

Formwork

Code of Practice 2016

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Foreword

This *Formwork Code of Practice 2016* is an approved code of practice under section 274 of the *Work Health and Safety Act 2011* (the WHS Act).

An approved code of practice is a practical guide to achieving the standards of health, safety and welfare required under the WHS Act and the *Work Health and Safety Regulation 2011* (the WHS Regulation).

From 1 July 2018, duty holders will be required to comply with either an approved code of practice under the WHS Act or follow another method, such as a technical or industry standard, if it provides an equivalent or higher standard of work health and safety to the standard required in the code.

A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the health and safety duties in the WHS Act, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks which may arise. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS Act and WHS Regulation. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

An inspector may refer to an approved code of practice when issuing an improvement or prohibition notice. This may include issuing an improvement notice for failure to comply with a code of practice where equivalent or higher standards of work health and safety have not been demonstrated.

Scope and application

This code provides practical guidance to persons conducting a business or undertaking on how to comply with their health and safety duties when carrying out construction work involving formwork including high risk construction work.

How is the code organised

In providing guidance, the word 'should' is used in this code to indicate a recommended course of action, while 'may' is used to indicate an optional course of action.

This code also includes various references to provisions of the WHS Act and WHS Regulation which set out the legal requirements. These references are not exhaustive. The words 'must', 'requires' or 'mandatory' indicate that a legal requirement exists and must be complied with.

1 Introduction

1.1 What is formwork?

Formwork is a temporary structure that supports part or the whole of a permanent structure until it is self-supporting. Individual components of formwork, for example frames, are plant. Once assembled the components form the temporary structure. Some formwork systems are designed to remain with the permanent structure.

Generally work carried out to design, construct, erect, alter, maintain, dismantle or remove formwork will be defined as construction work.

Formwork means the surface used to contain and shape wet concrete until it is self-supporting. This includes the forms on or within which the concrete is poured and the frames and bracing which provide stability. Although commonly referred to as part of the formwork assembly, the joists, bearers, bracing, foundations and footings are technically referred to as falsework.

For the purpose of this code, the term 'formwork' will be used to describe both formwork and falsework.

What is construction work?

WHS Regulation section 289: Construction work means any work carried out in connection with the construction, alteration, conversion, fitting-out, commissioning, renovation, repair, maintenance, refurbishment, demolition, decommissioning or dismantling of a structure.

Construction work includes:

- installation or testing carried out in connection with an activity referred to in the definition
- the removal from the workplace of any product or waste resulting from demolition
- the prefabrication or testing of elements at a place specifically established for the construction work, for use in construction work
- the assembly of prefabricated elements to form a structure, or the disassembly of prefabricated elements forming part of a structure
- the installation, testing or maintenance of an essential service for a structure
- work connected with an excavation
- work connected with any preparatory work or site preparation including landscaping as part of site preparation carried out in connection with an activity referred to in the definition above, and
- an activity referred to in the definition carried out on, under or near water including work on buoys and obstructions to navigation.

In addition, formwork may include construction work that is defined as high risk construction work in the WHS Regulation for which a safe work method statement (SWMS) must be prepared before the work starts (see section 3.3 for more information on SWMS requirements).

1.2 Who has health and safety duties in relation to formwork activities?

A person conducting a business or undertaking (PCBU) has the primary duty to ensure, so far as is reasonably practicable, workers and other people are not exposed to health and safety risks arising from the business or undertaking.

This duty requires the person to manage risks by eliminating health and safety risks so far as is reasonably practicable, and if it is not reasonably practicable to eliminate the risks, by minimising those risks so far as is reasonably practicable. It also includes ensuring, so far as is reasonably practicable the:

- design, provision and maintenance of safe formwork plant and structures
- safe erection, alteration, dismantling and use of formwork, and
- safe use, handling, storage and transport of formwork plant.

The WHS Regulation include specific duties for a person conducting a business or undertaking with management or control of a construction workplace, plant, powered mobile plant and plant that lifts or suspends loads.

Designers, manufacturers, suppliers and importers of plant or structures, including temporary structures, must ensure, so far as is reasonably practicable, the plant or structure is without risks to health and safety. This duty includes providing information to manufacturers so that plant can be manufactured and erected to the design specifications. Designers must give the person who commissioned the design of the temporary structure a written safety report.

People installing, constructing or commissioning plant or structures must ensure, so far as is reasonably practicable, all workplace activity relating to the plant or structure including its installation, use, decommissioning or dismantling is without risks to health or safety.

Officers, such as company directors, have a duty to exercise due diligence to ensure the business or undertaking complies with the WHS Act and WHS Regulation. This includes taking reasonable steps to ensure the business or undertaking has and uses appropriate resources and processes to eliminate or minimise risks from the formwork activity.

Workers and other people at the workplace must take reasonable care for their own health and safety, co-operate with reasonable policies, procedures and instructions and not adversely affect other people's health and safety.

1.3 What is involved in managing risks associated with formwork activities?

WHS Regulation section 297: A person conducting a business or undertaking must manage risks associated with carrying out construction work.

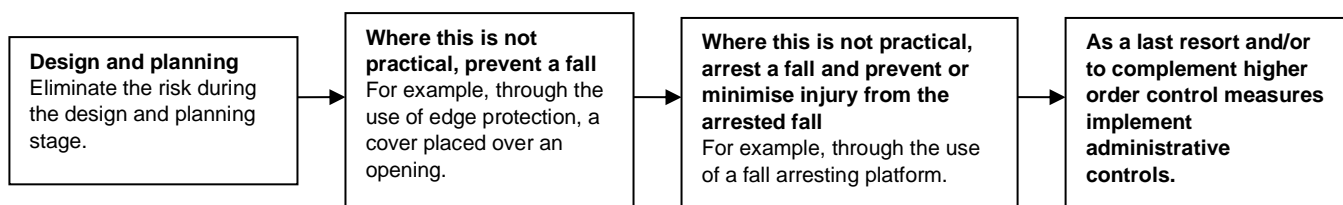
WHS Regulation section 34-38: To manage risk, a person conducting a business or undertaking must:

- identify reasonably foreseeable hazards that could give rise to risks to health and safety
- eliminate risks to health and safety so far as is reasonably practicable
- if it is not reasonably practicable to eliminate risks to health and safety—minimise those risks so far as is reasonably practicable by implementing risk control measures according to the hierarchy of control in WHS regulation 36
- ensure the control measure is, and is maintained so that it remains, effective, and
- review and as necessary revise control measures implemented to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety.

To properly manage risks, a person must:

- identify hazards – find out what caused the harm
- assess risks that may result because of the hazards – understand the nature of the harm that could be caused by the hazard, how serious the harm could be and the likelihood of it happening
- decide on control measures to prevent, or minimise the level of, the risks and implement control measures, and
- monitor and review the effectiveness of the measures.

Control measures to manage the risk of falls (see WHS Regulation sections 78 and 79) must be implemented in an order of priority and implemented before work commences. The following example illustrates the order of priority where there is a risk a person could fall.



Guidance on the general risk management process is in the *How to manage work health and safety risks Code of Practice*.

Hazards associated with work involving the erection, alteration and/or dismantling of formwork include:

- formwork collapse (before, during and after placement of concrete)
- falls from heights – see the *Managing the risk of falls at workplaces Code of Practice*.
- slips and trips
- falling objects
- noise – see the *Managing noise and preventing hearing loss at work Code of Practice*.
- dust
- manual tasks – see the *Hazardous manual tasks Code of Practice*.

Consulting workers

WHS Act section 47(1): The person conducting a business or undertaking must, so far as is reasonably practicable, consult with workers who carry out work for the business or undertaking who are, or are likely to be, directly affected by a matter relating to work health or safety.

WHS Act section 48(2): If the workers are represented by a health and safety representative, the consultation must involve that representative.

Consultation involves sharing of information, giving workers a reasonable opportunity to express views and taking those views into account before making decisions on health and safety matters.

Consultation with workers and their health and safety representatives is required at each step of the risk management process. In many cases decisions about construction work and projects are made before engaging workers so it may not always be possible to consult with workers in these early stages. However it is important to consult with workers as formwork activities progress. By drawing on the experience, knowledge and ideas of your workers you are more likely to identify hazards and choose effective control measures.

You should encourage your workers to report hazards and health and safety problems immediately so the risks can be managed before an incident occurs and you must consult your workers when proposing any changes to the work that may affect their health and safety.

Consulting, cooperating and coordinating activities with other duty holders

WHS Act section 46: If more than one person has a duty in relation to the same matter, each person with the duty must, so far as is reasonably practicable, consult, cooperate and coordinate activities with all other persons who have a duty in relation to the same matter.

Sometimes you may share responsibility for a health and safety matter with other business operators who are involved in the same activities or who share the same workplace. In these situations, you must exchange information to find out who is doing what and work together in a cooperative and coordinated way so that all risks are eliminated or minimised as far as reasonably practicable.

Further guidance on consultation is in the *Work health and safety consultation, co-operation and co-ordination Code of Practice*.

1.4 Information, training, instruction and supervision

WHS Act section 19(3)(f): A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking.

WHS Regulation section 39(2) and (3): A person conducting a business or undertaking must ensure that information, training and instruction provided to a worker is suitable and adequate having regard to:

- the nature of the work carried out by the worker

- the nature of the risks associated with the work at the time of the information, training and instruction, and
- the control measures implemented.

The person must ensure, so far as is reasonably practicable, that the information, training and instruction provided under this regulation is provided in a way that is readily understandable by any person to whom it is provided.

WHS Regulation section 317(1): A person conducting a business or undertaking must not direct or allow a worker to carry out construction work unless the worker has successfully completed general construction induction training and if the worker completed the training more than 2 years previously—the worker has carried out construction work in the preceding 2 years.

All persons who may be exposed to work health and safety risks resulting from formwork construction must be provided with information and training that is specific to the formwork system that is being used.

Such training and information should include details of:

- the formwork system, tasks, activities and components
- the way the manufacturer or designer of the formwork system intended the system to be erected, installed, used, moved, altered or dismantled
- specific training and information required to undertake or participate in specific tasks or activities
- control measures to minimise exposure to the risks, correct use of controls, and how to ensure they are kept in full working order
- safe working procedures, including the use of mechanical aids and devices, where appropriate
- how to use and maintain equipment, including any specific conditions and prohibitions on the use of equipment. Reference must be made to operator's manuals
- any special safety information needed such as safety precautions for working under certain conditions
- personal protective equipment required, including instruction in fitting, use, cleaning, maintaining and storing this equipment
- details of how accidents have occurred in the past involving the same work process(es).

Persons involved in formwork activities must also be provided with more general work health and safety information and training including:

- the effects of noise on their hearing and health
- Queensland's work health and safety legislation, including relevant parts of this code of practice
- the workplace's health and safety policies, and relevant procedures and safe work method statements
- the risk management process
- inspection and maintenance programs in place at the workplace
- how to access information such as manufacturer's instructions about hazards
- emergency procedures, including persons with specific emergency roles and responsibilities.

Training for persons involved in erection of modular formwork systems

Persons involved in the erection of modular formwork systems should be trained in the safe erection and dismantling of the system as well as inspection criteria for materials as an example, defects which would preclude the use of the materials. The modular system designer should provide written instructions on the erection and dismantling of the system and these instructions should at least provide equivalent levels of safety for a person as those detailed in this code. Training by representatives of the modular formwork system supplier is encouraged.

Training for persons working on jump forms, slip forms, self-climbing and crane lifted vertical formwork

In view of the specialised work systems and unique hazards that exist on jump forms and slip forms, specific training should be provided for persons intending to work on the forms.

Training should include, but not be limited to:

- The maximum loadings that can be applied to the various areas on the form. This would include information about areas where materials can be stored.
- Restricted access areas and procedures for installation and removal of edge protection.
- Climbing or jumping procedures for those involved in these operations.
- Emergency evacuation procedures for those required to work on the form.
- Firefighting procedures to be used in emergency situations prior to firefighting personnel arriving at the scene.
- Any other special work procedures that specifically apply to working on the form. As examples, time limits for working in cells where these apply or safe undertaking of manual tasks.

2 Design

Eliminating hazards at the design or planning stage is often easier and more cost effective to achieve than making changes later when hazards become real risks in the workplace. Safe design means the integration of control measures early in the design process to eliminate or, if this is not reasonable practicable, minimise risks to health and safety throughout the life of the structure being designed.

WHS Act section 22: A person (the designer) who conducts a business or undertaking that designs plant or a structure that is to be used, or could reasonably be expected to be used, as, or at, a workplace must ensure, so far as is reasonably practicable, that the plant or structure is designed to be without risks to the health and safety of persons who:

- use the plant or structure at a workplace for a purpose for which it was designed
- store the plant
- construct the structure
- carry out any reasonably foreseeable activity at a workplace in relation to the manufacture, assembly or use of the plant or structure for a purpose for which it was designed, or the proper storage, decommissioning, dismantling or disposal of the plant or structure, or
- are at or in the vicinity of a workplace and who are exposed to the plant or structure at the workplace or whose health or safety may be affected by one of the above uses or activities.

The designer must:

- carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary to ensure, so far as is reasonably practicable, that the plant or structure is designed to be without risks to the health and safety of persons
- give adequate information to each person who is provided with the design for the purpose of giving effect to it, and
- on request, so far as is reasonably practicable, give current relevant information to a person using the plant or structure for a purpose for which it was designed or when carrying out a reasonably foreseeable activity using the plant.

WHS Regulation section 294: A person who conducts a business or undertaking that commissions construction work (the client) in relation to a structure must, so far as is reasonably practicable, consult with the designer of the whole or any part of the structure about how to ensure that risks to health and safety arising from the design during construction are eliminated or minimised so far as is reasonably practicable.

Consultation must include giving the designer any information that the person who commissions the construction work has in relation to the hazards and risks at the workplace where the construction work is to be carried out.

Consultation should include the following:

- preparation of a project brief by the person commissioning the construction work that outlines the safety requirements and objectives for the project and provides the designer with all available site information that may affect health and safety (e.g. proximity to underground or overhead services — especially electric lines)

- the designer should ask the person commissioning the construction about safety issues such as the types of activities and tasks likely or intended to be carried out in the structure.

A safety report specifying the hazards relating to the design of a structure must be prepared by the designer for designs that have unusual or atypical features but not for common designs where the risks are already known. For example, a design specifying an unusual structure for a specific application may introduce unique hazards requiring specific risk controls. The written safety report should include information about:

- any hazardous materials or structural features and the designer's assessment of the risk of injury or illness to construction workers arising from those hazards,
- the action the designer has taken to control risks (e.g. changes to the design),
- how to use a component or component system safely,
- formwork methods
- the health and safety risk control measures to be used.

Where there is a principal contractor, the person conducting a business or undertaking who commissioned the construction must give a copy of the designer's safety report to the principal contractor.

Plant design registration

Structural components, including formwork frames, specifically intended to support formwork do not require design registration. However, if traditional prefabricated scaffolding is used as part of the supporting structure, these components require design registration. The person with management or control of design registrable plant must ensure the design registration number is kept where it is readily accessible. If you are hiring prefabricated scaffolding, the supplier must provide the design registration number, usually on the supply docket or agreement.

2.1 Safe design of buildings in relation to formwork

Safe design means the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risks to health and safety throughout the life of the structure being designed.

