Construction ergonomics

Introduction

Construction activities, whether they are on a small residential job, or a complicated, multi-employer project may have a higher prevalence of risk factors for sprain/strain and other soft tissue injuries. Collectively, these are called musculoskeletal disorders (MSD) injuries. These injuries may be either acute (a slip, causing a back strain) or cumulative (a back strain from repeatedly lifting materials in an awkward posture) in nature. Back and shoulder injuries are two common cumulative injuries occurring in the construction industry. Due to the changing nature of a construction job site and the varied tasks performed by workers, it can be difficult to identify changes to reduce the risk of injury. However, the risk factors for these injuries are well known and fall into two major areas. Those associated with the process and work activities over which the employer has a great deal of control and those related to how the employees perform the work, which are harder to control, but where you still have some ability to influence.

Risk factors

On the process side, the major risk factors are awkward posture (bending over at the waist, twisting, raised elbows, reaching overhead, prolonged kneeling or stooping), high force (lifting more than 75 pounds, holding an object or tool in a stationary position) and the degree of frequency and duration of the exposure. When people work or lift in awkward postures (e.g., bent or twisted back, extended reaching, etc.) they place much greater stress on their bodies than when working in a more relaxed or “neutral” posture. The closer to the ground they work, the greater the risk because the more they bend over, the more awkward their posture becomes.

Force (i.e., the object weight, or push/pull force) is the second major risk factor. Some of the questions you should ask include: How much weight does the person lift? From where is it being lifted? How hard are they pulling or pushing on an object? The greater the force, the greater the risk.

The next consideration should be the frequency and/or the duration of the awkward postures and the exertion of forces. The greater the amount of time spent in an awkward posture or exerting a force, the less recovery time is available, so that the individual tires more easily and is more likely to develop an MSD. Other occupational factors include prolonged sitting, poor ergonomic work space design and issues such as vibration, temperature extremes and slippery walking surfaces.

Risk control program

Ergonomics is a way of thinking about the design of work processes, the layout of jobsites, and the overall organization of projects with the goal of improving profitability in the construction industry. A common sense-based ergonomics program is designed to improve productivity, quality and efficiency while reducing injuries. Because it can have a dramatic impact on productivity and safety, good ergonomics is good business. This document describes common examples of construction activities. While your issue may not be precisely as described here, use these ideas to help you design your own solutions and reduce the injury risk to your employees.

When looking for ways to reduce the risk of injury you should apply a hierarchy of controls. These controls fall into three broad categories. In order of preference; they are: Engineering, Administrative and Safe Work Practices.

First, eliminate the issue whenever possible by using mechanical equipment in place of manual labor, or redesign the work process to remove the risk factors. When that is not possible, administratively control the exposure by breaking up the activity into multiple sessions, using multiple people, or otherwise reducing the risk to your employees. Last, establish and train employees in safe work practices and coach them as needed. Identify the proper methods for performing an activity and make it easy for employees to follow them.
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**Material handling**

**Description of issue**
Not all material handling causes injury. Knowing the issues associated with material handling that contribute to injury is important. Risk factors include, but are not limited to:

- Lifting too much weight
- Lifting while bending or twisting
- Static lifting, i.e., holding an item while it is being secured in place.

**Related injuries:**
- Low back strain
- Low back disc injury
- Shoulder strain
- Neck strain

**Possible solutions**

1. **Job site storage and material movement**
   - Select a "lay down" area that will minimize the multiple handling of materials.
   - Locate materials close to where they will be installed or use a mechanical device, such as a forklift or cart to move materials around the job site.
   - Position materials between knee and shoulder height.

2. **Material handling during installation**
   Consider the following factors when handling materials during installation:
   - The weight, physical size, ease of handling and fastening method.
   - Establish a lifting policy, such as: <50 lbs. = individual, 50-100 lbs. or object over 10 feet in length = team, >100 lbs. = mechanical device.
   - Use a hoist, lift or other mechanical device to handle objects that weigh more than 100 lbs., are awkward in size, difficult to grasp, or require a long "hold time" to complete the installation.
   - Color code or mark the weight on regularly handled tools, equipment or materials.

