



DRAFT

Code of Practice
**SAFE DESIGN OF
BUILDING AND STRUCTURES**



safe work australia

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FOREWORD

This Code of Practice on the safe design of buildings and structures is an approved code of practice under section 274 of the Work Health and Safety Act (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 Regulations (the WHS Regulations).

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 Regulations. 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.

Compliance with the WHS Act and Regulations may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code.

An inspector may refer to an approved code of practice when issuing an improvement or prohibition notice.

This Code of Practice has been developed by Safe Work Australia as a model code of practice under the Council of Australian Governments' *Inter-Governmental Agreement for Regulatory and Operational Reform in Occupational Health and Safety* for adoption by the Commonwealth, state and territory governments.

A draft of this Code of Practice was released for public consultation on 26 September 2011 and was endorsed by the Workplace Relations Ministers Council on [to be completed].

SCOPE AND APPLICATION

The Code provides practical guidance to persons conducting a business or undertaking who manage or control design functions for buildings and structures that will be used, or could reasonably be expected to be used, as a workplace (including redesign or modification of a design). This includes people who make decisions that influence the design outcome, such as clients, developers and builders in addition to those who are directly involved in the design activity, such as architects, building designers and engineers.

This Code applies to the design of 'structures' defined under the WHS Act to mean anything that is constructed, whether fixed or moveable, temporary or permanent, and includes:

- buildings, masts, towers, framework, pipelines, transport infrastructure and underground works (shafts or tunnels)
- any component of a structure, and
- part of a structure.

How to use this code of practice

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 Regulations 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

The most effective risk control measure, eliminating the hazard, is often most cost effective and more practical to achieve at the design or planning stage rather than making changes later when the hazards become real risks in the workplace.

Safe design can result in many benefits, including:

- prevention of injury and illness
- improved useability of structures
- improved productivity and reduced costs
- better prediction and management of production and operational costs over the lifecycle of a structure
- compliance with legislation
- innovation, in that safe design can demand new thinking to resolve hazards in the construction phase and in end use.

1.1 What is safe design?

Safe design means the integration of hazard identification, risk assessment and control methods 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 product being designed.

The safe design of a building or structure will always be part of a wider set of design objectives, including practicability, aesthetics, cost and functionality. These sometimes competing objectives need to be balanced in a manner that does not compromise the health and safety of those who work on or use the building or structure over its life.

Safe design begins at the concept development phase of a structure when making decisions about:

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

1.2 Who has health and safety duties in relation to the design of structures?

A person conducting a business or undertaking has the primary duty under the WHS Act to ensure, so far as is reasonably practicable, that workers and other persons are not exposed to health and safety risks arising from the business or undertaking.

A person conducting a business or undertaking that designs a structure that will be used, or could reasonably be expected to be used, as a workplace must ensure, so far as is reasonably practicable, that the structure is without risks to health and safety. This duty includes carrying out testing and analysis and providing specific information about the structure.

Design, in relation to a structure, includes the design of all or part of the structure and to redesign or modify a design. Design output includes any hard copy or electronic drawing, design detail, design instruction, scope of works document or specification relating to the structure.

A designer is a person conducting a business or undertaking whose profession, trade or business involves them in:

- preparing designs for structures, including variations to a plan or changes to a structure, or
- arranging for people under their control to prepare designs for structures, or

- making design decisions that will affect the health and safety of others.

Designers, in their capacity as persons conducting a business or undertaking, include:

- anyone who specifies or alters a design, or who specifies the use of a particular method of work or material (for example, a quantity surveyor who insists on specific material, or a client who stipulates a particular layout, a town planner)
- anyone specifying or designing how structural alteration, demolition or dismantling work is to be carried out
- architects, building designers, geotechnical engineers, civil and structural engineers, building surveyors, landscape architects and all other design practitioners contributing to, or having overall responsibility for, any part of the design (for example, drainage engineers designing the drain for a new development)
- building service designers, engineering practices or others designing fixed plant (including ventilation and electrical systems and permanent fire extinguisher installations)
- contractors carrying out design work as part of their contribution to a project (for example, an engineering contractor providing design, procurement and construction management services)
- temporary works engineers, including those designing formwork, falsework, scaffolding and sheet piling, as well as demolition and dismantling, and
- interior designers, including shopfitters who also help with the design.

1.3 Other persons with key roles in design and construction

The client

Under the WHS Regulations, the person conducting a business or undertaking who commissions the construction work or project has specific duties. In the construction industry, this person is commonly referred to as the 'client'. A client has an obligation to:

- consult with the designer, so far as is reasonably practicable, about how to ensure that health and safety risks arising from the design during construction are eliminated or minimised, and
- provide the designer with any information that the client has in relation to the hazards and risks at the site where the construction work is to be carried out.

Examples of hazards and risks relating to a construction project include overhead electric lines, access and egress, hidden or concealed services, contaminated ground or restrictions that may affect the work that will be undertaken or the health and safety of persons who will undertake the work.

The principal contractor

Under the WHS Regulations, a principal contractor is required for a construction project where the value of the construction work is \$250,000 or more.

The principal contractor has specific duties to ensure the construction work is planned and managed in a way that eliminates or minimises health and safety risks so far as is reasonably practicable.

The WHS Regulations defines the principal contractor as a person conducting a business or undertaking that:

- commissions the construction project (the client), or
- is engaged by the client to be the principal contractor and is authorised to have management or control of the workplace.

Further guidance on managing risks for construction projects, principal contractor duties, safe work method statements and WHS management plans can be found in the *[draft] Code of Practice: Managing Risks in Construction Work*.

1.4 What is involved in the safe design of buildings and structures?

A step by step process

A risk management process is a systematic way of making a workplace as safe as possible and it should also be used as part of the design process. It involves the following four steps:

- identify design-related hazards associated with a range of intended uses of the building or structure
- assess the risks arising from the hazards
- eliminate or minimise the risk by implementing control measures, and
- review the control measures.

General guidance on the risk management process is available in the *Code of Practice: How to Manage Work Health and Safety Risks*.

Consider the lifecycle

In the same way that designers consider the future impact of a building on environmental sustainability, designers should consider how their design will affect the health and safety of those who will interact with the building or structure throughout its life.

The WHS Act requires the designer to ensure, so far as is reasonably practicable, that a structure is designed to be without risks to the health and safety of persons who:

- use the structure for a purpose for which it was designed
- construct the structure at a workplace
- carry out any reasonably foreseeable activity at a workplace in relation the manufacture, assembly, use and proper demolition and disposal of the structure, or
- are at or in the vicinity of a workplace and are exposed to the structure or whose health and safety may be affected by an activity related to the structure.

This means thinking about potential hazards and design solutions as the building or structure is constructed, commissioned, used, maintained, repaired, refurbished or modified, decommissioned, demolished or dismantled and disposed or recycled. For example, when designing a building with a lift for occupants, the design should also include sufficient space and safe access to the lift-well or machine room for maintenance work.

Knowledge and capability

In addition to core design capabilities, the following skills and knowledge should be demonstrated or acquired by a designer:

- knowledge of work health and safety legislation, codes of practice and other regulatory requirements
- understanding the purpose of the building or structure and how it could be used in the future
- knowledge of hazard identification, risk assessment and control methods
- knowledge of technical design standards, and
- the ability to source and apply relevant data on human dimensions, capacities and behaviours.

Many design projects are too large and complex to be fully understood by one person. Various persons with specific skills and expertise may need to be included in the design team or consulted

during the design process to fill any knowledge gaps, for example ergonomists, engineers and occupational hygienists.

Consultation, co-operation and co-ordination

Consultation is a legal requirement and an essential part of managing work health and safety risks. A safe workplace is more easily achieved when people involved at the design stage communicate with each other about potential risks and work together to find solutions. By drawing on the knowledge and experience of other people, including workers, more informed decisions can be made about how the building or structure can be designed to eliminate or minimise risks.

