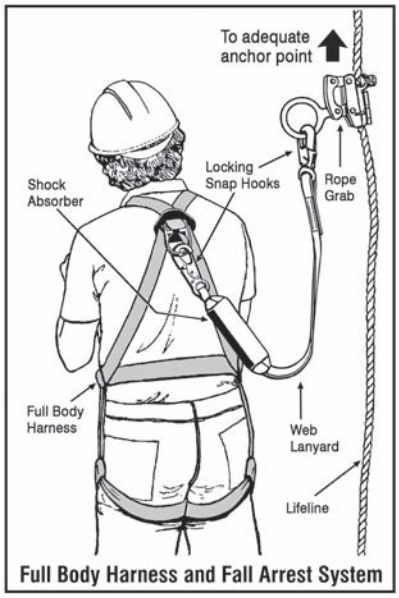
19 PERSONAL FALL PROTECTION

A worker at risk of falling certain distances (see chapter on Guardrails in this manual) must be protected by guardrails or, if guardrails are not practical, by a travel-restraint system, fall-restricting system, fall-arrest system, or safety net. This chapter describes travel-restraint systems and fall-arrest systems.

Personal fall protection equipment consists of the components shown in the following illustration.

This equipment can be used for travel restraint or fall arrest.



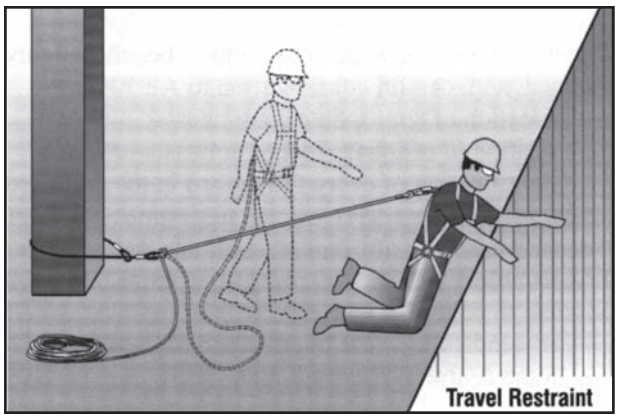
Full Body Harness and Fall Arrest System

Travel-Restraint Systems

A travel-restraint system lets a worker travel just far enough to reach the edge but not far enough to fall over.

The basic travel-restraint system consists of

- CSA-approved full body harness



- lanyard
- lifeline
- rope grab to attach harness or lanyard to lifeline
- adequate anchorage (capable of supporting a static load of 2 kilonewtons—450 pounds—with a recommended safety factor of at least 2, that is, 4 kilonewtons or 900 pounds).

Travel-restraint arrangements must be thoroughly planned, with careful consideration given to

- selection of appropriate components
- location of adequate anchor points
- identification of every fall hazard in the proposed work area.

Try to select an anchor point that is as close as possible to being

- perpendicular to the unprotected edge, and
- at the centre of the work area.

All fall hazards in the work area must be identified. Pay special attention to work areas with irregular shaped perimeters, floor openings, or locations near corners.

A fully extended lifeline and/or lanyard that adequately restrains a worker from a fall hazard in one section of the work area may be too long to provide the same protection in another section.

Two methods of travel restraint are commonly used in construction.

1) Connecting an adequately anchored lifeline directly to the D-ring of the worker's full body harness. It's absolutely critical that the length of the lifeline, measured from the anchor point, is short enough to restrain the worker from any fall hazard.
2) Attaching a lanyard from the D-ring of the worker's full body harness to a rope grab on an adequately anchored lifeline. There must be some means—such as a knot in the lifeline—to prevent the rope grab from sliding along the lifeline to a point where the worker is no longer restrained from falling.

Whether method 1 or 2 is used, the system must be adjusted so that the fully extended lifeline and/or lanyard prevents the worker from reaching any point where the worker may fall. The system must also be securely anchored.

Fall-Arrest Systems

Where workers cannot be protected from falls by guardrails or travel restraint, they must be protected by at least one of the following methods:

- fall-restricting system
- safety net
- fall-arrest system.

In the event of a fall, these systems must keep a worker from hitting the ground, the next level below, or any other objects below.

