FORMWORK
Health and Safety
Developed by trade labour-management health and safety committees, this manual is fully a document of accord between labour and management authorities.

In the past, members of the public have used printed information that was outdated by subsequent improvements in knowledge and technology. We therefore make the following statement for their protection in the future.

The information presented here is, to the best of our knowledge, current at time of printing and is intended for general application. This publication is not a definitive guide to government regulations or to practices and procedures wholly applicable under every circumstance. The appropriate regulations and statutes should be consulted. Although the Construction Safety Association of Ontario cannot guarantee the accuracy of, nor assume liability for, the information presented here, we are pleased to answer individual requests for counselling and advice.

Labour-Management

The Construction Safety Association of Ontario (CSAO) thanks the members of the Labour-Management Health and Safety Committees who contributed their knowledge, experience, and time in preparing this manual. In particular, CSAO thanks the members of the Carpenters Trade Labour-Management Health and Safety Committee and the High-Rise Forming Sector Labour-Management Health and Safety Committee for their work to develop this manual.
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This manual often refers to the Construction Regulation (Ontario Regulation 213/91). You can read this regulation online at www.csao.org, or you can order a copy (the “green book”) from the Construction Safety Association of Ontario by calling 1-800-781-2726.
SITE PREPARATION
There are two categories of formwork:
- low-rise (typically residential)
- high-rise.

Each category has its own specific concerns, but even the tallest reinforced concrete structures begin in an excavation.

Workers have to access excavations to build formwork for footings and foundations. The condition of the excavation can pose multiple safety concerns. If the bank is not properly sloped, or if a ladder or other type of access equipment is not provided, then workers risk injuries caused by slips and falls.

Steep banks lead to cave-ins. The banks of the excavation must be properly cut depending on the soil type and condition. The presence of heavy equipment or vibration along the top of the bank can lead to instability and sudden collapse. Follow proper excavation methods to ensure banks are cut back or shored appropriately according to soil type and site conditions.

The risk of a cave-in is made worse by surcharging the top of the bank with excavated soil and building materials. You must maintain a clear, level area extending at least 1 metre from the edge of the excavation. You must keep this area clear of equipment, excavated soil, rock, and construction material. Construction material must not be stored, stacked, or piled within 1.8 metres of the edge.

The following hazards can accumulate in the area between the formwork and the excavation wall if formwork is erected near the wall of a steep-banked excavation:
- hazardous gases
- fumes
- hot or cold temperature
- vapours.

Vapours from form-release oils or sewer gas from an open pipe are respiratory hazards. Heat stress is also a common health hazard in this situation.

Communication is very important when equipment and material is hoisted into the excavation, especially if the crane operator cannot see the load. When you can’t use
hand signals, there must be radio contact between

- the operator, and
- a responsible, competent member of the ground crew who can see the area where the load is being landed.

The operator and signaller must know what to do in case of radio failure in order to prevent injury or damage.

The excavation must also be managed in a manner that ensures proper access for concrete. It is hazardous for ready-mix trucks to “drive through anything” just to get in a position to discharge the load. Add-on chutes are no longer acceptable according to the Ready-Mix Concrete Association of Ontario.

You must have controls to manage vehicle movement around the formwork installation area. Controls include

- a trained signaller for reversing vehicles
- excavation ramps built properly with granular surfaces, adequate slope and width, and mud/snow/ice control.
2) SAFETY OF SITE AND SAFE ACCESS

RAMPS FOR VEHICLES AND EQUIPMENT ENTERING AND EXITING OPEN EXCAVATIONS

- The specification for runways and ramps is contained in Sections 73-74 of the Construction Regulation (Ontario Regulation 213/91).
- Ensure that ramps are sufficiently compacted to prevent wheels sinking in. (Wheels sinking in increases the risk of roll-over.)
- Do not use a ramp that is too steep or slippery for the type of vehicle being operated. Using granular materials on ramps and roadway surfaces will lessen the formation of mud on wet days and provide better traction for vehicles under all conditions. Slippery conditions can lead to loss of control resulting in collision, roll-over, and injury.

- Make ramps wide enough so that people can comfortably drive on them. A vehicle's wheels should not be right on the edge of the ramp, since this allows no room for driver error and makes the ramp susceptible to collapse.
- Follow proper procedure for backing up vehicles. Develop a traffic plan that eliminates or minimizes the need for vehicles to reverse. A trained signaller must direct reversing vehicles.
- Notify a supervisor immediately if ramp conditions appear inadequate or have deteriorated in a manner that will compromise safety. Equipment operators may be unaware of any damage they caused on the way down the ramp. If the damage isn't identified and corrected, the next operator may find out about the hazard part way down the ramp and lose control.

WORKER ENTRY AND EXIT

- Workers should enter and exit the excavation using a braced and secured ladder or, if height requires, a scaffold-type stair system complete with handrails and landings.
- A pedestrian ramp is also good. The ramp slope must not exceed a gradient of 1:3.
- Keep workers separated from vehicles wherever possible. This decreases the chances of injury.
- Workers must be protected from non-construction vehicles that are near the project. Public ways (roads, sidewalks, etc.) must also be protected from the construction project. Use signs and
signallers to direct material, equipment, and vehicles in and around the site. See sections 67-69 of the Construction Regulation.

BARRIERS

If an excavation is more than 2.4 metres deep and the banks are not sloped, a barrier, equivalent to a guardrail, of at least 1.1 metres high must be erected.

Barriers protect workers from falling into the excavation. They also protect workers who are at the bottom of the excavation by preventing objects from falling into the excavation.

HOARDING AND SITE PREPARATION

You must take steps to protect the public in areas surrounding a construction site. If work is performed on a building or structure that is within 4.5 metres of a public way (sidewalk, road, etc.), then that public way must be covered.

If work on a project may endanger the public, regardless of its proximity to any public way, then a sturdy fence at least 1.8 metres in height must be constructed between the public way and the project.

For further information see “Public Way Protection”, Sections 64-66 in the Construction Regulation.
3) WATER CONTROL

RISKS RELATING TO STANDING WATER

- Standing water must be removed
  - before work begins, and
  - regularly as it accumulates.
  Water left in the excavation can turn solid soil to unstable mud. Mud is hazardous for workers and can seriously endanger the stability of the formwork and structural integrity of the building.
- Standing water becomes ice in cold weather. Ice on the ground greatly increases the risk of slips and falls. Water should be drained before it freezes, or if necessary, ice should be shoveled up and removed.
- Standing water provides a place for mosquitoes to breed. Mosquitoes can carry West Nile Virus, a serious health risk. To decrease the risk of West Nile Virus, remove standing water whenever it accumulates. The site should be graded to prevent the accumulation of standing water.

DRAINAGE/PUMPING WATER

- A pump and discharge hose used to transfer water out of the work area can be heavy and awkward to carry, especially on a wet, muddy site. To reduce the risk of overexertion, separate the pump and hose and move them one at a time to the work area.
- For gasoline-powered pumps, store and transport fuel only in an approved container. Do not decant or refill fuel tanks near or over a body of water. Always handle fuel in a controlled and contained area to prevent any environmental contamination.
- Exhaust fumes from the engine can be deadly, so make sure the pump is set up in an open, well-ventilated area. Ensure that the fumes are not collecting at the bottom of a trench or excavation. If there isn’t enough air movement to prevent this, set up fans or keep workers out.

CONTROL AND DIVERSION OF WATER

- Water seeping and migrating from the banks of the excavation can have a serious effect on the stability of the soil. It endangers the lives of workers by decreasing soil stability and increasing the chance of a cave-in. You must address this problem.
- Running water must be diverted from the banks of the excavation to prevent the erosion of soil that can lead to cave-ins. Even small amounts of running water can erode and undermine footings, which can lead to instability and collapse of formwork. You must divert any water away from formwork and footings until a permanent weeping system is in place and functioning.
- If water infiltrates the form before the concrete has set, it can wash out the cement and seriously weaken the
structure. This situation may not be evident until the forms are being stripped.

**ELECTRICAL HAZARDS**

- There is a high risk of electrical shock when extension cords and electric hand tools are used in wet areas.
- Extension cords must not be run through water—they must be kept in dry locations to minimize the risk of shock.
- You must have ground fault circuit interrupter (GFCI) outlets when using electrical equipment outdoors.
- Cord casings must be free of cracks or other visible damage, and plugs must have all three prongs intact and be securely attached to cords.
- Electric hand tools must have ground prongs intact on their plugs OR be double-insulated.
4) CONFINED SPACES

Confined spaces can be deadly, so it is very important to read and understand all the requirements of the Construction Regulation relating to them. The following information is a brief summary, but must not be considered a comprehensive guide for working in a confined space. For more information, refer to the Construction Regulation and also to the chapter on confined spaces in the Construction Safety Association of Ontario’s *Construction Health and Safety Manual* (M029). Both documents are available on www.csao.org.