A person conducting a business or undertaking must consult, so far as is reasonably practicable, with workers who carry out work for the business or undertaking who are (or are likely to be) directly affected by a work health and safety matter.

If the workers are represented by a health and safety representative, the consultation must involve that representative.

If you are commissioning a new workplace or refurbishing your existing workplace, you must consult your workers who will be using the workplace in the planning stage, because their health and safety may be affected by the new design.

A person conducting a business or undertaking must consult, cooperate and coordinate activities with all other persons who have a work health or safety duty in relation to the same matter, so far as is reasonably practicable.

Often, the design process will occur over various stages and involve different people who make financial, commercial, specialist or technical decisions over a design, for example, clients, architects, project managers and interior designers.

Such decisions may positively or negatively affect the safety of a building. In these circumstances, each party will have responsibility for health and safety in the design stage.

Where it is reasonably practicable to do so, the duty holders involved must consult each other on the hazards and risks associated with the building and work together on appropriate design solutions. It may mean that the client co-operates with a designer in changing a design to address a health and safety risk identified in the design process.

The WHS Regulations require the person who commissions construction work to consult with the designer to ensure that risks arising from the design during construction are eliminated or minimised as far as reasonably practicable.

Further guidance on consultation is available in the *Code of Practice: Work Health and Safety Consultation, Cooperation and Coordination*.

Information transfer

Key information concerning hazards identified and action taken or required to control risks should be recorded and transferred from the design phase to all those involved in later stages of the lifecycle.

The WHS Act requires designers to give adequate information to each person who is provided with the design for the purpose of giving effect to it concerning:

- the purpose for which the structure was designed
- the results of any calculations, testing, analysis or examination

- any conditions necessary to ensure that the structure is without risks when used for a purpose for which it was designed or when carrying out any activity related to the structure such as construction, maintenance and demolition.

The designer must also, so far as is reasonably practicable, provide this information to any person who carries out activities in relation to the structure if requested.

The WHS Regulations require a designer to provide a written report to the person commissioning the design on the health and safety aspects of the design. This report must specify the hazards relating to the design of the structure that, so far as the designer is reasonably aware:

- create a risk to persons who are to carry out the construction work, and
- are associated only with the particular design and not with other designs of the same type of structure.

The information should include:

- any hazardous materials or structural features and the designer's assessment of the risk of injury or harm resulting from those hazards;
- the action the designer has taken to reduce those risks, for example changes to the design;
- changes to construction methods; and
- any parts of the design where hazards have been identified but not resolved.

Points for designers to consider when providing information include:

- making notes on drawings, as these will be immediately available to construction workers
- developing a register or list of significant hazards, potential risks and control measures
- providing information on significant hazards, as well as:
 - hazardous substances or flammable materials included in the design
 - heavy or awkward prefabricated elements likely to create handling risks
 - features that create access problems
 - temporary work required to construct or renovate the building as designed, for example bracing of steel or concrete frame buildings
 - features of the design essential to safe operation
 - methods of access where normal methods of securing scaffold are not available
 - residual risk where design change has minimised but not eliminated the risk
 - noise hazards from plant.

Development and use of a work health and safety (WHS) file could assist the designer to provide this information to others.

Communicating this information to other duty holders will minimise the likelihood of safety features deliberately incorporated into the design being altered or removed at later stages of the life cycle by those engaged in subsequent work on or around the building or structure.

1.5 What is the extent of the designer's duty?

A designer's duty is qualified by what is reasonably practicable. Deciding what is 'reasonably practicable' requires taking into account and weighing up all relevant matters including:

- the likelihood of the hazard or the risk concerned occurring
- the degree of harm that might result from the hazard or the risk
- knowledge about the hazard or risk, and ways of eliminating or minimising the risk
- the availability and suitability of ways to eliminate or minimise the risk, and
- after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

For example, in deciding what is reasonably practicable, consideration will be given to the prevailing standards of design and the hazards and risks known at the time the designer designed the building or structure.

In the process of designing buildings or structures it will not always be possible to clearly delineate who has responsibility, and in which circumstances, for the elimination or minimisation of hazards associated with a building or structure. The duties may be concurrent and overlapping.

Where more than one person has a duty for the same matter, each person retains responsibility for their duty and must discharge it to the extent to which the person has the capacity to influence or control the matter or would have had that capacity but for an agreement or arrangement claiming to limit or remove that capacity.

While designers may not have management and control over the actual construction work they can discharge their duty by consulting, co-operating and co-ordinating activities, where reasonably practicable, with those who do have management or control of the construction work, for example by:

- providing guidance on how a structure might be constructed safely
- applying risk management processes to more traditional designs and considering whether new or innovative approaches to design will eliminate or minimise risk and result in an intrinsically safer building or structure
- providing information of any identified hazards arising from an unconventional design to those who will construct or use the building, and
- carrying out the above in association with those who have expertise in construction safety.

A designer may be asked to provide health and safety information about a building they designed many years ago. The designer may not be aware of changes made to the building since it was constructed. In this situation, the extent of a designer's duty is limited to the elements of the design detailed or specified by the designer and not by others.

2. PRE-DESIGN AND CONCEPT DEVELOPMENT PHASE

This stage of the process involves:

- Establishing the design context in terms of the purpose of the building or structure, as well as the scope and complexity of the project
- Establishing the risk management context by identifying the breadth of workplace hazards that need to be considered
- Identifying the roles and responsibilities of various parties in relation to the project, and establishing collaborative relationships with clients and others who can influence the design outcome (see *Appendix A*)
- Conducting research and consultation to assist in identifying hazards, assessing and controlling risks
- Develop concept and evaluate options

2.1 Systematic risk management

A systems approach that integrates the design process with the risk management process is recommended (see *Figure 1*). The design brief should include a requirement to apply a risk management process in the design. This approach also encourages collaboration between a designer, constructor and client.