3. **Individual lifting behaviors**
   Educate employees in proper lifting techniques, such as:
   - Don’t bend over at the waist. When possible, squat or kneel down.
   - Avoid twisting. Turn with your feet.
   - Hold the load close to the body.
   - Discourage the "macho" image.

**Guideline for developing your solution**
Look for opportunities to use equipment rather than human power to move materials. Store materials so that people do not need to bend over to pick them up. Establish, train and coach workers in proper lifting techniques.
RISK CONTROL

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Equipment operator

Description of issue
Operating heavy equipment, such as a forklift, crane, backhoe or dozer, may seem easy, but it can be stressful to the body. Risk factors that contribute to injuries include, but are not limited to:

- Working long hours while seated in a worn out or non-adjustable seat.
- Awkward and repetitive hand movements to operate the controls.
- Extending the neck to look overhead or twisting with the neck and back to observe the work area or when driving backwards.
- Climbing in and out of the cab.
- Vibration.

Related injuries:
- Low back strain
- Low back disc injury
- Shoulder/neck strain
- Carpal Tunnel Syndrome
- Tendonitis

Possible solutions

1. Accessing the equipment
   - Use the ladder and handrails properly. Face the equipment when entering or exiting.
   - Maintain and use “3-Points of Contact” at ALL times.
   - NEVER jump off of the equipment.
   - Rungs should be an anti-slip design.

2. Operating the equipment
   - **Seat:** Adjust the seat so thighs are horizontal to the floor with feet and back well supported.
   - **Armrest:** If the equipment has an armrest, position it so the shoulders are relaxed, forearm slightly supported and hands free to move.
   - **Hand Controls:** Controls should position the hands in a neutral posture and operate smoothly with minimal vibration.
   - **Mirrors:** Use mirrors if available to minimize twisting of the neck and back.
   - **CCTV:** Provide closed circuit TV with a “heads up” display to limit crane operators looking overhead.
   - **Duration:** Limit the amount of time spent operating equipment, e.g., max. 8 hrs./day.
   - **Steps/Ladder Rungs:** Provide anti-slip surfaces to prevent slips and falls.
3. Selecting and maintaining equipment
Whether purchasing or renting equipment, consider the comfort of the operator and the adjustability features of the cab.

- Maintain the adjustability features of the equipment by performing preventive maintenance.
- Keep a spare seat available to maintain equipment in-service, without risking operator injury.
- Some manufacturers are producing equipment with reduced vibration features. Select lower vibration equipment when replacing outdated units.

Guideline for developing your solution
Purchase, rent or modify your equipment to minimize operator risk of back, hand or arm injury.
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Ladder use

Description of issue
Improper use of a ladder can result in serious injury due to falling or over reaching. Most of these injuries are caused by improper ladder selection, set-up or use.

Related injuries:
- Traumatic injury
- Low back strain
- Low back disc injury
- Shoulder/neck strain

Possible solutions

1. Selection
Select the proper ladder for the task performed. Consider the following:
- Type – Straight ladder or step ladder.
- Length – to safely reach work area.
- Material – Conductive or non-conductive (e.g., wood, fiberglass or aluminum).
- Capacity rating – Type 1, Type 1A, or Type 1AA is best.

2. Set-up
Set up the ladder correctly. If two ladders are needed, arrange them so both people maintain good body posture.
- Stepladder: Maximum height of work = 3 feet above top of ladder.
- Straight ladder: Maximum height of work = 2 feet above top of ladder. If used for access, the ladder should extend 3 feet above top support point.

3. Use
Follow safe work practices for ladder use.
- Position the work close to the body at about chest height.
- Don’t over reach! Keep your belt buckle inside the rails of the ladder.