Safe design must be factored in during the design phase and should begin at the concept development phase of a structure when making decisions about:

- the design and its intended purpose
- possible methods of construction, maintenance, operation, demolition or dismantling and disposal;
- materials to be used
- what legislation, codes of practice and standards need to be considered and complied with.

2.1.1 Build-ability

Designers, including engineers and architects, must consider the 'build-ability' of a structure or building and produce a design that eliminates or minimises the risk of injury during construction.

The design of the final concrete structure can have a major effect on the ease of formwork construction, and consequently, on the safety of persons during construction. Generally, the more basic and simple the final concrete structure, the safer it is to erect.

Some of the measures that should be considered by the designer of the building or structure to minimise exposure to risk of injury during the construction of formwork include:

- Reducing variations in the floor depth so that it has one consistent depth.
- Reducing the number of columns required and where columns exist, design the columns so capitals or dropdowns don't exist.
- Reducing cantilevered floor sections.
- Consider alternative designs (e.g. prefabricated concrete elements-columns, beams and floor panels).
- Planning for manual tasks. Consideration must be given to the suitability of the design of different formwork systems that will reduce manual tasks risks, including:

- table forms
- systems with lighter weights of materials to be handled
- methods of formwork erection, alteration and dismantling
- improved access and egress for workers and movement of materials and equipment
- methods for moving large and heavy components, materials and equipment (i.e. making allowances for a crane and other mechanical lifting devices to be used).
- Planning for adequate access and sufficient workspace, for example designing cells that have adequate floor area and height to enable workers to carry out their work in a safe environment. Issues to consider include:
 - adequate ventilation
 - material access
 - allowance for access and egress systems,
 - adequate space to perform work safely.
- Allow sufficient clearance to adjacent structures and safe methods for moving large and heavy components, materials and equipment (i.e. making allowances for a crane and other mechanical lifting device to be used).

Further guidance on safe design is in the *Safe design of structures Code of Practice*.

Changing floor levels

Formwork decks are rarely flat across the entire floor, generally due to deep beams or 'drop downs' (sometimes called 'capitals') around columns. Uneven floors introduce fall hazards. It is preferable that these hazards be eliminated at the design stage. These hazards are most effectively managed by ensuring that formwork supports and the deck are progressively constructed for the lower parts of the deck before work commences on the higher-level areas of the deck.

As illustrated in Diagram 1, decks of a consistent depth may result in savings in concrete and steel but will result in additional labour and material costs. Decks of a varying depth introduce a greater quantity of cantilevered beams and joists, which contribute to the risk of a person falling.

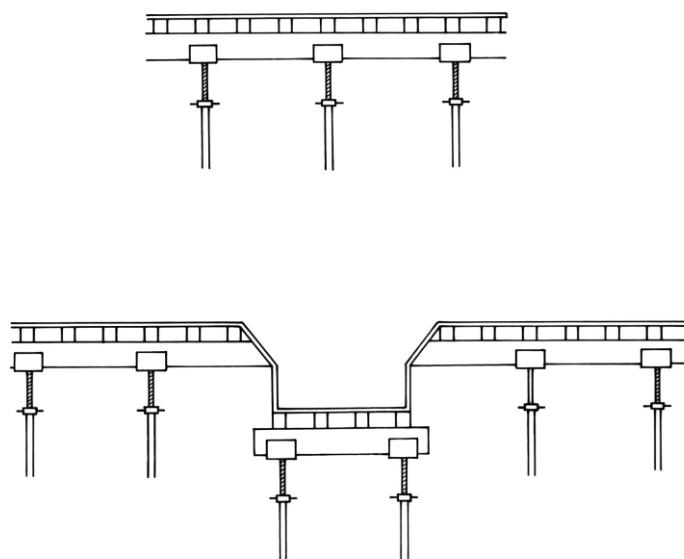


Diagram 1 - Flat floor and deep floor beams

2.1.2 Materials – traditional formwork

All materials and equipment used in formwork construction must be fit for the intended purpose and meet design specifications. Materials and equipment must be designed to conform to relevant Australian Standards. Where material is designed to an international or other standard, an engineer must certify that it conforms to the relevant Australian Standard. Materials and equipment must also be manufactured in accordance with a quality assurance system that ensures compliance with the design specification.

A suitable system must be implemented to ensure that only materials and components that comply with the specifications of the formwork design drawings and documentation are being used. Materials and components that are damaged, excessively worn or not fit for the intended use must not be used.

Evidence must be kept on site, which verifies that formply sheets conform to Australian Standards. Such evidence may include:

- a purchase order which details the specifications of the formply sheets ordered, or
- that the formply sheets be marked in accordance with Australian Standards (see *AS6669 Plywood – Formwork*).

For information regarding materials used in modular proprietary systems see section 2.2.2 – Modular proprietary system design.

Importers of material

Importers have a duty to ensure, so far as is reasonably practicable, plant (e.g. prefabricated formwork) is without risks to health and safety. This includes, eliminating or minimising risks to health and safety regarding the plant being supplied, where the manufacturer has not already done so.

Importers should confirm they are being provided with safe plant. For example, they must inspect and test the supplied plant and inspect or get third party verification of the manufacturing process. The level of inspection and testing done by an importer should be based on what is necessary to be confident that the product is safe.

When dealing with a new manufacturer or one whose products have been previously identified as non-compliant, the inspection and testing of the supplied plant may initially need to be more extensive.

Any imported plant must be inspected having regard to information provided by the manufacturer. If this information requires the plant to be tested then the importer must undertake this testing.

2.2 Formwork systems

The design of all formwork systems, both traditional and modular, must satisfy:

- *AS3610 - Formwork for concrete*
- *AS3600 - Concrete structures*.

2.2.1 Safe formwork design and certification

An 'engineer' (as defined in Appendix 1), such as a suitably qualified civil engineer experienced in structural design, is responsible for overseeing the safe design and certification of the complete formwork structure. This includes design of the formwork support structure, the formwork deck and connection details, and certification that the formwork drawings and other formwork documentation have been completed. Sample engineer's certification letters are provided at Appendix 2. The project engineer is responsible for providing project documentation (as detailed in section 2.2.3 of this code) to assist with the design of the formwork.

While this code requires that overseeing the safe design and certification of formwork systems may only be performed by an engineer, it is recognised that some design work may be performed by appropriate personnel such as a 'competent person' experienced in formwork design and documentation. Design documentation may only be prepared by a competent person in the circumstances listed in Table 1 if the competent person is using brochures, charts, tables and information which has previously been verified for compliance with *AS3610 - Formwork for concrete* by a suitably qualified engineer. 'Competent person' is defined in the dictionary at Appendix 1.

Formwork design and certification	
Vertical formwork (columns and walls)	
Less than 2.4m high	Competent person
2.4 to 3.5m high	Engineer
More than 3.5m high (single arrangement)	Engineer
More than 3.5m high (repetitive arrangement)	Engineer
Single-sided less than 2.4m	Competent person
Single-sided more than 2.4m	Engineer
Self-climbing or crane assisted formwork systems	Engineer
Soffit formwork	
Less than 3m high and less than 250mm thick	Competent person
More than 3m high or more than 250mm thick	Engineer
Infill slabs less than 4.5m high, 20m ² and 300mm thick	Competent person
Stair and landing formwork more than 3m high or more than 200mm thick	Engineer
Multistorey formwork and backpropping	Engineer

Note: the height specified in Table 1 is the height measured from the floor/ground immediately below.

When specifying the design of the formwork system, an engineer or competent person (as per Table 1) must allow for all loads that can be expected to be applied during construction, including loads applied by:

- the formwork deck, supporting members and formwork frames
- any false decks that may be provided
- concrete pouring techniques (i.e. kibble or pump)
- the concrete pour which includes both the weight of the concrete and dynamic factors applied. The concrete pour rate and pour sequence must be specified.
- workers on the formwork deck and false decks
- stacked materials
- crane lifted materials on both the complete and incomplete formwork deck
- wind to the system as detailed in *AS1170.2 Structural design actions - Wind actions*. An allowance for wind loading is particularly important for vertical forms.
- environmental loads including forces due to water flowing around the formwork. Rain and run off can have a detrimental effect if not considered by a designer.

Wind loading

An engineer must consider wind loadings on formwork, particularly for external walls, columns, free-standing shutters, blade walls and any platforms which may be subject to uplift.

Vertical elements must be fully braced prior to and during stripping, and until such time as the construction will provide adequate support and/or protection against wind loading.

Wind loading will vary depending on:

- the size of form
- the nature of the form
- wind speed
- wind resistance (e.g. screens)
- wind direction.

Shade cloth used on screens, signage and outside screens will increase the effective wind loading of an open structure.

The geographical location of the construction site will also have a bearing on the severity of wind on the structure. Wind generally has less effect in built up or hilly areas. *AS1170.2 Structural design actions - Wind actions* specifies four different terrain categories that must be taken into consideration by an engineer as well as basic wind speeds for different zones in Australia. There are three regions for Queensland:

- **Region A (normal)** – most of Queensland excluding coastal areas (includes Toowoomba and Mt Isa).
- **Region B (intermediate)** Queensland coastal areas south of Bundaberg and a narrow band behind region C (includes Brisbane and all of Gold Coast and Sunshine Coast).
- **Region C (tropical cyclones)** all coastal areas north of, and including, Bundaberg. Region C has the greatest wind speeds.

There are a number of other factors that need to be considered by an engineer when calculating wind pressure on wall and column forms and the resultant number of braces and size of anchorage point required. The number of braces for securing a column or wall form is not to be considered to be necessarily in direct proportion to wind speed. Wind pressure will vary as a function of the square of the wind speed. A small increase in wind speed produces a much larger increase in pressure and a much larger increase in the number of braces or size of brace anchors required.

2.2.2 Modular proprietary system design

A number of formwork support systems are designed as modular systems that are intended to be erected in specific configurations as prescribed by the designer and manufacturer. While modular systems require engineer design certification, this certification can be done once and used as evidence of design compliance provided:

- the design certification is carried out by an engineer
- the design certification is in the form of a signed compliance statement (in accordance with *AS3610 Formwork for concrete*)
- the compliance statement clearly identifies the modular formwork system and cross references the method in which the modular system must be erected.

The design certification can be provided as part of the brochure or erection instructions prepared by the manufacturer of the system.

The design certification only applies when the modular system is erected in accordance with the manufacturer's documented instructions. Specific engineering certification must be provided for the modular system if:

- there is any variation from the manufacturer's erection instructions
or
- the modular system is used in conjunction with a traditional formwork support system or any other type of modular system.

Timber used with modular proprietary systems may comply with the relevant standard where the system is manufactured provided:

- The standard is specifically for formwork applications
- The timber is designed and manufactured for outdoor use
- The timber is marked in accordance with the design standard
- The standard makes reference to a quality assurance standard that the timber is to comply with.

2.2.3 Documentation

Project documentation

Project documentation must include the following information:

- minimum stripping times and stripping procedures and requirements for health and safety
- any limitations on the magnitude and location of stacked materials and minimum strength of concrete to be achieved prior to materials being stacked
- requirements for the minimum number of levels of supports relative to the type of formwork, timing and sequence of its use, the anticipated time between construction of subsequent floors and the expected ambient temperature for multistorey structures
- limitations on the use of the permanent structure for the restraint of formwork
- details of and information on the effect of post-tensioning procedures on the formwork and any special procedures to be adopted in the stripping of formwork
- location of any mandatory joints and any special procedures for locating other joints

- sequence of placement of concrete
- requirements for propping of any composite construction
- details of the cambering of any slabs or beams
- design loads for the permanent structure
- details of any inserts, water stops, specially formed shapes or penetrations to be constructed, the location and details of which are critical to the serviceability of the permanent structure
- any known information about the foundation which is relevant to the design of the footings for the formwork assembly
- information about any permanent formwork systems, together with any limitations on deflections and any special requirements for their erection and concreting
- information on any architectural or structural component details to be cast into the structural concrete
- details of fall and edge protection, that is, perimeter scaffolding
- details of back propping that may be required and minimum time intervals between concrete pours.

Formwork drawings

Formwork drawings must explain:

- plans, elevations and sections to show the general arrangement of the formwork and to identify and locate all members and components including bracing
- wall and column form details
- the maximum point loadings to be applied
- the component types and spacings
- the maximum jack extensions
- the bearer and joist timber type, the dimensions and spacings
- the prop sizes and maximum extensions
- the methods for tying the structure together and spacing between ties (if required)
- the formply size.

Where eccentric loading is to be applied to U-heads (i.e. single bearers are positioned to one side of the U-head), the formwork drawings must state that this is permitted.

Other formwork documentation

The following information must also be provided in the formwork documentation:

- details sufficient to fully describe important or unusual features of the design
- reference to documentation for proprietary items
- safe work method statements for the erection and stripping of the formwork assembly
- the areas of the forms designed to carry stacked loads
- acceptance criteria for single use formwork
- requirements of the project documentation relating to formwork
- method of provision for field adjustment of the forms prior to and during concrete placement
- where required, location of weep holes, vibrator holes, clean-out holes and inspection openings
- sequence of concrete placement, including direction of intended pour on raking or sloping surfaces (e.g. car park ramps and minimum elapsed time between adjacent placements)
- wrecking strips and other details relating to stripping of the forms
- design assumptions, including those related to strength, stability and stiffness
- footing design assumptions, such as foundation material description, safe bearing value, limitations on settlement during erection of formwork, placement of concrete and dismantling of formwork. Reference to information sources such as geotechnical reports must also be included
- preparation of the foundation, such as filling, compaction and drainage
- footing details, such as type and size of footings, level of soffit, concrete strength, reinforcement, specification and details of site filling or compaction, and precautions against washouts
- engineer certification of non-proprietary equipment
- vertical pour rates, and
- methods of securing single or multiple props.

2.2.4 Design variations

All variations from the design of a formwork system must be checked by an engineer and:

- certified in writing by the engineer as being acceptable (that is, complying with *AS3610 Formwork for concrete*), if the engineer can verify this is the case
- altered in accordance with the written directions of an engineer in order to comply with AS3610, within a time frame specified by the engineer.

Potential variations include:

- structural design change (i.e. a thicker floor slab).
- a reduced number of formwork frames under the formwork deck
- different types of braces or props to the ones indicated on the formwork drawing
- different types and/or quantities of ties on the formwork structure
- increased spans on members supporting the formwork deck
- variations in the back-propping system specified by an engineer
- connections between traditional formwork and modular formwork.

2.2.5 On site coordination and verification

The following documentation must be available for inspection on site:

- Certification of maximum loads from stacked materials that the formwork assembly can withstand.
- Specifications for the concrete and when formwork can be removed.
- Back propping details (plans and elevations including tying in).
- Drawings for the formwork design. The drawings must be signed by an engineer or be accompanied by a certification letter that lists the drawing numbers and drawing revision numbers.

Verification of the structure with the design

Verification that the formwork structure complies with the design of the formwork system must be documented and provided. A construction check list (as illustrated at Appendix 3) can be used to assist in this process. Relying solely upon such a checklist will not be sufficient to verify compliance with relevant Australian Standards. The verification and documentation that a design has been complied with may be delegated to a 'competent person' (see Appendix 1) on site. Table 2 provides a list of circumstances where a competent person may perform an inspection.