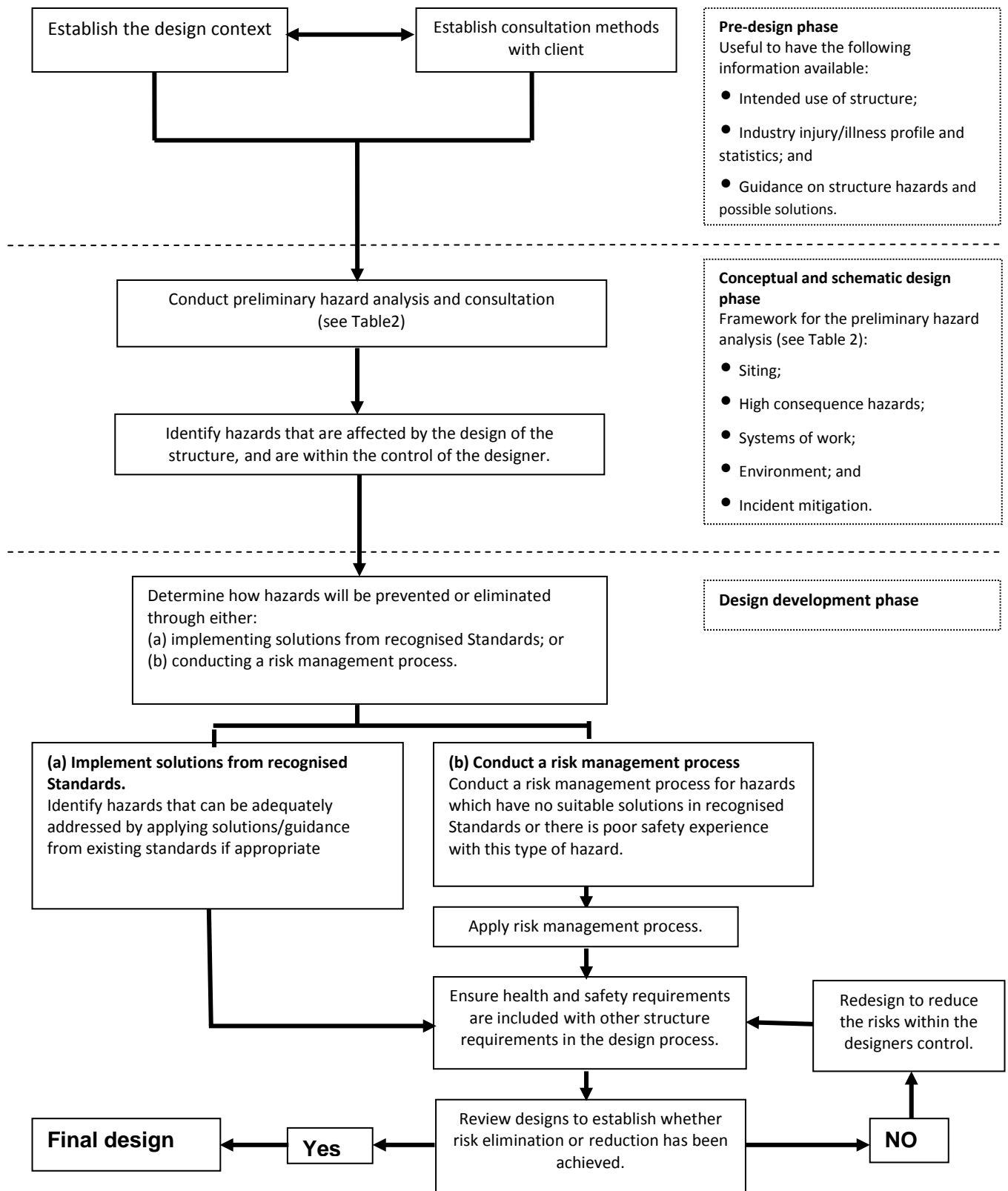


Figure 1: A systematic approach to integrating design and risk management

2.2 Research and consultation

Information can be found from various sources to assist in identifying hazards, assessing and controlling risks, including:

- WHS and building laws, technical standards and codes of practice
- Industry profile regarding injuries and incidents
- Statistics, hazard alerts or other reports from relevant statutory authorities, unions and employer associations, specialists, professional bodies representing designers and engineers, and
- research and testing done on similar designs.

Building good client relationships can provide the basis for seeking health and safety input. This can be achieved in various ways, for example:

- conducting workshops with clients at the conceptual design stage
- using models or mock-ups to facilitate user input
- receiving feedback through user surveys, and
- inviting specialist expertise (such as engineers) to participate in the risk assessment process.

Designers should ask their clients about the types of activities and tasks likely or intended to be carried out in the structure, including the tasks of those who maintain, repair, service or clean the structure as an integral part of its use. *Table 1* provides suggestions to promote an efficient consultation process between a designer and client. All issues identified through research and consultation should be documented so that they can be used to inform future phases of the lifecycle.

Table 1: Designer - client consultation

Step	Possible techniques
Initial discussions	<p>Obtain information on the:</p> <ul style="list-style-type: none"> • Purpose of the structure, including plant and ancillary equipment and tasks; • Industry injury profile and statistics and common hazards and safety issues; and • Guidance from health and safety authorities and relevant associations, and standards. <p>Establish the breadth of hazards and the consultation arrangements between the client and designer.</p>
Pre-design preliminary hazard analysis	<p>Useful techniques may include a combination of the following actions by the client:</p> <ul style="list-style-type: none"> • Conduct workshops and discussions with personnel from similar structures within the client company, including health and safety representatives; • Conduct onsite assessment of an existing similar structure with feedback from the users of the existing structure; • Research information or reports from similar structures on hazards and relevant sources and stakeholder groups and then complete analysis for own design needs; • Conduct workshops with experienced personnel who will construct, use and maintain the new structure; and • Conduct workshops with specialist consultants and experts in the hazards.
Determine what hazards are 'in-scope'	<p>Workshops/discussions to determine which hazards are involved. To be considered important, hazards must be affected, introduced or increased by the design of the structure.</p>

2.3 Preliminary hazard identification

Hazard identification should take place as early as possible in the concept development and design stages. It is important that the hazard identification is systematic and not limited to one or

two people's experiences of situations. *Table 2* outlines a framework for the preliminary hazard identification.

Broad groupings of hazards should be identified before design scoping begins. *Appendix B* provides examples of issues that should be considered. A designer and others involved in the preliminary hazard analysis should then decide which hazards are 'in scope' of the steps of the risk management process, and should be considered in the design process. A hazard is 'in scope' if it can be affected, introduced or increased by the design of the structure. At this early stage, consideration should be given to possible ways that hazards could be prevented or eliminated.

Where there are systems of work which are foreseeable as part of the likely activities in the intended use of a structure as a workplace, they should be identified in the preliminary hazard analysis. Information in the form of likely or intended workflows, if known, will be useful as part of the design brief prepared by the client, including details at the task level.

The brief may also include any activities and systems with hazards specific to the nature of the structure (for example, manual tasks in a health facility or occupational violence in a bank, the storage of dangerous goods in a warehouse) where the safety of these activities or systems is affected by the design of the structure. This may include foreseeable maintenance, cleaning, service and repair activities.

The designer should give consideration to any exceptional hazards or matters a competent builder or user would not be expected to be aware of.

For example, a builder would not necessarily be aware that a long steel span member was unstable until fully fixed into position or that particular props or braces are integral to the safety of a tilt-up panel.

In such situations, the designer should include relevant information either in the drawings or specifications or transfer the information to the builder for appropriate design management.

2.4 Assessing the risks

After identifying all reasonably foreseeable hazards, the risks associated with those hazards should be assessed. A risk assessment involves considering what could happen if someone is exposed to a hazard and the likelihood of it happening.

It is a way of deciding how much effort should be focussed on designing out a hazard – the more serious the risk of harm, the more time and effort should be dedicated to eliminating or minimising the risk.

Risk assessment is not an absolute science, it is an evaluation based on available information. Therefore, it is important those involved in a risk assessment have the necessary information, knowledge and experience of the work environment and work process.

If similar tasks or processes apply for a number of projects, or the design is of a fairly routine nature, a generic risk assessment model might be appropriate. However, the designer is still responsible for ensuring that the generic assessment is valid for the project, before deciding to adopt it.

Risk assessment methods for assessing design safety may include:

- fact finding to determine existing controls, if any
- testing design assumptions to ensure that aspects of it are not based on incorrect beliefs or anticipations on the part of the designer, as to how workers or others involved will act or react (see the above hazard checklist);

- testing of structures or components specified for use in the construction, end use and maintenance
- consulting with key people who have the specialised knowledge and/or capacity to control or influence the design, for example the architect, client, construction manager, engineers, project managers and safety and health representatives, to identify and assess risks; consulting directly with other experts, for example specialist engineers or designers, manufacturers and product or systems designers who have been involved with similar constructions, and
- when designing for the renovation or demolition of existing buildings, reviewing previous design documentation or information recorded about the design structure and any modifications undertaken to address safety concerns; and consulting professional industry or employee associations who may assist with risk assessments for the type of work and workplace.

Appendix C lists a number of risk assessment tools that can be used.

Example

A company managing a multi-million dollar construction project made design changes to improve safety after conducting a risk assessment using the CHAIR (Construction Hazard Assessment Implication Review). They included:

- corridors widened for safer access for movement of goods and people during construction which in turn aided the end users of the building
- standard doors enlarged by 25 per cent to improve access for equipment
- lighting repositioned to allow for easier/safer maintenance access
- windows changed to a 'flip over' style for cleaning from within the building, and
- air conditioners moved to ground level, with the ducts remaining in the originally planned position.