Guideline for developing your solution
Identify tasks currently being performed with ladders to determine if a mechanical lift could be used. Provide training in the proper selection, setup and use of ladders. Enforce safe ladder use.
Preventing slips and falls

Description of issue
Slip and fall losses can be extremely costly, as the resulting injury can vary from minor to fatal. The causes of these injuries include, but are not limited to:

- Slipping due to loss of traction, e.g., snow, water, oil, sand, etc., on the surface.
- Tripping over debris, construction materials or uneven surfaces, e.g., rebar, broken block, trash, holes or ruts in yard.

Related injuries:
- Low back strain
- Low back disc injury
- Shoulder strain
- Neck strain
- Knee or ankle strain
- Broken bones

Possible solutions
1. Improve traction
   - Wear boots with slip-resistant soles. Wear overshoes that have anti-slip treads.
   - Prevent water, snow or ice from collecting on walking/working surfaces.
   - Install anti-slip materials in areas such as: rungs on a ladder, ramp, and exterior stair towers.

2. Avoid uneven surfaces
   - Identify walkways through the job site ensuring that they are free of trip/fall hazards.
   - Identify and protect uneven surfaces that might cause injury.

3. Eliminate tripping hazards
   - Keep work area, aisles, and stairs clean and free of unnecessary debris, materials or equipment.
   - Audit work areas to monitor trip/fall exposures.
   - Correct unacceptable conditions, notifying the general contractor or construction manager when needed.

Guideline for developing your solution
Require that employees wear appropriate footwear. Alert employees to hazardous conditions. Monitor job site for trip/fall hazards.
Excavation and foundation work

Description of issue
There are a number of factors that increase the risk of developing repetitive strain injuries during excavation and foundation work. The main risk factors that exist when using heavy earth-moving equipment include, but are not limited to:

- Whole-body vibration.
- Poor seating comfort due to seat design.
- Awkward and static postures (twisting and turning of the neck and trunk) while operating equipment in reverse.
- Awkward postures, forceful exertions and hand-arm vibrations when using motorized tampers.

Risk factors that exist when doing foundation work include, but are not limited to:

- Low back stress due to awkward work positions and repetitive forceful exertions when digging to the final grade.
- Awkward postures and forceful exertions when building, setting and removing forms.
- Contact stress on the feet from walking or standing on narrow rebar.
- Slip/fall injuries entering or exiting excavations.

Related injuries:
- Low back strain
- Low back disc injury
- Shoulder strain
- Carpal Tunnel Syndrome

Possible solutions
1. For heavy equipment:
   - Newer models of heavy equipment include better seats, hand and foot controls and vibration isolation.
   - Retrofit older earth-moving equipment with adjustable seats that provide more neck, arm and lumbar support, and vibration isolation.

2. For foundation work:
   - Use hand-held shovels with a longer (and/or bent) shaft to reduce stress on the lower back.
   - Isolate hand-arm vibration by covering tamper handles with visco-elastic tape or by using anti-vibration gloves.
   - Wear boots with steel shank inserts to distribute the body load when working on narrow rebar.
   - Fabricate sections of the formwork on the surface where people can work in more neutral postures.
   - Use powered cutters to clip tie wires when stripping forms.
   - Provide stairways or ladders for access into excavations.

Guideline for developing your solution
Replace or update older equipment to remove/reduce vibration exposure. Use equipment to reduce forceful exertions and fabricate forms on the surface.
Concrete form work

Description of issue
Building and stripping concrete forms is strenuous work, requiring heavy lifting, awkward body postures and repetitive motion. The major risk factors include, but are not limited to:

- The type of form used, e.g., wood, SYMONS, PERI.
- Assembly of the form while in a poor posture, e.g., bent over at the waist, reaching overhead.
- Walking on uneven surfaces, e.g., rebar.