RECOGNIZING POTENTIAL HAZARDS

- A confined space exists in an area
  - that is either fully or partially enclosed,
  - that is not both designed and constructed for continuous human occupancy, and
  - in which atmospheric hazards may occur because of its construction, location, or contents, or because of work that is done in it.
- “Atmospheric hazards” means
  (a) the accumulation of flammable, combustible, or explosive agents, or
  (b) an oxygen content in the atmosphere that is less than 19.5 percent or more than 23 percent by volume, or
  (c) the accumulation of atmospheric contaminants, including gases, vapours, fumes, dusts, or mists, that could
    - result in acute health effects that pose an immediate threat to life, or
    - interfere with a person's ability to escape unaided from a confined space.
- **Atmospheric hazards** can be caused by such things as engine exhaust, welding fumes, form-oil (or other chemical) vapours, methane leaking from a damaged sewage pipe, and natural gas or propane leaking from a damaged supply line.
- Confined spaces can harbour a number of hazards which can pose serious threats to workers. Along with the potential for atmospheric hazards, there can be **physical hazards**. These hazards may cause injury or increase the severity of an injury caused by other means.
- Examples of **physical hazards** are
  - noise
  - temperature
  - radiation (welding, x-rays)
  - cramped working spaces
  - reactive or corrosive residues
  - poor means of entry and exit
  - rotating or moving equipment
  - electrical hazards
  - uncontrolled movement of liquids and solids
  - vibration.
- Inside a confined space, physical hazards often involve a greater risk and severity of potential injury than they do outside a confined space.
REQUIREMENTS FOR WORK IN A CONFINED SPACE INCLUDE (BUT ARE NOT LIMITED TO)

- Development and maintenance of a written program including an entry permit system.
- Adequate assessment of hazards carried out by a competent worker.
- Development and implementation of an adequate procedure for controlling hazards.
- Adequate worker training in accordance with the relevant program and plan.
- Establishment of methods of communication appropriate given the hazard assessment.
- Performance of adequate atmospheric testing as often as necessary.
- Every required document being available for inspection at the project.
- Preparation, by the constructor, of a coordination document may be necessary (the Construction Regulation describes when it is necessary).

See Section 221.1 to 221.19 of the Construction Regulation.
MATERIAL HANDLING
1) STORAGE OF FORMWORK PANELS

SAFE STORAGE METHODS

- Formwork panels, and all other loose material and equipment, should be placed on cribbing to keep them off the ground.
- The ground should be level, firm, and well-drained. This prevents items from sinking in and becoming stuck to the ground. Workers can be injured when trying to remove stuck objects.
- Material should be stacked in a straight, uniform manner where possible, not leaned against other objects, materials, equipment, or buildings. Level ground is the safest place to stack material and equipment because there is little risk of piles sliding or shifting and becoming unstable.
- Material must not be stored, stacked, or piled within 1.8 metres of the edge of the excavation.
- When planning the project, set up your storage/off-loading area so that trucks can drive through, avoiding the need for backing up. If this is impossible, designate a competent worker to act as a signaller.

DISTANCE TO OVERHEAD POWERLINES

- Formwork panels and any other material and equipment must be stored a safe distance from overhead powerlines. The safe distance depends upon the amount of power in the lines. Section 188 of the Construction Regulation defines the minimum safe distances:

**Proximity to overhead electrical equipment**

188. (2) No object shall be brought closer to an energized overhead electrical conductor with a nominal phase-to-phase voltage rating set out in Column 1 of the Table to this subsection than the distance specified opposite to it in Column 2.

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal phase-to-phase voltage rating</td>
<td>Minimum distance</td>
</tr>
<tr>
<td>750 to 150,000 volts</td>
<td>3 metres</td>
</tr>
<tr>
<td>more than 150,000 to 250,000 volts</td>
<td>4.5 metres</td>
</tr>
<tr>
<td>more than 250,000 volts</td>
<td>6 metres</td>
</tr>
</tbody>
</table>
Protective Devices and Equipment

189. Section 188 does not apply if,
(a) under the authority of the owner of the electrical conductor, protective devices and equipment are installed, and written measures and procedures are established and implemented, that are adequate to protect workers from electrical shock and burn; and
(b) the workers involved in the work use protective devices and equipment, including personal protective equipment, and follow written measures and procedures that are adequate to protect workers from electrical shock and burn.

- Storage of material and equipment is not the only issue affected by distance to overhead electrical lines. Building construction can also be affected if the powerlines are close to the new structure. Moving and placing flying forms can be difficult, and delivery of material may require special precautions to be taken.
- When in doubt about the amount of power in an overhead line, consider the worst-case scenario and keep people, equipment, and material a minimum of 6 metres away.
- For full information on protection and compliance around electrical conductors, refer to the “Electrical Hazards” section of the Construction Regulation.
MECHANICAL LIFTING DEVICES

2) MECHANICAL LIFTING DEVICES

TYPES OF LIFTING DEVICES

- To avoid overexertion, use dollies and carts to move panels and material. But they must be suitable for the terrain. Anything used on the ground should have a wheelbarrow-type tire to allow travel over rough surfaces. On slab, tires can be solid to prevent punctures but should be large enough to roll easily over small debris and scraps.

PRECAUTIONS

- When using dollies or carts on sloped surfaces, always stay uphill of the load—even when going uphill. Use the handles or a rope from the uphill side. Don’t push from the downhill side.
- Use extreme caution when near floor openings or edges and around excavations. A momentary loss of control could send a large load of material into a free-fall, with potentially fatal results.
- Make sure the load is secure, whether it is on a dolly, cart, front-end loader, forklift, or any other piece of equipment. It is not safe to walk beside the load in order to keep it stable. Losing your balance or missing a step can lead to being struck by the load or the equipment.

TRAINING REQUIREMENTS

- Written proof that a worker is trained in the safe operation of a crane, boom truck, forklift, or similar lifting or hoisting device is required.
3) MANUAL MATERIAL HANDLING

LIFTING TECHNIQUES AND BACK CARE

- Keep stored material neat and orderly to reduce the hazards of tripping and being struck against objects.
- Where possible, store materials on a stable platform at heights that reduce or eliminate the need to bend while lifting.
- Get someone to help you lift when a mechanical lifting device, such as a wheelbarrow or dolly, is not available.

HAZARDS

- Your sight lines can be reduced when carrying plywood and other sheet materials, so be very sure that your path is clear. Be aware of the location and path of travel of vehicles, equipment, and other workers.
- Plywood and other sheet materials can be difficult to handle in the wind. The added and unexpected extra load imposed by a sudden gust of wind can throw a worker off-balance and lead to a fall. In windy conditions, get help when carrying or moving sheet materials.

You often need two people to carry something safely over uneven surfaces or with awkward objects.
ASSEMBLY
1) HEALTH HAZARDS RELATED TO FORMWORK ASSEMBLY/PREPARATION

Workers are aware of the general health risks associated with working with concrete and concrete additives, and their effects such as dermatitis and silicosis. People may, however, overlook some other chemical hazards, especially when preparing forms.

SAWDUST: RESPIRATORY HAZARDS

When plywood and other form materials are cut, there is exposure to wood dust and epoxies. Cutting plywood containing laminates of hardwoods and softwoods generates particulate that, when inhaled, can cause asthma and bronchitis. Formaldehyde-containing adhesives can become airborne and be inhaled, causing irritation.

FORM OIL: RESPIRATORY AND OTHER HEALTH HAZARDS

Workers will be exposed to form release oil sprayed on the plywood before concrete is placed. A variety of form oils can be used and the chemical content varies widely. Chemicals can include fuel oil, vegetable oil, water-based or oil-based solvents, or naphtha. Even though the material safety data sheet (MSDS) may say that the oil is “low VOC” (low in volatile organic compounds) or vegetable-based, workers may become sick or suffer adverse health effects if over-exposed. Direct contact can cause dermatitis. CSAO recommends that you wear protective clothing and equipment such as chemically-resistant gloves, chemically-resistant boots, and a respirator.

Note the differences in exposure between different workers. The worker who sprays the oil usually uses a portable compression sprayer to coat the forms. The sprayed oil can form an aerosol mist that can be inhaled by not only that worker, but also other workers downwind. During spraying, there is also the hazard of direct contact with the spray and contamination of skin, clothing, and boots. Depending upon the square footage of the forms, the spraying task can take five to 10 minutes to complete, so the exposure can be brief but intense.

After spraying and placing forms, workers will lay out and tie rebar within the forms. While this is being done, workers are bent over with their mouths one to two feet away from the forms. They can breathe in the form-oil vapours being released in the heat or sunlight. Although the exposure intensity may be lower, rebar tying takes much longer, exposing the workers to perhaps more total form oil vapours than the person who sprays.

One of the problems compounding the health issue is the variety of form oil products available. The product used on one site may be different than the one used on another. As well, the temperature, wind, and even stage of construction (below grade vs. above grade) can affect worker exposures.
HEALTH HAZARDS RELATED TO FORMWORK ASSEMBLY/PREPARATION

PREVENTION

Form cutting
- Use a vacuum-equipped circular or table saw when possible.
- Wear eye and hearing protection.
- Wear an N-95 particulate respirator.
- Handle newly cut wood material with work gloves.

Form oil spraying
- Notify all workers downwind that spraying is starting.
- Wear eye protection.
- Wear chemically resistant
  - boots
  - coveralls
  - gloves.
- Wear a dual-cartridge organic-vapour/P-95 respirator.
- Wear chemically resistant gloves and a chemically resistant apron when dispensing form oil from the storage drum into the sprayer.
- Avoid contacting sprayed forms with bare skin.