A fall-restricting system is designed to limit a worker's free fall distance to 0.6 metres (2 feet). One type uses a belt grab or belly hook that attaches to a safety rail on a fixed ladder.

A safety net system must be designed by a professional engineer. The system is installed below a work surface where a fall hazard exists.

A fall-arrest system

- must include a CSA-approved full body harness
- must include a lanyard equipped with a shock absorber unless the shock absorber could cause a falling worker to hit the ground or an object or a level

below the work
- must include an adequate fixed support; the harness must be connected to it via a lifeline, or via a lanyard and a lifeline
- must prevent a falling worker from hitting the ground or any object or level below the work
- must not subject a falling worker to a peak fall-arrest force greater than 8 kilonewtons.

The construction regulation (O. Reg. 213/91) requires that

- all fall protection equipment must be inspected for damage, wear, and obvious defects by a competent worker before each use
- any worker required to use fall protection must be trained in its safe use and proper maintenance.

Any defective component should be replaced by one that meets or exceeds the manufacturer's minimum performance standards for that particular system.

The regulation also requires that any fall-arrest system involved in a fall be removed from service until the manufacturer certifies all components safe for reuse.

For any worker receiving instruction in fall protection, the manufacturer's instructions for each piece of equipment should be carefully reviewed, with particular attention to warnings and limitations.

Components

Canadian fall protection standards are regularly updated to incorporate the most current changes to fall protection systems. The following is a list of current CSA standards for personal fall protection equipment:

- CAN/CSA-Z259.1-M99 – *Body Belts and Saddles for Work Positioning and Travel Restraint*
- CAN/CSA-Z259.10-06 – *Full Body Harnesses*
- CAN/CSA-Z259.11 – *Energy Absorbers and Lanyards*
- CAN/CSA-Z259.12 – *Connecting Components for Personal Fall Arrest Systems (PFAS)*
- CAN/CSA-Z259.14 – *Fall Restrict Equipment for Wood Pole Climbing*
- CAN/CSA-Z259.2.1 – *Fall Arresters, Vertical Lifelines and Rails*
- CAN/CSA-Z259.2.2 – *Self-Retracting Devices for Personal Fall-Arrest Systems*
- CAN/CSA-Z259.2.3 – *Descent Control Devices*

For any component not covered by these standards, confirm with the manufacturer that the component is suitable for the particular system being considered.

The minimum strength of fall-arrest components depends on whether or not the system uses a shock absorber.

- In systems *without* shock absorbers, all components, including lifeline and lifeline anchorage, must be able to support a static load of at least 8 kilonewtons (1800 pounds) without exceeding the allowable unit stress of the materials used for each component.
- In systems *with* shock absorbers, all components, including lifeline and lifeline anchorage, must be able to support a static load of 6 kilonewtons (1350 pounds) without exceeding the allowable unit stress of the materials used for each component.

In designing both systems, it is recommended that a safety factor of at least two be applied to the stated minimum load capacity. In practical terms, anchorage should be strong enough to support the weight of a small car (about 3600 pounds).

Lifelines

There are three basic types of lifelines:
1) vertical
2) horizontal
3) retractable.

All lifelines must be inspected daily to ensure that they are

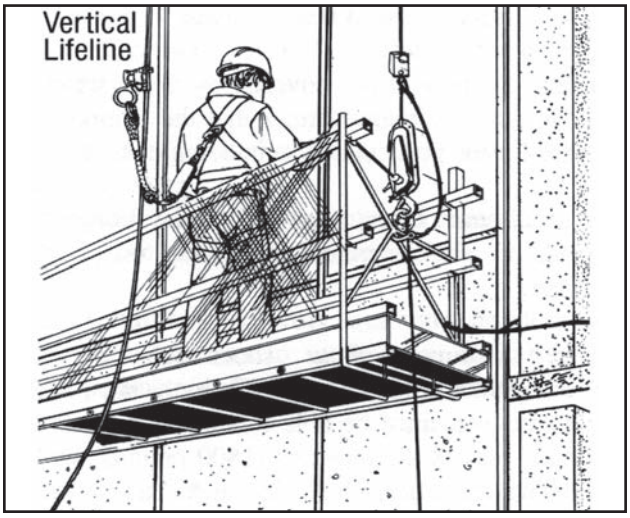
- free of cuts, burns, frayed strands, abrasions, and other defects or signs of damage
- free of discolouration and brittleness indicating heat or chemical exposure.