Table 2: Framework for the preliminary hazard identification

Category of hazards	Examples of hazards	Sources of information to decide risk or control measures
Siting of structure	Events or incidents occurring between multiple structures, arising from poor siting, or lack of separation.	Specialist risk techniques may be required. Controls will involve siting of structures. <i>National Construction Code of Australia</i> requirements.
High consequence hazards	The storage and handling of dangerous goods, or work with high energy hazards (for example, temperature, pressure) and health hazards such as biological materials.	Specialist techniques are likely to be necessary to assess risks and controls. Health and safety legislation, Codes of Practice, Australian Standards and guidance will provide information and possible control measures. Cumulative assessment of the overall risk may be necessary for these hazards. <i>National Construction Code of Australia</i> requirements.
Systems of work (involving the interaction of persons with the structure)	The systems of work (including cleaning and maintenance activities of the building or structure) that pose risks (for example, inadequate pedestrian or vehicle separation, restricted access for building and plant maintenance, exposure to hazardous substances, manual tasks, exposure to occupational violence, working at height).	Professionals such as engineers, ergonomists, occupational hygienists, and materials chemists can provide information on controls and suitable assessment techniques.
Environment	Environmental conditions that are not part of the specific system of work, such as inadequate ventilation or lighting and welfare facilities that do not meet workplace needs.	The requirements of standards (for example, <i>National Construction Code of Australia</i> , Australian Standards, building and other legislation are generally sufficient if particular hazards or systems of work do not require a specific approach).
Incident mitigation	The possibility of the structure to increase the consequences after an incident due to inadequate egress, siting of assembly areas, inadequate emergency services access.	<i>National Construction Code of Australia</i> requirements, building and other standards. Liaison with Emergency Services.

3. DESIGN DEVELOPMENT PHASE

In this phase the detailed design is developed, methods of operation are decided and construction documentation is prepared. The design reaches maturity and is handed to the client. The design development phase should involve (see *Table 3*):

- a) Identify hazards that can be adequately addressed by applying existing solutions in recognised standards, or
- b) Conduct a risk management process:
 - Identify hazards and assess the level of risk by combining the consequences and likelihood of something going wrong during the lifecycle.
 - Consider both technical and human factors, including humans' ability to change behaviour to compensate for design changes. Anticipate misuse throughout the lifecycle.
 - Develop a set of design options in accordance with the hierarchy of risk controls.
 - Select the optimum solution. Balance the direct and indirect costs of implementing the design against the benefits derived.
 - Test, trial or evaluate the design solution and redesign to control any residual risks, if reasonably practicable.
- c) Finalise the design and prepare risk control plans for the lifecycle of the product.

Table 3: Design process

Step	Possible techniques	By whom
Identify solutions from recognised standards	Consult with all relevant persons to determine which hazards can be addressed with recognised standards. Plan the risk management process for other hazards.	Designer led. Client approval of decisions.
Apply appropriate risk management techniques	Integrate detailed risk management into the design development process. For the risk assessment, further detailed information may be required on hazards: <ul style="list-style-type: none"> • hazard identification • risk assessment checklists developed by health and safety authorities (such as manual tasks, noise, plant, hazardous substances) and • job/task analysis techniques. A variety of quantified and/or qualitative risk assessment measures can be used to check the effectiveness of control measures. Scale models and consultation with experienced industry personnel may be necessary to achieve innovative solutions to longstanding issues that have caused safety problems.	Designer led. Client provides further information as agreed in the planned risk management process.
Discuss design options	Take into account how design decisions determine risks when discussing design risk control options.	Designer led. Client contributing.
Design finalisation	Check that the evaluation of design risk control measures is complete and accurate. Prepare information about risks to health and safety for the structure that remain after the design process.	Designer led. Client and designer agree with final result.
Potential changes in construction stage	Ensure that changes which affect design do not increase risks, for example, substitution of flooring materials which could increase slip/fall potential	Construction team in consultation with designer and client.

Step	Possible techniques	By whom
	and may introduce risks in cleaning work.	

3.1 Implement solutions from recognised standards

Other legislative provisions governing the design of buildings and structures in Australia include the building laws in each jurisdiction and the *National Construction Code of Australia* (NCCA). The Building Code of Australia (BCA) is part of the NCCA. In addition, there are technical and engineering guidelines and standards produced by other government agencies, Standards Australia and relevant professional bodies (see *Appendix D*).

The primary focus of the NCCA is to ensure buildings and structures achieve acceptable standards of structural sufficiency, safety, health and amenity. It contains technical provisions for the design and construction of buildings and other structures relating to structural sufficiency, fire spread within and between buildings, building occupant access and egress, fire fighting equipment, smoke hazard management and fire brigade access to buildings. In addition, health and safety amenity aspects such as ventilation, lighting, legionella controls, sanitary facilities and damp and weatherproofing measures are covered in the NCCA.

The NCCA refers to Australian Standards, but designers should be aware that these may not adequately control workplace risks if applied to a situation outside that contemplated in the Standard or if the Standard is out-dated. It should also be noted that the NCCA does not provide guidance for some specialised structures such as major hazard facilities (for example, refineries). WHS Regulations require work health and safety issues to be addressed in addition to those in existing legislative and regulatory provisions, such as the NCCA, which regulate the design of buildings and structures.

3.2 Conduct a risk management process

The hierarchy of risk control

The ways of controlling risks are ranked from the highest level of protection and reliability to the lowest. This ranking is known as the *hierarchy of risk control*.

The WHS Regulations require duty holders to work through this hierarchy to choose the control that most effectively eliminates or minimises the risk in the circumstances. This may involve a single control measure or a combination of two or more different controls.

- *Elimination* – The most effective control measure involves eliminating the hazard and associated risk. By designing-in or designing-out certain features, hazards may be eliminated. For example, designing components which facilitate pre-fabrication on the ground can avoid the need for working at height and therefore eliminate the risk of falls.

If it is not reasonably practicable to eliminate a hazard the following control measures should be considered:

- *Substitution* – replace a hazardous process or material with one that is less hazardous to reduce the risk. For example:
 - Using pre-cast panels rather than constructing a masonry wall
 - Using pre-finished materials in preference to on-site finishing
- *Isolation* – separate the hazard or hazardous work practice from people, for example designing the layout of a building so that noisy machinery is isolated from workstations
- *Engineering* – use engineering control measures to minimise the risk, for example, including adequate ventilation and lighting in the design, designing and positioning permanent anchorage and hoisting points into buildings where maintenance needs to be undertaken at height

- *Administrative* – If engineering controls cannot reduce the risk sufficiently, then administrative controls should be used, for example using warning signs or exclusion zones where a hazardous activity is carried out.
- *Personal protective equipment* – Personal protective equipment (for example hard hats, respiratory protection, gloves, ear muffs) should be used to protect the worker from any residual risk. It is the least effective control measure as it relies on the worker's behaviour and therefore requires thorough training and a high level of supervision to be effective.

In many cases a combination of control measures will be required to minimise the risks to health and safety. For example traffic flow at a workplace may be controlled by incorporating traffic islands (engineering) and erecting warning signs (administrative).

When considering which control measures to implement:

- look specifically at identifying any exceptional risks that a competent builder might not be aware of or have the appropriate level of expertise
- consider where residual risks remain, and ensure these are communicated to the builder and/or other people likely to exercise control in the next stages of the life cycle of the building or structure, for example clients and maintenance contractors
- take a holistic view on the interaction of hazards in the assessment of their risks and implementation of control measures, and
- assess alternative control measures for their applicability.

3.3 Reviewing control measures

Designers should review design solutions to confirm the effectiveness of risk controls and if necessary, redesign to reduce the risks as far as reasonably practicable.

Controls can be checked by using the same methods as in the initial hazard identification. Common methods include workplace inspection, consultation, testing and analysing records and data.

Feedback from users to assist designers to improve their designs could be provided through:

- post occupancy evaluations for buildings
- defect reports
- accident investigation reports
- information regarding modifications
- user difficulties, or
- deviations from intended conditions of use.

4. DESIGN CONSIDERATIONS FOR CONSTRUCTION, USE AND MAINTENANCE

This chapter provides examples of design options to control risks in various stages of the lifecycle. Further examples of risk controls are included in *Appendix E*.

