CSA GROUP RESEARCH

Study of Common Types of Mechanisms for Portable Ladder Incidents

March 2019

Authors

Peter Vi, Infrastructure Health and Safety Association

Advisory Panel

Brett Latimer, Werner Co.

Scott Patton, Little Giant Ladder Systems

Heather Ji, Investigations and Engineering Services, WorkSafeBC

Dave Shanahan, CSA Group (Project Manager)

Foreword

The focus of this paper is to summarize the results from a review of portable ladder incidents and causal factors. The findings presented will provide up-to-date data on portable ladder injury mechanisms that could help to inform standards on portable ladder use, new portable ladder safety programs and training, as well as new or improved ladder design, performance and safety accessory concepts.

During the development of the 2018 edition of CSA Z11 *(Portable Ladders),* the CSA Technical Committee determined that there was insufficient recent data available on the nature and causes of incidents involving the use of portable ladders. Most workplace data is over 10 years old and few data are from Canada on non-workplace incidents. Most data are from U.S. and European sources, and much of that was high-level statistics on incident frequency for various sectors and types of incidents.

The CSA Technical Committee recommended that greater effort be made to gather incident data that might be helpful in directing and verifying the user safety criteria in CSA Z11. This research report therefore summarizes research into the nature and causes of incidents in portable ladder use such that it may inform future revisions of CSA Z11, potential safety and training programs, as well as improved ladder design, performance and safety accessory criteria.

Contents

Executive Summary 5
Introduction 9
Research Findings 9
Conclusions 14
Acknowledgements 18
References 19
Ladder Safety Resources 20

Executive Summary

A large portion of work-at-heights incidents involves the use of portable ladders (especially among construction, utilities, and agricultural sectors).[1] The purpose of this study was to conduct a review of portable ladder incidents and causal factors to help inform standards on portable ladder use, new portable ladder safety programs and training, as well as new or improved ladder design, performance and safety accessory concepts.

Ladder-related injury reports spanning the period from 1992 to 2018 from British Columbia[3] and Ontario,[4] involving a total of 58,950 workplace incidents, were assessed as part of this project. Of these, 34,279 incidents were found to involve portable ladder use. Others involved fixed ladder systems, ladders mounted on vehicles, ladders attached to scaffold systems, and access systems not considered ladders as defined by CSA Z11 *(Portable Ladders).*

Of the portable ladder incidents analyzed:

- 28% involved falls from ladders;
- 21% involved physical strains and sprains while handling ladders;
- 15% involved physical strains and sprains while standing on ladders;
- 6% involved being struck by a ladder, strains;
- 5% involved falls while handling ladders; and
- 3% were incidents in which the use of a ladder was secondary to the cause of injury.

Of the incident reports analyzed:

- 0.6% resulted in a fatal injury;
- 2.3% resulted in serious, long-term injury;
- 7.5% resulted in fractured/crushed bones;
- 5.3% resulted in head concussion;
- 14.8% resulted in strains and sprains; and
- 35.4% resulted in cuts, abrasions, and bruises.

Given the nature of the data available, only the immediate causes of incidents could be derived from the information. Underlying root or systemic causal factors may have been implied, but could not be reliably concluded from the information provided in these reports.

In summary, the causal factors related to the incidents involving portable ladders were:*	
Individual missed the last step when climbing down	26%
Individual overreached while on the ladder	22%
Inappropriate type/size of ladder used	18%
Three points of contact not maintained	17%
Ladder not on firm, level ground	13%
Individual stood on the top rung or cap	12%
Poor ladder placement – insecure location/orientation	12%
Ladder not in good working condition	10%
Ladder dislodged while dismounting/remounting ladder top	10%
Poor environmental conditions (rain, snow, wind)	9%
Loss of balance while handling materials	8%
Ladder's duty rating was inadequate for the job	6%
Use of power tools while on ladder (kickback)	4%
Moving vehicles contacting ladder	3%
Supporting structure gave way	3%
More than one person on the ladder	2%
Inappropriate footwear used while on the ladder	2%
Contact with sources of electrical energy	1%
Fainting or loss of consciousness	1%

**As is the case with many occupational incidents, many of the ladder incidents analyzed were found to have multiple causes. Consequently, the percentages in the list above add up to more than 100*

Based on these findings, the following recommendations were made for the improvement of CSA Z11 and ladder safety training based on CSA Z11:

1. Ladders should be designed in a manner that reduces the risk of missing the last step. Bottom steps should be designed so as to give the user warning that his/her foot is on the last step.
2. Training on safe ladder use should include procedures that maximize awareness of individual users that they have one more step to descend before reaching the ground.
3. Focus should be placed on selecting the appropriate ladder for the task and work environment (duty rating, type of ladder, materials of construction, style of feet and top end).