The following general precautions apply to all workers
- Consult the material safety data sheet (MSDS) for chemical hazard information before starting each job.
- Don't smoke around form-oil drums or sprayed forms. (It can cause fire).
- Wash your hands before eating, smoking, or using the washroom.
- Stop work and notify your supervisor if you notice a rash, feel dizzy, or have problems breathing.

PHYSICAL HAZARDS ASSOCIATED WITH REINFORCING STEEL

- Reinforcing steel is typically shipped to the site in bundles. The bundles are usually so heavy that they are moved with either a crane or some other mechanical lifting device. Although heavy, reinforcing steel has considerable flexibility, and bundles can whip or bounce when being hoisted. Ensure that bundles are well secured while being hoisted, and that the path of travel does not endanger workers or the structure.
- The end of a piece of reinforcing steel can be sharp, so workers must be cautious when working around it. Wear long pants to prevent scratches and cuts.
CONSTRUCTING FORMS

2) CONSTRUCTING FORMS

SLAB, WALL, AND COLUMN FORMS

The main health and safety concerns during the formwork construction phase are related to

• general material handling and lifting
• cutting and connecting lumber and metal
• falling from heights.

Since much of the material needed for forming can be supplied to the work area by crane, hoisting and rigging safety is very important, as is worker awareness of the hazards of overhead loads.

For more information, see “Types of Formwork” in the Formwork section of the Construction Safety Association of Ontario’s Construction Health and Safety Manual (M029), which you can download free from www.csao.org.

1) FLYING FORMS

Flying forms are large sections of formwork, often including trusses, beams, shoring towers, braces, and other support mechanisms that are moved from one location to another. Although the term can be applied to any form that is moved by crane (or other hoisting device) to multiple locations, it is most commonly used to describe a unit of typical suspended slab formwork.

Flying forms are most often used on the “typical” floors of a reinforced concrete structure. Since each floor is the same, virtually no changes need to be made to the form from one pour to the next. This method increases production over traditional built-in-place frame-supported forming. It also improves overall safety of the forming operation by minimizing or eliminating the amount and type of heavy material handling associated with built-in-place methods.

There are three common types of flying forms:

- Deck-on-truss suspended slab forms.
  Large metal trusses—usually aluminum because of its light weight—are spanned by joists, which are in turn covered with sheathing to accept the concrete.

  The trusses are commonly 1.5 to 2 metres deep, and whatever length necessary to suit the project. The underside of the trusses has a series of shores or jacks that rest on a previously-poured section of slab. They allow the flying form to be raised and leveled into the correct position for the pour.

- Column/wall supported slab forms.
  Wide-flange beams are spanned by joists, which are in turn covered with sheathing to create this flying form.

  The beams are supported by hardware mounted to columns and walls from the previous pour, without the need for vertical shores or jacks. The hardware
allows for the suspended slab form to be positioned correctly, and then provides adequate support for the placement of reinforcing steel and concrete.

- **Deck-on-frame suspended slab forms.**

Shoring towers or posts are used to support a conventionally-built suspended slab form, and are fastened together to make an integrated unit. The vertical shores have jacks to allow the formwork to be leveled correctly, and the bases are attached to a continuous ledger that sits directly on the previously-poured slab to disperse the load.

Much like gang forms, the size of a section of fly form is often only limited by the lifting capacity of the site’s crane. The fly form is built slightly narrower in span than the distance between demising partitions or rows of columns in the typical location it will be used. Once it is in place and leveled, you install filler strips to make the formwork continuous.

Regardless of the type of fly form, all are designed to be lowered in place once the concrete has had time to set. Once lowered, the form is pushed, often on rollers, out past the edge of the supporting slab, and it is attached to the crane as it emerges. When it is fully supported by the crane and free of the building, it is hoisted to the next level where the process is repeated.
The main safety concerns when using fly formwork are

- falls
- being struck by or stuck against objects.

When receiving a section of fly form, workers are near the edge of the building. The edge must be free from obstructions, including guardrails. Workers must use fall protection.

When casting off a fly form, workers might be on top of the deck to attach slings for the crane lines. Typically, a permanent guardrail is in place at the end of the fly form, but when the form is pushed out of the structure, there is no guardrail protection along the sides of the deck.

Workers receiving the fly form on the previously poured suspended slab must beware of being struck by the incoming assembly. Never put yourself between the formwork and a column or wall. This also applies when the formwork is being rolled out. Being caught between a moving fly form and any part of the building can cause serious cuts, lacerations, contusions, broken bones, and amputations.

2) BUILT-IN-PLACE SUSPENDED-SLAB FORMING

Built-in-place suspended-slab forming is often used on non-typical areas of reinforced concrete construction. Beam and slab, flat slab or flat plate, and ribbed or waffle slab construction are all suited to this type of forming. It relies on shoring towers, frames, or posts appropriately cross-braced to support the joists, stringers, and sheathing necessary to create the form.

This type of forming is similar to knock-down forming for walls and columns since it’s most suited to a single-use application. It involves constructing most of the formwork in the location where it will be used, then stripping and removing it piece-by-piece once the concrete has set.

Overexertion injuries are a common hazard in this type of forming since it requires a large amount of manual material handling.

To advance the slab deck with traditional built-in-place methods, joists are placed loosely on top of stringers which are in turn supported by shoring frames or posts on the surface below.

Some modular suspended-slab formwork systems have been developed that change the work sequence and greatly reduce several safety risks associated with suspended slab formwork. Components of modular systems are usually light and compact enough to be handled easily by one worker. This
greatly reduces the chance of overexertion injuries. The design of components often allows for the columns and beams to be installed from the ground, eliminating the need for fall protection. The panels are small enough to be handled by one worker. While they may need to be installed from the top of the formwork deck, the worker can do this using a travel-restraint system rather than a fall-arrest system.

Workers can be struck by objects during stripping and removal. Exerting force on a piece of sheathing stuck to the underside of the suspended slab is dangerous. You must take steps to minimize the risk. Consider ways to drop down the shoring enough to allow for the release of the sheathing, but still prevent it from falling and hitting the worker.

It’s critically important to follow the proper sequence of disassembly during stripping and removal. Even when the suspended slab is sufficiently cured to support itself and its load, the shoring system may collapse if you don’t follow the proper dismantling sequence.

3) GANG FORMS

Gang forms are large assemblies—or an assembly made up of several connected smaller panels with independent structural integrity. They are designed to be erected, stripped, and re-used for vertical walls. The size of a gang form is for the most part restricted by the mechanics involved in moving it. The capacity of the tower crane is often the deciding factor for the size of the gang form.

Gang forms can be assembled flat and at ground level. This improves safety for workers, since it eliminates the need to climb or to lift tools or material to a height. Ideally, a material platform is set up at workers’ waist level, and the gang forms are assembled on top of the platform. This eliminates the need for workers to bend over while working. When the gang form is complete, a crane removes it from the assembly area.

Installing and stripping gang forms often involves work on platforms that are integrated into the outside of the formwork.
itself. Since gang forms can be used for continuous sections of exterior walls, workers often find themselves high above the ground as construction progresses. You must have proper guardrails on the platforms, and there must be a safe means of getting on and off the platforms. In addition, while the formwork is supported or stabilized by the crane, each worker on the platform must use a fall-arrest system including an anchor point which is independent of the formwork.

4) PREFABRICATED PANEL FORMWORK

Prefabricated panel formwork uses either manufactured or shop-built panels for wall and column forming. Pre-fab panels are durable, multi-use units that combine studs and sheathing. The size ranges from small units that can be physically managed by workers to large units needing a crane for positioning.

Once the units are in place, attaching braces, wales, ties, or proprietary system fasteners connects the units into a larger formwork assembly. These systems can be manufactured out of any combination of materials such as wood, metal, fibreglass, or plastic.

Hazards associated with this type of wall forming are

- falls
- overexertion
- being pinched or crushed between panels
- panels falling over during installation.

Avoid climbing the panels, especially during the placement and connection phase when the panels are not secure enough to resist shifting in place or falling over.

Stay clear of joints when panels are being set together. Being pinched in between two panels can lead to serious injuries. Also, if panels are to be placed by workers manually, use proper lifting techniques. Even if the overall weight is manageable, the actual dimensions of a panel can make it unwieldy and difficult to carry safely, especially in windy conditions.

5) KNOCK-DOWN FORMING

Knock-down forming is a single-use method for non-typical concrete construction, where the forms are built in place, usually with plywood and timbers. Once the concrete is cast and set, the formwork is dismantled, or “knocked-down”, and although the individual pieces of material will likely be re-used in another form, you don’t need to preserve the formwork assembly as a whole. It is put together almost strictly for a unique pour,
and once used is no longer needed. Hazards during assembly include falls (when working towards the top of the form), and overexertion (from manual material handling). The knock-down phase is dangerous, because you use pry bars and hammers to pull apart sections and components that were originally fastened securely. Use proper work platforms when constructing knock-down forms, placing reinforcing and concrete, and stripping.

6) BRIDGE CONSTRUCTION: CAST-IN-PLACE SEGMENTAL, SPAN-BY-SPAN/STEPPING FORMWORK

Fall protection is by far the overriding concern during bridge construction, in addition to all the other hazards noted in other areas of formwork. Work often takes place at significant height, processes are highly engineered, and there may be no access to services found at most building sites. Consider these issues when developing a fall response plan and emergency plan.