4.1 Building elements

Potential control measures to implement in relation to building elements include:

Excavation

- Avoiding additional or different excavation depths near site boundary, for example designing lift shafts away from boundaries.

Walls and tilt-up panels

- Limiting the size of tilt panels where site access is restricted.
- Installing mesh guards to window and door openings on panels prior to installation.
- Fixing windows in place at ground level prior to erection of panels.
- Considering the use of pour strips to assist in stability of wall panels as erection proceeds.

Nature and pitch of roofing

- Considering any maintenance requirements and the need for access.

Plastering

- Using suspending systems, pre-formed corner and bulkhead sections to reduce dust during finishing.
- Changing the design to use smaller sheets, use lifters to hoist sheets and preloading floors to reduce manual handling hazards.

Plumbing

- Using prefabricated risers to eliminate on site work and the need to work at heights.

Beams

- Designing concrete beams so they can be erected from above, to prevent the risk of workers being crushed should the beams become dislodged during installation.
- Designing beam to column connections to have support from the column during the connection process by adding a beam seat, extra bolt hole or other redundant connection point that provides continual support for beams during erection.

Flooring

- Considering floor treatment specifications to take into account the end use. For example, incorporating use of slip resistant surfaces in areas exposed to the weather, frequent spills or dedicated wet areas.

Lighting

- Ensuring adequate lighting for intended jobs and tasks in the building.
- Providing for exterior lighting that eliminates shadows at entry/exit points.
- Selecting lighting fixtures that can be lowered to ground level for repair.

4.2 Building techniques

Potential control measures to implement in relation to building technique include:

- Relocating power lines or placing them underground before construction.
- Ensuring power lines are the correct distance from the building to reduce exposure to radiation from the lines.
- Consider the exposure of people to extremely low frequency radiation from internal power sources such as distribution boards, electrical wiring and lifts.
- Clearly indicating on documents design loads for the different parts of the structure.
- Considering different erection processes for steel structures.
- Designing components to facilitate pre-fabrication off site or on the ground so they are erected in place as complete assemblies, reducing worker exposure to falls from heights or being struck by falling objects.
- Considering different construction sequences.
- Considering the complexity of the design.

4.3 Construction process

Potential control measures to implement in relation to the construction process include:

- Minimising or eliminating the need for confined/enclosed work spaces
- Considering work at heights
- Minimising the need to work at height, for example by positioning air-conditioning units and lift plant at ground level or designing to enable construction at ground level
- Designing parapets to a height that complies with guardrail requirements, eliminating the need to construct guardrails during construction
- Designing and scheduling permanent stairways constructed at the beginning of the project to help prevent falls and other hazards associated with temporary stairs and scaffolding.
- Consider the use of power tools by limiting the extent of on-site fabrication; and considering access and egress during construction for people and vehicles.

Specific Hazards or Risks

Potential control measures to implement in relation to specific hazards or risks include the following.

Falls

- Considering design features that can mitigate the risk of falls, both during construction, occupation, maintenance and demolition, such as reducing the spacing of roof trusses and battens or installation of meshing to decrease the risk of internal falls.

Electrocution

- Indicating, where practicable, the position and height of all electric lines to assist with site safety procedures.
- Reorienting the building or structure to avoid overhead or underground services.
- Providing adequate clearance between the building or structure and overhead power lines.
- Specifying Residual Current Devices (RCDs) are to be used in all temporary power circuits during construction.

Traffic

- Designing traffic areas to separate vehicles and pedestrians during construction and end use.
- Moving the building back from the roadway to facilitate safety of delivery workers.

Inhalation of fumes or dust

- Designing pre-fabricated panels with channels for electrical cables and plumbing to reduce chasing.
- Selecting materials like paints or other finishes that emit low volatile organic compound emissions.

Noise

- Encapsulation or isolation of noisy plant and equipment.
- Procurement of plant and equipment with noise levels that complement safe noise level guidelines.

Toxic gases, vapours, chemicals

- Selection of non-hazardous products or chemicals where available.
- Changing coating types to be non-toxic, especially where they are to be applied in enclosed spaces, such as underground car parks, kitchens and toilets.
- Selecting materials like paints or other finishes which emit low volatile organic compounds.

4.4 End use

Potential control measures to implement in relation to end use include the following.

Occupation and use

- Designing adequate access, for example, allowing wide enough corridors in nursing homes for the movement of patients on wheelchairs and beds.
- Designing interior acoustics to meet intended use requirements.
- Designing spaces to accommodate or incorporate mechanical devices to reduce manual handling risks.
- Considering exposure to specific hazards such as manual handling in a health facility, violence in a bank and dangerous goods storage in a warehouse.
- Considering injuries due to:
 - poorly designed seating
 - inadequate or poorly placed lighting, and
 - lack of consideration given to human behaviour including errors.

Maintenance and repair

- Allowing for access for maintenance, providing hatches, walkways or stairways.
- Designing so that maintenance operations, such as windows, light bulbs and smoke detectors, can be done from ground level or from the structure. For example, inward opening windows with window cleaning bays or gangways integrated into the structural frame.
- Incorporating building maintenance units for multi-storey buildings to avoid the use of rope access methods or long ladders for cleaning windows.
- Designing and positioning permanent anchorage and hoisting points where maintenance needs to be done at height.
- Using durable materials that do not need to be coated or treated after occupation.
- Including safety rails and harness connection points.
- Designing adequate access/egress. For example, considering how windows positioned high in a void area will be accessed for cleaning.

5. DESIGN CONSIDERATIONS FOR MODIFICATION, DEMOLITION AND DISMANTLING

5.1 Modification

Design is not always focussed on the generation of an entirely new structure. It can involve the alteration of an existing structure which may require demolition in part or whole.

Any modification of a structure requires reapplication of the processes detailed in the design phases. Consultation with professional engineers or other experts may be necessary in order to assess the impact of any proposed modifications or changes in design, for example changes in the load spread across a building floor when heavy equipment is relocated, modified or replaced.

This ensures that no new hazards are introduced, and that the safety features already incorporated into the design are not affected. Additional design issues identified in these phases should be passed back to the designer.

5.2 Demolition and dismantling

In relation to the proper demolition or disposal of a structure, designers also have a duty in the WHS Act to:

- carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary for the structure to be without risks to the safety of persons, and
- provide adequate information to each person who is provided with the design concerning any conditions necessary to ensure that the structure is without risks to health and safety.

This is particularly important with modern designs where 'limit state' design techniques are used by the structure designer. In this system, the designer considers the structure in its completed form with all the structural components, including bracing, installed. The completed structure can withstand much higher loads (for example, wind and other live loads) than when the structure is in the construction or demolition stage. With this in mind it is necessary for the designer to provide guidance to the demolisher on how the structure will remain standing as it is demolished or dismantled.

Designers should take into account the proposed work methods to be used during demolition when producing any final design documents relating to the demolition of a 'special structure'. If as-built design documentation is not available for special structures, then a competent person (for example, a qualified structural engineer) should be engaged to conduct an engineering investigation.

Demolition risk assessment documentation for special structures should take the following design matters into account:

- the stability and structural integrity of the assembled portions, single components and completed sequentially erected braced bays at all stages of demolition
- the maximum permissible wind speed for the partially demolished structure
- the effect of the structural engineer's approved demolition sequence on stability
- the structural engineer's assessment of loadings at all stages of demolition
- the provision of safe access and safe working areas
- the provision of clear instructions for temporary bracing
- the handling, lifting, storing, stacking and transportation of components, depending on their size, shape and weight
- the need for specific lifting arrangements to be detailed on structural member drawings to facilitate safe lifting

- the stability requirements for all components of the structure as it is sequentially demolished according to the structural engineer's requirements
- the proposed methods for handling heavy, bulky or awkward components as may be described in the Safe Work Method Statement (SWMS)
- the plant to be used for the work, including the size, type, position and coverage of proposed demolition crane(s) should be indicated on a site plan; locations such as unloading points and storage areas (if any) should be shown, and
- the need to ensure that the ground is compacted to any design specifications to enable plant to be moved and used safely at the workplace.