4. Work should be planned so that the ladder user can maintain secure contact at all times. Such pre-planning should be recommended in CSA Z11 and be part of user training.

5. As a basic principle, when circumstances demand special adaptations, they should be carried out following some thought and consultation with those having expertise in the dynamic forces involved. This recommended approach should be added to CSA Z11.

6. Ladder users should be trained on how to evaluate ground conditions and feet placement so as to ensure square upright and secure ladder positioning. If the ground at the base of the ladder is not level or is composed of loose material or water-saturated soil, consideration should be given to relocating the ladder to more solid, level ground. If that is not a possibility, a secure, level base should be constructed and installed.

7. Standing on the top steps or top cap continues to be a significant problem, even among professional users. Ladders should be designed so as to discourage this practice. Worker training should focus on the dangers of working in such unstable positions.

8. Ladder positioning (1:4 angle of inclination, square to the supporting structure, with level feet and top) continues to be an issue. As noted in Recommendation 3, workers and supervisors need to select the right ladder for the job and environment and should assess ladder positioning (orientation) appropriately. Workers and supervisors should be trained on how to conduct these on-site assessments and reject unsafe positioning as an option.

9. Portable ladders may not always be the best choice for access to work at heights. CSA Z11 and training should emphasize the need for selecting access equipment based on hazard/risk assessments and industry best practices.

10. Portable ladders should be inspected by users at the beginning of each work day or prior to use when taken out of storage. CSA Z11 should detail the nature of these pre-use inspections and the recourse if damage, loose fittings, or other wear-and-tear is observed. Training should include how to conduct these inspections and report findings.

11. Ladder maintenance procedures recommended in CSA Z11 should include periodic inspection by maintenance personnel specially trained in assessing ladder function and condition. CSA Z11 should specify that ladders found with minor damage, or to be in questionable condition, should be repaired in accordance with manufacturer's instructions. Ladders in poor, unrepairable condition should be removed from service.

12. CSA Z11 should specify that ladders not be placed over dangerous surfaces (e.g., where sharp objects, moving machinery, dangerous inclines, unstable materials, pools of liquid, or hot surfaces are present). Avoidance of climbing over such danger zones should be part of user training.

13. CSA Z11 should specify that, where there is risk of serious injury due to falls, a secondary means of fall prevention or fall-arrest equipment should be used. These high-risk situations include work procedures where three points of contact cannot be maintained, work involving the use of power tools, and when working at heights of 3 metres or more.

14. CSA Z11 and CSA Z195 *(Protective Footwear)* should specify that properly-fitted footwear be worn when climbing ladders. This footwear should have good-quality soles with slip-resistant treads.

15. Accessories attached to portable ladders (e.g., outriggers, stabilizers, clamps, adaptors, extensions) should be selected with care and in consultation with the ladder manufacturer or distributor. Personnel assigned responsibility to select and attach accessories should have good knowledge of the work conditions, job demands, and dynamic forces associated with ladder use. Inspection of ladder accessories should be included in the ladder maintenance program.

16. CSA Z11 should specify that ladder selection, safe use, and training be an integral part of a work-at-heights safety program as established by the organization using ladders (i.e., the job site owner or employer).

    Note: *Software tools are available to aid in the management of such programs.*

17. CSA Z11 should emphasize that awareness of electrical dangers is vital to the pre-work routine. Portable ladders should only be used in areas well clear of overhead electrical power lines and other types of live electrical equipment. CSA Z11 should furthermore direct that the work site be inspected for electrical dangers prior to ladder placement.

18. As with other types of hazardous work, CSA Z11 should advise on appropriate emergency preparedness. Emergency plans should include rescue of anyone caught in a precarious position or taken ill while on a ladder. These plans should also include first aid treatment of anyone falling from heights, suffering strain, or taken ill while working with ladders.

"A large portion of work-at-heights incidents involves the use of portable ladders."

Introduction

A large portion of work-at-heights incidents involves the use of portable ladders (particularly among construction, utilities, and agricultural sectors). Many of these incidents result in falls from elevation or strains while carrying or manipulating portable ladders. Others result in workers being struck by objects, injury to feet and ankles, pinched hands/fingers, or electrical shock.[1-2]

This study endeavours to assess the nature of ladder incidents and their causal factors to draw conclusions and recommend possible preventative measures, particularly as they relate to ladder design, selection, use, and maintenance. These conclusions and preventative measures will provide important guidance for future revisions of CSA Z11 *(Portable Ladders),* as well as for safety authorities, safety advocacy organizations, and industry groups in the development of ladder safety programs and training, and for ladder manufacturers and distributors in the development of new ladder design, performance, and ladder safety accessory concepts.