7) ONE-SIDED FORMS

There are times when concrete must be poured vertically against an existing surface. This existing surface acts as a permanent side of formwork, and often it must also be able to support anchors which secure the one-sided forms. The existing surface could be earth or rock, or even a building, shoring, lagging, or other engineered surface. It’s important that you examine the surface thoroughly. The system of ties, anchors, braces and supports must be engineered.

TYPICAL MATERIALS USED FOR FORMWORK

Regardless of the type of formwork system being used, you almost always need wood. In some cases, the lumber component of the formwork may be small, in which case cutting can often be done in close proximity to the forms. In the case of larger projects, and where wood is the primary forming material, a jobsite carpentry shop or formwork mill is often set up before you can begin constructing formwork. Although the carpentry shop is “outside,” there are several ways to increase safety.

Build a deck for the cutting tables and saws. This gives workers a clean, level, and even surface to work from. Help keep the cutting area dry by having a roof. Workers operating saws and handling material in a clean, dry area are less likely to slip, trip, or fall. Preventing slips and falls is always important, but slips can be even more hazardous when tools such as table saws are in the area.
CONSTRUCTING FORMS

Closing in at least two sides of the work area can also improve safety. Wind can make it difficult and dangerous to carry material, especially sheet material such as plywood. It can lead to overexertion injuries, slips, and falls. Wind can also shift material on the cutting table, causing a saw to bind or kick back, causing broken bones, contusions, or amputations.

Wind can also blow around sawdust, shavings, and wood particles. When these particles get in your eyes, they can cause eye injuries. They can also lead to other serious physical injuries when you become disoriented by sudden vision impairment.

Use walls or tarps to block the wind in the shop area. It will be more difficult for dust and debris to become airborne. Reduce the amount of material that can become airborne by using saws fitted with dust extractors and by cleaning up the shop area regularly.

Accumulated sawdust, wood shavings, scraps, and general clutter not only slow down production, but they also present a fire hazard. Keep the shop area clean.

Even if your shop area is perfectly clean, the Construction Regulation requires that you have adequate fire extinguishers or other fire protection systems in place. See the “Fire Safety” chapter of the Construction Regulation.

Give thought to fall protection in the shop area. Workers constructing a form can be exposed to a fall even if the form is nowhere near its final destination. If constructing a form exposes a worker to a fall, then you must have fall protection methods in place. Proper training, along with equipment such as scaffolds, guardrails, harnesses, and lanyards must be provided and used.

Choose the right storage space for incoming forming material. Ideally, the storage area should be easily accessible by delivery vehicles so that material can be unloaded and stored with the least number of intermediate steps. The more time workers have to spend physically handling the material, the greater the risk of overexertion and repetitive strain injuries.

Likewise, the storage area should be close to the shop to minimize intermediate handling. Material storage should be easily accessible from both the cutting area and the assembly area of the shop. After assembly, the completed form sections should go to a staging area. From there, they can be delivered to the erection site. Depending on the nature of the project, forms may be delivered by hand, on carts, dollies, or vehicles, or by crane.

Aluminum and steel can be used to varying degrees in formwork. Aluminum beams are often used as wales in place of lumber. Aluminum, when manufactured into wide-flange beams, has a very high strength-to-weight ratio, making it easy to carry and place. Aluminum beams are durable and aren’t susceptible to rot or decay. Unless an aluminum beam is damaged by a drop or impact, it will not warp or twist as lumber does when exposed to the environmental conditions of a jobsite.
Metal can also be used for studs, struts, sheathing, and complete panels. The main concern with metal components is their weight. Formwork sections—and often even individual panels—can be too heavy to be placed by hand so you have to use a crane or other suitable hoisting device. Safe hoisting and rigging procedures must be understood and followed whenever any hoisting device is used.

**REQUIREMENTS FOR MATERIAL STRENGTH**

The formwork drawings must be engineered, and must specify the size and grade of lumber to be used for the job. You must follow this information strictly. You must carry out all the details on the drawings. The grade assigned to a piece of wood indicates its strength based on engineering standards, and you need that strength to ensure the success of the form.

Many factors affect the pressure on forms. Temperature and chemical admixtures will not cause a direct increase or decrease in the amount of pressure, but by accelerating or delaying concrete curing rates they can determine how long the formwork is subjected to pressure.

Consolidation methods—such as the use of a vibrator or hammer—can have an immediate effect on the formwork, and if not done properly, can lead to formwork failure and partial or total collapse. See the chapter on Consolidation in the Concrete section of this book.

Pressure increases as the height of the form increases, but not as width increases. This makes the concrete mix design as important as the formwork design itself. Concrete slump and admixtures are factors that determine the rate of curing, and the rate of curing controls the pour rate that the formwork is designed to withstand. So never make changes to the concrete mix—such as adding water on site—without the engineer’s approval.

All components of a form can experience tremendous forces when the concrete is being placed. If even one inadequate piece is used, it can fail and start a chain reaction that could bring the whole form down. When one member or support fails, its load is immediately transferred to the members beside it. They can become overloaded, resulting in further and accelerated failure.

**TYPES OF TIES AND FASTENERS**

**Light forming**

For light forming, form ties made of either flat steel bar or heavy-gauge steel wire are typically used. These ties have components manufactured into them that maintain consistent spacing between opposing faces of form panels, preventing the panels from narrowing (thereby reducing wall thickness) or spreading (increasing wall thickness).

This class of tie is held in place by an end fastener designed to work with the particular type of tie being used. Quite commonly, the end fasteners for light concrete forming have a wedge design. Once the concrete is placed in the form and sufficiently cured, the end
Common types of light-gauge form ties.
Common types of medium-gauge form ties.
CONSTRUCTING FORMS

Fasteners can be removed and re-used, and the protruding ties broken off and discarded to make it easier to remove the forms. When you break off ties, ensure that no portion of the tie is protruding from the concrete in a way that could injure a worker. The edges of a broken tie can be extremely sharp.

If the ties do protrude out of the concrete, they must be cut flush with the face of the concrete to prevent workers from being scratched, cut, impaled, or otherwise injured in the event of contact.

Medium and heavy forming

For medium and heavy forming, ties are often made from steel rod, either tapered or threaded to facilitate removal from the concrete after it has set. These types of ties are typically threaded at the protruding end, and the width of the form is controlled by a plate/washer and nut installed after the rod is passed through the form.

Use the appropriate tools and techniques when installing and removing all types of ties. Improper installation can damage the tie or the face of the form, weakening it before the pour and increasing the risk of formwork failure. Due to the load created by the concrete, you may require considerable force to remove the end fastener from the tie, and the tie from the concrete.

Workers must not climb the formwork when removing form ties. Removing fasteners and ties can require substantial effort, so you also need solid footing.

Use the proper strength and type of ties for the project. This information will be specified in engineer’s design drawings for formwork. Mixing up ties can confuse workers, leading to installation errors and ultimately form failure. Ensure that all ties used within any form are of the same strength, size, and type.

Requirements for Engineering

Requirements for formwork, falsework, and re-shoring are stated in the Construction Regulation under the heading of Forms, Formwork, Falsework and Re-shoring. The Construction Regulation states, among other things, that formwork, falsework, and re-shoring must be designed by a professional engineer, installed or erected in accordance with the design drawings, and inspected before placement of concrete by a professional engineer or someone that the engineer designates.

For formwork that will be used repeatedly in the same configuration, you can use “typical” engineered formwork drawings and details. It is common practice in high rise construction that the layout and design of the below-grade and first few above-ground levels are all unique, but past that, several floors will...
be identical. Since the floor plan repeats itself, it is possible to use the same formwork in the same area over and over. However, regardless of how many typical floors are being built, it is extremely important to follow the engineered drawings during assembly and the inspection procedures prior to concrete placement.

The information provided in engineered drawings and details must be followed. Any variation from the quality or quantity of ties, supports, braces, accessories, etc., can lead to formwork failure and worker injury or death. To prevent such incidents, variations must be approved by the professional engineer responsible for the form design. See Sections 31 and 87-92 of the Construction Regulation.

ATTACHMENT POINTS ON FORMWORK

You must give careful consideration to the placement of, and connection to, attachment points on form panels. They must be shown on the design drawings. The lift points must be able to support the total load applied when the form is lifted. They must also be located in places such that the worker who is connecting and disconnecting hoist lines to them is not endangered. The lift points must keep the panel stable so that it stays in the proper plane while it is being hoisted.

You may need a scaffold or ladder, set up in a safe manner, to connect and disconnect hoist lines to the top of wall, column, or other forms. Likewise, guardrails or personal fall protection may be required for fly forms or any other panel or slab system that requires a worker to be near an open edge at height. Climbing the braces, wales, or any other part of the formwork or falsework is unsafe, and should not be done to connect or disconnect hoisting lines—or for any other reason.
3) OILING FORMWORK

TIMING OF APPLICATION
Generally, a form-release coating (form oil) is applied when construction of the form is complete, and before placing reinforcing steel. Applying form oil immediately after stripping increases the likelihood of contaminating the workers handling and re-locating the form, and also makes the pieces more difficult to handle. Applying form oil after the rebar is placed can lead to contamination of the rebar. This does not pose an immediate hazard to the worker, but it can lead to the failure of the structure due to an insufficient bond between the rebar and the concrete encasing it.