1) Vertical Lifelines

Vertical lifelines must comply with the current edition of the applicable CSA standard and the following minimum requirements:

- Only one person at a time may use a vertical lifeline.
- A vertical lifeline must reach the ground or a level above ground where the worker can safely exit.
- A vertical lifeline must have a positive stop to prevent the rope grab from running off the end of the lifeline.

Vertical lifelines are typically 16-millimetre (5/8-inch) synthetic rope (polypropylene blends).



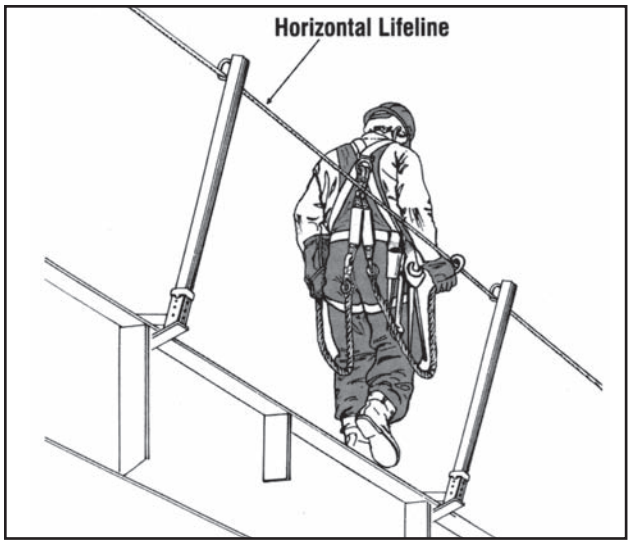
2) Horizontal Lifelines

The following requirements apply to any horizontal lifeline system:

- The system must be designed by a professional engineer according to good engineering practice.
- The design can be a standard design or specifically engineered for the site.

The design for a horizontal lifeline system must

✓ clearly indicate how the system is to be arranged, including how and where it is to be anchored
✓ list and specify all required components
✓ clearly state the number of workers that can safely be attached to the lifeline at one time
✓ spell out instructions for installation, inspection, and maintenance



✓ specify all of the design loads used to design the system.

The system must be installed, inspected, and maintained in accordance with the professional engineer's design.

Before each use, the system must be inspected by a professional engineer or competent worker designated by a supervisor. A complete and current copy of the design must be kept on site as long as the system is in use.

CAUTION: The construction regulation requires that "a horizontal or vertical lifeline shall be kept free from splices or knots, except knots used to connect it to a fixed support." Knots along the length of either a horizontal or vertical lifeline can reduce its strength by as much as 40%.

3) Retractable Lifelines

Retractable lifelines consist of a lifeline spooled on a retracting device attached to adequate anchorage. Retractable lifelines must comply with CAN/CSA-Z259.2.2.

In general, retractable lifelines

- are usually designed to be anchored above the worker
- employ a locking mechanism that lets line unwind off the drum under the slight tension caused by a user's normal movements
- automatically retract when tension is removed, thereby preventing slack in the line
- lock up when a quick movement, such as that caused by a fall, is applied
- are designed to minimize fall distance and the forces exerted on a worker's body by fall arrest.

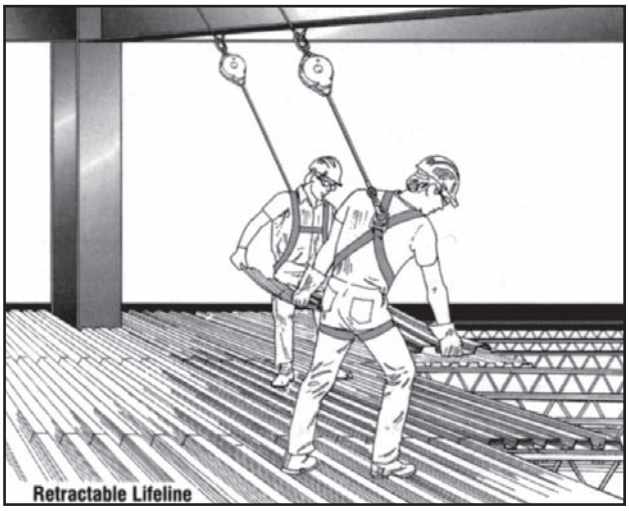
Always refer to the manufacturer's instructions regarding use, including whether a shock absorber is recommended with the system.