This study was limited to incidents involving significant injury (those requiring medical aid), however, it should be noted that many ladder incidents occur that do not result in injury. Non-injury incidents may result in damaged equipment and property and they may have the potential for severe injury. Reliable incident data spanning all occupational sectors in Canada is limited to workers' compensation (insurance) systems. Data for this research report was obtained from workers' compensation incident reports in British Columbia[3] and Ontario.[4]

Data from 34,279 incidents were analyzed, and causal factors were available from 22,912 of these reports. Several results included multiple causal factors, therefore all causes were recorded for each incident.

Research Findings

Nature of Incident Data

The data reviewed in this study originated from detailed incident reports provided by the provinces of British Columbia[3] and Ontario.[4] British Columbia provided 57,024 incident reports involving portable ladders ranging from 1992 to 2017. Data from Ontario reported on 1,926 incidents between 2012 and 2017.

The extent of the details available from these data sets varied considerably. Some incident reports appeared to focus on the nature of the injuries sustained (e.g., concussions, fractures, strains, lacerations, etc.). Others provided more details on the incident description from which the type of incident statistics was derived.

Of the 58,950 workplace incidents provided in these data sets, 34,279 incidents were found to involve portable ladder use (as defined by CSA Z11). The remaining ladder-related incidents involved fixed ladders, sliding ladder systems, truck-mounted ladders, ladders attached to scaffolds, rolling platforms, fold-away ladders/stools, and other non-descript ladder types.

Figure 1: *Proportion of Incidents by Occupational Sector*

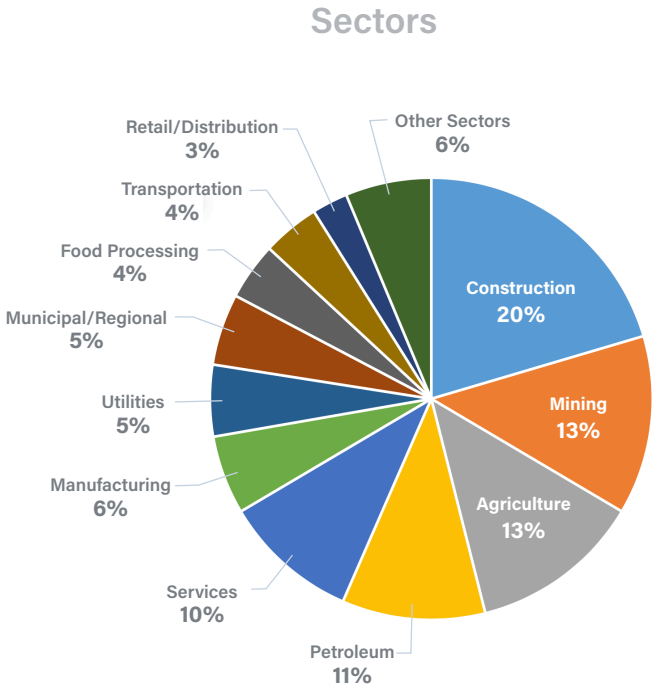
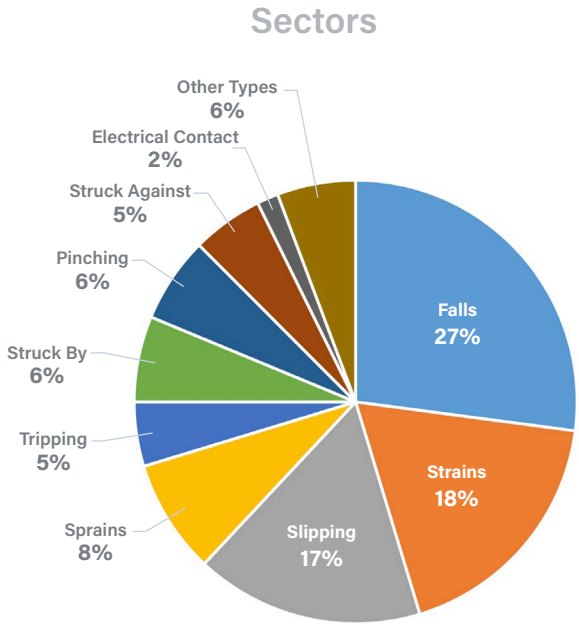


Figure 2: *Types of Ladder Incidents**



**Note that some injuries occurred at a time when the ladder was set up, but not actually being used. In these cases, the injured worker was standing beside or near the ladder and was struck by the ladder as it fell or by falling materials on or adjacent to the ladder. In other such cases, the worker was injured while trying to catch the ladder as it was falling.*

The incidents involving portable ladders were analyzed to determine causal factors. Of these, incident causes could be derived from 22,912 of these reports. For many of these, multiple causal factors were determined, resulting in over 41,000 incident-causal data points being included in the analysis.