SLIPPING HAZARD AWARENESS
In general terms, the more porous a surface is, the less slippery it will be. This is because the surface will absorb the form oil instead of the oil staying on the surface. So, if form oil is applied at the same rate to both plywood and metal formwork, the plywood may be less slippery because some of the oil will soak in, while with metal, the oil will lie on the surface.

FIRE HAZARD
Some form oils are flammable. Refer to the product label and the material safety data sheet (MSDS) to determine the flammability of the product you’re using. If it’s flammable, then you must comply with the Construction Regulation’s requirement that at least one fire extinguisher (ULC 4A40BC rating) be provided where flammable liquids or combustible materials are stored, handled, or used. Every worker who may have to use the fire extinguisher is required to be trained. See the Construction Regulation for all of your responsibilities regarding preventing fire.

HEALTH AND ENVIRONMENTAL HAZARDS
Review and understand the material safety data sheet (MSDS) for any hazardous product used, and follow all instructions including those regarding health hazards and required protection, as well as environmental issues.

METHODS OF APPLICATION
Typically, you apply form oil with a pump-pressurized sprayer. The advantages of this method are a high application speed, a consistent application rate, and low physical demand. Disadvantages include potential overspray on surfaces near the form, and worker exposure to airborne mist.

You can also use a roller and tray to apply form oil. The method is similar to applying
OILING FORMWORK

A sprayer, pressurized by pumping the top handle, is a common way to apply form oil.

paint by roller. The advantages of this method include having more control over the application area (by eliminating overspray), and minimal airborne mist. The disadvantages include slower application speed and higher physical demand.
4) SLEEVES, BULKHEADS, BLOCK-OUTS, BUCKS

PHYSICAL HAZARDS

You often need sleeves on walls and suspended slabs, but sleeves can increase the risk of cuts during certain phases of forming.

They are often installed before reinforcing steel. This is when the hazard is greatest because the sleeve protrudes out from an otherwise smooth surface of formwork. This can lead to workers walking into or tripping over a sleeve. Workers can be injured either from bumping into the sleeve or from a fall by tripping over it. A way to prevent this is to make the sleeve a different colour than the formwork it is attached to. This makes it more obvious and visible.

MATERIALS

A sleeve is a sub-structure built into formwork to create a permanent void in the concrete. These holes are specifically planned for and positioned for use as door and window openings, as well as for installing mechanical, electrical, and other essential services and systems throughout the building.
SLEEVES, BULKHEADS, BLOCK-OUTS, BUCKS

There are two basic types of sleeves.

1) **Boxout sleeve.** This is a form within the form and is put in place to create an opening or pocket in the concrete. A boxout can be made out of form-ply, metal, plastic, concrete, or any other material strong enough to maintain its position and shape while concrete is being placed.

2) **In-fill or solid sleeve.** This is a solid piece of material that is installed on the formwork where the permanent opening is needed, and it completely fills the void.

Unlike a boxout, an in-fill can’t collapse in the concrete. Either type of sleeve, however, can be moved out of its intended position if it’s not fastened properly, or if the crew is careless during the pouring and consolidation phase.

In some instances, the boxout sleeve may be the actual door frame or window frame that will remain as part of the finished project. Any stiffeners, bucks, and braces that were installed to preserve the shape of the frame during the placing and curing phase get removed with the formwork, but the frame itself stays in place.

If the permanent presence of a sleeve would create a problem—such as when you’re required to maintain fire separations—then the sleeve will be removed. Otherwise, some or all of it may stay in place.

**CAUTIONS REGARDING PLACEMENT**

The position of any major sleeve will be shown on the formwork drawings. Since a sleeve would be useless if reinforcing steel passed through it, the reinforcing must be designed to accommodate sleeve locations.

Form tie placement must also accommodate sleeve locations. The location of a sleeve must be considered and accounted for when calculating the requirement for ties, and ties must be placed accordingly.

**IDENTIFYING LOCATIONS**

Once the form is in place, it can be difficult or impossible to see the location of bulkheads or block-outs from the outside.

Take care around bulkheads, because breaking a bulkhead could lead to concrete entering a section of the form that may not be suitably braced, tied, or anchored, or a section that is unfinished. Once this happens, there is an increased risk of formwork failure—including total collapse.
To reduce this risk, clearly mark and identify the location of bulkheads and block-outs on the outside of the formwork. As well, crews placing the concrete must be trained in the proper placing techniques around bulkheads and block-outs. Workers must understand that concrete should be allowed to run up to a bulkhead, not be poured directly onto it, and that the concrete vibrator must not be held against the bulkhead. This will reduce the likelihood of damage to the bulkhead and failure of the form.
5) WATERSTOP

HEALTH HAZARDS

Depending on the application, waterstop may or may not be metal. It may be necessary to connect two pieces of waterstop in an end-to-end manner on the jobsite. This process is referred to as “welding,” and in the case of metal waterstop (typically stainless steel) it’s done by either TIG or MIG welding.

Exposure to fumes is hazardous in each type of welding. Inhalation may be harmful to a worker’s health. Splicing or welding should only be done in well-ventilated areas. Protect exposed skin against burns from hot material, and protect eyes from splash and spatter of molten material as well as eye flash.

PHYSICAL HAZARDS

PVC/Rubber waterstop can be cut with a utility knife, but given the durability of the material, you may need to use a lot of force to make the cut. This means that if you slip, you can be severely injured.

Minimize the risk by making all cuts on a flat, level, and stable surface, and by securing the waterstop to the cutting surface before cutting. The cutting table should be arranged so the knife is drawn away from the worker, not towards.

Once cut, waterstop can have very sharp edges. Watch out for them until you’ve finished splicing. Wear gloves to handle the material.

Polyvinylchloride (PVC) or Thermoplastic Elastomeric Rubber waterstop is joined by heating the two ends with a specially-designed heating iron. These irons typically operate at 350 degrees Fahrenheit or higher. They work by melting the material, which is then pressed together and held until it cools and solidifies, making a bond.
ERECTING FORMWORK
1) INTRODUCTION

Workers can use suitable **pry bars** to do the final positioning of heavy panels or formwork. **Beware of overexertion injuries from trying to lift, push, or pull panels or formwork into place.** Take care when using a pry bar. Its leverage gives a worker the ability to move a very heavy object a small distance with only moderate effort. But if the pry bar slips under the load, you can get injured. You can suffer contusions, lacerations, or broken bones if a pry bar slips and kicks back while under heavy load. You can also be injured from a fall if the pry bar slips out under load.

When the exterior panels are in the right location, they must be plumbed and securely braced. The **bracing** must be strong enough to keep the formwork in position during the installation of reinforcing steel and the interior panels, but also adjustable enough to allow for final re-positioning if required once the entire assembly is complete. The bracing must also be set up in a way that does not create a trip or struck-against hazard for workers in the area.

Placing **rebar** bundles on suspended slab formwork is a critical safety issue. Spread the bundles out around the deck. This disperses the load. Reinforcing steel and all other material must be placed on the deck in a manner and location that does not overload the formwork, shoring, or any other part of the structure. Refer to the formwork drawings for information about where to place material.

**Interior panels** are carried or hoisted into place, and are then fixed to the exterior panels. They allow you to set the proper form width. There are many products commercially available to connect opposing form panels, but the type, size, and quality of **tie** specified in the design drawings must be used without exception.

The same goes for the spacing of **ties**. Changes to the design, layout, specifications, dimensions, or other aspects must not be made except under the direction of an engineer. Formwork and all related components must be erected in accordance with the engineered drawings, and confirmed through inspection before placing the concrete. A failure of the form ties can result in complete collapse of the formwork, which can cause serious injury or death.

**Bracing** is the last step in preparing the formwork for concrete placement. You may need to make adjustments to the bracing that...
ERECTING FORMWORK

The braces on this column offer support and are adjustable.

secures the exterior panels in order to bring the panels back into plumb, square, and alignment with grid lines. If spreaders and ties have been used properly, then positioning the exterior panels correctly should position the interior panels correctly. Once this is confirmed, braces can be installed on the interior panels to make the formwork ready for concrete.

Engineered braces must be secure. If the formwork drawings specify their locations, you must place them in those locations.

Detail of the brace attachment.
RIGGING AND CRANE WORK

2) RIGGING AND CRANE WORK

COMPETENT WORKERS

The success of any hoisting operation depends on the competency of the riggers and swampers. They must be able to
- communicate clearly with the operator
- connect the load safely
- receive and place the load effectively.

The safety and success of the project demands that these workers have a high level of training, knowledge, and experience.

WIND LOADS AND SPECIAL ENVIRONMENTAL CONCERNS

Even a single sheet of plywood has enough surface area to cause a worker carrying it to lose balance in windy conditions. Standing up panels can be very dangerous, and you may need additional bracing to prevent the formwork from blowing over.

Loads being moved by crane must be carefully controlled with tag lines (ropes hanging from corners of the load). Workers must ensure that they won’t be struck by the load. Workers must never place themselves between the incoming load and a solid object, or close enough to an open edge to be knocked off if the load swings or sways in the wind.

SIGNALING

Before hoisting begins, the crane operator and ground crew must clearly understand the hand signals they will use for communication. Hand signals can be effective so long as there is a clear line of sight.

Radios are commonly used between the ground crew and the crane operator. They give the signal person the ability to provide the operator with clear and precise direction. The operator can transfer loads even when there is no clear sight line to the pick-up or drop-off areas.