Designers of new structures are well placed to influence the ultimate demolition of a structure by designing-in facilities such as lifting lugs on beams or columns and protecting inserts in pre-cast panels so that they may be utilised for disassembly. Materials and finishes specified for the original structure may require special attention at the time of demolition and any special requirements for the disposal and/or recycling of those materials or finishes should be advised to the client through the risk assessment documentation.

Further guidance on the demolition of buildings and structures can be found in the *[draft] Code of Practice: Demolition Work*.

APPENDIX A – ROLES AND RESPONSIBILITIES

Some design tasks, although related, may be controlled by different designers due to contractual arrangements. *Figures 2 a-e* illustrate the often complex arrangements established for construction projects, and how the parties could consult, co-operate and co-ordinate safe design activities with each other.

Note: There can only be one principal contractor for a construction project. The client may appoint the Construction Manager or one of the Prime Contractors as the Principal Contractor depending on who will have management and control of the workplace.

Figure 2a

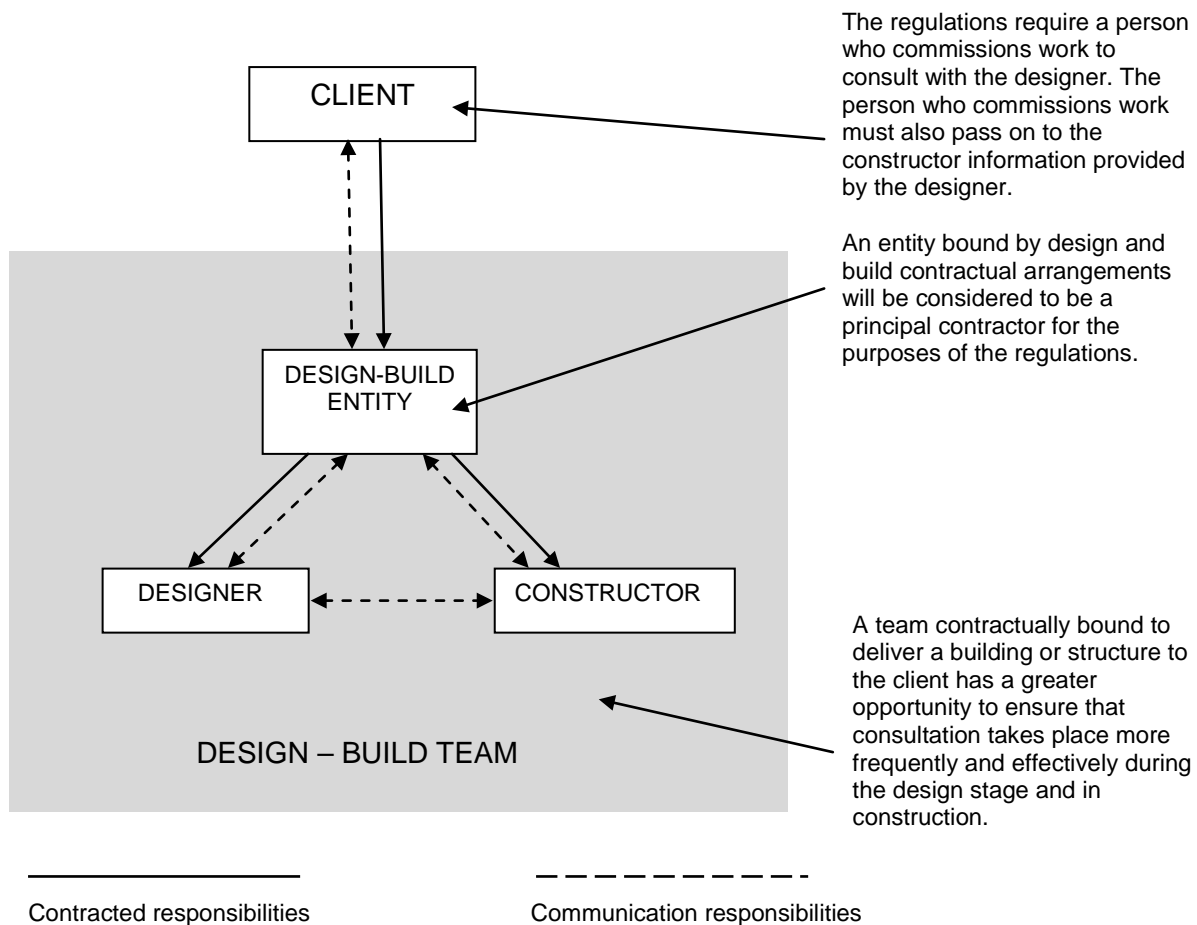


Figure 2b

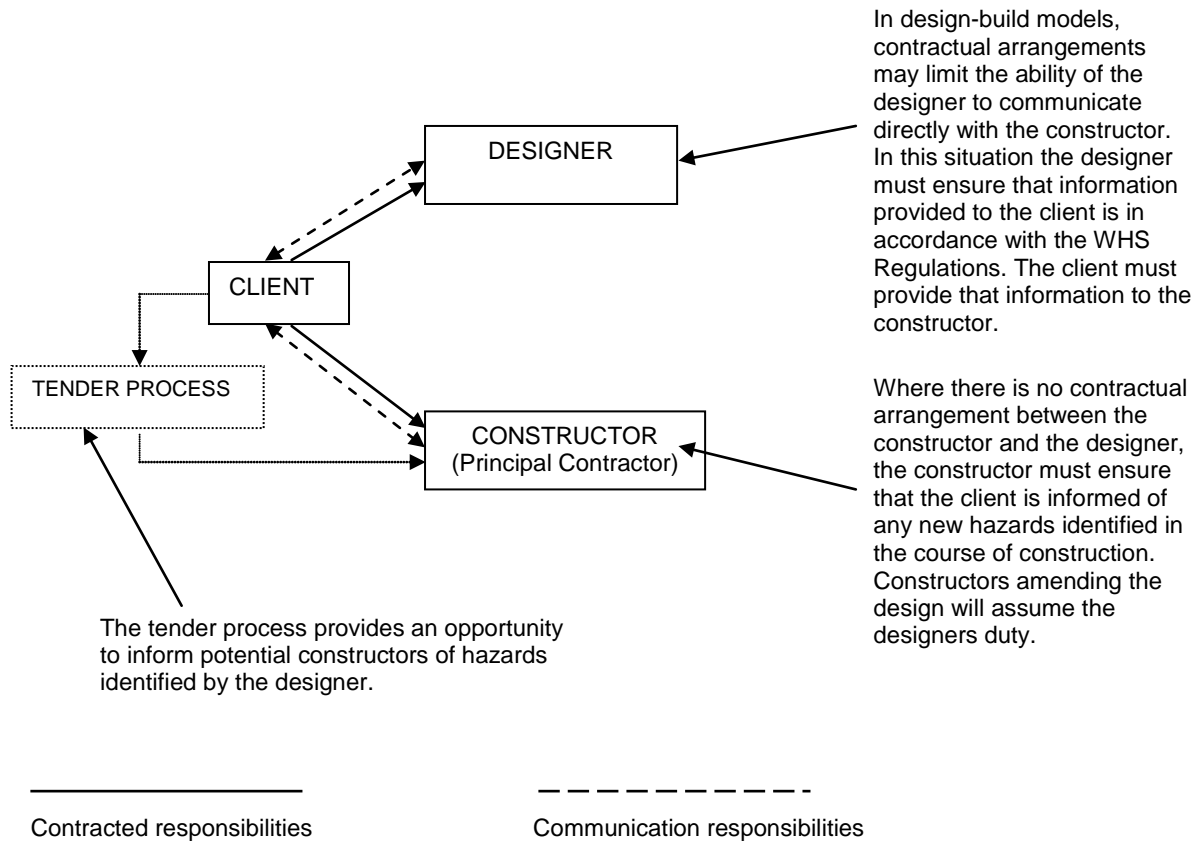


Figure 2c

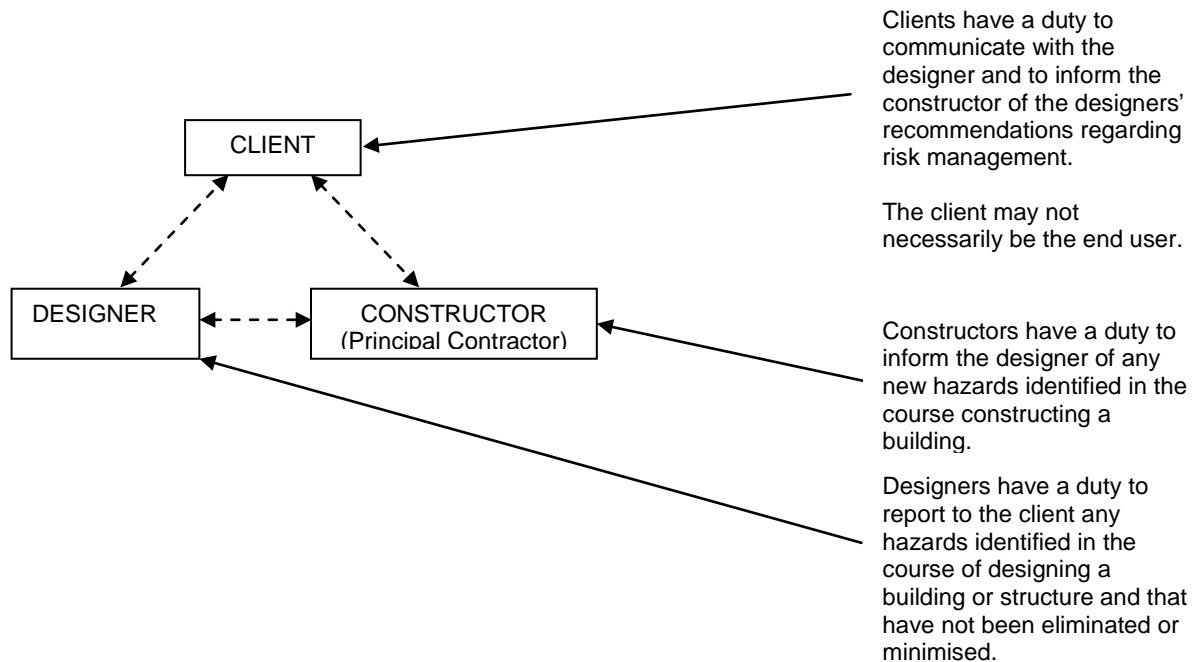


Figure 2d

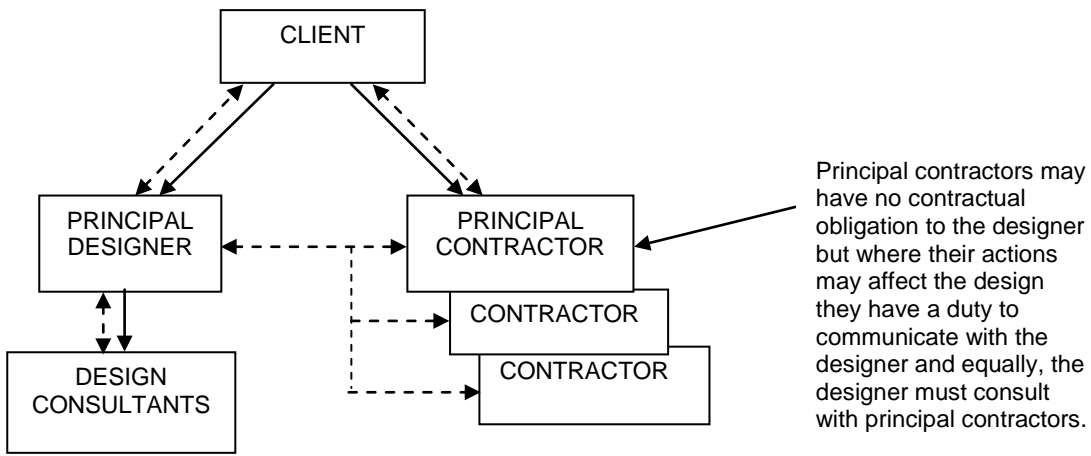
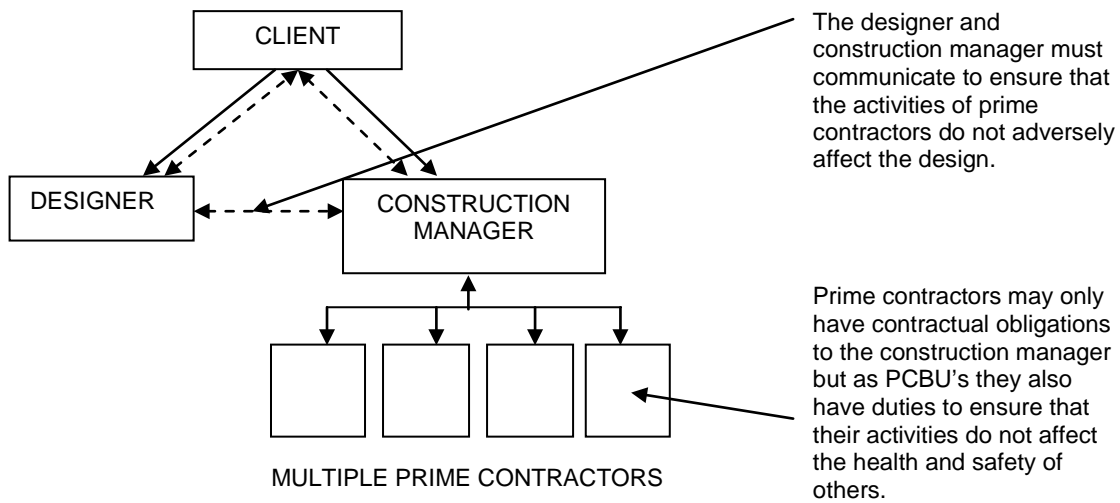


Figure 2e



APPENDIX B – HEALTH AND SAFETY CONSIDERATIONS

Electrical safety

- Electrical installations
- Underground power cables
- Proximity to exposed cables
- Work near high voltage power lines
- Number and location of power points

Fire and emergencies

- Fire risks
- Fire detection and fire fighting