Types of Incidents and Associated Workplace Sectors

Figure 1 indicates the major occupational sectors in which these incidents occurred.

Among the incidents analyzed, several incident types were identified. Figure 2 displays the breakdown of incident types.

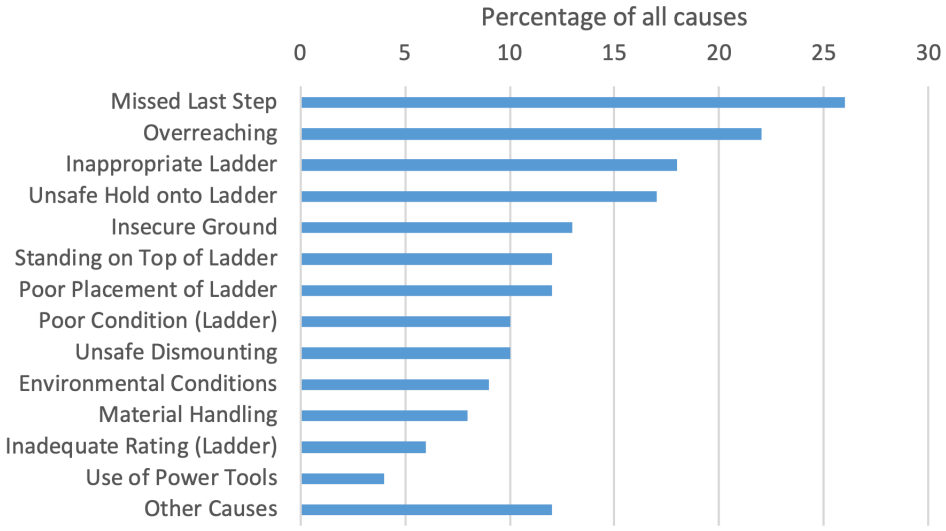
Many other injuries occurred when a ladder was being manually transported, either being moved from one position to another or being transported across the job site. Other injuries occurred while the ladder was being removed from or placed back in storage, either in a storage area or on storage racks.

Analysis of Incident Causal Factors

The following methodology was employed in determining likely causal factors based on incident descriptions, the circumstances surrounding each incident, the work environment at the time of the incident, and the nature of the work being performed:

1. The incident description and nature of the injuries were extracted from the incident report.
2. The type of portable ladders being used was noted (e.g., step ladder, straight non-extension, extension, articulated, telescoping, etc.).
3. The type of workplace or application was noted (e.g., construction, agriculture, mining, marine, manufacturing, services, etc.).

Figure 3: *Ladder Incident Causal Factors*



4. If the incident description contained sufficient detail, the related circumstances leading up to the incident were evaluated.

5. If available, the work environment and weather conditions were noted.

6. The nature of the work being performed, either by the individual injured or relevant work in the immediate area, was noted. In many cases, the nature of the work was derived by inference based on the incident description.

7. All of these factors and conditions were then analyzed to determine likely causal factors. In many cases, the evaluated causal factors were provided in the incident reports.

From this lengthy analysis of the 34,279 portable ladder incidents, likely causal factors could be determined for 22,912 incidents. For many incidents, only one causal factor could be determined by this method. For a minority of incidents, this analysis method allowed more than one causal factor to be derived. In total, more than 100 unique causal and over 41,000 incident causes were identified. Many of these were determined to be relatively rare and unusual (e.g., slip and fall while approaching the ladder, dust blown in eyes while on ladder, striking head on overhead beam while ascending ladder). Less frequent causal factors (frequency less than 1% of occurrences) were excluded from the final analysis if they were deemed that they would not contribute to recommendations for improvement to CSA Z11 or training programs.

Nineteen causal factors were found in 1% or more of the incidents evaluated. Figure 3 indicates the breakdown of major causal factors for ladder incidents and a description of each causal factor is presented below.

1. Individual missed the last step when climbing down (26%)

When descending the ladder (particularly under adverse conditions), the worker either missed or slipped off the bottom step/rung. The resultant injuries were lower leg lacerations, injured ankles, strained ligaments, fractured bones in the foot or ankle, or other injuries sustained when the individual fell to the ground. In many of these cases, the worker had thought he/she had reached the ground level and stepped back. In other cases, they were distracted by other activities or carrying a load.