The disadvantage is that a radio is a piece of electronic equipment, and may break down or be subject to signal interference. You need a back-up plan. The plan must ensure that if communication is lost between the operator and the ground crew, each party follows the same steps until communication is re-established.

More importantly, in case of radio failure, you must ensure the safety of workers and the security of the load. A procedure must be in place to guarantee safety. The hoisting operation must be stopped immediately.

The operator must also be able to identify the signal person clearly from the cab of the crane, so that there is no confusion about who is giving direction to the operator. A distinctively coloured hard hat and reflective vest help make the signal person stand out easily.

If there is a fall hazard, the signal person must be protected from the edge by a
guardrail or personal fall protection. When signal persons are looking up at incoming loads, they may be unaware of how close they are to the edge, and they risk falling.

**INTERACTION WITH THE FORMWORK CREW**

Riggers must be familiar with the loads that are being lifted, and know the type and size of lifting hook required. They must attach hooks in a way that allows for quick and easy disconnection once the load is in place, but which prevents hooks from rolling out when the load is being lifted. Failing to attach load hooks correctly, or using the wrong load hooks, can lead to the load falling.

*The rigger must ensure that the form will not be damaged when tension is applied to the lifting lines during the hoist.* If the pick points can’t be seen from directly above, it’s possible that the lifting lines will exert force on part of the formwork as the lines go tight. The riggers must know if this will damage the form. The load could fall or the formwork could fail during the pour.

The load must be stable while it is suspended, otherwise it can be hazardous to land. The lift points must be located so that the load is suspended in the same position in which it will ultimately be used. The form must hang stable and steady.

If workers are exposed to a fall hazard, fall protection must be provided and used (see the Construction Regulation for how a fall hazard is defined). Lift points should be in
locations that allow for easy access when attaching and disconnecting lift lines. If the lift points cannot be reached from ground level, then suitable access must be provided. Climbing the formwork or shoring towers is not an acceptable method of access.

Tag lines—ropes hanging from corners of the load—are the safest and easiest way to control the load as it is being lifted out and lowered into place. It is important that there are no knots, hooks, etc., on the tag lines, because these things can catch a worker’s clothing or body and cause them to fall.

Tag lines should be long enough for workers to reach them without risking being struck by the load as it comes in—but not so long as to coil up. A coil of rope is a tripping hazard for workers trying to land a load. Stepping in a coil when the load is being lifted out can pull a worker off balance. It can also lift the worker off the ground with the load, leading to a fall.

It is important to brace a panel properly once it is in place, but the bracing must not interfere with the position of any subsequent panels or their bracing. You need a clear understanding of the entire formwork layout, including initial and final bracing.

Potential tripping and struck-against hazards must be kept to a minimum in any area where loads are being delivered by crane. Workers in this area must keep their eyes up to manage the incoming load—they’re at greater risk of tripping or walking into objects. Make braces visible, and install them with consistent placement.

Kick plates are strips of material attached to the deck or ground so that wall and column forms are landed in the proper place—and stay in place. They act as a template, and are placed before the installation of the forms. If installed correctly, kick plates reduce the hazards associated with hoisting formwork by allowing the crew to focus on the task of landing the form on its pre-determined mark. They don’t have to measure and make fine adjustments to the panel’s position.
3) TIES

STRENGTH OF TIES

Ties are specified as part of the design, and should be shown on the formwork drawings. Different ties have different strengths, so never make substitutions when installing ties unless an engineer approves.

INSPECTION BEFORE POURING

Ties must be free of bends, kinks, dents, chips, or any other visible deformation or damage. Damage can greatly reduce a tie’s strength. Even a single tie weakened by damage can give way under pressure, leading to a chain-reaction failure of surrounding undamaged ties. Inspection of ties must be ongoing during installation and before placing concrete. Discard any ties that show signs of damage.

LAYOUT AND INSTALLATION

The layout and location of ties are specified as part of the design. They should be shown on the formwork drawings. Tie spacing and strength are directly related, so tie spacing should never deviate from the design. Increasing the tie spacing from the dimensions shown on the formwork drawing has the same effect as using ties of lesser strength, and increases the chance of form failure.

The strength of ties is also related to the location of holes on opposing formwork panels. In order for the tie to withstand the load it was designed to bear, the holes must be directly across from one another. This allows the tie to be installed perpendicular to the panel. If it is installed on an angle from one panel to the other, the tie strength is diminished. This means that the more out-of-square the tie is relative to the form, the weaker it becomes. This weakness increases the chance of form failure.

Installation can present safety concerns. Over-tightening ties can cause certain types of ties to pull partially through the formwork, which can reduce their effective strength. If part of the tie becomes embedded in the concrete because of overtightening, it can require much more force to remove during the stripping phase. This increases the chance of overexertion injuries. It is important that you follow the manufacturer’s instructions when it comes to installation methods.

TYPES OF TIES

Some form ties require special tools for installation and removal. Don’t substitute different tools. The wrong tool can fail during use and lead to the worker’s injury. The wrong tool can also install the tie improperly, increasing the risk of form failure.
4) REINFORCING STEEL

SMALL-SCALE PROJECTS
On smaller projects, the carpenters who build the forms may be responsible for installing the reinforcing steel as well. On larger projects, there is typically a crew dedicated full-time to placing rebar. Regardless of who places the rebar, the carpenters will return to close in the form.

PHYSICAL HAZARDS
A common hazard when placing rebar is overexertion, which can mean back injuries and muscle strains. Practice proper lifting and back care techniques. For instructions, refer to the Construction Health and Safety Manual (M029), available from the Construction Safety Association of Ontario.

Tying rebar can lead to repetitive strain injuries, particularly in the wrist and forearm. Changing hands while tying reduces the risk of injury. So does using a rebar tying machine. Whenever possible, rebar assemblies should be made on a workbench or table so that workers are not forced to bend over.

CUTTING REBAR
Theoretically, rebar is fabricated specifically for each project, so you shouldn’t need to cut bars on site. In many cases, however, you often need to cut some bars to suit particular situations.

The tool often used for cutting is a gasoline-powered quick-cut saw. Workers must use appropriate personal protective equipment, including eye and hearing protection. Make sure that the saw has a metal cutting blade before use. Always operate the saw in a well-ventilated area to avoid the accumulation of deadly carbon monoxide fumes.

Cutting torches are also used to cut rebar. There are several issues relating to the safe use of cutting torches, including appropriate personal protective equipment and fire protection. For specific information, refer to the Construction Safety Association of Ontario’s Construction Health and Safety Manual (M029), available on www.csao.org or by calling 1-800-781-2726.

Prevent fire by operating the saw or torch well away from any flammable or explosive substances. Even a worker’s clothing can be ignited by the shower of sparks created by cutting rebar.
Have fire extinguishers available and ensure that workers are trained how to use them.

Bolt cutters can be used for small gauge rebar and reinforcing mesh. Use rebar shears for large gauge rebar. Know where the pinch points are on these tools. Never place any part of their body within the cutting jaws. These tools are capable of slicing through a work boot. **When using manual cutters, never try to increase the cutting power by putting extensions over the handles to increase your leverage. If you can’t cut the bars, get a bigger tool. Don’t alter the one you’ve got.**

The ends of reinforcing steel can be sharp. They can also be hot enough to burn your skin after pieces have been job-cut. You can get cuts, abrasions, and punctures from the ends of reinforcing steel, so **you must cover the ends wherever workers can encounter them.** You can do this by putting manufactured caps over the ends, or by tying long pieces of lumber perpendicular to the rebar at the ends.

**PROPERLY TIED AND SECURED**

Ensure that rebar, once placed, is properly tied and secured. The long-term integrity of the structure depends upon every piece of reinforcing steel remaining in its intended location.

Workers installing rebar often stand on their completed work as they continue the installation. You’re more likely to slip, trip, or fall if the rebar is not tied and secured. Bars should not roll, slip, or kick up when you walk on them.
5) SHORING AND BRACING

ENGINEERING REQUIREMENTS

Site conditions may prevent braces from being installed as shown on formwork drawings. Changes to those site conditions are not always practical, so changes to the bracing design, location, etc., may be necessary. Any changes must be made by the engineer, and those changes must be followed on site.

The kind of formwork usually determines the kind of braces you need. A manufactured panel system may have braces designed and built to work as part of that system. In this case, you must not substitute these braces with different braces. Whatever type of formwork system is being used, follow the information provided on the formwork drawings regarding the size, location, and means of attachment for braces.

ACCESS

Climbing shoring frames is not permitted under the Construction Regulation because the frames do not meet the definition of a ladder. Therefore, a suitable ladder or temporary stairs must be installed to provide access to the top of the shoring frames. As well, a suitable work platform with guardrails must be in place for workers. If installing guardrails is not practicable, then personal fall protection must be provided and used.

As with bracing, shoring must not be altered on site without the approval of the engineer.
CONCRETE
1) PREPARATION BEFORE PLACING CONCRETE

BEING PREPARED

- The most important consideration is to make sure the formwork and falsework are complete. They must be ready to accept the massive weight and force that will be applied to them when concrete is placed. Formwork and falsework must be inspected by a professional engineer (or by a competent worker designated in writing by the engineer) to ensure they have been built in accordance with the engineered drawings.*

- Avoid installing bracing and supports at the last minute, since it results in rushing, tension, stress, and the possibility of dangerous mistakes. Usually, this indicates poor planning and inexperience on the part of the supervisors.

