maynard and Robertson (2007) who proposed a continuum based on socio-technical system approaches. Key elements in this continuum included management leadership, education and training, hazard surveillance, floor slipperiness assessment, incident and injury reports, floor surface selection, floor surface treatments, mats, housekeeping and maintenance, warning signs and instructions, and slip-resistant footwear.

Safety climate, which is a multilevel factor, is defined as employees' shared perceptions of their organization's safety policies, procedures, and practices regarding the relative value and importance of safety (Zohar, 2003). Safety climate has been demonstrated to predict safety behavior and safety-related outcomes, such as incidents and injuries, in the workplace and could be related to workers' perceptions of injury risk (Huang *et al.,* 2007; Mearns & Flin, 1996). Safety climate has been linked to overall injury outcomes in general, but not to particular injury types. However, Kaskutas *et al*. (2010) reported that safer work climate scores had significant links with safer crew behavior scores and fall injuries.

## Tribology

Correlation between the level of friction and subjective perception of slipperiness was shown to be statistically significant as summarized by Chang *et al.* (2006). The potential for slip and fall incidents can be increased by local variations in friction due to unexpectedly encountering an abrupt reduction in friction across floor surfaces (Strandberg, 1985). Chang *et al.* (2008) reported that two friction reduction variables evaluated could have a slightly better correlation with the perception rating score than the mean COF of each working area based on the results obtained from a field study.

Surface texture of nominally flat floors and shoe surfaces has been shown to influence friction at the shoe and floor interface under liquid contaminated conditions (Chang *et al*., 2001b). Surface roughness and waviness parameters that had strong correlations with the

measured friction were identified (Chang *et al*., 2004).

Tread patterns on shoe surfaces also affect friction, especially when surfaces are contaminated with solid particles or liquid. SATRA published guidelines, without supporting scientific data, for selecting proper tread patterns on shoe soles (Wilson, 1990). The results obtained by Li and Chen (2005) and Li *et al*. (2006) showed that the measured COF was significantly affected by the tread depth, width and orientation.

Wear development and characteristics of shoe and floor surfaces remains a critical issue. Kim *et al*. (2001) reported that progressive wear on the shoe sole was initiated by plowing, which was followed by simultaneous plowing and abrasion.

Although human movements during slip incidents have been reported in the literature (Perkins, 1978), when slip measurement devices to measure various types of friction at the shoe and floor interface were constructed, design and reproducibility issues necessitated some simplifications in shoe movements. More drastic simplifications were made with portable slipmeters than with laboratory-based devices due to constraints of weight and portability. These simplifications resulted in significant differences in the results measured with various devices. The measurement conditions of these devices are still far from perfect and are inconsistent across various devices (Chang *et al*., 2001a).

Friction modelling has been widely used in tribology. Beschorner *et al*. (2009) developed a friction model for steady sliding between the shoe and floor interface and their results were confirmed by experimental data.

Scientific investigations on the operating protocols and performance of slipmeters focused on surfaces with liquid contaminants. Solid contaminants such as sand, sugar or flour particles are an understudied potential slip hazard. Friction measurement on surfaces covered with sand particles was investigated by Li *et al*. (2007).

A statistical model was introduced by Chang (2004) to estimate the probability of slip incidents by comparing the stochastic distributions of the required and available friction coefficients. In contrast to typical biomechanical experiments in which human participants are asked to walk on a walkway on which a section is covered with contaminants, this statistical model is an alternative way to investigate slip incidents when unexpectedly encountering a low friction coefficient area with a reduced gait bias. With this approach, human participants walk on only dry surfaces for the required coefficient of friction measurements, and the available friction coefficient is measured with a slipmeter.

Floor cleaning has received very little attention despite the efforts by Underwood (1991) and Quirion *et al*. (2008). Underwood (1991) developed a procedure to produce realistically fouled tiles in a laboratory environment with which cleaning procedures and products could be evaluated. Cleaning procedures observed at work sites were used to evaluate their effectiveness on different quarry tiles and porcelain tiles in a laboratory environment by Quirion *et al*. (2008) and improved procedures were identified.

## Injury prevention and practices

The causes of occupational falls on the same level are well understood, but fall and injury prevention is another matter. Attention has been given in the literature to specific hazards and controlling of risks. For example, the use of proper slip- resistant footwear and floor surfaces can increase the friction at the foot-floor interface (e.g. Aschan *et al*. 2009; Verma *et al*. 2011). There remain notable gaps in our knowledge on occupational falls prevention. For example, knowledge about floor cleaning, the level and character of lighting, and the effectiveness of training, education and improved awareness to reduce fall related injuries is underdeveloped. Moreover, only limited research has adopted an ergonomics systems approach that addresses the '…important latent failures or the upstream organisational and cultural contexts within which workplace STF occur' (Bentley, 2009). Another, perhaps surprising, aspect is the paucity of prospective studies and evaluated occupational fall prevention intervention programs.

For occupational falls, however, our evidence base of evaluated, multi-factorial

interventions is formed of the sole, important study by Bell *et al*. (2008) who applied a comprehensive package of interventions to three hospitals in the United States which were based on analysis of the historical accident reporting data and on-site risk assessment. Their results showed that the overall workers compensation STF injury claims rate for the hospitals declined more than 50% during the post-intervention time period. A major success of the intervention showed that a comprehensive and sustained intervention can have a major effect in reducing occupational fall- related injuries. However, the study was unable to reveal the relative effect or interdependency of the intervention components.

Without evidence from evaluated interventions, a structured risk management approach to occupational falls reduction is needed with three overarching components: primary prevention, residual risk reduction, and measures to maximise individual capability (Haslam & Stubbs, 2006).

*Primary prevention*

The purpose of primary prevention is to eliminate fall hazards at source, through the design of the built environment and work/activity systems. Flooring should offer appropriate slip resistance for the different conditions. Walkways and walking areas should be designed and constructed to avoid trip hazards. In addition, primary prevention involves attention to the equipment used (e.g. to avoid spillages and other walkway contamination), the manner in which equipment is arranged and stored, the tasks workers need to perform, and the extent to which each of these might affect the risk of falling. Provision of sufficient, accessible storage is a measure to reduce trip hazards. The provision of sufficient lighting is important to allow monitoring of the walking surface. Walking surfaces and pathways will need to be properly designed and installed, then cleaned and maintained. In addition, installations should be durable and resistant to damage.