Any retractable lifeline involved in a fall arrest must be removed from service until the manufacturer or a qualified testing company has certified it for reuse.

Lifeline Hazards

Ultraviolet light – Exposure to the sun may damage or weaken synthetic lifelines. Ensure that material being considered for lifelines is UV-resistant.

Temperature – Extreme heat can weaken or damage some lifelines while extreme cold can make others brittle. Ensure that material being considered for lifelines can stand up to the most extreme conditions expected.



Friction and abrasion – Normal movement may wear, abrade, or otherwise damage lifelines in contact with sharp or rough surfaces. Protection such as wood softeners or rubber mats can be used at contact points to prevent wear and tear.

Sparks or flame – Hot work such as welding or flame cutting can burn, melt, cut, or otherwise damage a lifeline. Ensure that material being considered for lifelines is flame-resistant or provide appropriate protection where sparks or flame may be encountered.

Chemicals – Chemical exposure can burn or degrade a lifeline very quickly. Ensure that material being considered for lifelines will resist any chemicals encountered on the job.

Storage – Always store lifelines separately. Never store them where they may contact hazards such as sharp objects, chemicals, or gasoline.

Anchor Systems

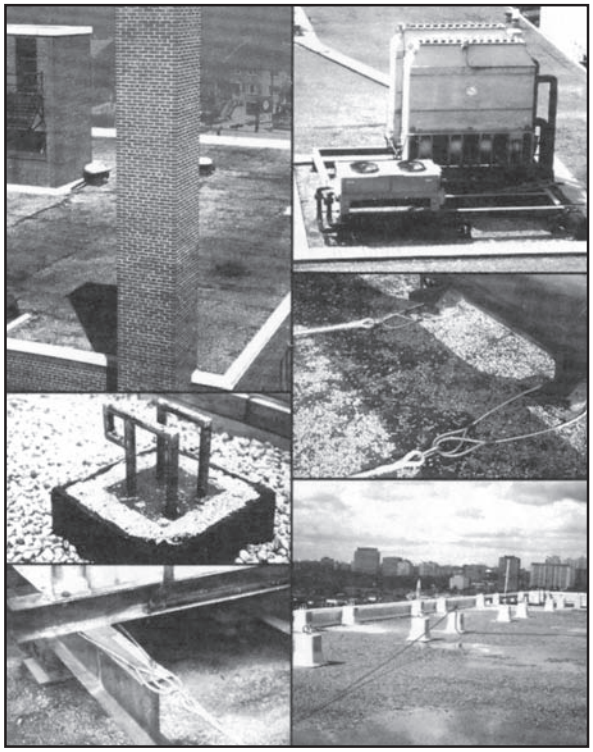
There are three basic types of anchor systems for fall protection:

1) **designed fixed support** – load-rated anchors specifically designed and permanently installed for fall protection purposes as an integral part of the building or structure (for example, roof anchors on high-rise buildings)
2) **temporary fixed support** – anchor systems designed to be connected to the structure using specific installation instructions (for example, nail-on anchors used by shinglers)
3) **existing structural features or equipment** not intended as anchor points but verified by a professional engineer or competent person as having adequate capacity to serve as anchor points (for example, rooftop mechanical rooms, structural steel, or reinforced concrete columns).

Designed fixed support can be used to anchor a fall-arrest system, fall-restricting system, or travel-restraint system if the support has been installed according to the *Building Code* and is safe and practical to use.

Temporary fixed support can be used as anchorage if it meets the following conditions:

✓ it can support at least 8 kilonewtons (1800 pounds) without exceeding the allowable unit stress for each material used;
✓ when used with a fall-arrest system incorporating a shock absorber, it can support at least 6 kilonewtons (1350 pounds) without exceeding the allowable unit stress for each material used; or



Examples of adequate anchorage

✓ when used with a travel-restraint system, it can support at least 2 kilonewtons (450 pounds) without exceeding the allowable unit stress for each material used.

In all cases, **a safety factor of at least two** should be applied when determining the minimum load that an anchor point must support.