Table 2 Circumstances where a competent person may perform an inspection

	Inspection	
	Access for trades	Pre-pour
Vertical formwork (columns and walls)		
Less than 2.4 m high	Competent person	Competent person
2.4 to 3.5 m high	Competent person	Competent person
More than 3.5 m high (single arrangement)	Competent person	Engineer
More than 3.5 m high (repetitive arrangement)	Initial pre-pour inspection by engineer on first arrangement only and then competent person thereafter	
Single-sided less than 2.4 m	Competent person	Competent person
Single-sided more than 2.4 m	Competent person	Engineer
Self-climbing or crane assisted formwork systems	Initial pre-pour inspection by engineer and then competent person thereafter	
Soffit formwork		
Less than 3m high and less than 250mm thick	Competent person	Competent person
More than 3m high or more than 250mm thick	Competent person	Engineer
Infill slabs more than 4.5m high, 20m ² and 300mm thick	Competent person	Engineer
Stair and landing formwork more than 3m high or more than 200mm thick	Initial pre-pour inspection by engineer and then competent person thereafter	
Multistorey formwork and backpropping	Competent person	Engineer

Note: the height specified in Table 2 is the height measured from the floor/ground immediately below.

A competent person, if not an engineer, must have appropriate training and knowledge to perform onsite inspections of the formwork system. This delegated person needs to be experienced in formwork construction and be competent in reading drawings and be able to certify that the formwork structure satisfies the details on the formwork drawings, specifications and any other formwork documentation.

Should the competent person on-site not be an engineer, the delegated person can only verify that the designer's specifications and drawings have been complied with. A competent person who is not an engineer must not authorise variations to the design. The delegated person may require corrections to the formwork system if some details do not pass as indicated on the construction checklist by providing written instructions on remedial action to be undertaken prior to the concrete pour.

If any items on the construction checklist are to be referred to an engineer, then the competent person must refer them to an engineer in writing. A competent person must ensure the remedial action has occurred prior to the concrete pour including any items referred to an engineer for certification and modified as instructed by an engineer.

A pre-pour inspection should focus on verifying that the design has been complied with and matters such as:

- correct spacing of frames, props and timbers
- correct joist and bearer sizes
- acceptable jack extensions
- quality of materials being used
- back propping
- adequate bracing to ensure stability.

An effective quality control system must be implemented for the construction of formwork. A pre-pour inspection is a check to assist in ensuring the specifications of the engineer have been complied with. A pre-pour inspection should be a part of any quality control system.

Sign-off by an engineer or competent person as specified in Table 2 is required following the final pre-pour inspection. A sample pre-pour structural certificate is provided at Appendix 4.

Appendix 5 illustrates some of the more common defects which are likely to occur in a formwork system. This list is intended to give guidance to a competent person and should not be considered to be exhaustive. In any individual case, some items will be less important than others and only a competent person with appropriate experience can assess their relative importance.

3 Coordination and administration

3.1 Work program

The risk to a person's health and safety must be considered when designing a work program for erecting, altering and/or dismantling formwork. Consideration must be given to:

- sequencing work to ensure sufficient time is allowed for each work activity
- coordinating trades to allow work to be completed free from obstruction
- allowing for the progressive clean-up of work areas to prevent rubbish becoming a trip hazard and allowing access for mechanical aids
- taking account of edge protection requirements and ensuring these are designed and constructed appropriately.

3.2 The work environment

WHS Regulation section 40: A person conducting a business or undertaking must ensure, so far as is reasonably practicable, that:

- the layout of the workplace allows, and is maintained to allow, persons to enter and exit the workplace and move within it safely, both under normal working conditions and in an emergency

- work areas have space for work to be carried out safely
- floors and other surfaces are designed, installed and maintained to allow work to be carried out safely
- lighting enables each worker to carry out work safely, persons to move around safely and safe evacuation in an emergency
- ventilation enables workers to carry out their work without risk to their health and safety
- workers exposed to extremes of heat or cold are able to carry out work without risk to their health and safety
- work in relation to or near essential services (such as gas, electricity, water, sewerage and telecommunications) do not affect the health and safety of persons at the workplace.

Formwork construction, because of its constantly changing work environment, restricted access through frames and formwork supports and a large volume of material and waste, requires ongoing monitoring of housekeeping practices.

3.2.1 Entry and exit

Clear access is important for the safe movement of materials, equipment and persons on site. Designated access ways must be provided. Persons must be instructed to use the access ways and keep them clear of any rubbish, plant or materials. In some situations, it may be necessary to use hazard taping or other visual methods to clearly show where access ways are located. This is particularly important where access is required through formwork frames.

Emergency access and egress must be considered and provided to all parts of the workplace where persons are required to work (refer to section 7.1 for slip form, jump form, self-climbing and crane lifted vertical access and egress requirements). Where the plant listed in column 1 of Table 3 is available onsite for emergencies, the corresponding mechanisms in column 2 should be provided as a dual emergency access and egress option. Two forms of emergency access and egress should be maintained at all times.

Table 3 Dual emergency access and egress solutions

	Emergency access and egress solutions required	Additional emergency access and egress solutions required
1	Man and material hoist	Stretcher stair and single scaffold stair
2	Crane only	Stretcher stair and single scaffold stair
3	Man and Material Hoist and crane	Stretcher stair and single scaffold stair
4	No crane or man and materials hoist	Two stretcher stairs are to be provided for emergency access

Further information regarding access and egress requirements is provided in section 4.5 (use stair tread systems and ladders).

3.2.2 Material storage

Materials must be stored so as to minimise manual tasks hazards, trip hazards and the potential for falling objects. Smaller components such as U-heads, couplers, base plates and 'Z-bars' should be contained in material boxes. Where practicable, frames and formply should be strapped until it is time to use them. Bearers and joists should also be strapped together in bundles or stacks. These bundles or stacks should be located back from the edge of the deck or openings to prevent materials or persons accessing the materials falling through or off the deck.

It is preferable to lay wall forms flat on the ground instead of leaning them against structures or other forms that are not purpose made "A" frames. Timbers, or another effective means, must be provided under the forms where slings are to be placed under the forms for crane lifting.

When not in use, wall forms may be stacked in or against purpose made "A" frames. This is preferable to leaning the forms against other structures. If this is not practical, wall forms must be

stacked in such a way that they cannot move away or rotate from the surface they are placed against. An engineer must verify in writing that a surface to be used for the stacking of forms is capable of withstanding the impact of all imposed loads, including wind loading. The engineer also needs to consider both maximum and point distributed loads on the formwork deck and record this information in the formwork drawings.

Incorrect materials delivery and storage can create significant manual tasks. Safe work practices to minimise exposure to these risks include:

- ensuring the formwork materials are delivered as close as possible to the job
- designing and designating a small section of the formwork as a loading platform to load ply and other components
- ensuring mechanical aids are used to handle loads wherever possible
- storing loads on trolleys to minimise double handling or on raised platforms to minimise manual lifting from ground level
- having adequate storage space or lay down area to safely store materials and equipment and to minimise double handling.

3.2.3 Rubbish storage and removal

Rubbish storage and removal for formwork may include the provision of rubbish skips and wheel barrows that are moved as work progresses. However, rubbish skips should only be positioned where the supporting structure has adequate strength to support the total weight of the bin and likely contents.

3.2.4 Lighting

Sufficient access lighting and task lighting must be provided, whether it is from a natural or artificial source, to allow safe movement around the workplace and to allow workers to perform their job without having to adopt awkward postures or strain their eyes to see. Additionally, emergency lighting must be provided for the safe evacuation of people in the event of an emergency.

AS/NZS1680.1: 2006 – *Interior workplace lighting* and the *Managing the work environment and facilities Code of Practice* provide guidance on the recommended illumination levels for various types of tasks, activities or interiors.

3.3 Safe work method statements

WHS Regulation section 299(1): A person conducting a business or undertaking that includes the carrying out of high risk construction work must, before high risk construction work commences, ensure that a safe work method statement for the proposed work is prepared or has already been prepared by another person.

A safe work method statement (SWMS) must be prepared for high risk construction work before the work starts.

A range of activities defined as high risk construction work may be carried out including work:

- involving a risk of a person falling more than 2 metres
- carried out on a telecommunication tower
- involving demolition of an element of a structure that is load-bearing or otherwise related to the physical integrity of the structure
- involving or likely to involve the disturbance of asbestos
- involving structural alterations or repairs that require temporary support to prevent collapse
- carried out in or near a confined space
- carried out in or near –
 - a shaft or trench with an excavated depth greater than 1.5 metres
 - or
 - a tunnel
- involving the use of explosives

- carried out on or near pressurised gas distribution mains or piping
- carried out on or near chemical, fuel or refrigerant lines
- carried out on or near energised electrical installations or services
- carried out in an area that may have a contaminated or flammable atmosphere
- involving tilt-up or precast concrete
- carried out on, in or adjacent to a road, railway, shipping lane or other traffic corridor that is in use by traffic other than pedestrians
- carried out at a workplace in which there is movement of powered mobile plant
- carried out in an area in which there are artificial extremes of temperature
- carried out in or near water or other liquid that involves a risk of drowning
- involving diving work.

The SWMS must:

- identify the type of high risk construction work being done
- specify the health and safety hazards and risks arising from the work
- describe how the risks will be controlled
- describe how the control measures will be implemented, monitored and reviewed.

A SWMS must be developed in consultation with workers and their representatives who are carrying out the high risk work.

4 Work systems

4.1 Formwork erection – traditional systems

Formwork must be erected systematically and tied in and/or braced progressively to stabilise the structure. Where a person is to install joists from underneath, the vertical distance between the formwork deck and the false deck can be increased. This is illustrated in Diagram 2 below.

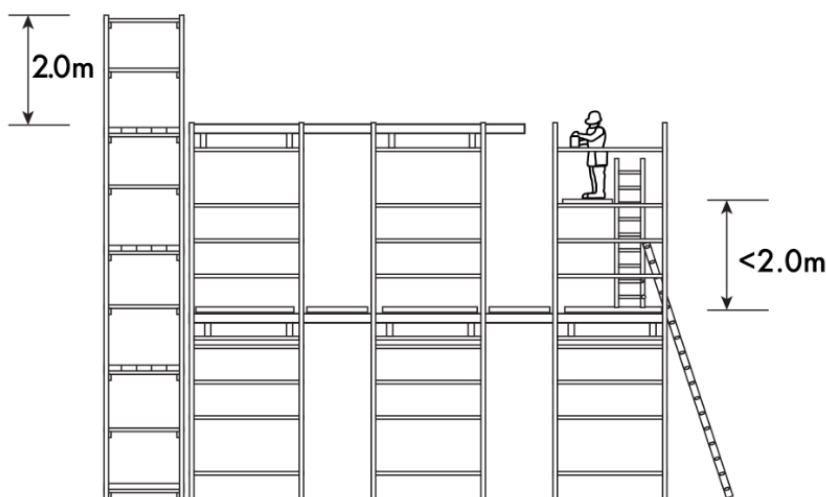


Diagram 2 - Worker erecting formwork on two planks

A person must be provided with a working platform of at least 450 mm wide (i.e. two planks). It is not acceptable for a person to stand on a single bearer or a single plank.

4.1.1 Foundations

Formwork must be erected on a stable base to prevent the risk of collapse. Suspended slabs must be able to safely support loads that may be applied by the concrete pour, workers and crane lifted loads.

Base plates must be provided under props and standards on formwork frames unless the prop or standard has an integral foot or an engineer documents that a base plate is unnecessary. Sole boards designed to suit the ground conditions should also be used under props and standards on natural ground, unless an engineer states otherwise. Frames and props must be located on a firm base,

which is ground that will not subside, fail or get washed away. The principal contractor is responsible for providing all information on ground conditions to the engineer.

4.1.2 False deck

In situations where a deck is at a height that would require persons to stand at heights of two metres or more to install bearers and joists for the formwork deck, a “false” deck, which is a full deck the same area as the area being formed, should be provided (see Diagram 3). This deck should be provided both inside and between formwork frames and can typically consist of formply, scaffold planks or modular platform sections. When erecting backpropping frame towers over two metres high, a full deck of planks is to be provided within the tower. A protected access opening can be left in the deck to enable materials to be lifted up. The use of a captive platform system is preferable to lapped planks because a captive system cannot be accidentally dislodged. Lapped planks may only be used if secured against uplift and slipping. The false deck must be constructed such that no gap exceeds 225mm width and gaps may only exist where a vertical member of a frame passes through the deck.

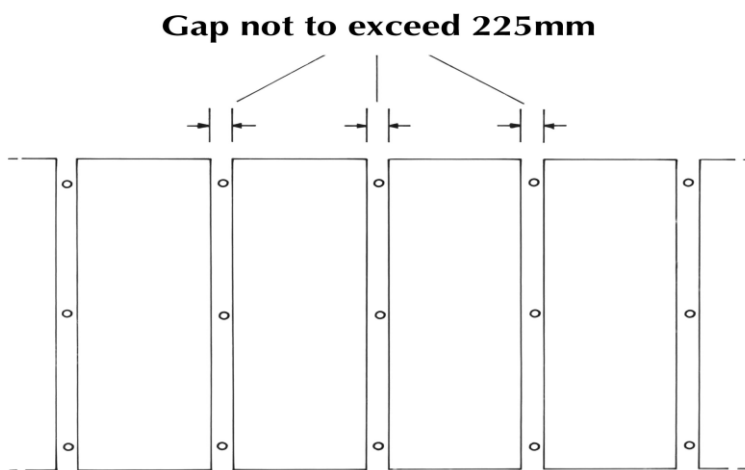


Diagram 3 – A false deck

The false deck must be designed and installed to have adequate strength to support persons required to stand on the deck and any materials or persons that could fall onto the deck or be placed on the deck. The deck must be able to withstand:

- a point load of 2kN distributed over an area of 100 x 100mm (2 kN is approximately equivalent to a mass of 200kg)
- a uniformly distributed load of 2kPa which is equivalent to a mass of 200kg per square metre.

When considering the design of the deck for the erecting, altering and/or dismantling of formwork the weight of the false deck, and live load should be applied to the formwork support structure.

The height between the false deck and the pouring deck must allow access for a person during stripping.

4.1.3 Erecting frames

WHS Regulation section 81: A person must not carry out high risk work, including scaffolding work, unless the person holds a high risk work licence for that class of high risk work. For example, a person must hold a scaffolder's licence if they are undertaking scaffolding work which involves erecting, altering or dismantling a temporary structure that is or has been erected to support a platform from which a person or thing may fall more than four metres.

Persons erecting formwork frames must be trained in their safe erection.

Formwork frames must be erected in a progressive manner to ensure both the installers safety and the stability of the overall structure. Braces must be attached to the frames as soon as practical.

The risk of a fall can exist on edges of formwork frames during their erection. In this situation, it is necessary to install edge protection on the frames as they are erected. Provided the side bracing (or other edge protection) is installed progressively and as soon as enough material has been raised up, additional control measures to prevent a fall occurring do not have to be provided. Many conventional formwork frames consist of diagonal braces that cross in the middle. While these braces are not considered to be suitable edge protection for a completed formwork deck, they may provide reasonable fall protection during frame erection. This is only the case where braces are installed in a progressive manner as soon as the braces are handed up to a person.

As the height of formwork frames increase, there is a greater need to provide lateral stability to the frames. All framing must be carried out so that it complies with on site design documentation and any manufacturers' requirements.

4.1.4 Installing bearers

Bearers must be placed in position so that persons are located no more than two metres from the floor or from the fall arresting platform located immediately below them. For example, the bearer can be lifted up onto the top of the formwork frame with a person standing on a platform erected no more than two metres from the floor or false deck located immediately below them within the frame.