*Risk reduction*

Even with primary prevention, fall hazards will still be present in the environment. Risk reduction aims to reduce the likelihood of injuries arising from these hazards. An important starting point is to raise awareness of the problem and, through education, promote understanding of risk factors for falling and how they can be improved with proactive risk assessment and management.

It is important that adequate procedures are implemented to detect slip or trip hazards and to remedy the situation. During the floor cleaning process, fall hazards might be introduced. Routine inspection programs should be arranged for walking areas. In all cases, housekeeping procedures should be designed to be sustainable, so that initial good practices do not deteriorate.

Where fall hazards cannot be removed immediately, signage warning of a slip risk should be used. Both carrying items and hurrying should be discouraged in circumstances where other fall risk factors are present. Poor weather with ice or snow is frequently accompanied by an increase of falls, unless appropriate precautions have been taken.

*Maximise capability*

A third strand of the fall prevention process is to maximise individual ability to negotiate the workplace environment. Use of footwear commensurate with underfoot conditions is a measure that can reduce slipping. Protective clothing, such as respirators and hearing protection, can restrict movement and cause sensory impairment. Protective eyewear can distort vision. Thus, consideration needs to be given to safety from falls when specifying and managing the use of workplace apparel.

Promoting regular eyesight testing among workers, along with encouragement to use spectacles appropriately, could reduce the risk of falling. Encouraging exercise can help improve balance. Certain medications that may be prescribed for individual workers for health conditions can cause drowsiness, dizziness, unsteadiness and blurred vision, all undesirable from a falls prevention perspective. Tiredness, as may arise among shiftworkers, can affect concentration and attention. Although the effects of alcohol on coordination and balance are

well known, there is a particular need to avoid the existence of fall hazards in workplace locations where alcohol is consumed regularly (e.g. in bars and clubs).

## Conclusions

This paper summarized the state of science on occupational slips, trips and falls on the same level. The summary revealed the complexity of these problems that would require multi-disciplinary system approaches. Despite the current research progress in recent decades, we still urgently need to develop systematic approaches to understanding the mechanisms involved, and to evaluate and implement preventive interventions in the field.

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# CURRENT PRIORITIES IN FALL PREVENTION RESEARCH AT THE LIBERTY MUTUAL RESEARCH INSTITUTE FOR SAFETY

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At the Liberty Mutual Research Institute for Safety (LMRIS), our approach to fall prevention research recognizes the importance of integrating diverse perspectives across a multiplicity of relevant disciplines, including tribology, biomechanics, epidemiology, and behavioral sciences. This paper is an update of our paper presented at ICFPP2010, providing a brief overview of current LMRIS research efforts aimed at advancing our understanding and prevention of falls.

## Introduction

Since its inception nearly 60 years ago, the Research Institute's mission has been the advancement of scientific knowledge in workplace and highway safety, and work disability. The scientific research conducted at the Institute is predicated on Liberty Mutual's creed "to help people live safer, more secure lives." Consistent with this non-proprietary mission, the research findings are published in the peer-reviewed scientific literature. Thus, Liberty Mutual Insurance (LMI) is distinguished as the only property and casualty insurer with a world-class research program dedicated to safety and disability research that adheres to the highest objective standards of scientific integrity.

Until very recently, the research conducted by the Institute has been primarily concerned with occupational safety and related work disability. The focus on occupational safety reflects the historical standing of Liberty Mutual as a workers compensation carrier. Liberty Mutual today is a highly diversified carrier and as part of the Institute's strategic realignment, the scope of research is diversifying to address non-occupational injuries.

Falls represent the leading cause of nonfatal unintentional injury in the U.S. In 2007, there were 8 million reported cases (NEISS, 2007), accounting for 28% of among adults aged 18-64. Falls also represent a leading cause of severe occupational injuries, representing over 25% of compensable losses. According to the 2012 Liberty Mutual Workplace Safety Index (2012), the most disabling workplace injuries and illnesses that occurred in 2010 (the latest year for which data are available) amounted to $51.1 billion in direct U.S. workers compensation costs. Fall on same level ranked second as a leading cause of disabling injury. With direct costs of $8.61 billion, this category accounted for 16.9% of the total injury burden. Fall to lower level ranked fourth at $5.12 billion. Together, the cost of slips and falls on same level and to lower level in 2010 amounted to $13.7 billion, representing 26.9% of the total burden (see Figure 1). The burden would actually be about 5% higher if bodily injury were to be included, representing slips and trips without falling.

According to the Bureau of Labor Statistics data, over the period 1998 to 2010 the frequency of falls on same level and falls to lower level that resulted in more than 5 days away from work declined by 17% and 31%, respectively. It is remarkable that while the frequency of

work-related falls has declined over the 12 years, the burden associated with falls has grown considerably over this same period. The cost burden associated with falls on same level and falls to lower level actually increased by 42.3% and 3.7%, respectively. In fact, the cost burden associated with falls grew substantially more than any other injury category.

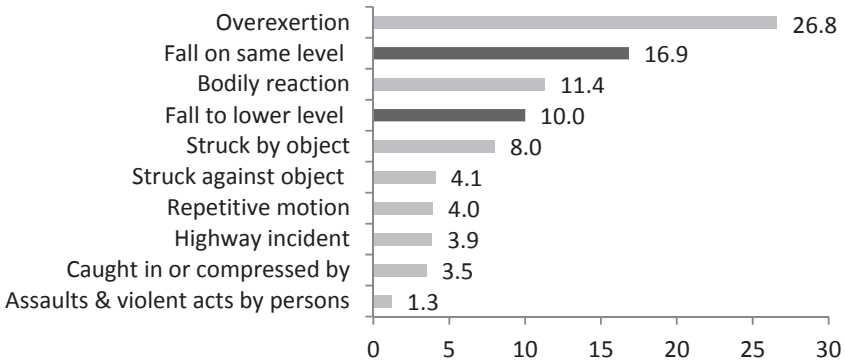


**Figure 1. 2012 Liberty Mutual Workplace Safety Index: Top ten causes and % of burden**

Slips, trips and falls occur as a result of the confluence of factors, and a comprehensive program of research must bring together engineering, biomechanical, epidemiological and cognitive and sociotechnical systems perspectives. A unique strength of the Institute is its ability to engage a broad range of disciplines in addressing the key domains of research interest - slips, trips and falls being a core domain. The Institute's four research centers, specializing in injury epidemiology, physical ergonomics, behavioral sciences and return-to-work, provide complementary perspectives to falls-related research. The studies described below provide a brief overview of current research on falls.