As a general rule with fall-arrest systems, choose an anchor capable of supporting the weight of a small car (about 3600 pounds).

When existing structural features or equipment are used as anchor points, avoid corners or edges that could cut, chafe, or abrade fall protection components.

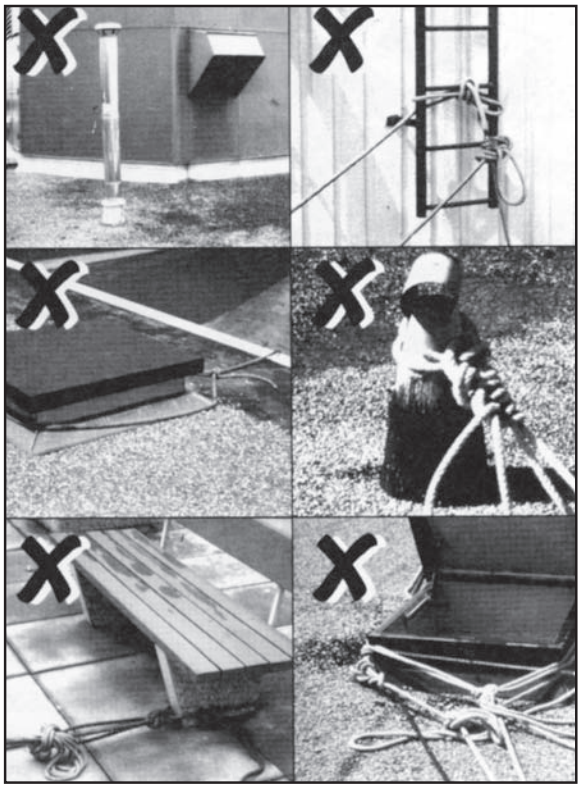
Where necessary, use softeners such as wood blocking to protect connecting devices, lifelines, or lanyards from damage.

Never anchor to

- roof vents or stink pipes
- roof hatches
- small pipes and ducts
- metal chimneys
- TV antennas
- stair or balcony railings.

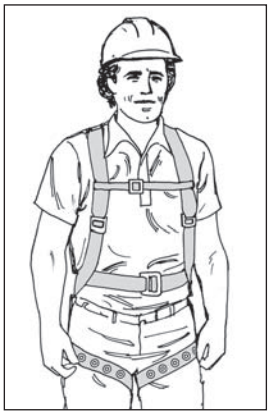
Full Body Harness

- Chest strap should be adjusted so that it's snug and located near the middle of the chest. In a headfirst fall a properly adjusted chest strap will prevent the worker from coming out of the harness.
- Leg straps should be adjusted so the user's fist can fit snugly between strap and leg.
- Harness straps should be adjusted to put the D-ring between the shoulder blades. A properly positioned D-ring will keep a worker upright after fall arrest.



Examples of inadequate anchorage

Inspect harness for



✓ burns, cuts, or signs of chemical damage
✓ loose or broken stitching
✓ frayed web material
✓ D-ring and keeper pads free from distortion and signs of undue wear or damage
✓ grommets and buckles free of damage, distortion, or sharp edges.

Lanyards

- Use manufactured lanyards only. They can be made of wire rope, synthetic fibre rope, or synthetic webbing.
- Lanyards are manufactured to specific lengths. Never try to shorten a lanyard by tying knots in it. Knots can seriously reduce its rated strength.
- Never store lanyards around chemicals, sharp objects, or in wet places. Never leave them exposed for long periods to direct sunlight.
- Inspect lanyards for

- ✓ burns, cuts, or signs of chemical damage
- ✓ loose or broken stitching
- ✓ frayed web material.

Shock Absorbers

- Shock absorbers absorb some of the force generated by fall arrest. Shock absorbers can be purchased as separate equipment or built into lanyards.
- One end of the shock absorber must be connected to the D-ring on the full body harness.
- In most cases the shock-absorbing component is enclosed in a snug-fitting jacket to protect it from the user's day-to-day activities. In a fall, the jacket tears open as the shock absorber deploys.
- Check the cover jacket for stress or tearing (many shock absorbers have a tag on the jacket that tears if the unit is exposed to a shock load—make sure this tag is intact).
- Ensure that a shock absorber built into a lanyard has a constant cross-section or diameter.