Bearers must be positioned such that they will not fall off the top of the frames. The usual method of ensuring this is by placing the bearers in U-heads on top of the frames and by ensuring cantilevers are minimised. Where only single bearers are placed in the U-head, the bearer must be placed centrally in the U-head unless an engineer states otherwise. Where the top of the supporting member consists of a flat plate, the bearer must be nailed or otherwise effectively secured to the plate. Flat plates may only be used where specified by an engineer.

4.1.5 Fall protection from the formwork deck

WHS Regulation section 78(1) and (2): A person conducting a business or undertaking must manage risks to health and safety associated with a fall by a person from one level to another that is reasonably likely to cause injury to the person or any other person. This includes the risk of a fall:

- in or on an elevated workplace from which a person could fall
- in the vicinity of an opening through which a person could fall
- in the vicinity of an edge over which a person could fall on a surface through which a person could fall, or in any other place from which a person could fall.

WHS Regulation section 306C and 306D: A person conducting a business or undertaking who intends to do construction work where the risk of falling is at least two metres must, before work starts, use control measures to:

- prevent a person falling any distance, or
- if prevention is not practicable to arrest a person's fall to prevent or minimise the risk of death or injury.

A person conducting a business or undertaking who intends to do construction work where the risk of falling is at least two metres must, before work starts, use control measures to prevent a person falling any distance or arrest a person's fall.

During formwork construction the structure is constantly changing. Hence, continual modification of fall protection measures is also necessary. One of the biggest challenges is to provide adequate fall protection on the leading edge of the formwork deck. Where there is only one leading edge (i.e. the other edges are provided with two metre high edge protection), the provision of fall protection on the leading edge is relatively straightforward. However, where there are multiple leading edges and/or the deck is not at one consistent level the provision of fall protection can be very difficult to implement. Designers of buildings are therefore encouraged to design floor slabs that are one consistent thickness.

Control measures are required where a person could fall onto an object, such as frames, reinforcing steel or a rubbish skip.

Edge protection on the formwork deck

WHS Regulation section 306E: Edge protection must be designed to withstand the downwards or outwards force of the impact of a fall against it of any person who may reasonably be expected to fall against it to ensure that the person does not fall from the surface from which work is to be done.

Where the design of the formwork is complex, it may be impractical to provide edge protection on leading edges because the profile of the deck is constantly changing and construction of leading edge protection would create more hazards than it would control. For example, the persons installing the edge protection could be exposed to risk when installing the edge protection. However, in some situations it may be necessary to provide perimeter edge protection on edges of the formwork deck. Examples where edge protection must be installed are:

- There is a change in deck height along the side of the deck being constructed (i.e. a drop down for a beam) and no joists and/or formply has been provided at this different height.
- If a leading edge is to be left unattended and access onto the deck by persons other than form workers is required (i.e. the formwork deck has not been barricaded off and provided with “keep out” signs).

The most effective means of providing edge protection on a completed formwork deck is by providing perimeter scaffolding or proprietary screen systems. Edge protection is erected prior to the formwork and prevents workers falling off the completed deck. The main advantage of these systems is that persons are not required to install edge protection on the perimeter of the formwork deck and are therefore not exposed to a risk of falling. The other advantage is that edge protection for persons installing the final perimeter formply sheets is already in place.

Where scaffolding over four metres in height is provided, any erection, dismantling or alteration of the scaffolding must only be undertaken by licensed scaffolders. Any scaffolding components must be replaced following removal. Gaps between a completed floor and scaffolding, that may exist after the formwork support system is removed, must be covered where there is a risk of a person or materials falling through the gap.

In some situations, it may be impractical to provide perimeter scaffolding. If this is the case, the work system used to install perimeter edge protection on the deck must ensure that a control measure is provided to ensure against the risk of a fall. The use of harness systems is discouraged, because it does not provide an adequate and practical control for the risk of a fall from height.

In some situations edge protection can be substituted with an alternative control measure provided this measure prevents a person falling from the edge. One alternative is the provision of a barricade 1.8 metres back from the edge with clearly visible “keep out” signs.

Unsuitability of harness system for formwork activity

The use of:

- travel restraint harness systems to prevent a fall
or
- fall arrest harness systems to arrest a fall when erecting, altering and/or dismantling formwork are not recommended because:

Travel restraint harness systems

Travel restraint systems, as a means to prevent a person falling, are impractical for formwork because:

- The contour of the leading edge is constantly changing so that the length of the travel restraint line needs to be continually adjusted
- Multiple lanyard anchorage points may be required
- The greater the number of workers building the formwork deck, the greater the likelihood of lines becoming tangled.

Fall arrest systems

- When erecting, altering and/or dismantling formwork there will be inadequate free fall distance underneath the working area and a person will strike the ground, a frame or other obstruction prior to the fall being arrested.

- A falling person can require in excess of 6 metres free fall distance for the fall to be safely arrested by a harness system. In some situations this distance can be substantially reduced by the use of shorter lanyards and/or higher anchorage points.
- The erection of formwork frames using fall arrest harnesses requires the user to regularly connect and reconnect to anchorage points. This requires use of a double lanyard.

4.1.6 Laying formply on the deck

A formwork deck must be laid in a progressive way such that persons will be provided with a method of preventing them from falling below the deck. This control measure is particularly important in situations where a false deck has not been provided below the level of the deck to be laid.

Where a false deck has not been provided formply may only be spread on the joists provided where:

- Persons commence laying the formply sheets from the perimeter scaffolding or other edge protection that has been provided on the perimeter of the formwork.
- A minimum of four joists at 450mm centres (400mm gaps, totalling 1.8 metres) are located on bearers next to the person and in the other direction joists extend for at least 1.8 metres (see Diagram 4). Therefore, if a person falls they will fall onto the joists and should be prevented from falling further. (Note, in some situations, there may be a possibility of a person falling through the joists if the joists spread as the person's body makes contact. This is more likely to be a potential hazard when the person falls onto the joists such that the person's fall is in the same direction as the joists. Implementing controls to minimise sideways movement of joists will minimise this possibility).
- Persons lay the formply in front of their bodies so that if they stumble they are likely to fall on top of the sheets being laid.

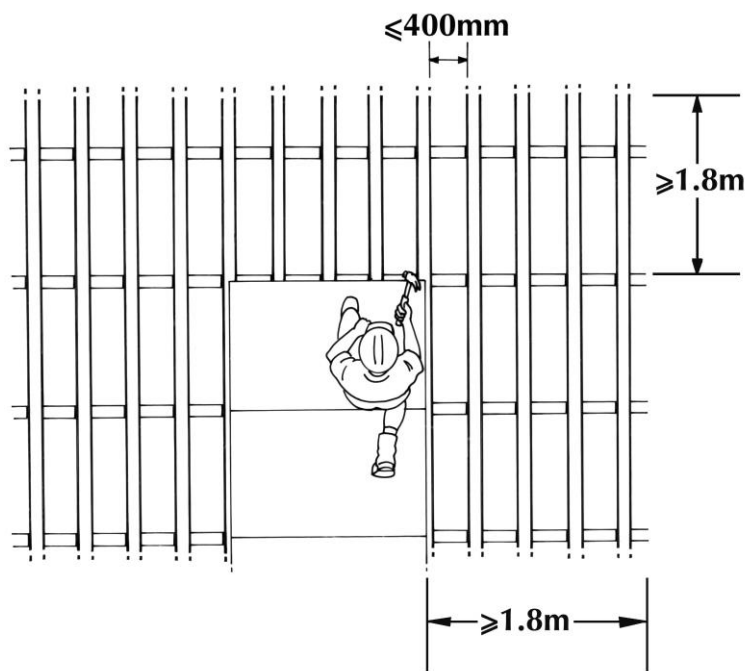


Diagram 4 – Maximum spacing of timbers around worker where false deck is over 2 metres below

Typical work system for a leading edge

The following work system may be used by persons to construct the formwork deck for typical or multi-level construction. The work system may be used irrespective of the distance to the false deck or floor below, but is specifically intended for situations where the vertical distance below the deck being constructed is greater than two metres.

- Place bearers on the U-heads of the formwork frames from the working platform provided immediately below. Secure bearers to prevent movement (i.e. by nailing to or wedging in the U-heads) before joists are placed on top. No eccentric (un-centred) loads should be applied to the U-heads.

- Place joists on the bearers in a progressive manner from the work platform located directly below the area to be worked on, and spaced at 450mm centres (maximum) or so that the gap between joists does not exceed 400mm.
- Cantilevered bearers and joists must be secured against uplift prior to persons being supported by them, if the cantilever distances exceed those specified in Table 4 (in section 4.1.7 of this code).
- Formply, or other deck material, must be laid out progressively. Wherever possible, the direction of the leading edge should be perpendicular to the joists (or parallel to the bearers).
- Formply should be placed on the joists with the installer located behind the sheet as it is positioned whilst standing on the previously laid sheet or provided work platform. In the event of a person tripping or stumbling they should fall on the sheet and not off the leading edge.
- Cover or protect all penetrations left behind the leading edge. Covers must be securely fixed and clearly signed to indicate they are protecting a penetration (see section 4.1.8).
- Nail or otherwise secure formply to the joists in accordance with the formwork design as soon as practical.
- Only persons involved in the construction of the formwork should be located in the formwork construction zone (see Diagram 7). Any person not involved in construction of the formwork deck and support structure should be excluded.
- The leading edge should be free of oil, sawdust and obstructions to reduce the likelihood of slips and trips, and fall prevention control measures should be provided for all leading edges, not just the direction formply is being laid.

4.1.7 Cantilevers

Cantilevered bearers, joists and ply sheets can be hazardous when left unsecured. The weight of a person standing on the cantilever may make the timber see-saw and cause the person or material to fall. When designing the formwork system the use of cantilevers should be kept to a minimum. However, in some situations the use of cantilevered sections is unavoidable. Where this is the case, an engineer must consider the potential for persons and stored materials to cause cantilevers to pivot. Wherever the weight of a person will cause a cantilever to pivot, the cantilever must be positively secured such that this will not occur.

Table 4 provides guidance on the maximum permissible cantilever length without securing the back of the cantilever. The information is based on a person's weight of 120kg and includes a factor of two to allow for live loading when a person steps on to the cantilever:

Table 4 - Maximum unsecured cantilevers for structural members

Member section size and material type	Total length of member	Maximum cantilever without securing
150 x 100mm oregon bearer	5m	420mm
150 x 100mm oregon bearer	4m	270mm
150 x 100mm oregon bearer	3m	150mm
150 x 77mm LVL (laminated veneer lumber) bearer	5m	330mm
150 x 77mm LVL (laminated veneer lumber) bearer	4m	220mm
150 x 77mm LVL (laminated veneer lumber) bearer	3m	120mm
100 x 75 mm oregon joist	6m	310mm
100 x 75mm oregon joist	5m	220mm
100 x 75mm oregon joist	4m	140mm
100 x 75mm oregon joist	3m	80mm

Where self-weight of timber is inadequate to ensure the stability of the cantilever, all cantilevers should be secured in accordance with the designer's instructions. This may include nailing or another effective method such as bolting. Nailing should be carried out such that the nail will not pull out of the timber or shear off. Where skew nailing is used a minimum of two nails should be used and the nail should meet the designer's specifications.

Wherever practical, it is preferable to secure cantilevers such that the nail or bolt is loaded in pure shear (i.e. no pull-out load). The use of purpose designed brackets should also be considered.

Materials should not be stacked or stored on a cantilever section unless written certification is provided by an engineer.

4.1.8 Penetrations

WHS Regulation section 306F: A fall protection cover used as a control measure must be able to withstand the impact of a fall onto it of any person who may reasonably be expected to fall onto it to ensure that the person does not fall and be securely fixed in place to prevent it being moved or removed accidentally.

Open penetrations, such as stairwells or penetrations to allow for services, create hazards for persons on the deck. A person may fall through a larger penetration, sustain injury by stepping into a smaller penetration or an object may fall through the opening onto persons below. Any penetration where there is a risk that a person or an object could fall through should be covered.

All penetrations on completed slabs should be provided with a cover mechanically fixed to the floor or otherwise effectively restrained so that it remains in position except for plumbing and inspection hole covers. Mechanical fixings for a penetration cover should be structurally adequate and require the use of a tool to be removed (e.g. an insert type anchor requiring a spanner or socket). Fixings must be placed an adequate distance from the cover edges to prevent the failure of the cover, its fixing or the supporting surface into which the fixings are placed (see Diagram 5).

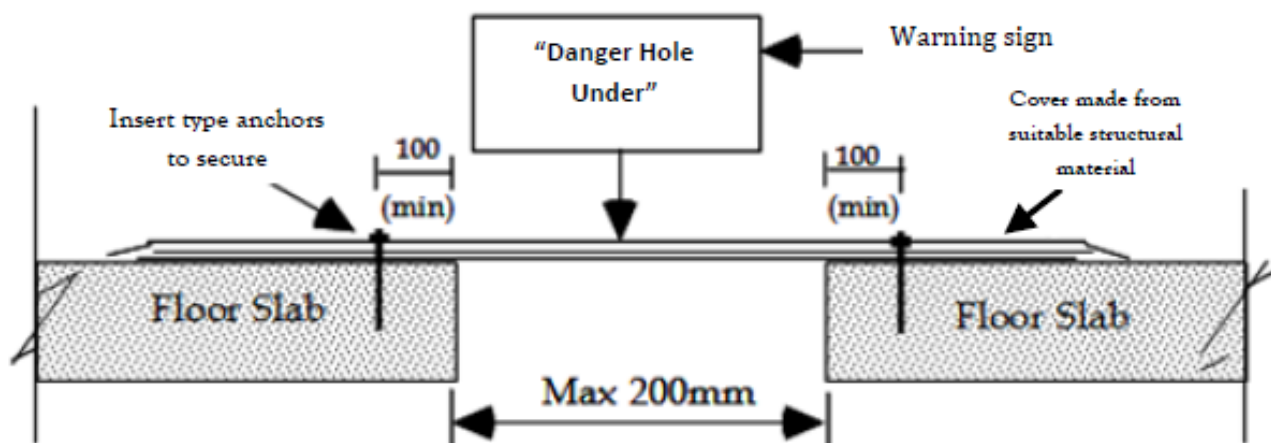


Diagram 5 – Example of a horizontal penetration cover

Open penetrations must be protected either with edge protection (e.g. handrails) or securely covered. Cast-in metal mesh should be used for small diameter penetrations. Vertical penetrations (e.g. lift doors) must be fully enclosed with mesh as a minimum standard. The mesh should have a small aperture (e.g. 50 x 50mm mesh size or smaller), and be made of material capable of withstanding the potential imposed load. Mesh provided over larger penetrations may require engineering certification to ensure it can withstand potential loads, including those applied by people, equipment and material (see Diagram 6).