## Falls on same level

*Slips and falls among limited-service restaurant workers*

A multi-disciplinary field study of slips and falls among limited-service restaurant workers was conducted in conjunction with research partners at the Harvard University School of Public Health. In this study, we examined the slip and fall experiences of workers from 36 limited-service restaurants in six U.S. states. The study investigated how factors such as floor surface characteristics, slip-resistant shoes, floor cleaning practices, safety climate, and transient risk factors (e.g., contamination, distraction and rushing) affect the risk of slipping. A total of 475 workers participated in the study. For each restaurant surveyed, participants completed a baseline survey that gathered information on demographics, perceptions of floor slipperiness, slip-resistant shoe use, floor cleaning practices, and number of slips experienced in the four weeks prior to the start of the study. In addition, restaurant managers provided information on floor cleaning protocols and shoe policies. During the subsequent 12 weeks, participants reported their slip experiences.

The data indicated a high rate of slipping in these restaurants, with an overall rate of 22 slips annually per full-time worker. (Verma, Chang *et al.*, 2010) The mean individual slipping rate varied among the restaurants from 0.02 to 2.49 slips per 40 work hours. Liquid and grease were implicated in more than 70% of slips, and the highest numbers of slips occurred in the sink and fryer areas. The rate of slipping decreased by 21% for each 0.1 increase in the mean coefficient of friction (COF).

About 70% of the restaurants used enzyme-based floor cleaners. In these restaurants, however, 63% of study participants reported that they used hot/warm water to dilute the cleaner, which is contrary to the manufacturers' instructions to use cold water and may decrease cleaning effectiveness. Other findings are described below under separate headings. These

findings will be used to inform safety recommendations and guidelines with respect to floor selection, floor cleaning protocols, slip-resistant shoe use, and safety policies related to fall prevention.

*Slip-resistant shoes and risk of slipping (Verma, Chang et al., 2011)*
A strong association was observed between the use of slip-resistant shoes and the rate of slipping. A shoe was considered slip-resistant if it bore the manufacturer's "slip-resistant" marking on the sole. After adjusting for age, gender, body mass index, education, primary language, job tenure, and type of restaurant chain, the use of slip-resistant shoes was associated with a 54% reduction in the reported slipping rate. These results support the use of slip-resistant shoes along with measures to increase COF as preventive interventions to reduce slips, falls, and related injuries.

*Factors influencing the use of slip-resistant shoes among limited-service restaurant workers (Verma, Courtney et al., 2012)*
To understand the factors that influence an individual's use of slip-resistant shoes at work, researchers examined demographic and job characteristic data from the study's 475 participants. Restaurant managers were asked whether the employer provided and paid for slip-resistant shoes; and, if not, whether the employer had given any guidance regarding slip-resistant shoe use. A multivariate analysis indicated that slip-resistant shoe use was lowest in the 15- to 19-year-old age group. Education level, job tenure, and the mean COF had no significant effects on the use of slip-resistant shoes. Women were 18% more likely than men to wear slip-resistant shoes. Workers whose employers provided slip-resistant shoes were 52 percent more likely to wear them and these workers had the highest proportion of use (91%), as compared to workers who received no shoes and no guidance regarding slip-resistant shoe use. These results suggest that employer provision of slip-resistant shoes was the strongest predictor of their use. Given their effectiveness and an average cost of about US $30, slip-resistant shoes can be a cost-effective intervention to reduce slips and falls.

*Impact of transient risk factors on slipping (Verma, Lombardi et al., 2011)*
A nested case-crossover design was used to examine the association between certain transient risk factors—rushing, distraction, and walking on a contaminated floor— and the rate of slipping. The data included average work hours, average weekly duration of exposure to each transient risk factor, job tenure at the current location, weekly slip experience, and whether any of the three transient risk factors were present at the time of slipping. The results indicate that the rate of slipping when workers were rushing was 2.9 times higher than when they were working at a normal pace. Distraction and walking on a contaminated floor also significantly increased the rate of slipping by 1.7 and 14.6 times, respectively. Slip-resistant shoe use decreased the effects of rushing and walking on a contaminated floor, and the effects of all three transient factors (rushing, distraction, and contamination) decreased monotonically as job tenure increased. Participants on average reported walking on a contaminated floor for about one third of their work time. These findings suggest that rushing, distraction, and floor contamination have significant effects on slipping rates among restaurant workers. Reducing the transient exposures of rushing, distraction, and floor contamination; encouraging the use of slip-resistant shoes; and establishing a greater safety focus may help reduce the incidence of slipping.

*Perceived versus actual risk of slips and falls (Courtney et al., 2013)*
To examine the association between subjective measures of risk and the actual risk of slipping in the workplace, participants were asked to rate floor slipperiness using a four-point scale in eight functional areas of the restaurant kitchen: front counter, drive-through, sandwich assembly, fryer, grill, sink, cooler/freezer, and ice machine at the baseline. Participants reported their slip experience every week for the following 12 weeks. The results indicated that each 1-point increase in mean restaurant-level perception of slipperiness (on the 4-point scale) was associated with a 2.71 times higher rate of subsequent slipping. These data indicate that

perceptions of slipperiness and the subsequent rate of slipping were strongly associated, suggesting that worker perceptions of slipperiness could be used as a leading indicator to identify slipping hazards and assess intervention effectiveness.

## Risk of slips, trips, and falls in full-service restaurants

This study extends the work described above to study the effects of floor surface, shoe type, and floor cleaning practices on the risk of slips and falls in full-service restaurants. It also aims to investigate the impact of restaurant design and other factors related to slip, trip, and fall risk. In each of the 48 restaurants that participated in the study, researchers measured the COF on selected floor tiles in the kitchen and dining areas. They also gathered data on floor types, transitions from one floor type to another, and lighting. During working hours, researchers recorded practices or designs that could affect the risk of slipping and tripping. They also examined workers' shoes to determine slip resistance and collected data from managers on floor-cleaning frequency, products, and protocols. Interviews held with over 750 participants gathered basic demographic data, as well as information on job tasks, responsibilities, and prior experiences related to slips, trips, and falls. Specific questions related to fatigue were included, such as information on working hours, break times, double shifts, personal sleeping patterns, and levels of alertness during the workday. Following the interviews, study participants submitted weekly reports of their slip, trip, fall, and injury experiences and hours worked over a 12-week period. Analyses are underway and should enhance our understanding of worker slip, trip, and fall risks in the kitchen and dining areas of full-service restaurants. The information gained is expected to have significant safety implications for restaurant workers and patrons.