Connecting Devices

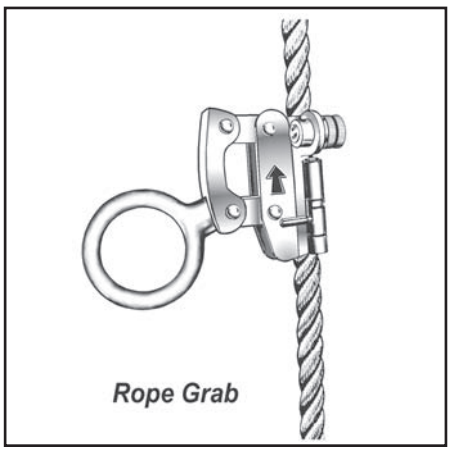
Locking Snap Hook – has a spring-loaded keeper across the opening of the hook that cannot be opened unless the locking mechanism is depressed.

Karabiner (D-Clip) – designed not to open under twist loads. To open the gate or keeper requires two separate actions: 1) twisting the locking mechanism and (2) pulling the locking mechanism back. When released, the spring-loaded locking mechanism flicks back into the locked position.

Rope Grab – used to connect lanyard to lifeline. These devices can be moved up and down the lifeline when a steady force is applied but will lock when a sharp tug or pull is applied. They will remain locked on the lifeline until the applied force is released.

Each rope grab is designed and manufactured for use with a specific diameter and type of lifeline. **Rope grab and lifeline must be compatible**. Specifications are usually listed on the housing.

The rope grab must also be attached to the lifeline in the correct direction—not upside down. On most rope grabs an arrow indicates the direction in which to orient the device. In addition, each rope grab is designed for use with a specific length of lanyard, normally two or three feet maximum.



Check all connecting devices for

- ✓ damage, cracking, dents, bends, or signs of deformation
- ✓ connecting rings centred—not bent to one side or otherwise deformed
- ✓ rust
- ✓ moving parts working smoothly
- ✓ signs of wear or metal fatigue.

Fall-Arrest Planning

Before deciding on a fall-arrest system, assess the hazards a worker may be exposed to in case of a fall.

Before the fall is arrested, will the worker "bottom out," that is, hit ground, material, equipment, or a lower level of the structure? Will the pendulum effect cause the worker to swing from side to side, possibly striking equipment, material, or structure? In the event of fall arrest, how will the suspended worker be rescued? Planning must take into account these and other concerns.

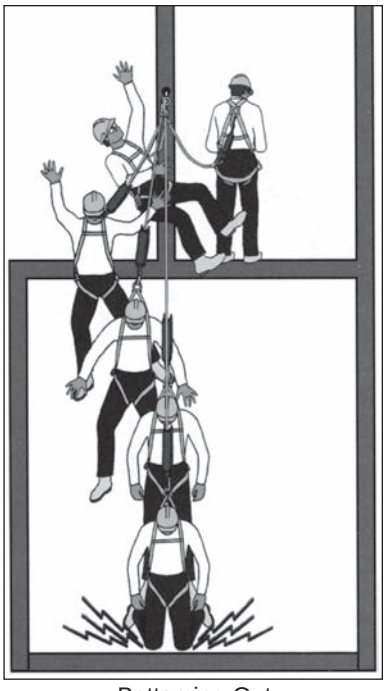
Total Fall Distance is the distance required to fully arrest a fall. It consists of

- Free Fall Distance, which should be kept to 1.5 metres (5 feet) or less, plus
- Fall Stopping Distance, which includes stretch in the lanyard (minimal) and lifeline, slack in the harness (maximum 30 cm or 1 foot due to allowable adjustments for user's comfort), and deployment of the shock absorber (maximum 1.1 metres—or 42 inches).

Free Fall Distance is measured from the D-ring of a worker standing on the work surface down to the point where either the lanyard or the shock absorber begins to arrest the fall. It is strongly recommended that this distance be kept as short as possible.

To minimize free fall, workers should tie off to an anchor overhead and use as short a lanyard as the work will allow.

Where a worker is connected to a vertical lifeline by a rope grab, the rope grab should be positioned as high above the D-ring as the work will allow. By doing this, the worker minimizes not only the Free Fall Distance but also the Fall Stopping Distance required to completely arrest a fall.