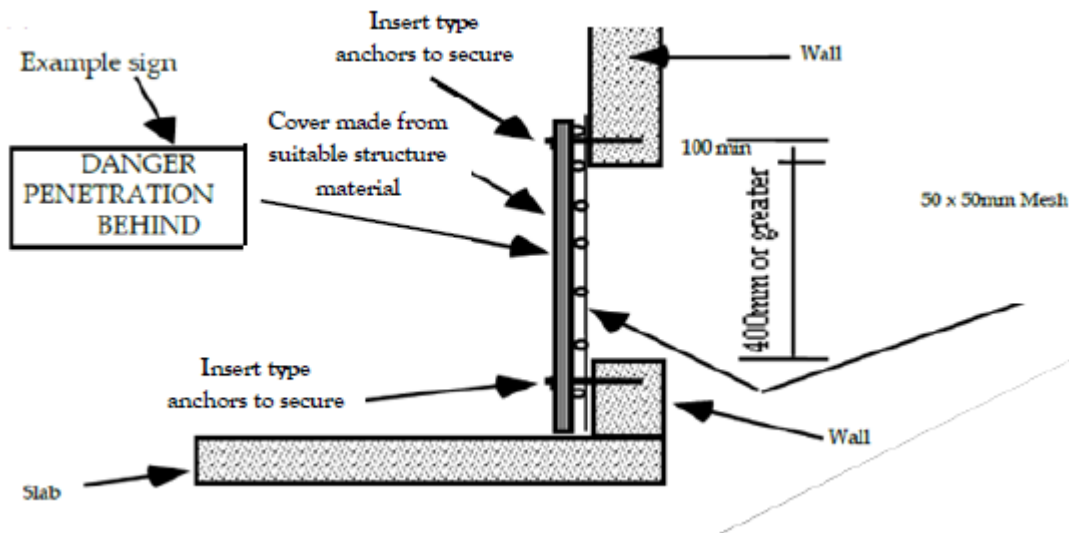


Diagram 6 – Example vertical penetration cover

Where holes are cut in the mesh for services to pass through, the hole should be cut to the profile of the service so that mesh remains in the penetration.

Ply covers on their own are not to be preferred because:

- the cover may be indistinguishable from other pieces of ply
- it may be difficult to determine if the ply is properly secured
- secured ply covers can be unsecured to gain access and not re-secured.

Where ply covers are used, they are to be a single piece of ply without multiple pieces and joins and the edge of the penetration should be bevelled to minimise any trip hazard. The ply cover should also be designed to safely withstand a point load of at least 2 kilonewtons (i.e. 200 kilograms). This is the same point load as required for heavy duty scaffolding – see *AS/NZS1576.1:2010 Scaffolding Part 1: General requirements* for further details.

Where a ply cover is used in addition to cast-in mesh, it acts as a back-up system. Ply covers should be painted in a bright colour and be marked with the words “Danger Hole Under” or words to that effect. The cover should be firmly secured to the concrete and be designed for potential loads that may be applied.

Before stripping formwork, ensure the penetration that will be exposed as the formwork is stripped is covered and or protected prior to the commencement of the stripping operation.

Penetrations are also hazardous before the deck is laid. Joists placed up to the edge of the penetration should be secured so that the timbers cannot spread if a person falls on them.

4.1.9 Working areas for steel fixers and others

Steel fixers, plumbers and electricians, often follow closely behind the formwork erection. Consultation between formworkers, the person conducting a business or undertaking and other trades should be undertaken to ensure a suitable hand over of completed elements of the formwork deck is provided. Following consultation, and access to the deck by required installers for water and power, trades that will be working on the deck and a delegated ‘competent person’ on site should signoff that the following has been completed:

- penetrations are covered
- handrails are installed
- water and power are installed
- there is a stair tread system provided for safe access and egress to the working deck.

The formwork zone must be sufficiently large to ensure that these other persons are clearly separated from formworkers. A ‘formwork only’ zone should be maintained behind the leading edge. This zone should be clearly demarcated by signage and flagging. Diagram 5 illustrates the ‘other work’ zone, the formwork zone and the area retained as edge protection (four joists spaced 1800mm beyond the laid deck).

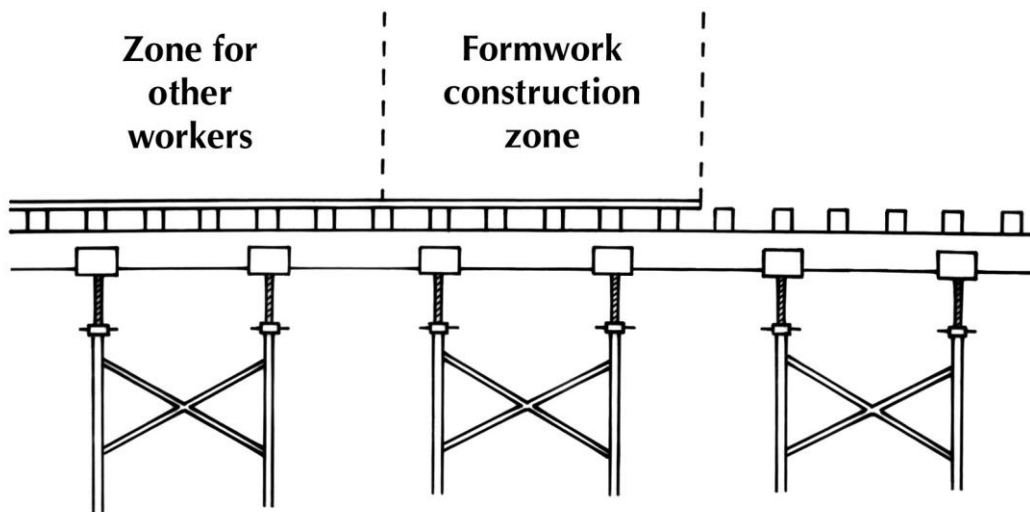


Diagram 7 – End view of deck showing working zones

4.2 Formwork erection – modular formwork systems

The basic principles discussed in section 4.1 on traditional systems should be applied to the erection of modular formwork systems. Although the erection technique and member dimensions may vary greatly between traditional systems and modular systems, the principles of maximum potential fall distance and gap width at the working level should be applied. The width of any gap on a working level is not to exceed 400mm unless a false deck has been provided within two metres of the working level. Working platforms used for modular systems should also have a minimum width of 450mm.

Modular and traditional formwork systems should be designed to comply with the loadings and general principles of *AS3610: Formwork for Concrete*.

Traditional formwork systems are sometimes used next to and connected to modular systems, particularly around unusually shaped areas. Where this is the case, the formwork drawings should show this and should be certified by an engineer. However, components from other types of formwork systems should not be used as an integral part of the modular formwork system unless the designer of the modular system states in writing that this is permitted.

Modular formwork systems are often lighter weight and require less physical effort than traditional systems because they are often constructed from aluminium instead of steel and they eliminate the need for tasks such as repetitive hammering. This reduces a person's exposure to the risk of injury resulting from undertaking manual tasks. However, because of their lighter weight, modular systems may be more susceptible to falling over during the erection of the system, due to factors such as wind loading. This will generally only be an issue prior to placement of the deck on the modular system. To effectively control this issue the formwork system should be progressively braced in accordance with the suppliers instructions during its erection.

4.3 Stripping formwork

Stripping formwork can be one of the most hazardous phases of concrete construction. While falling objects are the primary hazard, there may also be fall hazards as a result of floor collapse and manual tasks hazards from a person working in awkward postures, repetitive handling of materials and limited task variety. As with formwork erection, the stripping operation must be carried out in an orderly, progressive manner.

4.3.1 Safe work method statement

A safe work method statement (SWMS) for the stripping operation should be prepared and provided to those who will be involved in this high risk activity. The SWMS should:

- identify the work that is high risk construction work
- state hazards relating to the high risk construction work and risks to health and safety associated with those hazards
- describe the measures to be implemented to control the risks
- describe how the control measures are to be implemented, monitored and reviewed; and include:
 - The number of persons in the stripping crew.
 - The sequence of stripping activities – this would need to detail how the frames and/or other supports should be removed (that is, how far U-heads are to be lowered).
 - Whether the support system is to be completely removed in a zone prior to removal of the formwork deck or whether the supports are to be lowered slightly but still remain under the formply while it is being removed.
 - When back-propping is required or only part of the support system is to be removed, how the structural members are to remain in place and/or the type and layout of members that will replace the formwork system.
 - Any other special requirements involved in the stripping and or building process (e.g. checking of back-propping after post-tensioning).

4.3.2 Certification prior to stripping

Prior to commencement of the stripping operation, a competent person, from the principal contractor (i.e. the project engineer), is to provide written certification that formwork can be removed. This certification should be based on an engineer's specifications for the building, the strength of the concrete mix and the time period that has elapsed since the pour. An engineer will also be required to have input into the stripping safe work method statement to ensure the concrete element will not fail and must have provided details on the structural engineering drawings as required by *AS3600 - Concrete structures*.

Documentation from the concrete supplier verifying the concrete specification should be available on request. A concrete sampling and testing procedure should be in place to verify concrete meets its design specification. Guidance on sampling and testing systems for concrete is provided in *AS1379 - Specification and supply of concrete*.

It is important to note that the compressive strength of laboratory cured test specimens may differ from the actual compressive strength due to factors such as temperature and humidity on site, poor curing techniques and the addition of water to the mix. Some builders may therefore choose to have test samples on site to give an indication of the variation between 'on site' tests and laboratory tests.

4.3.3 Exclusion zone

Only persons involved in the stripping operation should be permitted in the area to be stripped. Stripping areas should be cordoned off and signs should be displayed. The signs should require persons to keep out of the area (e.g. "Danger - Formwork stripping in progress – authorised persons only"). It is preferable to restrict access to the whole floor where soffit stripping is taking place and this should reduce the quantity of signage and barricades required. Where other trades are required to work on the same floor during stripping of walls, columns or small sections of soffit, the principal contractor or PCBU should ensure that stringent controls are applied that prevent other persons from entering the stripping area.

4.3.4 Drop stripping

'Drop stripping' is a term sometimes used to describe the method used when all of the formwork support system is removed and the formply is allowed to drop to the floor either by its own weight or by persons levering it off. In general, this method of stripping should not be used to strip formwork. It can be hazardous because the formply is likely to fall in an uncontrolled manner and can strike persons underneath.

However, in some situations, sheets can be dropped to the floor provided the following is ensured:

- The formwork support system (e.g. props or frame) is only removed from under the sheet to be dropped. Once the sheet is dropped the process progressively continues until all sheets are dropped.
- The person levering off the sheet is not at risk of being struck when the sheet falls to the floor, keeping in mind that sheets may fall at an angle due to their large surface area and effect of the air – for example, the person does not stand directly under the sheet but stands far enough away and uses a pinch-bar to lever the sheet off. It should be noted that this method can only be used on relatively low ceiling heights unless the person can be positioned on a working platform or elevating work platform. The advantage of using a platform is that the person will generally be able to get closer to the sheet to be removed without being at risk.
- The formwork system and sheets are not left in a haphazard manner on the floor but are placed in stacks and progressively removed from the floor area.

Formwork removal must be carried out in a systematic manner, such that the deck is progressively removed as the support system is gradually removed. One way to remove the formply is by partially lowering the support system and then dropping the segment of the deck (sheet) onto the support system. This is preferable from a manual tasks perspective also as it eliminates the need to lift sheets of ply from ground level.

4.4 Crane and load handling systems

4.4.1 Loading materials during formwork construction

Materials, including stacks of ply, forms, bearers and joists, are sometimes lifted onto a deck during formwork erection, and before the deck is signed over. Stacked materials create point loadings which the formwork structure may not be designed to bear. Materials should be stored only where and when the deck is able to bear the load.

Formwork is not suitable for any loading until it is fully secured, that is, the deck is in place with tie-ins and back-propping complete. In practice, some loading often occurs before the deck is completed, for example, unloading packs of ply and joists used to continue the deck.

To minimise the risk of collapse and other hazards:

- Formwork drawings should clearly identify the maximum (pre-pour) point loadings for the deck.
- Point loadings should not exceed the maximum weight specified by an engineer.
- Crane crews should be notified when an area of deck is ready to take a load, and where that load should be placed.
- Crane crews should not lift materials onto the deck until there is a designated lifting zone.
- Loads should only be placed in the area(s) designated as safe.
- Loads must not be placed on the formwork deck if the formwork documentation prohibits loadings.
- Delivery of materials to the site should be planned so that loads are not lifted onto unsecured decks.
- Prior to persons leaving the site, materials and equipment should be secured to prevent them being moved by wind.

4.4.2 Access for persons slinging loads

Safe access must be provided for persons slinging and un-slinging loads.

A dogger or other person working at two metres or more above the deck must be provided with adequate fall protection, unless the person is performing 'permitted work'.

Use of fall arrest systems for persons slinging formwork loads is usually impractical and is not recommended.

It may be more practical to fit platforms and edge protection to lift forms to protect persons when slinging the loads. The platforms must be at least 450mm wide. Persons required to access the

platforms from ladders should have a safe means of access provided between the ladder and platform. They should not climb over the top of the edge protection.

4.4.3 Lifting gear

Guidance on the use and inspection of chains, wire ropes and synthetic slings is provided in the following publications:

- *AS2759 – Steel wire rope - Use, operation and maintenance.*
- *AS3775.2 – Chain slings for lifting purposes – Grade T – Care and use.*
- *AS4497 – Roundslings – Synthetic fibre.*
- *AS1353.2 – Flat synthetic-webbing slings – Care and use.*

Non-positive lifting gear such as plate clamps and suction devices are not to be used.

Basic items that should be checked include:

- The lifting gear is tagged and all relevant information listed (e.g. relevant information for a chain sling is grade of chain, safe working load, manufacturer, chain size and Australian Standard marking).
- Lifting hooks are provided with operable safety latches.
- Shackles are prevented from unscrewing (e.g. mousing or similar).
- Lifting eyes and inserts are compatible and the same proprietary brand.
- Lifting slings are not damaged (e.g. excessive wear, damaged strands, cracks, deformation and/or severe corrosion).
- The sling is appropriate for loads being lifted, including adequate capacity and protection from sharp edges.

All lifting gear, including slings, hooks and material boxes, should be periodically inspected for damage and wear. The period between inspections shall depend on the severity of use. In the case of chain lifting slings and material boxes, a formal documented inspection should be completed at intervals not exceeding 12 months. Documented maintenance records for the lifting gear should be available on site.

4.4.4 Lifting formwork materials

Crane-lifted loads should be slung and secured so that the load (or any part of it) cannot fall, as follows:

- Tare mass of wall, lift or column forms should be provided on site with formwork documentation and made available for inspection by all interested parties.
- Safe working load mass should be clearly marked on bins.
- Lifting boxes should be appropriate for the material being lifted, and be engineer-designed and certified.
- Four chains (one in each corner) should be fitted to lift boxes.
- Specifically-designed lifting boxes should be used to lift smaller components (e.g. spigots, U-heads, base plates and couplers). Boxes should have enclosed sides or robust mesh (with openings less than the minimum size of materials being lifted).
- Lifting boxes should be inspected and maintained, and inspection records kept.
- Loads within lifting boxes should be secured against movement.
- Materials should not be stacked higher than the side of the box unless they are adequately secured, but at no time should the box become top heavy.
- Formwork frames should either be strapped together or lifting slings should be wrapped around the load.
- Loads of joists or bearers should be strapped together before lifting.
- Use tag lines as required to control loads and well as forms.
- Formply loads should be strapped together and lifted in a flat position.
- Ensure where possible all loads are supported with dunnage and the load is uniformly distributed over the supporting surface.

4.4.5 Lifting lugs

Slings attached to lugs or holes cut into part of the load are often used to lift bins, and wall, lift or column forms (instead of wrapping the lifting slings around the load). Information verifying the structural adequacy of the lifting points should be available.