- A good supervisor will have a clear idea of when the formwork will be ready for concrete placing. Minor adjustments may be necessary and are quite acceptable, but unfinished formwork could be the trigger for a collapse.

- A badly planned and poorly executed concrete pour can show that other factors need improvement. Inexperienced or poorly trained concrete crews, critical equipment breakdowns, lack of proper work platforms, unrealistic schedules, and formwork failure are things which can all be overcome by proper planning.

- Before starting the pour, ensure that guardrails are in place anywhere where a worker could fall to another level, such as the perimeter of the deck, stair and shaft openings, and work platforms on wall and column forms.

- Inspect the power supply and extension cords, and test the vibrator before the pour begins. Look for
  - properly-functioning ground-fault circuit interrupter (GFCI) outlets
  - cords and plugs free of visible damage
  - a working on/off switch.

Also make sure the vibrator has a carrying strap. Do not use the power cord to carry the vibrator unless it has been specifically designed for that purpose by the manufacturer.

- Have tarps, lights, heaters, and other equipment or materials prepared before starting to pour concrete. Have them nearby and ready to use if there is any chance that
  - the work will extend past daylight hours, or
  - the weather will require protecting the concrete.

Scrambling and searching in the dark or the rain can lead to slips, trips, falls, and other injuries.

*For full details on engineering and inspection requirements regarding forms, formwork, falsework, and re-shoring, see Sections 87-92 of the Construction Regulation (O. Reg 213/91).
Cleansing Out, De-icing

- You need to clean out foreign materials from the forms before placing concrete. Water movement, wind, and other factors can cause soil or other material to end up in the form before the concrete is placed. This material must be removed to maintain the integrity of the structure. Failure to do so could lead to a collapse during the pour, while stripping forms, or later in the project. The task of cleaning out material must be handled carefully, with attention paid to fall protection, personal protective equipment, the potential for confined spaces, and rebar safety, among other things.

- Forms are often de-iced using compressed air, torches, or heaters. The de-icing process is very similar to cleaning out other foreign materials, with one major additional hazard: fire. If a torch is used, be certain that a comprehensive emergency fire-response plan is in place and followed strictly. This includes recognizing the presence of flammable form oil and taking steps to prevent fire.

Location of Equipment

- The location of the pump or concrete truck around formwork and the excavation can have serious safety consequences. The weight and vibration of equipment can cause movement or collapse of the soil or forms. All equipment must be at least 1 metre from the edge of the excavation.**

- Chutes or the pump discharge hose can add significant weight to a form or the bank of an excavation, increasing the likelihood of a collapse, rupture, or failure. Be certain to use chutes in accordance with concrete supplier policies.

Access

- The scaffold to access the top of the form must be erected before the pour starts. Ensure that all scaffold requirements are met, and that the work platform is at a height suitable to allow pouring operations to proceed smoothly and safely.

** For full details on requirements for the top of excavations, see Section 233 of the Construction Regulation (O. Reg 213/91).
PRECAUTIONS FOR WORKING WITH CONCRETE

2) PRECAUTIONS FOR WORKING WITH CONCRETE

PERSONAL PROTECTIVE EQUIPMENT

- The caustic nature of wet concrete makes it a potentially harmful product to handle.
- Cement can contain a metal called hexavalent chromium. This metal causes allergic dermatitis (inflammation of the skin).
- Use appropriate personal protective equipment to protect skin from contact and long-term exposure, which can lead to chronic dermatitis. Keep fresh water nearby to rinse concrete off your skin and clothes.
- Wash your hands before eating.

ADDING WATER

- Concrete slump is directly affected by the amount of water, and is part of the design of the concrete mix. The addition of water at the site can delay the concrete set time, which is a primary factor in determining the pour rate. Adding water may require a corresponding reduction in the pour rate. Unless an engineer has given approval to do so, don’t add water.
3) PLACING CONCRETE

BEFORE POURING

- Before starting the pour, someone must be designated to monitor the condition of the forms as the concrete is placed. They must be able to identify any sign of bulging, slipping, uplifting, sagging, etc., and have the authority and the means to stop the pour immediately.
- Extra shores and other material and equipment that might be needed in an emergency must be readily available.
- Have a procedure to ensure worker safety in the event of any sign of form movement or failure.

POUR RATE

- Understand and strictly adhere to the rate, techniques, and procedures of the pour. **Forms are designed to accept concrete at a certain rate, so increasing the pour rate can cause failure.** This includes heaping or piling concrete when pouring walls and suspended slabs. Allowing concrete to pile up in one location can overload the form and lead to a collapse.

The pour rate is specified on the formwork drawings. Pouring techniques and procedures can vary site to site, so they must be communicated to the placing crew before starting the pour. Improper placement of concrete can cause uplift, upset, collapse or other kinds of formwork failure. **It is important that the placing crew understands the limitations of the system and equipment they are using, and not go beyond them.**

CONVEYANCES

- When using pumps, beware of
  - overhead contact with electrical lines
  - the hazard of being struck by the equipment
  - line thrust causing damage to formwork or falsework from the discharge pipe on the ground
  - pinch points.

- Buckets present the hazards of
  - striking workers
  - overhead contact with electrical lines.
Keep workers not involved in the pouring away from the bucket’s landing area.
PLACING CONCRETE

- Have a procedure in place so that the bucket does not pass over workers.
- In some circumstances, concrete may be poured from the truck into engineered chutes supported by the formwork itself. The chutes must be capable of supporting whatever loads and forces may be applied to them, and they must not be supported by work platforms. To protect workers, the chute needs an independent means of support.
- Admixtures: Follow information on the material safety data sheet (MSDS). Provide and use the required personal protective equipment.
4) CONSOLIDATION

PROPER USE OF VIBRATOR

Vibration created by concrete consolidation can cause the formwork to collapse if there is insufficient diagonal bracing within the shoring assembly. Improper use of the vibrator can also lead to form ties being broken, causing formwork failure.

Shoring must be engineered. Follow design drawings to ensure that you don’t overlook diagonal bracing. **Workers operating vibrators must be trained to know the location of form ties. They should not strike ties with the vibrator.**

SIZE OF VIBRATOR

The size of the vibrator head matters for successfully consolidating the concrete, and it also matters for safety. Its size must allow it to fit within the spaces between the reinforcing steel and the forms. If it’s too big, there will be areas that can’t be reached and consolidated, and there may also be damage to the formwork, falsework, or reinforcing steel from direct and prolonged contact with the vibrator.

Concrete vibrators must not be used as a means of spreading concrete. **Concrete must be distributed evenly throughout the form—not heaped and then vibrated level. Heaping concrete overloads the formwork and can lead to collapse.**

The vibrator itself is a health issue. It can affect the worker’s hands and arms. The worker can get hand/arm vibration syndrome (HAVS). See “Physical Hazards” in the “Hand/Skin Protection” section of the Construction Safety Association of Ontario’s *Construction Health and Safety Manual* (M029), available on www.csao.org or by calling 1-800-781-2726.

CONSOLIDATION TECHNIQUES

The worker operating the vibrator must recognize where form ties, bulkheads, sleeves, and block-outs are, and avoid hitting them with the vibrator. Be cautious when approaching corners with the vibrator. Corners are the weakest part of the form, and have a higher chance of failure if damaged.

Broken or damaged ties can lead to form collapse. Vibration and consolidation must take place at prescribed intervals during the pour, based on several site conditions including but not limited to:
CONSTRUCTION SAFETY ASSOCIATION OF ONTARIO

CONSOLIDATION

- width of form
- amount and configuration of reinforcing steel
- temperature
- slump of concrete.

DEPTH OF CONSOLIDATION

Be aware of the capacity of the vibrator (the maximum depth at which it will effectively consolidate the concrete). Don’t overwork the machine. Pushing the vibrator past fresh concrete into layers of partially set concrete can lead to improper curing and reduced strength of the structure.

Over-vibration can lead to segregation of concrete, also resulting in reduced strength of the structure.

Although these things may not cause an immediate hazard during the placement of concrete, they can lead to overall weakening of the final structure.

ELECTRICAL HAZARDS

- There is a high risk of electric shock when extension cords and electric hand tools are used in wet areas.
- Extension cords must not be run through water. They must be kept and used in dry locations to minimize the risk of electrical shock.
- Ground fault circuit interrupter (GFCI) outlets are required for outdoor use.
- Cord casings must be free of cracks or other visible damage.
- Plugs must be securely attached to cords, and must have all prongs intact. Electric hand tools must have all three prongs intact on the plug OR be double-insulated.
- Do not use extension or tool cords that are defective or have been improperly repaired.
- Do not wire plugs into outlets. Disconnecting them will take too long in an emergency.
- Protect cords from traffic.
5) FINISHING

VENTILATION

- A gasoline-engine power trowel is the most common tool used to float and finish concrete floors. Carbon monoxide (CO) from engine exhaust is deadly, so you must have adequate ventilation.
- Do NOT allow the use of or operate gasoline-powered engines or tools in poorly ventilated areas or near fresh-air intakes. Using gasoline-powered tools indoors where CO can accumulate can be fatal. Overexposure to CO can occur in a matter of minutes. See sections 46-47 of the Construction Regulation for more information on ventilation and the operation of internal combustion engines.
- Recognize the signs and symptoms of CO overexposure:
  - headache
  - nausea
  - weakness
  - dizziness
  - vision problems
  - changes in behaviour
  - loss of consciousness.
  Any of these symptoms and signs can occur within minutes of exposure.
- Electrically powered engines or tools may be used in enclosed or semi-enclosed areas, but ventilation must still be monitored.