## Multidisciplinary approaches toward the measurement of slipperiness in a laboratory environment

This study is part of a larger project aimed at understanding the relationships among perception, gait and related mechanisms involved in falls due to slips. Figure 2 represents a simplified conceptual model of the perception-action cycle of a pedestrian walking on a floor surface. The "Perception" box represents a version of the original Brunswik Lens Model (Brunswik, 1952) in which multiple inputs are differentially weighted. In this case, visual and proprioceptive cues are evaluated with weightings dependent on exposure. That is, early gait adjustments are based primarily on visual information and subsequent adjustments incorporate both visual and proprioceptive feedback.

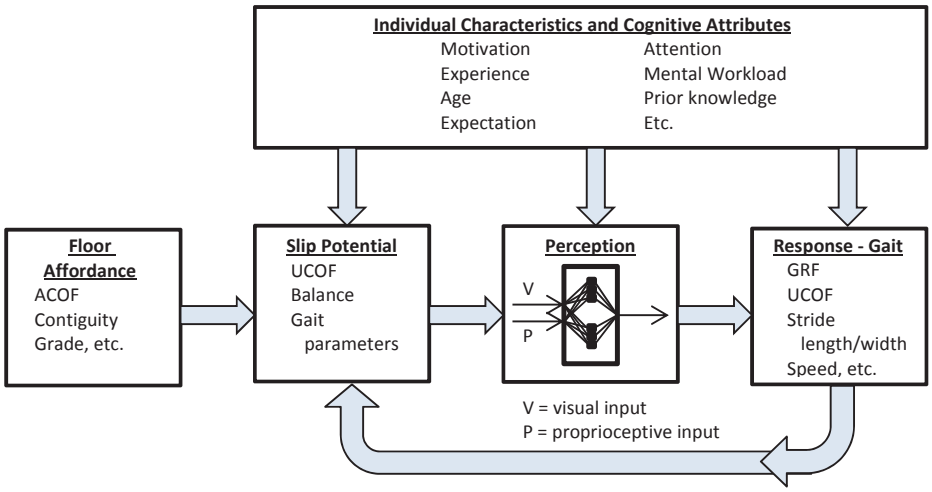


**Figure 2. Conceptual model of perception-action cycle in walking**

In this first study, we were interested in the principal components of the measurement of slipperiness. Participants were exposed to 15 conditions of different degrees of slipperiness (five floor surfaces and three conditions: dry, water, glycerol) and were asked to walk as fast as possible without a slip. The five floor surfaces were selected from 37 common floor types due to their distinctive features that represented different combinations of friction levels and perceptual cues to slipperiness. Preliminary multiple and bivariate regression analyses examined the relationships among perception ratings of slipperiness, gait parameters and COF. The results indicated that the frictional demand, heel angle and perception ratings of slipperiness had the highest adjusted $R^2$ in the multiple linear regression analyses. Although each variable in the final data pool could reflect some measurement of slipperiness, these three variables are more inclusive than others in representing the other variables. Additional analyses will examine the interrelationships among behavioral, biomechanical and tribological mechanisms.

## A statistical model to predict slip probability (Chang *et al.*, 2012)

The probability of a slip can be estimated using a statistical model by comparing the available coefficient of friction (ACOF) with the required coefficient of friction (RCOF). The models available in the literature use mean values to estimate the risk of slips. However, it may be possible to derive more accurate estimates by determining the stochastic properties of these variables. This study investigated the stochastic distributions of the ACOF of five different floor surfaces under three conditions; dry, water and glycerol. The results of 50 participants showed that in 86% of the time the RCOF can be represented by the normal distribution, though in 76% of the cases the distributions for the left and right foot were different. The distributions of the ACOF could only be represented by the normal curve in 20% of the cases. In practice, the ACOF can be considered a constant when it is near zero or much higher than the RCOF.

## Falls to lower level

*Risk factors for work-related portable ladder falls (Lombardi et al., 2011)*
A field study designed to identify ways to prevent or reduce the risk for work-related falls from portable ladders, which account for the majority of disabling ladder-related injuries, was conducted in collaboration with the Harvard University School of Public Health, the U.S. Consumer Product Safety Commission (CPSC), the National Institute for Occupational Safety and Health, and the Center for Construction Research and Training (CPWR). Using cases identified from the National Electronic Injury Surveillance System (NEISS) – a stratified national probability sample of all injuries reported in US emergency rooms, we interviewed 306 workers who had experienced and were treated for a ladder-fall injury. Initial analyses focused on specific, modifiable factors that may trigger portable ladder falls. Secondarily, we evaluated the risk of fractures—the most frequent and severe outcome from ladder falls—as a function of several variables related to work environment, equipment, and the workers themselves. The injured workers were most often employed in construction, installation, maintenance and repair, and sales-related fields. The falls originated from a step, trestle, extension, straight, or rolling ladder, at an average height of 7.5 feet (35% of falls originated from <5 feet, and 5% from >20 feet). The most frequent bodily injury sites were the arm, elbow or shoulder; the head, neck or face; and the lower trunk. Diagnoses were primarily fractures, strains or sprains, and contusions or abrasions. Typically, workers were most often standing or sitting while working on the ladder while installing or hanging an item or performing repairs and maintenance tasks preceding their falls. Ladder movement was an important mechanism; in 40% of the cases studied (varying by ladder type), the bottom of the ladder moved before the fall. The study found a significant monotonic relationship between increasing fall height and fracture risk, and this relationship was also influenced by an increase in worker age, and increased when working on the ladder, as

compared to climbing up or down. The findings have particularly important implications for older workers, who comprise the fastest-growing segment of the U.S. workforce.

*Effect of rest breaks on injury risk for ladder falls (Arlinghaus et al., 2012)*
Additional analyses of the 302 cases from the NEISS examined whether workers who take rest breaks are able to work longer into the workday without injury than workers without rest breaks, and, if so, whether a longer accumulated rest-break time has a greater protective effect (i.e., a longer time-to-injury) than a shorter total break time?

The findings indicated that longer accumulated rest break time exhibited a significant protective effect allowing for a prolonged time spent on task without injury (see Figure 3). This finding suggests that rest-break design could be used to inform fatigue management strategies aimed at improving workplace safety.