2. Individual overreached while on the ladder (22%)

In attempting to reach for something, perform work, or climb around an impediment, the worker imbalanced the ladder causing the ladder to be displaced or collapse altogether. In most of these cases, the ladder was not secured at the top. In some cases, the worker was able to hold onto the ladder while gripping a supporting structure but strained upper body parts in doing so. In a few cases, the individual had to be rescued from a precarious position.

3. Inappropriate type/size of ladder used (18%)

The wrong type of ladder was used for the demands of the job. In many cases, a light-duty consumer ladder was used to perform heavy-duty professional tasks. The light-duty ladder eventually failed and the individual was injured in the collapse of the support. In other cases, a relatively short step ladder was used where an extension ladder should have been used. In a few cases, the ladder was not designed to provide safe access to constrained or tight spaces (e.g., a difficult-to-access work location). In other cases, a job-made heavy ladder was used where a ladder designed and manufactured for the application should have been used. In most of these instances, the employer or contractor did not have a documented selection process for portable ladders.

4. Three points of contact not maintained (17%)

The worker either fell from the ladder or slid down the ladder when he/she did not maintain a safe position on the ladder. These incidents occurred during all modes of movement: while ascending, while standing, and while descending. They often involved work being performed while on the ladder or materials/tools being carried up and down the ladder. In some cases, this causal factor was associated with overreaching (see Item 2).

5. Ladder not on firm, level ground (13%)

In these incidents, the ladder feet or base was positioned on either soft unstable ground (or materials) or on an uneven surface (rough irregular ground or sloped surfaces). In many of these cases, the feet either sank into soft ground or slid on shifting granulated material (e.g., sand, gravel, snow). For step ladders, these surface conditions often resulted in one foot losing contact with the ground or causing a torsional shifting of the ladder frame. In straight or extension ladders, these surface conditions resulted in the ladder leaning to one side or not being aligned with the supporting structure. In other cases, an unstable surface caused the feet or base to slip sideways or backwards. In many cases, the ladder fell because it was overbalanced (i.e., not positioned with an optimal incline or having too great a lateral sway).

6. Individual stood on the top rung or cap (12%)

The worker either stood on the top rung/step while performing work or used the top cap of a step ladder or stool climb onto or down from an elevated position. In most cases, the ladder either fell from its position or was dislodged (i.e., it did not collapse). The result was that the worker fell to the ground or was left hanging from an upper support structure.

7. Poor ladder placement – insecure location/orientation (12%)

Similar to the uneven/unstable ground causal factor described in Item 5, these incidents involved ladders being placed or positioned in an unstable orientation. These include too steep or too shallow an inclination, ladders leaning against an unstable or non-flat support structure, ladders tilted to one side, ladders placed close to the edge of a precipice, and ladders placed on top of other objects. These situations are sometimes precipitated by physical constraints of the work area or by using the wrong type of ladder for the job (see Item 3).

8. Ladder not in good working condition (10%)

Incident reports indicated that these ladders were in poor condition, either having been treated harshly or having been used for many years. In these cases, the ladder either collapsed or components failed, causing the ladder to become unstable. In most of these instances, the employer or contractor did not have a documented inspection and maintenance process for portable ladders, nor were these processes included in worker training.

9. Ladder dislodged while dismounting/ remounting ladder top (10%)

Many of these incidents appear to be related to rushing on and off the ladder, often with materials and tools in hand. Similar to the overreach causal factor (see Item 2), in most of these cases, the ladder was not secured at the top. In some cases, an inappropriate ladder was being used (e.g., too short or wrong type). Some of the injuries sustained in these types of incidents were quite severe.

10. Poor environmental conditions (rain, snow, wind) (9%)

These are contributing factors in many incidents. Often, these factors cause increased risk levels for routine work. They usually combine with other immediate causes to lead to incidents. One of the factors often missed in job planning is the potential for wind gusts while working at heights. Cold weather (wind chill) can lead to numbing of hands and limbs, especially on metal ladders. Both improper gloves and cumbersome clothing can interfere with the worker's ability to maintain secure contact with the ladder.

11. Loss of balance while handling materials (8%)

Handling materials while on a ladder, especially those with large surface areas, can significantly increase the risk of overbalancing and interfere with the worker's ability to maintain safe contact with the ladder. In some cases, the worker lost his/her balance while attempting to place materials on or pull materials from an elevated surface. These incidents often resulted in falls from the ladder.

12. Ladder's duty rating was inadequate for the job (6%)

This causal factor is related to inappropriate ladder type/size factor (see Item 3). It is also related to the poor working condition factor (see Item 8) as use of under-rated ladders often leads to excess wear and tear. In many of these cases, a light-duty consumer ladder was used in a situation where a heavy-duty professional ladder should have been selected.