- Emergency routes and exits
- Access for and structural capacity to carry fire tenders
- Other emergency facilities

Movement of people and materials

- Safe access and egress
- Traffic route and control
- Loading bays and ramps
- Other emergency facilities

Radiation

- Exposure to ionising radiation
- Exposure to non-ionising radiation, for example, electromagnetic radiation

Working environment

- Ventilation for thermal comfort and general air quality and specific ventilation requirements for the work to be performed on the premises
- Temperature
- Lighting including that of plant rooms
- Acoustic properties and noise control, for example, noise isolation, insulation and damping
- Seating
- Slipperiness of floor surfaces for buildings
- Space for occupants

Plant

- Tower crane locations, loading and unloading
- Mobile crane loads on slabs
- Plant and machinery installed in a building or structure
- Materials handling plant and equipment
- Maintenance access to plant and equipment
- The guarding of plant and machinery
- Lift installations

Amenities and facilities

- Access to various amenities and facilities such as storage, first aid rooms/sick rooms, rest rooms, meal and accommodation areas and drinking water

Earthworks

- Excavation (for example, risks from earth collapsing or engulfment in swampland)
- Exposure to underground utilities

Structural safety

- Erection of steelwork or concrete frameworks
- Temporary fragility or instability of structure
- Load bearing requirements
- Stability and integrity of the structure

Manual handling

- Methods of material handling
- Accessibility of material handling
- Loading docks and storage facilities
- Access and egress paths and doorways to facilitate doorway or other mechanical aids
- Assembly and disassembly of pre-fabricated fixtures and fittings