Related injuries:
- Low back strain
- Low back disc injury
- Carpal Tunnel Syndrome
- Shoulder strain

Possible solutions
1. Selection, set-up and maintenance of concrete forms
   - Choose the right form for the job.
   - Minimize strenuous and repetitive tasks during construction.
   - Minimize concrete adhering to the form by using clean forms and high grade form release (form oil).

2. Building concrete forms
   Minimize a person’s risk of injury by:
   - Locating materials close to where the forms will be built.
   - Encouraging “team” lifting, balance the load, use dollies or a forklift if possible.
   - Preassembling at a comfortable working height. Avoid bending at the waist.

3. Stripping concrete forms
   Minimize a person’s risk of injury by doing the following:
   - Keep work area clean and free of debris.
   - Use longer pry bars.
   - Use pulling devices like come-a-longs.
   - Use a form carrier, crane or forklift to move forms around the job site.

Guideline for developing your solution
Select and maintain the forms you use. Encourage proper handling of forms. Minimize overexertion during form stripping.
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**Tying rebar**

**Description of issue**
Tying rebar requires handling heavy materials and repetitive motion. Tasks like these can strain the body causing injury. Risk factors include, but are not limited to:

- Tying rebar requires repetitive and forceful hand motions.
- Tying rebar in place can require climbing rebar, awkward postures, carrying heavy materials and tools.
- Walking on uneven surfaces.

**Related injuries:**
- Low back strain
- Low back disc injury
- Shoulder strain
- Carpal Tunnel Syndrome

**Possible solutions**

1. **Preparing to tie rebar**
   Minimize a person's risk of injury by doing the following:
   - Reduce material handling by positioning rebar close to where it will be installed. When possible, store the bar off the ground on a support or dunnage. If tying off-site or in a jig, position the rebar to avoid repetitive bending and twisting.
   - Encourage “team” lifting to reduce the weight that a person lifts or the awkwardness of long pieces. When lifting, try to center the load. Use a hoist, forklift or crane when possible.
   - Purchase and use automatic rebar tying machines.

2. **Tying rebar**
   **Where to tie rebar:**
   - Set-up a jig upon which to assemble the rebar.
   - Tie rebar off-site, and then truck it to the job.
   - When tying rebar in place, position the work at chest height.

   **How to tie rebar:**
   - Use an automatic tying machine if possible.

   **When to tie rebar:**
   - Break up the task of rebar tying to spread-out the repetitive motion exposure.

**Guideline for developing your solution**
Keep the worker in an upright posture. Use proper tools to improve efficiency and reduce the risk of injury.
Wire pulling

Description of issue
Wire pulling can be a strenuous task. Maneuvering spools of wire and manually pulling wire can strain the body resulting in back and shoulder injuries.

Related injuries:
• Low back strain
• Neck strain
• Shoulder strain
• Elbow strain
• Tendonitis
• Wrist strain

Possible solutions
1. Handling wire spools
To avoid injury, use available equipment and follow safe work practices:
• Use a forklift or hoist to move feeder wire (e.g., 350 or 500 MCM)
• Use two-person team to move spools of MC wire (e.g., 1000 feet of 12-3)
• Use proper lifting techniques when handling wire spools (e.g., THHN)

2. Pulling wire – by hand
If pulling wire by hand, consider:
• Size and number of wires
• Diameter of pipe, length of pipe
• Number of sweeps
• Lubricate the feeder end
• Don’t cut and drag. Feed from a spool.
• Use a handle that grasps the fish-tape to improve grip during wire pulling.

3. Pulling wire – using a wire puller
• Use a mechanical puller whenever possible, e.g., chugger/tugger, pusher, winch, come-along.
• Pre-plan and communicate safe work practices for handling wire or operating a wire puller.
• Know when a wire puller is needed and use it.