13. Using power tools while on ladder (kickback) (4%)

In these cases, the worker was using a power tool while standing on a portable ladder. This is a particular problem in the agricultural sector but is also prevalent on construction sites. Typical tools being used included chain saws, power drills, cut-off saws, power hammers, and grinders. In addition to excess weight causing imbalance, the energy of the tool (e.g., pull, torque) propelled or forced the worker's arms and shoulders into uncontrolled motion, dislodging them from the ladder. In other cases, the power tool propelled material into the worker's face or severed a structural member supporting the ladder.

14. Moving vehicles contacting ladder (3%)

In these instances, ladders were placed in an area exposed to industrial traffic or mobile equipment. Many of these contacts were at low speed but were of sufficient force to dislodge the ladder feet. Many occurred in areas where the sight lines were poor (e.g., blind corners). Many involved equipment being operated in the reverse direction. A few involved remotely-controlled or autonomous mobile equipment.

15. Supporting structure gave way (3%)

These incidents were caused by either the vertical support structure giving way or by a collapse of the horizontal surface on which the ladder was placed. These causal factors are related to pre-job planning and assessing the integrity (strength) of supporting structures. As identified in the power tools causal description (see Item 13), a number of these incidents occurred when the supporting structure was damaged by the work being done.

Note: *In a few cases, the damage was done prior to the incident by other work activity, thereby creating a pre-existing weakness.*

16. More than one person on the ladder (2%)

These incidents often occurred when members of a work crew were ascending or descending a ladder simultaneously. Other occurred when a tradesperson was working with an assistant who was standing on the ladder in order to pass up tools and materials or hold/move an object on which work was being done. Others attempted to hold the ladder in position by standing on the bottom step/rung.

"Ladders should be designed in a manner that reduces the risk of missing the last step."

17. Inappropriate footwear used while on the ladder (2%)

In some cases, casual (non-work) footwear was worn with soles having poor traction. In other cases, the footwear was poorly fitted (oversized for the individual). In cold-weather conditions, some incidents occurred because the worker was wearing large snow boots. In many cases, the tread on the work boots was worn flat. Similar to the missed the last step causal factor (see Item 1), the resultant injuries included lower leg lacerations, injured ankles, strained ligaments, and fractured bones in the foot or ankle.

18. Contact with sources of electrical energy (1%)

Most of these incidents occurred when portable ladders were being carried by hand, being set up, or being repositioned. In most incidents, a metal ladder made contact with power-supply lines or with exposed live electrical equipment. While there were a few noteworthy fatalities (i.e., electrocutions), most of these inadvertent contacts resulted in non-lethal shocks and burns to the hands or other parts of the body. In many cases, the worker was not aware of the overhead wires or exposed electrical equipment. In a few cases, the equipment had been exposed by earlier damage.

19. Fainting or loss of consciousness (1%)

There were many causes of fainting or loss of consciousness. They included poor health, hot environments and the worker's head striking an object.

In the great majority of these cases, the worker fell from the ladder in an uncontrolled manner. In a few cases, the worker was caught on the ladder or an adjacent structural member.

Conclusions

The incident causation analysis resulted in the following conclusions being drawn:

1. The data showed that the leading causal factor in portable ladder injuries was either missing or slipping off of the bottom step/rung. This was found to be related to a number of factors including inattention, rushing, slippery conditions, handling tools and materials, and poor footwear. In some cases, these incidents may have also been related to improper ladder positioning. Ladders should be designed in a manner that reduces the risk of missing the last step. Bottom steps should be designed so as to give the user warning that his/her foot is on the last step.

2. Related to the causal factor in Conclusion 1, training on safe use of ladders should include procedures that maximize awareness of individual users that they have one more step to descend before reaching the ground.

3. Selecting the right ladder for the job is an issue for many employers and contractors. Some utilize the same ladder for jobs with differing demands. In other instances, a portable ladder is used where another means of access should be used (e.g., a scaffold or a

powered platform). Focus should be placed on selecting the right ladder for the job and work environment (duty rating, type of ladder, materials of construction, style of feet and top end).

4. Maintaining a secure position on ladders continues to be a problem. Incident investigations have concluded that many of these insecure situations are created when the worker is performing work from the ladder or is holding/carrying an object while ascending or descending. Work should be planned so that the ladder user can maintain secure contact at all times. Such pre-planning should be recommended in CSA Z11 and be part of user training.

5. Incident investigations also showed that awkward and unbalanced situations were created when unusual circumstances were encountered, necessitating some degree of innovation. As a basic principle, when circumstances demand special adaptations, they should be carried out following some thought and consultation with those having expertise in the dynamic forces involved. This recommended approach should be added to CSA Z11.