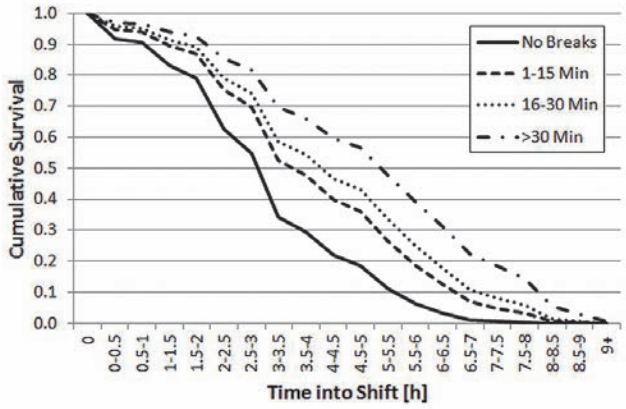


**Figure 3. Effect of rest breaks on time to injury stratified by rest break duration**

**lateral reaching while on stepladders: Balance control and risk perception**

In 2010, falls from ladders accounted for 5.5% of injuries involving days away from work in the U.S. construction industry sector (Bureau of Labor Statistics, 2011) and are also a major cause of injury in other industries. Several laboratory experiments examined factors affecting lateral reaching while on stepladders. For example, one study examined the effect of ladder experience and risk perception on lateral reaching distance and stability. Twenty-four experienced and 24 novice male ladder users performed lateral reaches while standing on 6- and 12-foot stepladders. Participants stood on the third rung from the top of the ladder and reached for a target as researchers measured lateral reach distances, ground reaction forces, postures, and kinematics. The study also examined the effect of motivation on maximum reach, induced by placing a reach-to target at the extreme lateral position for the participant (as opposed to the unmotivated condition where no target was presented). The data indicated that the average maximum lateral reach distance was 66 mm shorter on the 12-foot stepladder than on the 6-foot ladder. Acclimation led to a 35 mm increase in unmotivated reach distances. Motivation brought about a further increase of 66 mm. Across all conditions, the sum of the forces under the two ladder legs furthest from the target decreased from approximately 50% to 12–18% of the total vertical forces created by the individual and ladder. After a short period of acclimation, users were able to reach further without significantly affecting the forces underneath the ladder.

## Straight ladder set-up and use in a field environment

Prior research has explored ladder setup methods and friction requirements in laboratory settings (Chang *et al*., 2004). However, few studies have observed individuals set up and use ladders in real-world settings. In this research, we studied a group of utility workers who routinely use ladders, following each worker as they proceeded to various worksites during the

course of a normal workday. We collected information on climbing behavior, the use of personal protective equipment, ladder-carrying, and ladder setup angle, as well as relevant ground and weather conditions. At the end of each workday, participants completed a questionnaire assessing their knowledge of ladder setup. The results are currently being analyzed to determine the relationships between setup behavior, training, and setup outcomes. In addition, the data are being analyzed to ascertain the impact of safety climate on ladder use and injury outcomes. Study findings will provide insight into the effectiveness of training on ladder use and setup, and will be used to inform and update ladder safety recommendations.

## Summary

The LMRIS program comprises both field and laboratory studies to identify risk factors and underlying mechanisms associated with falls. The program is focused on falls on same level due to slips and falls from ladders. Our program is leveraged through joint research with several partners including the Harvard University School of Public Health. Findings from these studies provide a scientific basis for the development of cost-effective interventions and strategies for reducing the incidence of work and non-work related slip and fall-related injuries.

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# PRESENT SITUATION AND FUTURE DIRECTION OF FALL ACCIDENT PREVENTION MEASURES BASED ON THE INDUSTRIAL SAFETY AND HEALTH LAW

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In Japan, fall accident prevention measures are established based on the Industrial Safety and Health Law, and the Industrial Safety and Health Regulation was amended in 2009 to strengthen the measures for fall prevention from scaffolding. Among occupational death accidents in the construction industry, the ratio of the number of fall accidents is the highest; especially fall accidents from roofs or ladders are more increasing than that from scaffolding. Ministry of Health, Labour and Welfare (MHLW) started 12th Industrial Accident Prevention Plan in April 2013. The MHLW will examine safety-related measures in the future for fall from scaffolding and other high places, and will amend safety-related regulations, if necessary, to strengthen the occupational accident prevention measures.

## Occupational accidents

In Japan, the number of casualties who are absent from work for more than four days and the number of deaths caused by occupational accidents have tended to decrease over a long period of time. However, the number of casualties who are absent from work for more than four days and the number of deaths has continuously increased during the past three years. The number of deaths has repeatedly increased and decreased in recent years. The number of occupational accidents in the construction industry has tended to decrease over a long period of time due to decreases in the amount of construction investment and the number of workers. In 2012, the number of casualties who were absent from work for more than four days increased to 17,073, and the number of deaths increased to 367 (Figure 1 - 2). Among occupational accidents in the construction industry, the ratio of the number of fall accidents to the number of accidents resulting in casualties who are absent from work for more than four days is approximately 35%, while the ratio to the number of accidents causing deaths is as high as approximately 43%. Regarding places where accidents resulting in casualties who are absent from work for more than four days occur, devices for high-place work such as ladders are ranked first, followed by roofs and scaffoldings, in that order. Regarding places where accidents causing death occur, roofs are ranked first, followed by scaffoldings and buildings, in that order.

## Industrial Safety and Health Law and scaffolding-related provisions

In Japan, occupational accident prevention measures are established based on the Industrial Safety and Health Law and related cabinet orders, ministerial regulations, public notices, announcements, and notifications. Therefore, fall accident prevention provisions in the Industrial Safety and Health Law and related regulations are described first.