Guideline for developing your solution
Use a wire puller whenever possible. Know when it’s safe to pull wire by hand. Follow safe work practices when moving spools.
Installing pipe hangers

Description of issue
Installing pipe hangers in concrete or steel can contribute to injury. Risk factors include, but are not limited to the following:

- Drilling a hole in concrete and hammering in an anchor sleeve can cause strain to the back and shoulder area.
- Fastening a pipe clamp to structural steel can be highly repetitive causing strain to arms and shoulders.

Related injuries:
- Low back strain
- Low back disc injury
- Shoulder strain
- Carpal Tunnel Syndrome

Possible solutions

1. **Follow safe work practices**
   - Ensure clear access to the spot where the hanger will be installed.
   - Position the ladder or lift directly below the work area.
   - Use a sharp drill bit.
   - Avoid awkward postures when hammering.
   - Hand turn the pipe clamp fastener (i.e., nut) until it meets resistance.
   - Use a power driver or proper fitting ratchet or wrench to torque nut.

2. **Use mechanical assistance**
   - Use a long handled, powder-actuated tool to install pipe hanger anchors to steel or concrete.
   - Pre-plan the job to minimize the exposure.
   - Knowing where piping will be installed can help determine when to install hangers to avoid obstacles that cause awkward posture.
   - For new construction with a steel deck, prior to concrete being poured for the floor above, lay out piping, drill down and install anchors. This prevents drilling and hammering overhead after the concrete has been poured.

Guideline for developing your solution
Preplan the task to minimize the amount of unnecessary drilling and hammering. Avoid working overhead if possible.
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Drop ceiling installation

Description of issue
Overhead work is a significant risk factor in many construction operations, and is clearly present for drop ceiling installations. Elevating arms and shoulders can pinch neck/shoulder nerves and blood vessels, which may cause decreased blood flow to fingers.

The main risk factors present in the installation of drop ceilings include, but are not limited to:

- Cramped work spaces.
- Static load on arms, neck and shoulders from overhead work.
- Bad posture due to overhead work.
- Stress on hands, wrists, arm, neck, shoulders and back.
- Significant use of hand tools, such as tin snips and pliers.

Related injuries:
- Low back strain
- Low back disc injury
- Shoulder strain
- Carpal Tunnel Syndrome

Possible solutions
- Use ergonomically designed power screwdrivers, tin snips, and pliers to help maintain neutral wrists.
- Improve tool handle design to allow for better grip and more torque.
- Use adjustable-height work platforms, or motorized work platforms instead of ladders.
- Elevate the worker as much as possible with the goal being to keep the hands below shoulder level.
- Make sure that full eye protection is always worn because of the overhead exposure.

Guideline for developing your solution
Solutions can be found in tool (re)design and materials engineering. When possible, rotate employees who are constantly working overhead. Project planning for eworker differences, limitations, and reactions is good for employees and the bottom line.
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Drywall and stud installation

Description of issue

Large amounts of work above shoulder or below waist level are significant contributors to neck, shoulder and low back disorders. Installation of the ceiling plates is often accomplished on a scaffold or using an extension on the powder-actuated tool with hands overhead. The base plate is installed at floor level, and may involve significant amounts of bending. Installing the drywall can involve heaving lifting and more overhead work. The main risk factors that exist in drywall and stud installation operations include, but are not limited to:

• Stress on arms and shoulders from overhead work.
• Excessive bending.
• Excessive kneeling.
• Stress on the low back due to frequent bending and handling heavy objects.

Related injuries:

• Low back strain
• Low back disc injury
• Shoulder strain
• Carpal Tunnel Syndrome

Possible solutions

• Use of adjustable-height work platform or motorized work platforms that can be lowered or raised in small increments.
• Use kneeling pads when working at floor level.
• Use of powder-actuated tools that can be used in the standing position.
• Use handles when carrying large sheets of drywall.
• Use dollies and carts to transport drywall.
• Use a drywall panel lift when installing sheets overhead.
• Rotate employees among tasks requiring frequent overhead or low-level work.