Bottoming Out

Bottoming Out

Bottoming out occurs when a falling worker hits a lower level, the ground, or some other hazard before the fall is fully arrested.

This occurs when Total Fall Distance is greater than the distance from the work

surface to the next level, the ground, or some other hazard below.

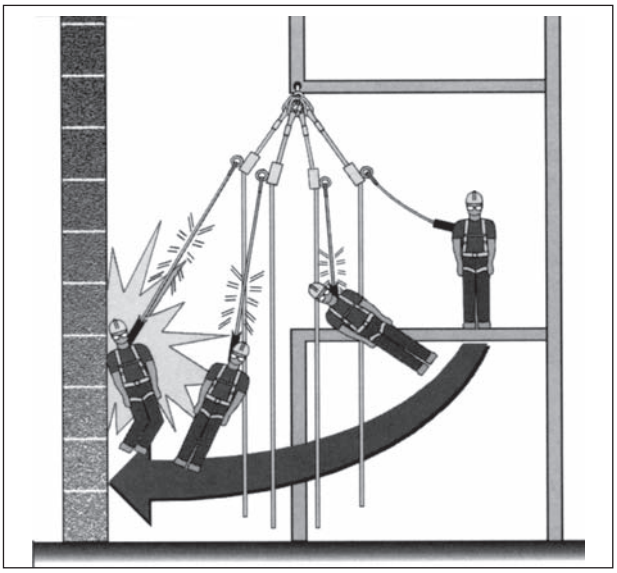
Fall-arrest systems must be planned, designed, and installed to prevent any risk of bottoming out.

Pendulum Effect

The farther you move sideways from your anchor point, the greater the chance of swinging if you fall. This is known as the "pendulum effect." And the more you swing, the greater the force with which you'll strike columns, walls, frames, or other objects in your path.

Swinging may even cause your taut lanyard or lifeline to break where it runs over rough or sharp edges.

Swing Fall or Pendulum Effect



To minimize pendulum effect, workers should keep lanyard or lifeline perpendicular from edge to anchor. Where work extends along an open edge, anchor points can be changed to keep lanyard or lifeline perpendicular as work progresses.

Another solution is to run a horizontal lifeline parallel to the edge. The worker attaches lanyard to lifeline, moves along the edge, and the lanyard travels at the same pace, remaining close to perpendicular at all times.

Emergency Rescue

The construction regulation (O. Reg. 213/91) requires that before workers use any fall-arrest system or safety net on a project, the employer must develop written rescue procedures. It's important that a worker involved in a fall arrest be brought to a safe area as quickly as possible without causing injury or putting rescuers at risk.

In many cases, the rescue plan can be simple. A ladder or elevating work platform can be used to reach suspended workers and get them down safely. Other workers may be hauled back up to the level from which they fell or pulled in through a nearby window or other opening.

In other cases, procedures may be more complicated. For instance, workers trapped on a failed swingstage, or hanging from it, may need to be rescued by specially trained and equipped personnel from the local fire department. Aerial ladder trucks or other high-reach equipment may be necessary. In extreme cases, the fire department may use rappelling techniques to reach trapped workers and lift or lower them to a safe level.

Plans should cover the on-site equipment, personnel, and procedures for different types of rescue. Any off-site rescue services that might be required should be contacted and arranged in advance to familiarize them with the project. IHSA's Emergency Response poster (P103) can be used to indicate the nearest hospital and the phone numbers of fire, ambulance, and police services.

Site management must ensure that

- everyone on site is aware of the rescue plan
- equipment and other resources are available
- designated personnel are properly trained.

Workers must receive training from their employer regarding the specific fall protection equipment and procedures they will use. Products differ not only between manufacturers but also between product lines in a single company. Training must therefore cover the exact harness, lanyard, shock absorber, rope grab, lifeline, and anchorage each worker will rely on, as well as the applications to be encountered.

Conclusion

Employers, supervisors, and workers all have responsibilities in reducing or eliminating falls in construction.

This section has provided guidelines for fall protection, including both fall prevention and fall arrest. But the information means nothing unless employers, supervisors, and workers apply it on the job.

Workers who have any questions about fall hazards or fall protection should ask their supervisor. When it comes to fall protection, make sure you know how the equipment works and how to use it. Your life depends on it.