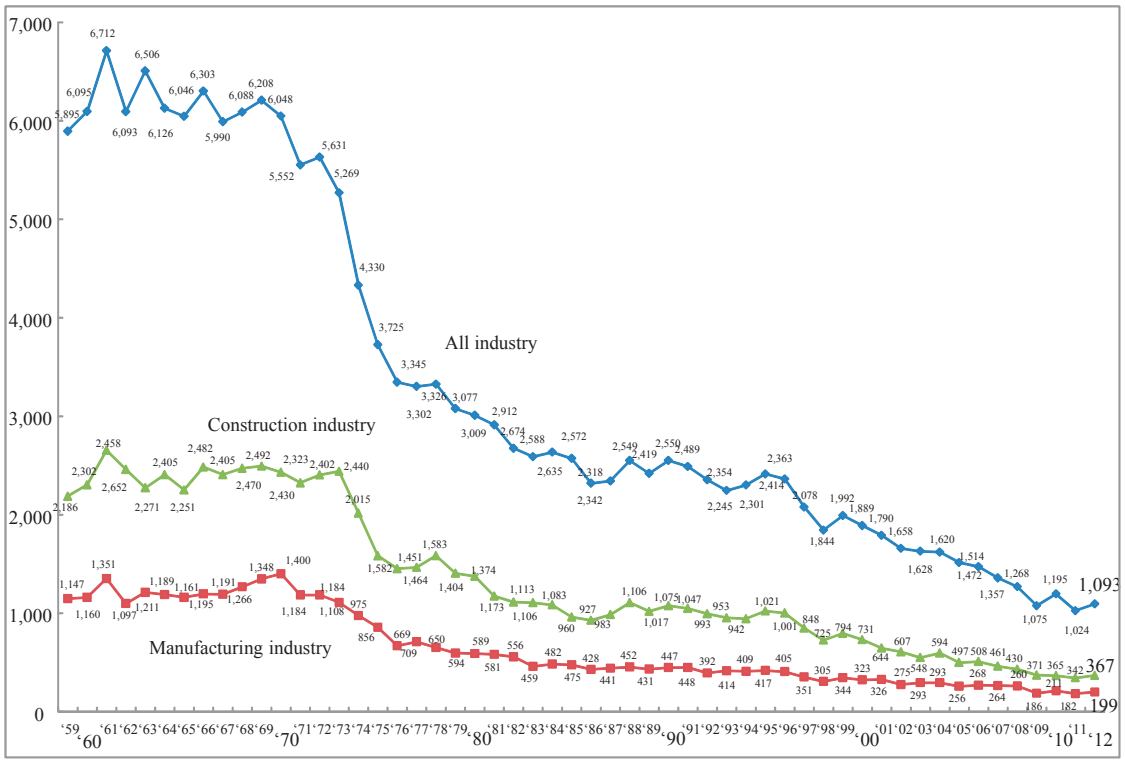


**Figure 1. Changes of number of occupational death accidents from 1959 to 2012 (persons)**

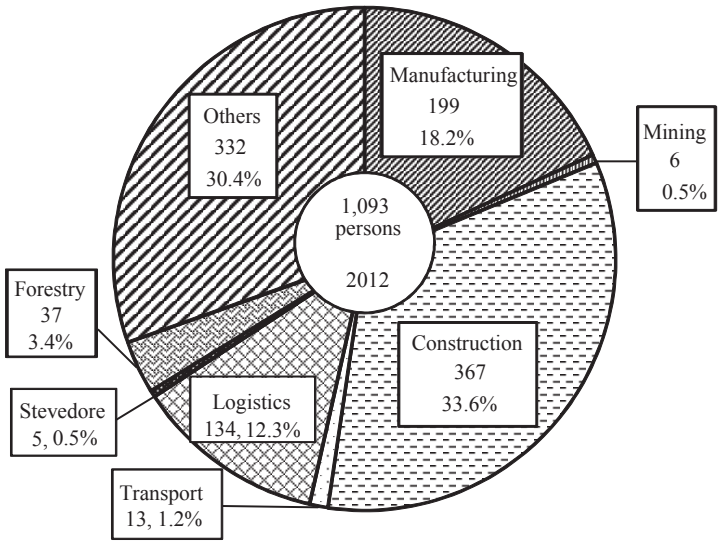


**Figure 2. Classification of number of occupational death accidents in 2012 (persons)**

The Industrial Safety and Health Regulation provides the standards that are intended to prevent fall accidents. The Regulation states that an employer shall provide a working floor by scaffolding or by other methods if an employer carries out an operation at a place having a height of 2 meters or more. If working floors are difficult to install, the employer shall take the measures of installing a protective net, having workers use safety belts, etc. to prevent workers from being injured due to falling. The Industrial Safety and Health Regulation also provides various measures that employers must take to prevent fall accidents and requirements for passages and scaffoldings. The public notice of the Minister of Health, Labour and Welfare also provides the strengths and shapes of components and furniture used for steel-pipe scaffolding.

When setting up scaffolding which is more than 5 m above the floor level, the employer must select a chief worker, and operations must be performed under the command of the chief worker.

When setting up scaffolding which is more than 10 m above the floor level, the employer must submit the operation plan to the Chief of the Labour Standards Inspection Office.

According to the Industrial Safety and Health Law, the principal employers (general contractors who contract with the ordering bodies) are obliged to execute comprehensive safety and health management in order to prevent occupational accidents that occur when workers of different employers cooperate in a same place to perform operations at one time. The Industrial Safety and Health Law stipulates provisions which focuses on the characteristic of the construction industry.

## Fall accident prevention measures taken by the Ministry of Health, Labour and Welfare

In Japan, the construction works are generally pursued after receiving orders. Workers work at different worksites every new order and the contents of the operation change within a short period of time. Furthermore, workers from different employers often cooperate in a same place to perform operations at one time under a multilayered contract system, and a business structure is adopted in which branches and business offices of companies are in charge of multiple worksites. Based on the above facts, the Ministry of Health, Labour and Welfare (MHLW) established "comprehensive occupational accident prevention measures for the construction industry" in which the safety and health management measures performed by principal employers and related contractors were summarized according to the type of implementing body. The abovementioned measures were exhibited in the form of the notification by the Director-General of the Labour Standards Bureau. The MHLW has guided principal employers and related contractors to precisely execute occupational accident prevention measures based on the abovementioned measures. The MHLW has also guided and urged associations on occupational accident prevention, construction-related associations, and ordering bodies to perform occupational accident prevention activities according to their roles.

In the case where encouragement of companies' voluntary approaches is effective for preventing occupational accidents, the MHLW has entrusted activities such as training to associations on occupational accident prevention. At present, the activities performed as fall accident prevention measures are as follows:

1) Projects for promoting fall accident prevention measures (construction)
   - A preceding handrail construction method for scaffolding is instructed at worksites for its diffusion.
2) Projects for diffusing fall prevention measures in high-place work where scaffolding is difficult to install
   - A standard operation manual is created for works on roofs where scaffolding is difficult to install.
   - A workshop that demonstrates fall accident prevention measures is held for works on roofs where scaffolding is difficult to install.