Guideline for developing your solution

Look for mechanical equipment to reduce or eliminate heavy lifting, or holding materials overhead. Select tools and equipment that will reduce the risk factors.
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Interior electrical work

Description of issue
Electrical work requires precision hand manipulation to make connections at electrical boxes, while strength is required for pulling cables through conduit. The work also requires extensive use of hand tools above ductwork and pipes. The main risk factors present during interior electrical work include, but are not limited to:

- Precision hand manipulation.
- Back and shoulder strain from cable pulling.
- Extensive use of hand tools.
- Wrist injuries while using hand tools in cramped spaces.
- Arm, shoulder, and neck stress from high grip force while working in overhead positions.
- Static load from overhead work.

Related injuries:
- Low back strain
- Low back disc injury
- Shoulder strain
- Carpal Tunnel Syndrome

Possible solutions
- Store materials off the floor on pallets or stands to limit bending.
- Use of battery-powered screwdrivers to increase productivity and reduce repetitions.
- Use ergonomically designed pliers, wire cutters, wire strippers, and other tools.
- Use TORX (with six-sided holes) rather that Phillips head screws to reduce grip force.
- When feasible, pre-assemble parts of the installation at an off-site or location better designed for working in neutral posture.
- Take short breaks during continuous work to relax and stretch muscles.

Guideline for developing your solution
Perform some work off-site if it can be done better and in a more neutral posture. Use power tools and better designed tools to remove awkward posture and repetition risk factors.
Fixtures, trim and finish work

Description of issue
Typically, when most of the interior space is completed, trim and finish work is performed on ceiling and wall fixtures, baseboards, on/around doors, and cabinets. A good bit of this work is done at floor level. The main risk factors present during fixture, trim and finish work include, but are not limited to:

- Kneeling while working at floor level.
- Back strain while hanging interior doors.
- Postural problems in arms and shoulder due to overhead work.
- Lifting and moving heavy objects.
- cramped work postures.

Related injuries:
- Low back strain
- Low back disc injury
- Shoulder strain

Possible solutions
The following are some ideas for reducing risk factors:

- Use of foot levers specially designed for hanging doors to reduce back strain.
- Use of devices that mechanically handle doors to reduce material handling.
- Use knee pads when kneeling on hard surfaces.
- Use lifts to raise workers closer to the work.

Guideline for developing your solution
Use mechanical equipment to lighten loads and reduce forceful exertions.
Painting

Description of issue

Once the drywall has been installed and finished, the surface can be painted. Paint is often sprayed on or requires the use of the long-handled rollers for overhead painting. Each of these painting techniques presents its own ergonomic issues. Painting requires the carrying of paint buckets containing fluids that shift when moved. The main risk factors that exist for painters include, but are not limited to:

- Arms, shoulders and neck strains due to overhead painting.
- Repetitive motion problems in the back, arm and wrist.
- Lifting and carrying heavy fluid-filled paint buckets with poorly designed handles.
- Hand and wrist stress when opening paint bucket lids and doing manual painting.

Related injuries:
- Low back strain
- Low back disc injury
- Shoulder strain
- Carpal Tunnel Syndrome

Possible solutions

Below are some ideas to help reduce risk factors present in painting operations:

- Minimize hand work by using rollers and spraying when possible.
- Use of a simple flange on the pole handle reducing the requirements for grip force and static load.
- Use of easier-to-open lids.
- Larger diameter paint bucket handles. Fabricate slip-on handles out of rubber hose sections.

Guideline for developing your solution

Reduce work load by using mechanical equipment. Purchase or modify tools and equipment to be more ergonomically friendly.
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For more information, log in to the Risk Control Customer Portal at travelers.com/riskcontrol. (Need help? Read our Registration Quick Guide.) You also can contact your Risk Control consultant or email Ask-Risk-Control@travelers.com.