The certification should be provided by an engineer who should verify the:

- structural adequacy of the lifting lug
- means of attachment to the load (usually welded or bolted to the load).

4.5 Use of stair tread systems and ladders

Stair tread systems are to be used as the primary form of access and egress to and from a formwork zone unless it is not reasonably practicable to do so. Examples where it may not be reasonably practicable to use a stair tread system include:

- accessing column boxes up to 3.5 metres high (e.g. a platform ladder may be used for the purpose of tightening z bars, securing props, plumbing & checking inside box)
- accessing wall shutters to 3.5 metres high (e.g. a platform ladder may be used for the purpose of installing rebates and penetrations to the shutter, locating z bars, splicing timbers on shutters, securing props, plumbing and checking inside box)
- conventional core walls up to 3.5 metres (e.g. straight ladders may be used inside shafts for access, locating z bars, splicing shutters and working corners and tread scaffold stairs may be used for accessing pouring platforms at the top of cores)
- trenches/pits where a stair tread system would not fit within the space (e.g. a straight ladder may be used)
- core systems (e.g. a straight ladder can be used for access and working inside boxes and cells and tread stairs up to one metre wide can be used to access the system externally from the top of the system to the working soffit/slab below)
- safety screens (e.g. a straight ladder can be used to go platform to platform within screens and tread stairs up to one metre wide can be used when accessing floor to floor with a stairway on the outside or incorporated into the screens)
- drop panels/isolated beam to 4.5 metres high (e.g. formworkers could use a straight ladder for access). Where workers other than formworkers need access to drop panels/isolated beams there will need to be a stair tread system
- soffits (e.g. access to decks should be by tread stairs up to one metre wide or stretcher stairs one metre to 1.8 metre wide)
- high scaffolding support system (e.g. depending on the scaffold layout, access in scaffold should be by ladders for scaffolders and narrow tread stairs for formworkers getting up under the deck)
- initial entry to wall systems (e.g. may use a plywood stair tread system).

Adequate edge protection must be provided on the stair tread system and the area it provides access to in accordance with section 306E of the *Work Health and Safety Regulation 2011* and *AS/NZS 1576.1:2010 Scaffolding Part:1 General Requirements*.

Temporary timber or plywood framed steps, stairs, treads or ramps may be fabricated by competent tradespersons to gain access to vertical formwork systems and from scaffold platforms onto adjacent formwork decks. The maximum height of a timber stair, steps or ramp should not exceed 1.5 metres. The finished walking surface of the temporary timber or plywood framed steps/stairs/ramp is to be slip resistant and provide grip for inclined surfaces. Temporary stair and step fabrication information is available from *AS/NZS 1576.1:2010 Scaffolding Part:1 General Requirements*.

Stair tread systems are not required for isolated areas that are not integral to the main slab (i.e. drop panels and fire corridors).

Where single or extension ladders are used they must be secured, either:

- at the top to prevent it moving (e.g. tying the top of the ladder to a plate fixed to the top of a wall frame or clamping the top of the ladder to structural steel);
or

- at or near the bottom to prevent it moving.

Other issues regarding the safe use of ladders include:

- At no time is material to be carried while using a ladder – three points of contact must be adhered to.
- A person's feet should not be higher than 900mm from the top of the ladder, and when using a platform ladder, a worker's feet should not be more than two metres above the base of the ladder.
- Ladders should be set up on a firm, level surface. They should not be used on scaffolding or elevated work platforms to gain extra height.
- Ladders should not be handled or used if they may come into contact with electrical power lines. Metal or metal-reinforced ladders should not be used in the vicinity of live electrical equipment (timber ladders often have metal running along their length).
- Ladders must not be positioned above or adjacent to openings or edges where a potential fall could occur. Work platforms with edge protection should be provided in this instance.

Ladders can only be used if equipment can be operated with one hand. Activities requiring use of both hands must not be performed while standing on a ladder, for example:

- removing tie bar from wall and column forms during form stripping – this usually requires both hands and/or the use of a 'tie-bar puller'
- carrying timbers, formply, props or frames
- using power tools, such as circular saws.

Ladders used for access must extend at least one metre above the accessed surface. Ladders should not be used in access ways or where there is pedestrian traffic, vehicles or mobile plant.

AS1657 – (fixed platforms, walkways, stairways and ladders-design, construction and installation) must be complied with where fixed or permanent ladders are provided.

5 Falling objects

WHS Regulation section 54: A person conducting a business or undertaking at a workplace must manage risks to health and safety associated with an object falling on a person if the falling object is reasonably likely to injure the person.

WHS Regulation section 315H: A principal contractor must ensure that, before construction work starts, the adjoining area is closed under section 315M to the extent necessary to prevent objects falling, and perimeter containment screening complying with section 315I is erected along each part of the structure from which an object could fall.

Falling objects are significant hazards, creating risks to workers and others during formwork erection, alteration and stripping, when slipping and jumping forms, and whenever loads are lifted over work areas.

PCBUs have a duty to workers and other persons who could be injured or killed by any falling object during formwork activities.

The control measures that are implemented should firstly aim to prevent objects from falling, but equally prevent injury if an object has fallen. Small objects, such as bolts and concrete aggregate, falling from a height can cause serious injury.

5.1 Preventing objects from falling

Controls should be applied at the source to prevent objects from falling, that is, eliminate the risk. This is the most effective control to prevent injury or death caused by falling objects.

Good housekeeping practices are the most effective way of preventing small objects from falling. Ensure items are cleaned up and kept away from edges, voids and penetrations.

One control measure to prevent objects from falling is the use of perimeter containment screens. This Code recommends that perimeter containment screening be provided as a control measure for falling objects with equal regard for a person's safety and protection on site as well as for the protection of the public in adjoining areas.

5.1.1 Perimeter containment screening

WHS Regulation section 315I: If the perimeter containment screening is used to redirect a falling object onto a catch platform, each screen must be fitted vertically to the top of, or flush with, the outer edge of the catch platform to redirect a falling object that may reasonably be expected to hit the perimeter containment screening, onto the catch platform.

If the perimeter containment screening is not used to redirect a falling object onto a catch platform, each screen must be designed to prevent an object, that may reasonably be expected to hit the perimeter containment screening, from falling on persons from the level at which the work is to be done.

Each screen must be made of mesh or of timber, plywood or metal sheeting.

Each of the following gaps must be not over 25 mm:

- the gap, measured horizontally, between screens immediately beside each other or a screen and the framework supporting it;
- the gap, measured vertically, between a screen and another screen immediately above it or a screen and the framework supporting it.

The framework supporting a screen must be able to bear the load of the screen.

Containment sheeting is a protective structure fixed to the perimeter of a building, structure or working platform to prevent objects and people from falling. Containment sheeting should be used around the perimeter of a building or structure during construction, and especially during formwork erection or stripping. It is usually sheeted with: timber, plywood, metal or synthetic mesh or sheets.

Containment sheeting may be supported by the building, structure, or specially designed scaffolding. It must extend at least one metre above the working surface. When formwork is being erected or dismantled in the immediate vicinity of the screening, the screening should be captive to the building and extend at least 1 metre above the top of the completed floor slab. Examples of perimeter edge protection for falling objects include:

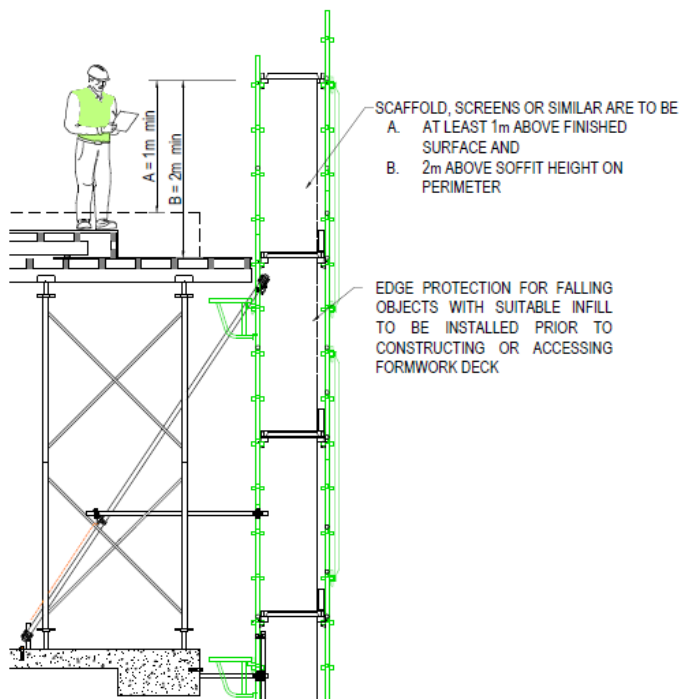


Diagram 8 - Typical single or multi-story construction

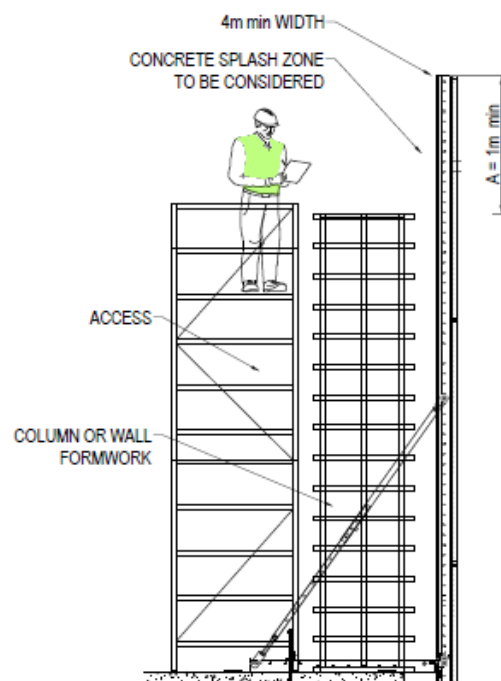


Diagram 9 - Typical single or multi-story construction

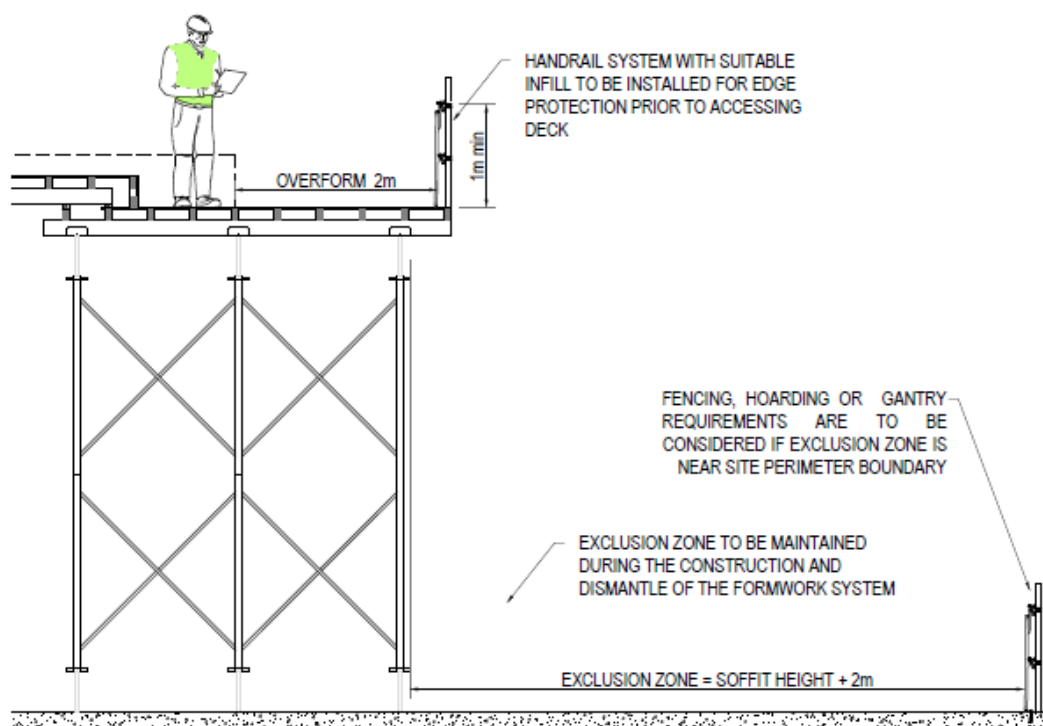


Diagram 10 - Typical single level construction

When selecting containment sheeting consideration must be given to:

- ability to support or contain imposed loads including building materials, equipment and waste materials
- ability to contain ejected objects
- pattern and frequency of fixing points
- degree of protection required from rain or washing down operations
- chemical reactivity

- flammability
- light transmission requirements (refer AS1680 for guidance)
- ventilation requirements (refer AS1668.2 for guidance)
- frequency of inspection
- wind loads on the supporting structure
- gaps created by a fixing method
- the ability for the containment sheeting to move within the supporting structure.

Perimeter containment screens used for formwork must be placed in position prior to formwork erection commencing and are not to be removed until all stripping is completed and all formwork materials are removed from the underside of the concrete as formed and/or removed from or stacked on the floor.

5.2 Building step-ins

Perimeter containment screens must extend above the formwork erection area so that materials cannot fall to the ground or other area where persons may be. Where the horizontal surface under construction steps in from the building perimeter, such as in the case of a plant room on a building roof, the perimeter screens must be erected to a height that will prevent any materials falling to the ground (see Diagram 9).

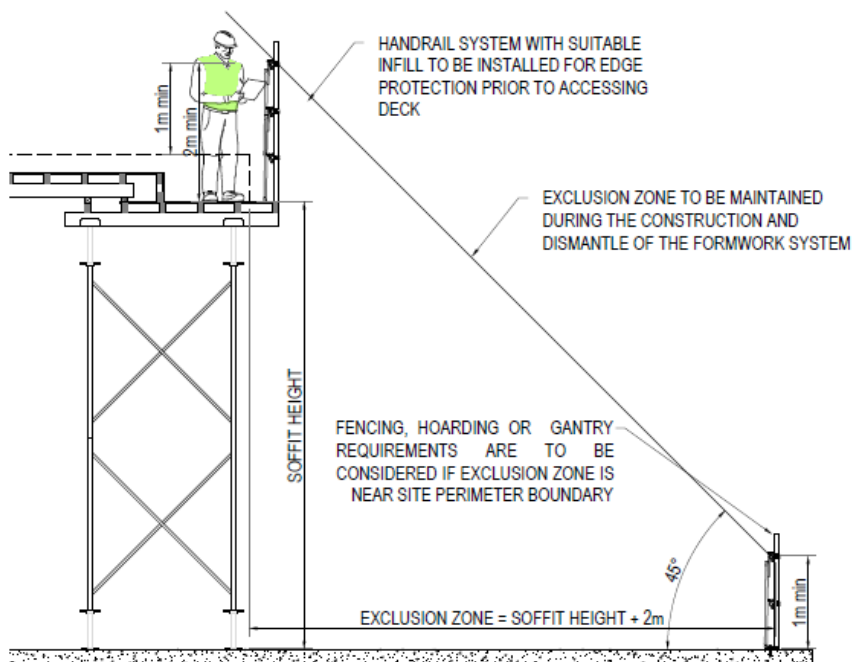


Diagram 11 - Typical set back or single construction

Persons not involved in formwork erection should not be located in the area of the building next to the step-in, unless controls have been implemented to prevent these persons being struck by falling objects.