GUARDS

All guards must be in place on power trowels. It’s dangerous to operate any piece of equipment with the guards removed. Also dangerous is bypassing built-in safety devices.

The critical safety feature on a power trowel is the circular frame around the outside of the trowel blades. This guard greatly reduces the chance of the blades catching against an object while they are spinning.

If the blades do come in contact with something, they can stop suddenly, transferring the power to the frame of the machine and causing it to spin. Anything ranging from minor finger, hand, and wrist injuries to fatal falls can result.

The drive-belt guard is another safety feature on a power trowel. It protects against injury.
FINISHING

in case a belt breaks during operation. It also prevents parts of the body or clothing from getting caught in the pulleys.

OTHER HAZARDS

Review and understand the material safety data sheet (MSDS) for any hazardous product used. Follow all of its instructions, including those regarding

- health hazards and required protection
- environmental issues.
STRIPPING AND REMOVAL
STRIPPING AND REMOVAL

1) GENERAL

OVERVIEW

The process of hardening that concrete undergoes once it is poured is called curing. Concrete becomes increasingly harder as time passes and it continues to cure. According to the Construction Regulation, formwork and falsework shall not be removed unless

- the concrete is strong enough to support itself and any loads that may be applied to the structure, OR
- the concrete and the structure are adequately re-shored.

The strength of the concrete is the most critical factor relating to the stripping and removal of formwork and subsequent re-shoring. It must be cured sufficiently to maintain its shape once the formwork is removed. The type and placement of re-shoring is determined by the concrete strength at time of stripping.

Commonly, sample cylinders of concrete are cast at various stages of each pour to be used for testing. The concrete mix is designed to reach a certain strength after a specific time. Compression tests are performed on the cylinders to verify that this strength has been reached. Once this has been confirmed through testing, the stripping process can begin.

Stripping forms before verifying cylinder strength is a dangerous, extremely risky practice, so don’t do it. Undercured, “green” concrete has unpredictable characteristics, and cannot be trusted to stand unsupported.

The strength of the concrete affects not only stripping and re-shoring, but it also affects the placement of guardrails. You must take great care to ensure that the concrete is cured enough to support the attachment of guardrail posts—especially any posts that must be fastened into the concrete.

While formwork is being removed, workers must check the structure for loose concrete. Any rubble, debris, spalling, or over-pour must not be left on columns, walls, or other structures since it may fall unexpectedly and injure workers below. Remove such material when the forms are being stripped.

You need personal protective equipment during the stripping stage, especially gloves and eye protection. Concrete can chip easily, and there are countless places where pinches, cuts, scrapes, abrasions, and other injuries can occur. Wear eye protection, gloves, and long sleeves at all times when stripping formwork.

Formwork—whether knock-down forms, fly forms, or gang forms—must be braced sufficiently to prevent it from falling, while allowing it to be broken free of the concrete. Falling formwork can hit workers and damage equipment.
HOUSEKEEPING

Housekeeping is important at all stages of construction. It becomes critical when stripping forms because of the fast rate at which material and debris can accumulate in the work area. During stripping, the construction site becomes a demolition project, with material being dismantled and removed rather than installed.

Depending on the nature of the formwork, much of the material can have sharp, broken, or uneven edges, and have nails protruding. The material is often taken from the forms and put on the ground. It is then cleaned from the ground after the forms are dismantled.

Workers must not be allowed to throw material to the ground from a work platform. Stripped material must be placed securely on the platform and then lowered by a controlled means to the ground.

MATERIAL HANDLING

There is a high risk of overexertion during stripping and removal of formwork. Reaching, prying, pulling, and pushing, as well as lifting and carrying, can put considerable strain on joints, muscles, and bones.

Follow proper lifting and carrying techniques—such as keeping feet together to lift and keeping the load close to the body when carrying. When stripping, be certain you’re in a stable position and have firm footing when you pull, push, or pry to remove formwork. Ensure that workers are not in danger of falling when the piece being removed breaks free. If there is fall hazard, fall protection must be provided and used.

TOOLS AND EQUIPMENT

Tools must not be modified, altered, or added to in order to gain leverage or reach. Changes made to a tool can put more stress on the tool than it was designed for, and lead to the tool breaking under the increased load. If the tool breaks under load, the worker faces an increased chance of

- hitting into an object
- having the broken tool strike them or another worker
- losing balance and falling.

Regardless of the task, choose the appropriate tool and use it correctly in accordance with the manufacturer’s instruction manual.

If a specialized tool is needed to remove form ties, make sure that you use that specific tool. Substituting a hammer or pliers in place of a tool designed and manufactured to remove a certain type of form tie increases the risk of injury.
STRIPPING AND REMOVAL

ACCESS

A proper work platform with safe access must be provided for workers stripping forms at any height above the ground. If workers are stripping forms in an area with a fall hazard, fall protection must be provided and used.

In addition, sufficient temporary lighting must be provided for workers stripping and removing formwork. The underside of a deck or suspended slab can be very dark. It can also be cluttered with shoring posts, towers, cross-braces, columns, walls, and other objects. The risk of injury is high, and increases as stripping and removal of formwork progresses. The risk of injury is greatly reduced if the area is well lit.
2) KNOCK-DOWN SLAB SYSTEMS

Knock-down formwork is usually dismantled in the reverse order of its installation. The dismantling crew must be familiar with the proper order, since this will minimize the effort and reduce the likelihood of the formwork falling or collapsing.

During dismantling, material can accumulate quickly, so it is important to have a system of safely removing the stripped material from the stripping area. Coordination among workers will keep the dismantling progressing and the work area safe and orderly.

It may be necessary to assign housekeeping to a particular individual or individuals. In any case, it should be clear who is responsible for keeping the work area clear of material and debris.
FLYFORMS

3) FLYFORMS

Flyform for suspended slabs is typically built on jacks so that once the concrete is sufficiently set, the form can be lowered to remove it from service. Working from underneath, the jacks are released and the weight of the flyform is transferred to rollers, which makes it easier to move. It is then pushed out to the open edge of the structure. As it emerges from under the recently completed suspended slab, it is connected to the crane.

Re-shoring begins immediately behind the removal of the flyform. This provides support so that the form can be placed on top of the slab from which it was removed. Hazards at this stage are:

- Falls off the open edge because guardrails must be taken down to allow for removal of the form. Workers must use personal fall protection systems during the stripping and removal phase of fly forming.
- Being crushed, or being struck by the form, when rolling the form out.
4) WALL AND COLUMN FORMS

Wall and column forms resting on the slab can be broken out from the set concrete before being attached to the crane, provided sufficient bracing remains in place to prevent them from falling over.

Pick points should be designed as part of the form, clearly identified and easy to reach. Workers must not climb the forms to reach the attachment points. A properly installed ladder is the safest and quickest way to reach the top.

For forms that may not be resting on the slab (exterior walls, inside shafts, etc.) make sure the form is attached to the crane before you begin removing the ties and breaking out the form. Any worker accessing a work platform on such a form must be protected by an independent means of support.

Once the form is attached to the crane, the slack must be taken out of the hoist line to prevent shock loading and subsequent damage from the form being broken out. The crane must not be used to dislodge the form. Although the line should be free of slack, it should also not be under any substantial tension. The idea is to prevent the form from dropping once it is released from the concrete, but also to keep the line just loose enough that workers can pry the panel free.

Workers familiar with the formwork construction sequence should be involved in its removal. This will reduce likelihood of injury because if the formwork is dismantled in the proper order, it will come apart relatively easily. The less that workers have to exert themselves physically, the lower the risk of injury.

Dismantling formwork out of order may cause parts or pieces to fall unexpectedly. If the crew does not know the sequence, a supporting member may be mistakenly removed without the accompanying members having adequate support. This could lead to collapse and injury.
SUMMARY

Regardless of the type of formwork, following these steps will help minimize risks and hazards:

- Formwork (formwork, falsework, re-shoring) must be designed by a professional engineer, or the formwork components must be tested to failure and the test results verified by a professional engineer.

- The formwork must be built in accordance with the engineered drawings.

- An inspection—by a professional engineer or the engineer’s designated inspector—must be done to verify that the formwork has been installed according to the engineered drawings.

- The person who carries out the inspection must put the findings of the inspection in writing.

- If there is a deviation from the engineered drawing, the professional engineer must review the deviation and make any necessary amendments either to the drawing or to the actual jobsite implementation of the formwork. The drawing and the reality of the formwork must be consistent.

- At least one competent worker must monitor the forms for movement during concrete placing, and such a worker must have the authority to immediately stop the pour if any problems develop.

- Sample concrete cylinders must be cast at random times during each pour, and be allowed to cure in the same conditions that the building or structure will face.

- Subject the concrete cylinders to compression testing at pre-determined intervals to verify the strength of the concrete.

- Stripping of falsework and formwork, and re-shoring must be done only when testing verifies that the concrete has reached the required strength. Stripping and re-shoring must be done only in the manner described and detailed in the engineer’s drawings.
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