## Recent revision of regulations

In order to prevent occupational accidents due to falls from scaffolding, the Industrial Safety and Health Regulation was amended in March 2009, and the revised provisions were enforced in June 2009. The amended points are as follows (Figure 3):

Regarding prefabricated scaffoldings, installation of a crossing diagonal brace was sufficient before the amendment. After the amendment, lower rails must be installed at a position 15−40 cm above the floor level, or more than 15cm toe boards or preceding handrails must be installed.

Regarding scaffolding other than prefabricated scaffoldings, such as tube and coupler scaffolding, the height of a handrail was increased from 75 cm to 85 cm. Furthermore, middle rails must also be installed at a position 35−50 cm above the floor level.

In April 2009, “further safety measures,” which are desirable to be adopted together with enforcement of the amended Industrial Safety and Health Regulation, were exhibited in the form of the notification by the Director-General of the Occupational Safety and Health Department. There have been a variety of efforts to implement these further safety measures. The key points of these further safety measures are as follows:

- Regarding prefabricated scaffolding, additional upper rails and scaffolding specific to preceding handrails should be installed.
- Regarding scaffolding other than prefabricated scaffolding, toe boards should be added.
- A preceding handrail construction method should be used and easy-to-work and comfortable scaffolding should be installed.
- Safety check of scaffolding etc. should consistently be performed.

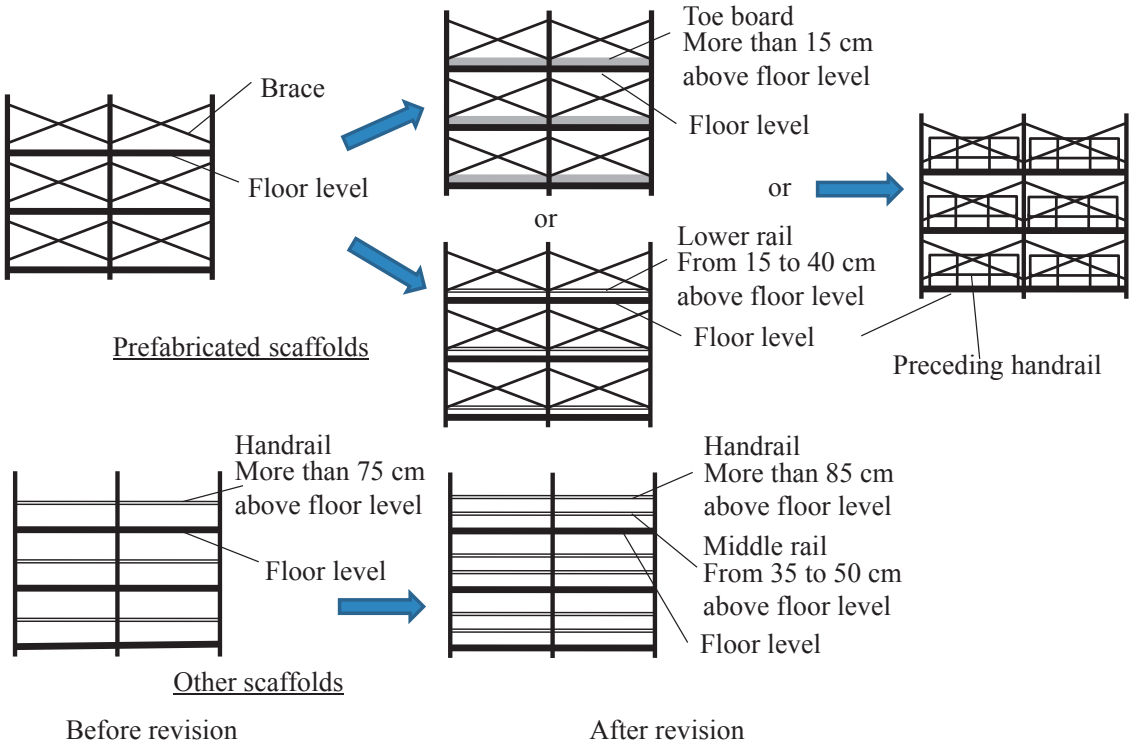


**Figure 3. Revision of the Industrial Safety and Health Regulation in 2009**

## Evaluation of regulation amendment and further measures

After the amendment of the Industrial Safety and Health Regulation in 2009, the MHLW has analyzed data on accidents caused by falls from scaffolding every year. The MHLW has also held “meetings to verify and evaluate the effectiveness of measures to prevent falls from scaffolding” consisting of professors and researcher. The MHLW summarized the suggestions and opinions expressed in the meeting and issued a report every year.

According to the results obtained by analyzing data of the fiscal year 2011 (latest data), approximately 90% of accidents caused by falls from scaffolding occurred at worksites where measures based on the Industrial Safety and Health Regulation were not appropriately taken. Approximately 9% of the accidents occurred at worksites where measures based on the Industrial Safety and Health Regulation were taken, but workers behaved unsafely, such as climbing on the outside of scaffolding. Slightly more than 1% of the accidents occurred at worksites where measures based on the Industrial Safety and Health Regulation were taken and no unsafe behaviour was observed.

Therefore, in the meeting report, the following measures were pointed out:

- Observance of the Industrial Safety and Health Regulation
- Enforcement of measures to avoid unsafe behaviour
- Further diffusion of a preceding handrail construction method
- Development and diffusion of easy-to-fabricate scaffolding devices and easy-to-use scaffolding parts

Based on suggestions in the meeting report, "guidelines for promotion of comprehensive measures to prevent scaffolding accidents" were established in February 2012 in order to prevent scaffolding accidents by diffusing "further safety measures" and a preceding handrail construction method. The guidelines were exhibited in the form of the notification by the Director-General of the Occupational Safety and Health Department. The MHLW has facilitated scaffolding accident prevention measures based on this guideline.

## 12th Industrial Accident Prevention Plan

Since 1958, the MHLW has formulated a revised version of the Industrial Accident Prevention Plan 11 times and positively implemented various policies based on these plans. Based on the recent situation of occupational accidents and social changes, the 12th Industrial Accident Prevention Plan, a five-year plan that starts in fiscal 2013 and is to complete in fiscal 2017, has started in April 2013. The 12th plan contains the following six important activities:

1) Concentration of occupational accident prevention measures according to the changing situation of occupational accidents and diseases.
2) Prevention of occupational accidents by administrative bodies in cooperation with associations on occupational accident prevention and industry associations.
3) Encouragement of societies, companies, and workers to change their way of thinking about safety and health.
4) Implementation of policies based on scientific evidence and international trends.
5) Intensification of endeavour by ordering bodies, manufacturers, and managers of facilities
6) Further measures that will correspond with the issues on the Great East Japan Earthquake and Tokyo Electric Power Company's Fukushima No.1 Nuclear Power Plant Disaster.