6. If the ground at the base of the ladder is not level or is composed of loose material or water-saturated soil, consideration should be given to relocating the ladder to a more solid, level ground. If that is not a possibility, a secure, level base should be constructed and installed. This need is an opportunity for improving ladder feet and accessories for the feet, such as attachments with broader, adjustable bottom plates. Nevertheless, ladder users should be trained on how to evaluate ground conditions and feet placement so as to ensure square upright and secure positioning of the ladder.

7. Standing on the top steps or top cap continues to be a significant problem, even among professional users. Ladders should be designed so as to discourage this practice. Worker training should focus on the dangers of working in such unstable positions.

8. Ladder positioning (1:4 angle of inclination, square to the supporting structure, with level feet and top) continues to be an issue. As noted in Conclusion 3, workers and supervisors need to select the appropriate ladder for the job and environment and should assess ladder positioning (orientation). Workers and supervisors should be trained on how to conduct these on-site assessments and reject unsafe positioning as an option.

9. As identified in Conclusion 3, portable ladders may not always be the appropriate choice for access to work at heights. For example, in situations where at-heights work must be performed across the face of a structure, handling materials, or using power tools, the best choice may be a powered platform, a powered lifting device, or a scaffold. CSA Z11 and training should emphasize the need for selecting access equipment based on hazard/risk assessments and industry best practices. Individuals responsible for making these decisions should be knowledgeable and experienced in evaluating work demands, the work environment, and site conditions.

10. Ladders in poor condition were found to be a factor in many incidents. While some of these involved damaged ladders, many involved wear conditions that were less obvious. Examples include ladders with loose fittings or connections, ladders with worn steps, ladders having minor bends and twists, and ladders with worn locking devices. Portable ladders should be inspected by users at the beginning of each work day or prior to use when taken out of storage. CSA Z11 should detail the nature of these pre-use inspections and the recourse if damage, loose fittings, or other wear-and-tear is observed. Training should include how to conduct these inspections and report findings.

11. Repair of portable ladders is a controversial matter across many occupational sectors. Manufacturers typically advise that ladders be evaluated and repaired (if possible) at authorized shops. Some industries recommend that their own maintenance personnel inspect and repair ladders. Employers in the agricultural sector advocate that farmers learn to assess and repair their ladders. Ladder maintenance procedures recommended in CSA Z11 should include periodic inspection by maintenance personnel specially trained in assessing ladder function and condition. CSA Z11 should specify that ladders found with minor damage, or to be in questionable condition, should be repaired in accordance with manufacturer's instructions. Ladders in poor, unrepairable condition should be removed from service.

"Selecting the right ladder for the task is vital to incident prevention."

12. Another common issue found in incident investigations is a lack of awareness of dangers lurking beneath the ladder user. In other cases, the dangers were observed, but not thought to pose a significant risk. CSA Z11 should specify that ladders should not be placed over dangerous surfaces (e.g., where sharp objects, moving machinery, dangerous inclines, unstable materials, pools of liquid, or hot surfaces are present). Avoiding climbing over such danger zones should be part of user training.

13. Extension ladders of up to 22 metres in length are being used on job sites. Step ladders can be up to 6 metres in height. Falls from such heights are often fatal or can cause permanent disability. CSA Z11 should specify that, where there is a danger of serious injury due to falls, secondary means of fall prevention or fall-arrest equipment should be used. These high-risk situations include work procedures where three points of contact cannot be maintained, work involving use of power tools, and when working at heights of 3 metres or more.

14. This study demonstrated that footwear can play a significant role in slips and falls from ladders. While the risk level might be increased in the presence of slippery conditions, inappropriate footwear was found to be a significant causal factor. CSA Z11 and CSA Z195 should specify that properly-fitted footwear be worn when climbing ladders. This footwear should have good-quality soles with slip-resistant treads.

15. There are a great variety of after-market accessories offered for portable ladders. For many of these, there are no nationally-recognized quality assessment systems. While many purveyors of ladder accessories make claims of compatibility with various makes and models of ladders, their products are not endorsed by ladder manufacturers. Great care must be exercised in the use of ladder accessories, not only that they are compatible with the ladder model, but also that they are appropriate for the tasks at hand. Any accessories attached to portable ladders (e.g., outriggers, stabilizers, clamps, adaptors, extensions) should be selected with care and in consultation with the ladder manufacturer or distributor. Personnel who are assigned the responsibility to select and attach accessories should have good knowledge of the work conditions, job demands, and dynamic forces associated with ladder use. Ladder accessory inspection should be included in the ladder maintenance program.

16. As discussed in Conclusion 3, selecting the right ladder for the task is vital to incident prevention. Poorly selected ladders lead to risky maneuvers and activities used to complete assigned tasks. CSA Z11 should specify that ladder selection, safe use, and training be an integral part of a work-at-heights safety program as established by the organization using ladders (i.e., the job site owner or employer).