5.3 Gaps

Gaps between perimeter screens and the formwork deck or floor should not be large enough to allow materials to fall below. This can be done by:

- fixed ply covers,
or
- ply or rubber deflector shields that are connected to screens and the adjacent area cleaned up before they are moved.

Deflector shields deflect objects onto the deck, preventing objects from falling further down the gap. They should be attached to the screens by a system that will ensure the shields do not fall when the

screens are lifted and that is robust enough to withstand the environment. Deflector shields should be designed by an engineer and be adequate to resist impact loads likely to be applied (i.e. from bearers, formply props, etc.) Where chain is used to secure deflector shields, it should have a minimum link size of 5mm and be corrosion resistant. Light gauge domestic type chain is not suitable as it is easily damaged and will rust. Gaps on standard decks may have ply covers that are secured using nails, however fixings used on ply covers and deflector shields for jump forms, slip forms, self-climbing and crane lifted vertical formwork should only be bolted or screw connections – nails should not be used.

Covers should be designed for:

- potential loadings such as loads applied by workers
- the impact loadings of falling materials
- marking with their safe working load if they can be accessed as a platform.

5.4 Prior to lifting

Prior to lifting, the following should take place:

- formply, wall and column forms and other materials should have concrete removed to ensure it does not fall onto persons below
- an inspection carried out to ensure all loose materials and tools are removed from loads to be lifted.

Reference should also be made to section 4.4.4 of this code Lifting formwork materials.

6 Special requirements for wall and column forms

6.1 Bracing for wind loading

Wall and column forms should be designed to withstand wind loading prior to, during and after the concrete pour. The bracing and forms should not be removed from the cast element until it can safely withstand potential impact loads and wind loads.

Prior to commencing formwork stripping operations, a competent person (as described by this code) must verify that sufficient concrete strength has been achieved in accordance with the design documentation, and provide written certification that the formwork can be removed.

Lateral support can be provided to vertical elements in a variety of ways including horizontal and angled braces and structural connections to other parts of the building. A bracing element must be verified and signed off by an engineer. The bracing element must also be able to resist both tensile and compressive loads that may be applied by the wind. Anchors for braces should preferably be cast-in type anchors or 'through-bolts' that extend through both sides of the anchoring medium. Insert type anchors of the following types may be used provided they are installed in accordance with the manufacturer's instructions:

- Undercut type anchor that do not rely on friction to function.
- Expansion anchors of the high-load slip, torque controlled type. These anchors have a working load of at least 60 per cent of the first slip load and are generally suitable for structural tensile loads.
- Coil bolts.

The correct operation of insert type anchors is greatly dependant on their being installed in accordance with a manufacturer's specifications (e.g. drilling the correct size hole and applying the correct torque in concrete of adequate strength).

Insert type anchors are to be installed using a calibrated torque wrench or another reliable method that is specified by the anchor manufacturer. Written and signed records verifying the anchors have been installed in accordance with the manufacturer's instructions are to be available on site.

6.2 Access platforms

Suitable access for doggers, steel fixers and concreters should be provided and may include mobile scaffolding, purpose built work platforms or elevating work platforms. Edge protection should be

provided on the access platforms. The access method should allow adequate room for a person and be positioned at a height and distance from the form so as to minimise movement and a person's exertion. Any concrete pouring system should permit adequate space for a person to stand with edge protection provided. All mobile work platforms should have their castors locked at all times except when moving the mobile platform. Platforms should also be designed to resist any side loading that may be applied during a concrete pour to ensure the platform does not overturn. Aluminium scaffolding may not have adequate self-weight to ensure this. The [Scaffolding Code of Practice](#) provides additional guidance on the design and use of scaffolding.

6.3 Lifting methods

Wall and column forms should be provided with lifting points that have been designed by an engineer. Documentation must be available that verifies this. Holes cut with oxy-acetylene torches are not permitted as they may damage the form, are inaccurate and may make it difficult to attach lifting gear. Where lifting lugs are attached to the form the weld size and length should be specified by an engineer and the manufacturer should ensure that the weld complies with the engineer's requirements (that is, is of the correct size and has adequate weld penetration).

Wall and column forms must only be lifted with a positive lifting system such as lifting lugs or by slinging the lifting slings around the form such that the form cannot slip out of the slings. Purpose designed lifting lugs are preferable to slinging the load because there is less risk of the load becoming inadvertently disconnected from the crane hook.

When lifting wall and column forms always make sure:

- there is an engineer's drawing or certification for lifting the form
- the lifting lug type, location and attachment are the same as specified on the drawing
- the types and spacing of members on the form are the same as those specified on the engineer's drawing
- the numbers, types and spacing of bolts and screws on the form are the same as those specified on the engineer's drawing
- the form is engineer certified for any side loading lifting (i.e. when flipping the form onto or when using multi-legged slings)
- any bracing on the form is the same as that specified on the engineer's drawing
- a competent person from the formwork contractor inspects the form every time it is lifted and verifies it is safe to lift.
- there is a documented system so the forms are inspected for damage or deterioration and remain safe.

It is important to:

- never lift a wall or column form unless the form complies with the engineer's drawing
- never lift a form that has lifting parts that are damaged or rotten
- never change the lifting points without engineer approval
- never drill extra holes in the lifting parts of the form
- never use bolts, screws or timbers different to those listed on the engineers drawing,
- never allow suction between two members.

7 Requirements for slip forms, jump forms, self-climbing and crane lifted vertical formwork

This section applies to slip forms, jump forms and crane lifted forms that incorporate working platforms and enclosed cells in which persons are required to work.

Slip forms and jump forms are the terms given to self-climbing formwork systems specifically intended to construct concrete walls and columns in high rise buildings and other concrete structures such as chimneys. In slip forms, the climbing is usually carried out continuously during the concrete pour. With jump forms, the climbing is done in steps, following the concrete pour. The term “climb form” is also used to describe a slip form or jump form. The power for the climbing operation can be provided in a variety of ways, but usually by means of hydraulic rams or electric motors connected to climbing feet or screw shafts.

Slip forms and jump forms usually consist of a number of decks and may also be fitted with trailing screens that are suspended from the form. As with perimeter screens, trailing screens may provide edge protection for persons, prevent materials from falling; provide support for work platforms or a combination of these uses. No two slip forms or jump forms will be identical because their design depends on the size and configuration of the structure under construction.

The work systems and layout of some crane-lifted forms may also be similar to those associated with slip forms and jump forms. This may be the case for crane-lifted forms provided for the inside of lift shafts. While most of the information in this section applies to slip forms and jump forms, some of the principles may also apply to crane-lifted forms.

When designing and operating these types of form, the following issues should be addressed:

- provision for safe access to all areas and work platforms
- control of risk associated with working at height
- provision of sufficient working space and head room
- specification of appropriate manual tasks methods for shutters and other components, e.g. the use of cranes to lift shutters and provision of safe access for persons attaching slings to shutters
- provision for retrieval of an injured or incapacitated person from any work area located within the structure.

It is acknowledged it may not be practicable to provide an access system and working environment on a jump form or slip form that are of the same standard as elsewhere. This is primarily due to structure characteristics and weight limitations. A designer must endeavour to minimise potential hazards.

7.1 Access and egress

Access to the form may be provided in a variety of ways including one or more of the following:

- personnel and material hoists on the building
- permanent stair systems in the building
- a trailing stair system suspended from the slip form or jump form
- an internal trailing ladder system.

A trailing access stair system should be the primary means of access over a ladder system because it is safer for persons to ascend and descend and emergency evacuation is generally safer on a stair system. Two forms of access and egress to the form should be maintained at all times. Where formwork systems are used on single cell cores, columns or isolated walls, a single stair tread system is acceptable provided the site crane or other alternative is available for emergency removal of workers. If the site crane, or another suitable alternative, is not available then no workers should access the system.

The access area between the trailing access system and the building should be clear of trip hazards and there should be no gaps between platforms exceeding 100mm wide.

A designer of formwork should ensure the trailing access system is designed for loads that could be applied in an emergency evacuation situation. Both the strength of the system itself, and the ability of the form to withstand applied loads from the access system, should be adequate. The trailing stair access system should be designed for a load of at least 2.5kPa unless the designer is able to justify a lesser load based on the anticipated number of persons on the form at any one time.

Where the designer of the formwork specifies a lesser live load than 2.5kPa, the following should be ensured:

- A sign stating the maximum load that can be applied to the stairs should be fixed to the stairs in a visible position.
- Written procedures are implemented to ensure the total acceptable number of persons on the form is not exceeded.

Ladders must be secured in place and be placed at an angle between 70 and 80 degrees to the horizontal, where this is practical.

Access openings for ladders on working decks should be provided with trapdoors that are closed except when being accessed. Trapdoors should be provided with a device so that they can be easily opened from above. This device should not pose a trip hazard for persons on the deck.

Access ways should be kept free of materials and rubbish to prevent objects falling to the level(s) below.

7.2 Working platforms and penetrations

The following points highlight specific issues that may apply:

- All penetrations should be covered by formply that is secured in position or should be provided with leading or perimeter edge protection.
- When placing steel or pouring concrete into a form, controls should be provided to prevent a person falling into or off the form. This becomes more of an issue when the width of the form is greater than 225mm prior to placement of reinforcing steel. A person working in proximity to projecting reinforcing steel or other objects must be protected from the risk of being impaled by these objects. Suitable controls may include edge protection on the internal side of the working platform or sheets of steel re-enforcement mesh temporarily placed on top of the form that is, the steel can be fed through the gaps in the mesh.
- All platforms that may be affected by uplift should be positively secured so that uplift cannot occur. Uplift can occur from wind loading or when a platform is out-of-level and unsecured. In the latter instance, the platform can see-saw when a load is applied to the end of the platform and then drop a person off the platform if one of the platforms supports moves. This may be the case where work platforms are supported by a trailing screen on one side and a parapet of the building on the other.
- Where individual cells of the form are climbed at different times, edge protection should be provided on each of the raised cells.

7.2.1 Trapdoors

Where penetrations exist, work procedures should be implemented to minimise the risk of workers and materials falling through the penetrations. This should include a process that helps workers to be aware of the location of trapdoors and covers. This will reduce the risk of workers tripping on penetration covers or inadvertently jumping on to a trapdoor without knowing they are doing so.

Trapdoors are to be constructed so that the trapdoor itself and its support will not fail. Trapdoors need to be able to support persons walking or standing on them. Persons should not jump onto trapdoors or penetration covers.

The following applies to trapdoors:

- The trapdoor itself should be constructed from a single piece of material.
- The material used to construct the trapdoor should be a structurally rated material. For example, if plywood is used to construct the trapdoor the plywood should be of a structural grade to an

appropriate design and manufacturing standard such as *AS/NZS2269 Plywood-Structural* or *AS6669 Plywood-Formwork*.

- The trapdoor should be designed and installed to be supported, when closed, around as much of its edge as practical. For example, support should be provided under all four edges of the trapdoor, except under the area of the trapdoor removed to allow the ladder to pass through the closed trapdoor.
- The support under the trapdoor should be by structural bearers and not strips of timber that have been screwed to the formwork deck.
- In order to allow the ladder to protrude through the deck, part of the trapdoor will need to have a section removed. This cut out should be as small as possible, while allowing a ladder angle of 4 to 1. The cut out should not be wider than the outside of the ladder stiles.
- Where a trapdoor is no longer in use it should be locked or fastened so that it cannot be easily opened.
- The hinges on the trapdoor are to be robust and remain serviceable for the life of the trapdoor.
- Trapdoors should be marked with the words 'Danger Hole Under' or, 'Danger Penetrations Below; or similar.

7.3 Trailing screens and platforms

Trailing screens can provide edge protection, a means of preventing falling objects and be designed to incorporate working platforms. Where platforms are provided these are usually for the purpose of patching the building or carrying out minor repairs, and for access for persons climbing the form. A designer of formwork will specifically need to address all issues for which the trailing screen system is designed. The following issues must be included in the design:

- A suitable design loading for any platforms on the trailing system. As a guide, platforms should be designed to support a minimum load of 2.5kPa. A designer may reduce this if the number of persons is strictly limited and controls are implemented on site to ensure this. If the design load is less than 2.5kPa, signs should be fixed to the platforms that state the maximum load permitted in kilograms. Persons on site should be made aware of the maximum loading that may be applied to the trailing platform and this should be stated in documentation kept on site.
- Adequate controls should be provided to control the risk of falling materials (see section 5 of this code for further guidance).
- All platforms should be secured to prevent uplift or any other movement.
- Safe working loads when the trailing screen is used as work platform.

Except where it is impractical to do otherwise, a person should not be located on trailing platforms while the platforms are crane lifted. If a person is located on a platform while it is being lifted by a crane, the following controls must be implemented:

- A person should be prevented from falling down any gap that may exist on the inside edge of the platform that is, between the platform and the wall being constructed. It is preferable to provide edge protection on the inside edge to ensure this. Fall arrest harnesses may be provided for workers as long as workers are trained in their safe use and a rescue procedure for retrieval of workers following a fall has been prepared.
- Persons on the platform hold at least a dogger or rigger licence class or a person with such a licence class is also located on the platform as it is lifted.
- A clear method of communication between the crane operator and the dogger responsible for directing the lift exists that is, a whistle or two way radios.
- Any crane making the lift complies with the requirements for cranes used to lift persons specified in *AS2550: Cranes, hoists and winches – safe use*.

7.4 Climbing the form

It is important to ensure the different parts of the form remain level during the climbing process. Climbing is usually carried out using a series of climbing devices set up to lift at the same time and at the same rate. If the lifting system is not properly synchronised the form may become wedged on the structure or structural members may be overloaded. There should therefore be a system to ensure that the form does not go out-of-level during the climbing procedure. This system may be an

automated system or may rely on operators stopping the climbing process. The following must be ensured:

- Only persons directly involved with the climbing process should be located on the form during the climbing process.
- Any potential nip or shear points where a person could be injured during the climb are identified and controlled.
- All obstructions on the form have been removed prior to the form being climbed. A 'sign-off' procedure for this should be provided. This includes the removal of 'Z-bars', ferrule bolts and other material that would snag on the structure if they were not removed.
- Services including electrical cable and water pipes have been designed so that they will not rupture or snag as the form is climbed.

When removing a form from a vertical element, the form must be effectively supported such that it never relies on suction for support. Serious incidents have occurred when it has been assumed that a form is supported from above when it is in fact relying on 'through bolts' through the wall for support. When the bolts have been removed the form has fallen, with the persons still standing on a platform attached to the form. This hazard can apply both to crane lifted forms and jump forms.

A checklist (as illustrated in Appendix 6) can be used to assist in this process.

7.5 Ventilation and amenities

Adequate ventilation and access to all cells in jump forms or slip forms should be provided where reasonably practicable. It is difficult for persons to spend extended periods in cells due to the heat and cramped working conditions. Allowance should be made for these issues and it may be necessary to specify maximum times for particular cells depending on temperature, humidity and cell size. These times should be developed as part of a safe work method statement following consultation between the workers and their PCBU.

Adequate ventilation and access should also be provided within cells and it may be necessary to provide ventilation fans or access ways in the cells.

Clean drinking water should be provided on the top level of the slip form and jump form. On larger slip forms and jump forms it may be necessary to provide clean drinking water on other levels. A chemical toilet should be provided on the top of the jump form when installation of a plumbed toilet is not practical.

7.6 Engineering issues

The design of jump forms and slip forms is more complex than the design of formwork systems for floors. Greater technical input from a designer is required including consideration of wind loading. For this reason, the slip form or jump form designer must be an engineer.