The construction industry aims to decrease the number of fatal accidents by more than 20% in 2017 compared with 2012. The following four measures will be implemented for the construction industry:

(1) Promotion of fall accident prevention measures
  (a) Promotion of measures to prevent accidents due to falls from various places
  In addition to promotion of scaffolding accident prevention measures, devices and methods to prevent accidents caused by falls from ladders, roofs etc. should be developed and diffused (Figure 4).
  (b) Diffusion of harness-type safety belts
  Safety belts, which ease impact at the time of a fall, should be diffused in such a way that harness-type safety belts are mandatory under certain conditions (e.g. work at the place of difficulty in rescuing a worker when the worker falls).

(2) Promotion of policies on the basis of nationwide manpower shortage following the Great East Japan Earthquake
  Administrative bodies request ordering bodies of construction works to integrate expenses required for securing safety and health. Administrative bodies also guide principal employers to execute comprehensive safety and health management at construction sites.

(3) Promotion of safety measures in demolition works
  Administrative bodies establish the Guidelines for safety measures in demolition and repair works of buildings, etc. .

(4) Promotion of safety measures in restoration and reconstruction works due to natural disasters
  Occupational accident prevention measures should be thoroughly adopted in restoration and reconstruction works due to natural disasters caused by typhoons, heavy rains, heavy snows, and tornados, which have occurred frequently in recent years.

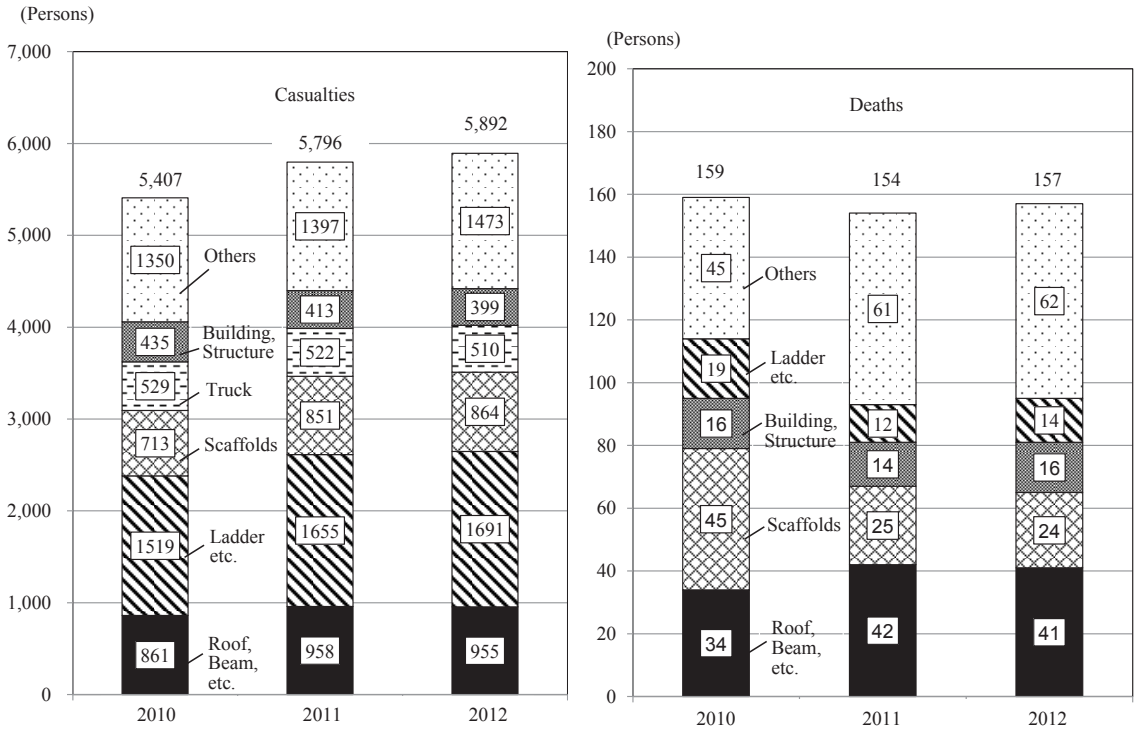


**Figure 4. Classification of fall place when accidents happened from 2010 to 2012**

## Future direction

Regarding scaffolding accident prevention measures, the MHLW held a "meeting to verify and evaluate the effectiveness of measures to prevent falls from scaffoldings" in September, which consisted of professors, researcher and representatives from scaffolding and construction equipment manufacturers and construction-related associations. In the future, the meeting will be continuously held to examine the effectiveness of prevention measures established based on the Industrial Safety and Health Regulation, which were amended in 2009, and to discuss what type of measures will be required.

In the case where scaffolding is difficult to install, such as cleaning of building window glasses and inspection and repair of bridges, rope-access works must be performed. Therefore, a "meeting to examine safety measures in rope-access works" will be held to examine safety measures for rope-access works.

Recently, the MHLW has requested the National Institute of Occupational Safety and Health, Japan (JNIOSH) to develop devices and methods to prevent accidents caused by falls from ladders and roofs. After these devices and methods have been developed, the MHLW will attempt to diffuse them.

Regarding methods and devices to prevent falls from roofs and buildings in repair works, since fall accidents have frequently occurred in repair works for house roofs which were damaged in the Great East Japan Earthquake in 2011, the JNIOSH formed an "examination committee to prevent falls from roofs and buildings" and made a report in cooperation with the Japan Safety Appliances Association. The MHLW has been publicizing and instructing construction-related companies on the contents of this report.

The MHLW will guide companies to execute occupational accident prevention measures and will entrust the related projects to institutes and companies, while concentrating measures contained in the 12th Industrial Accident Prevention Plan. The MHLW will hold meetings to examine the safety-related measures in the future, while also listening to opinions of professors, researchers and persons from the construction and manufacturing industries. The MHLW will amend safety-related regulations, if necessary, to strengthen the occupational accident prevention measures.