    Note: *Software tools are available to aid in the management of such programs.*

17. Electrical hazards are often the "invisible beast" on job sites, particularly for outdoor sites and in locations not familiar to the worker. CSA Z11 should emphasize that awareness of electrical dangers is vital to the pre-work routine. Portable ladders should only be used in areas well clear of overhead electrical power lines and other types of live electrical equipment. CSA Z11 should furthermore direct that the work site be inspected for electrical dangers prior to ladder placement.

18. Prior to experiencing a serious incident, many employers underestimate the need to prepare for emergencies. Without rescue plans, emergency contact provisions, and appropriate levels of first aid on site, many injuries are worsened by slow response, particularly in remote locations. Worse still are situations where the worker is alone or unsupervised. In such situations, a fallen worker may lay unconscious for many hours or even days, leading to long-term disability or even death. As with other types of hazardous work, CSA Z11 should advise on appropriate emergency preparedness. Emergency plans should include the rescue of anyone caught in a precarious position or taken ill while on a ladder. These plans should also include first aid treatment for anyone who has fallen from a height, suffered a strain, or taken ill while working with ladders.

Acknowledgements

In addition to the direction and advice provided by the members of the Advisory Panel, we wish to acknowledge the contributions of WorkSafeBC, Infrastructure Health and Safety Association, Workplace Safety North, the Canadian Agricultural Safety Association, the Institute for Work & Health, and the American Ladder Institute. These organizations provided guidance on the sources of incident data, past studies in ladder safety, and ladder use practices in various occupational sectors.

References

1. Infrastructure Health & Safety Association. (2012). *Ladder Use in Construction Guideline.* Mississauga, ON. https://www.ihsa.ca/pdfs/topics/ladders.pdf. Last accessed: February 15, 2019.

2. Safe Work Manitoba. (2014). *Portable Ladder Safety.* Winnipeg, MB. https://www.safemanitoba.com/Page%20Related%20Documents/resources/bulletin_177_swmb_sept_2014.pdf. Last accessed: February 15, 2019.

3. WorkSafeBC. (1992-2017). British Columbia Ladder Incident Reports.

4. Infrastructure Health and Safety Association. (2012-2017). Ontario Ladder Incident Reports.

Additional Ladder Safety Resources

1. American Ladder Institute. (2018). *ALI Ladder Safety Training and Citations Report.* Chicago, IL. https://cdn.ymaws.com/www.americanladderinstitute.org/resource/resmgr/files/ali_309901-18_citationreport.pdf. Last accessed: February 15, 2019.

2. Canadian Centre for Occupational Health & Safety. (2016). *Ladders – Portable. OSH Answers Fact Sheets.* Hamilton, ON. https://www.ccohs.ca/oshanswers/safety_haz/ladders/portable.html. Last accessed: Feb 15, 2019.

3. Workplace Safety & Prevention Services. (2014). *Ladder Safety.* Mississauga, ON. http://www.wsps.ca/WSPS/media/Site/Resources/Downloads/Ladder_Safety_Final.pdf. Last accessed: February 15, 2019.

4. American Ladder Institute. (2013). *Reducing Falls in Construction: Safe Use of Extension Ladders* (OSHA FS-3660 – 2013). Chicago, IL. https://www.osha.gov/Publications/OSHA3660.pdf. Last accessed: February 15, 2019.

5. American Ladder Institute. (2013). *Reducing Falls in Construction: Safe Use of Job-made Wooden Ladders* (OSHA FS-3661 – 2013). Chicago, IL. https://www.osha.gov/Publications/OSHA3661.pdf. Last accessed: February 15, 2019.

6. American Ladder Institute. (2013). *Reducing Falls in Construction: Safe Use of Stepladders.* (OSHA FS-3662 – 2013). Chicago, IL. https://www.osha.gov/Publications/OSHA3662.pdf. Last accessed: February 15, 2019.

7. WorkSafeBC. (2007, May 14). *Ladder Safety.* Richmond, BC. Retrieved from https://www.worksafebc.com/en/resources/health-safety/videos/ladder-safety/ladder-safety?lang=en. Last accessed: February 15, 2019.

CSA Group Research

In order to encourage the use of consensus-based standards solutions to promote safety and encourage innovation, CSA Group supports and conducts research in areas that address new or emerging industries, as well as topics and issues that impact a broad base of current and potential stakeholders. The output of our research programs will support the development of future standards solutions, provide interim guidance to industries on the development and adoption of new technologies, and help to demonstrate our on-going commitment to building a better, safer, more sustainable world.

CSA GROUP™