The jump form or slip form designer must be involved both in the initial design of the form and in addressing ongoing design issues that will occur during form erection and during the life of the building project. Many of the design problems associated with jump forms and slip forms will not become apparent until the job is progressing, and it is likely that alterations to the design of the form will be necessary. The designer must therefore inspect the form on site and work closely with persons involved in its operation, and the principal contractor, to determine if difficulties are being encountered.

Section 2 of this code discusses engineering issues. In addition, the following factors must be addressed by the designer of these types of formwork:

- Minimum concrete strength required prior to climbing.
- Allowance for all loads, including dynamic and wind loads that may be applied to the form. Loads applied by workers and concrete placing activities must also be allowed for. Allowance may also need to be made for impact loading when materials are lifted onto the deck of the form. The designer must consider the effects of eccentric loading on the form, both during climbing and at other times, and note the requirements in the operating procedures for the form.

- The maximum degree to which the form can be out-of-level during climbing, and the procedure required both to minimise the likelihood of this occurring and how to remedy the situation if the form becomes out-of-level.
- Consideration of rescue procedures that may affect the design of the form. The rescue procedure may require access to all levels of the form and cells, either through the provision of gates or removal of panels on the form.

7.7 Emergency issues

Fire extinguishers, hoses and other means of fire prevention and control must be provided on the jump form or slip form in accordance with relevant legislation.

Emergency procedures for the jump form or slip form must be developed, documented and implemented. Persons must be trained in these procedures and a list of persons who have received the training must be documented.

The emergency procedures must include, but not be limited to the following:

- the method of alert in the event of an emergency and the method of extracting persons from each location or cell that the persons have access to or could fall into
- when to evacuate persons from the form
- evacuation muster points both on and off the form
- training in the use of fire extinguishers
- identifying persons responsible for ensuring evacuation takes place
- rescue procedures in the event of severe medical conditions
- identifying persons responsible for rescuing workers, and
- rescue training for persons involved in rescuing others, where outside experts will not be responsible for performing the rescue.

Where the form can be accessed using cranes on site, a first aid box for emergency rescue of injured and incapacitated persons must be readily available and accessible at all times while work is being undertaken.

Response to emergency situations must be considered during formwork design stages and in an ongoing way during construction. Emergency situations requiring evacuation of an injured worker from a formwork 'cell' need to consider how to safely remove an immobilised or unconscious person. This may include creating emergency access holes and doorways through decks and screens. Procedures must identify how to access lift-voids and other areas, including cells within the core which may have limited access. In relation to emergency evacuation from vertically lifted systems two forms of access and egress should be provided as set out in Table 3 in section 3.2.1.

Emergency services contacts must be clearly identified and available. These must be nominated by all parties on site, including the principal contractor, sub-contractors and workers.

Appendix 1: Dictionary

Bearer:	Primary horizontal support members for a formwork deck that are placed on top of formwork frames. Bearers are usually constructed from timber but are sometimes constructed from metal, such as in the case of some modular formwork systems.
Cell:	An area of a slip form, jump form or crane lifted form where a worker or workers are required to carry out work. The cell will at least be enclosed by all sides and a bottom surface.
Competent person:	<p>In relation to performing an inspection or other task for a control measure is a person who has acquired, through training, qualifications or experience knowledge and skills, including:</p> <ul style="list-style-type: none">• sound knowledge of relevant Australian Standards, relevant codes of practice and other relevant legislation,• ability to read and interpret drawings• sound knowledge of, and competence in, the risk management process for the erecting, altering and dismantling of formwork, including:<ul style="list-style-type: none">– hazard identification and risk assessment– measures to control exposure to risks– safe work practices and procedures– how to plan and prepare formwork.
Containment sheeting:	A protective structure fixed to the perimeter of the building, structure or working platform to contain objects and prevent them from falling.
Edge protection:	<p>A barrier to prevent a person falling erected along the edge of:</p> <ul style="list-style-type: none">• A building or other structure.• An opening in a surface of a building or other structure.• A raised platform.
Engineer:	<p>In relation to the performance of a task, means a person who:</p> <ul style="list-style-type: none">• is a registered professional engineer under the <i>Professional Engineers Act 2002</i>• is competent to perform the task.
False deck:	A deck provided to safely arrest a falling person and/or provided as a working platform (different to the 'pouring deck').
Form:	An object used in the casting of concrete walls or columns that has part of its surface in contact with the concrete during the concrete curing process.
Formwork frame:	A structural assembly, a number of which are used to support a formwork deck. Bearers are placed directly on these frames.
Horizontal member:	Any horizontal member of a formwork frame that is provided as stiffening for the frame and may also be used to support a working platform.
Intermediate platform:	A platform at least two planks wide, located less than 2 metres above a continuous deck.

Joist:	Secondary horizontal support members for the formwork deck that are placed on top of bearers, at right angles to the bearers. Joists are usually constructed from timber but are sometimes constructed from metal, such as in the case of some modular formwork systems.
Licence class:	A class of high risk work endorsed on a licence to perform a class of high risk work.
Modular formwork systems:	A formwork system that is specifically designed for formwork and consists of components that are not designed to be used with other systems.
Perimeter edge protection:	Edge protection that is provided on the perimeter of the formwork to be erected. (Note: Perimeter edge protection will prevent a fall off the outside perimeter of the formwork but will not prevent internal falls through the formwork).
Pouring deck:	A deck on which concrete is poured.
Prop:	A slender structural member placed in a vertical position between two horizontal surfaces and used to support the upper surface. The proprietary term “Acrow” is often used to describe the prop. The height of a prop is usually adjustable.
Vertical member:	A vertical structural member which may or may not form part of a frame, also known as standard, vertical tube.

Appendix 2: Sample engineer's certification letters

(A) Engineer's certification letter – no variation to design

.....

.....

.....

.....

Dear Mr/Ms

Project

I certify that the formwork system detailed below has been designed in accordance with Australian Standards AS3610 – Formwork for concrete and AS3600 – Concrete structures and the project documentation including the structural engineering drawings and specification. The system is detailed on the drawings and documentation listed below.

Drawing number	Drawing name
Specifications	

Yours faithfully

Signature

Engineer's name

RPEQ No.

(B) Engineer’s certification letter – variation to design

.....
.....
.....
.....

Dear Mr/Ms

Project

I certify that the variations to the formwork system detailed below have been checked and satisfy the Australian Standards *AS3610 – Formwork for concrete* and *AS3600 Concrete structure* and the project documentation including the structural engineering drawings and specification.

Variation number	Details of variation of formwork system

Yours faithfully

Signature
Engineer’s Name

RPEQ No.

Appendix 3: Construction checklist

Note: '#' denotes an item that, if not passed by the competent person, must be referred to the engineer. All other items not passed by the competent person must be corrected on site and certified by the competent person when he/she is satisfied.

Loads

- What are the stacked load limits at all stages?
- Are the stacked materials on spreaders?
- # Will the loads be exceeded by any construction procedure?

Materials

- # Are the correct form materials being used?
- Is the formface appropriate to the finish required?

Formwork frames

- # Are the formwork frames in the correct location and correct number?
- Are they to dimension and within tolerance?
- Are they accurate to line, level and plumb?

Bracing/props

- # Are there different props or braces to the ones indicated on the formwork drawings?
- Are the props plumb?
- Are all loads centrally placed?
- Are supported elements wedged and nailed?
- Are props straight?
- Are base plates on adequate foundations?
- Is the bracing correct?
- Is the bracing firmly connected?

Fixing

- Is the nailing/screwing adequate?
- # Are the ties the correct type?
- # Are they on the correct grid?
- Are all ties, clamps and bolts tight?
- Are wedges tight and nailed?
- # Are connections between traditional formwork and modular formwork correct?

Back-propping

- # Is the back-propping system correct?
- # Are the number of floors required for back-propping correct?

Cleanliness

- Are the formfaces cleaned?
- Is any damage correctly repaired?
- Is the correct release agent in use?
- Is it being correctly applied?
- Has all debris been removed from within the form?

Water-tightness

- Are all joints properly sealed and cramped?
- Are the construction joints sealed?

Concrete/concreting

- What is the maximum rate of placement permitted?
- Are the forms maintaining line, level, plumb, shape, etc. during concreting?

Stripping

- What are the minimum stripping times?
- Has the project designer permitted modification of these?
- Do the procedures enable stripping without damage to form or concrete?
- Are the provisions consistent with the re-use times required?
- Has the crane the necessary slings, etc. to move the forms quickly?
- What curing methods must be used once the formwork is removed?
- Is the storage area for the formwork organised?

Safety

- Are there adequate guardrails, handrails, walkways, signs, etc. in position?

Appendix 4: Sample structural (pre-pour) certificate

Engineer's/Competent person's name:..... Telephone.....

Address:

FAX:.....

Mobile:

Date:

Project:

.....

Level:.....

Area:.....

This is to certify that the Formwork for the above project has been inspected and is considered to have been erected in accordance with the formwork design documents and meets relevant Australian Standards including *AS3610 Formwork of concrete*.

The following items were included in the inspection:

ITEM	CONDITION	WORK REQ'D Yes/No??
Base plates	OK	No
Frame spacing	OK	No
Frame bracing	OK	No
Frame extensions	OK	No
Bearer size and spacing	OK	No
Joist size and spacing	OK	No
Prop spacing	OK	No
Prop bracing	OK	No
Eccentric loading	OK	No
Prop inclination	OK	No
Timber condition	OK	No
Steel condition	OK	No
Nails in plates as req'd	OK	No
Column framing	OK	No
Column bracing	OK	No
Plywood fixing	OK	No
Back propping	OK	No
Quality of materials	OK	No

If there is any additional work required before the pour takes place please detail what is required

.....
.....
—

.....
Engineer's / Competent person's name

.....
Signature

Appendix 5: Defects commonly found in formwork systems

Sole plates

- (a) not levelled in or eccentrically placed
- (b) inadequate load-carrying capacity of the ground and uneven bedding
- (c) deterioration with time (e.g. due to weather conditions)
- (d) deterioration of load-carrying capacity of the ground, (e.g. washouts)
- (e) crushing due to inadequate load distribution from vertical and horizontal members.

Horizontal supports

- (a) folding wedges cut to too coarse a taper, not properly cleated, cut from wet material
- (b) inadequate lateral and torsional bracing, (e.g. between telescopic centres, centres carrying heavy loads over long spans, steel props supporting heavy loads at, or near, maximum extension and between towers supporting independent spans)
- (c) horizontal members not centrally placed in forkheads
- (d) inadequate supports to cantilevers, (e.g. struts supporting deep beam sides on the outer face of the structure)
- (e) inadequate bearing areas to vertical supports and underside of principal members causing crushing
- (f) inadequate support to prevent overturning of deep principal members because stirrups or forkheads often omitted
- (g) bolted timber connections not staggered creating tendency to split out.

Vertical supports

- (a) inadequate bracing during erection
- (b) support not plumb
- (c) inadequate lateral ties and/or vertical and plan bracing
- (d) no ties between standards at point of loading (most important where telescopic centres are being supported)
- (e) incorrect provision of props from floor to floor
- (f) lack of rigidity of screw connections due to over-extension or lack of bracing
- (g) adjustable steel props with nails, mild-steel bolts and reinforcing bars used in place of correct pins
- (h) omission of scaffold forkheads or supports, otherwise eccentrically loaded without allowance having been made for this condition
- (i) bearing plates distorted (top and bottom plates of steel props)
- (j) inadequate or discontinuous bracing to scaffold.

General

- (a) excessive tolerances in construction
- (b) failure to check tightness of bolts, wedges, etc.
- (c) failure to control vertical rate of placement of concrete
- (d) failure to control placement of concrete, causing uneven loading of forms
- (e) inadequate allowance for uplift of concrete under inclined forms
- (f) inadequate allowance for the effects of vibration on joints
- (g) inadequate allowance for stresses induced by prestressing, temperature and moisture movements
- (h) no allowance for wind loading
- (i) no allowance for the effect of vibration on ties, struts, braces, and wedges
- (j) unrealistic assessment of stresses due to over-simplification of design assumptions
- (k) unequal load distribution between two or more members carrying a common load.

Appendix 6: Perimeter screen handover checklist

Project:		Date:	
Scope:	Checklist for climbing screens		
Activity:	Climbing the perimeter safety screens		

#	Description of activity	Screen Supervisor	Sign	Area Foreman	Sign
1	Pre-climb prep				
2	Actions during the climb				
3	Post climb actions				
4	Task completion checklist				
5					
6					
7					
				Yes	No
Pre climb preparation of the screens					
The screen supervisor and area foreman have checked that formwork is clear of screens.					
All platforms on the screens and building edges have been swept and cleaned at least 1 meter from the edge of the building line.					
The screen supervisor has briefed the screen crew, crane crew and other workers involved in the task.					
Two way radio communication is established between screen crew and spotter(s).					
The screen crew have verified that edge protection is in place at the building edge on all levels – including the level that is exposed after screen is climbed, and barricades and screen crew only signage is in place (exclusion zones) a minimum of at least 960mm barricade mesh.					
All flaps, needles, push pull props, tie down bolts are released from behind compliant edge protection or by a worker anchored in a safety harness. See SWEMS 0058 and SWEMS 0068 trailing screen procedures and SWEMS 0074 using a safety harness.					
All flaps, push pull props, infill's, are properly chained or secured to the screens					
Exposed back props closer than 2/3 the length of the prop from the exposed edge have been bolted to the concrete					
The screen supervisor has contacted and area foremen to confirm the screens are clear from the building and ready to jump.					
Ensure availability of the cane to lift and secure a series of screens in sequence before the crane is taken away for other lifts. Confirmation consultation with crane crew and builder before preparing to lift screens.					
Dogman to connect the chains to the identified lifting points on the screen. Chains to be connected where there the dogman can reach after lifting. Note: crane crew to be inducted into the lifting of the screen procedure.					
Actions during the climbing of screens					
All workers in the screen crew are watching for hang ups from behind compliant edge protection and must notify the Screen Supervisor of any problems					
If workers have to stand outside the edge protection to free hang ups they must be anchored in a safety harness - see SWEMS 0074					
Post climbing actions					
All needles / push pull props / connection Z-bars are fixed to concrete slab and all screens are secured to the building					
Platforms on all levels have flaps in place					
				YES	NO
Note: When the live deck is being laid it is the responsibility of the formworkers to re-fix					

the flaps and in-fills when the soffit reaches the trailing screens		
All flaps and infill's are in place and secured		
Gaps between screens do not exceed 25 mm on all levels.		
Mesh infill panels are covering gaps greater than 25 mm		
Shade cloth in-fills are in place where required		
All platforms and flaps are free of rubbish and loose material		
All exclusion zones no longer required are removed		
Screen supervisor to retain checklist until task complete		
Task completion checklist		
Are the screens secured to the building		
Are raking shores secured to the needles if required		
Are the flaps and in-fills on the platforms secure		
Can workers safely access the platforms to work		
Is the climb completed		
Are falling object / person controls in place – edge protection established on the levels where there is no longer screen protection		
Have the barricades, exclusion zone and signage been removed		
Has access / egress been re-established		
Have other trades been notified that the works are complete		

	Signature	Date	Time
Screen supervisor			
Area foreman / Structure foreman			
Finishing foreman			
Comments or additional control measures required:			
Corrective actions or issues:			