Substances

- Exposure to hazardous substances and materials including insulation and decorative materials
- Exposure to volatile organic compounds and off gassing through the use of composite wood products or paints
- Exposure to irritant dust and fumes

Falls prevention

- Guard rails
- Footholds on or near guard railing
- Window heights and cleaning
- Anchorage points for building maintenance and cleaning
- Access to working spaces for construction, cleaning, maintenance and repairs
- Scaffolding
- Temporary work platforms
- Roofing materials and surface characteristics such as fragility, slip resistance and pitch

Specific risks

- Exposure to biological hazards
- Use of explosives
- Confined spaces
- Risk of drowning
- Over and under water work, including diving and work in caissons with compressed air supply

Noise exposure

- Exposure to noise from plant
- Exposure to noise from surrounding area
- Design of workplace layout

APPENDIX C – RISK ASSESSMENT TOOLS

CHAIR (*Construction Hazard Assessment Implication Review*) has been specifically developed for the construction industry by WorkCover New South Wales. The primary aim of CHAIR is to identify hazards and eliminate or minimise risks as early as possible in the life of a project. While it is focused on safety, the process also takes into account operational requirements, aesthetics and financial considerations, with a view to producing the safest possible design in all the circumstances.

The designer misconception tool helps designers systematically test products and processes for misconceptions about how people will act or fail to act in particular situations. It complements other tools for technical analysis and is based on the premise that many design faults are due to the fact that the designer either has an incorrect belief about how a person will act or a situation will develop, or fails to anticipate these.

Event tree analysis (ETA) is used to identify initiating events and then considers how often they might occur and possible outcomes. The initiating event may be a failure within a system or an external event. ETA starts with the initiating event and then searches forward. Event trees are well suited to analysing failsafe mechanisms in safety critical systems, for example a centralized gas heating hot water system in a building.

Fault tree analysis (FTA) is a technique used to identify and pictorially depict conditions and factors that can lead to undesirable events. Possible causes of fault modes in functional systems are identified by assessing what could go wrong. It is a technique that could be used to further analyse undesirable events identified during the CHAIR process. FTA can assist the designer or engineer to focus on causes and faults likely to have the most severe consequences and how frequently these might occur. FTA could be used in a construction setting to analyse and assess the importance of the consequences of a failure of computer driven systems within a building.

Fault mode effects analysis (FMEA) is used to identify potential failures in a structural or mechanical design. The process breaks down the design into appropriate levels for examination to identify the potential modes and consequences of failures and the effect that this may have on the component and the systems as a whole. This technique asks the question: if this part fails, in this manner, what will be the result? Further questions are then asked about:

- how each component might fail;
- the possible causes of these failures;
- the effects of these failures;
- the seriousness of these failures; and
- the means of detection of each failure mode.

FMEA typically considers and ranks severity from 1-10, minor to major, and consequences in categories I-IV, minor to catastrophic.

Preliminary hazard analysis (PHA) is used to identify hazards, hazardous situations and events that can cause harm in particular situations. It is often used early in the development of a project but can be used in other phases of the life cycle, for example prior to renovation or demolition.

Human reliability assessment (HRA) deals with the impact of people on system performance and the influence of human errors in reliability.

Constructability ('buildability') review is a review of plans and the design to check for buildability. It is an approach that links the design and construction processes. This type of review

can be useful for identifying potential hazards and risks in the design of a building or structure, allowing these to be addressed at less cost than when construction commences.

Building Information Modelling (BIM) The risk assessment process can also be assisted by the use of software programs such as BIM. BIM is a sophisticated 4D tool for managing complex projects and has advantages in that it can enable designers to predict unsafe situations that will emerge during the construction phase, for example determining if there are conflicts between elements such as air conditioning ductwork and structural columns or beams and in doing so, eliminate unnecessary work at heights or onsite adjustments in less than ideal conditions. BIM can also predetermine optimum positions for cranes or other plant and therefore, predict opportunities to position large and/or heavy structural sections or fixed plant under optimum conditions. BIM also facilitates the prefabrication or preassembly of building components which can minimise work needed on site, and therefore, reduce risks by allowing complex tasks to be undertaken in more controlled environments.

APPENDIX D – TECHNICAL STANDARDS AND OTHER REFERENCES

Technical Standards

Technical standards are developed and published by organisations such as Standards Australia (AS), European Standards (EN), American National Standards Institute (ANSI), British Standards Institute (BS), and Standards New Zealand (NZS), that are authorised for that purpose by their national government. International bodies, such as the International Organisation for Standardisation (ISO), also develop and publish standards, which may be adopted by individual organisations.

Note: This list of technical standards is not intended to be exhaustive. Designers should identify additional technical standards relevant to a specific project.

Reference	Title
AS 1170 (Part 1)	Structural design actions - Permanent, imposed and other actions
AS 1170 (Part 2)	Structural design actions - Wind actions
AS 1319	Safety signs for the occupational environment
AS/NZS 1576 (set)	Scaffolding - General requirements
AS 1657	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS 1674.1	Safety in welding and allied processes – Fire precautions
AS/NZS 1680.1	Interior and workplace lighting – General principles and recommendations
AS/NZS 1680.2.4	Interior lighting – Industrial tasks and processes
AS 1668.2	The use of ventilation and air conditioning in buildings
AS 1735	Lifts, escalators and moving walks (known as the SAA Lift Code)
AS 1940	The storage and handling of flammable and combustible liquids
AS 2550 (set)	Cranes, hoists and winches - Safe use - General requirements
AS 2601	The demolition of structures
AS 3000	Electrical installation (known as the Australian New Zealand wiring rules)
AS 3610	Formwork for concrete
AS 3610 (Sup 2)	Formwork for concrete – Commentary
AS 3600	Concrete structures
AS 3828	Guidelines for the erection of building steelwork
AS 3850.1	Prefabricated concrete elements – General Requirements
AS 3850.2	Prefabricated concrete elements – Building Construction
AS 4024.1 (set)	Safety of machinery

Reference	Title
AS 4100	Steel structures
AS/NZS 4114	Spray painting booths
AS/NZS 4360	Risk management
AS/NZS 4389	Safety mesh
AS/NZS 4576	Guidelines for scaffolding
AS/NZS 4801	Occupational health and safety management systems – Specification with guidance for use
AS/NZS 4994	Roof edge protection equipment

Other References

Australian Code for the Transport of Explosives by Road and Rail (3rd edition), Commonwealth of Australia 2009

Building Code of Australia, Australian Building Codes Board 2010

Workplace Exposure Standards for Airborne Contaminants, Safe Work Australia

Guidance on the Principles of Safe Design for Work, Australian Safety and Compensation Council 2006

APPENDIX E – RISK CONTROL EXAMPLES

<p>Design for safe construction</p>	<p>Risks relating to the construction of a structure can be controlled by:</p> <ul style="list-style-type: none"> • Providing adequate clearance between the structure and overhead electric lines by burying, disconnecting or re-routing cables before construction begins, to avoid ‘contact’ when operating cranes and other tall equipment. • Designing components which facilitate pre-fabrication off-site or on the ground to avoid assembling or erecting at heights and to reduce worker exposure to falls from heights or being struck by falling objects. • Designing parapets to a height that complies with guardrail requirements, eliminating the need to construct guardrails during construction and future roof maintenance. • Using continual support beams for beam-to-column double connections, be it adding a beam seat, extra bolt hole, or other redundant connection points during the connection process. This will provide continual support for beams during erection – to eliminate falls due to unexpected vibrations, misalignment and unexpected construction loads. • Designing and constructing permanent stairways to help prevent falls and other hazards associated with temporary stairs and scaffolding, and schedule these at the beginning of construction. • Reducing the space between roof trusses and battens to reduce the risk of internal falls during roof construction. • Choosing construction materials that are safe to handle.
<p>Design to facilitate safe use</p>	<p>Consider the intended function of the structure, including the likely systems of use, and the type of machinery and equipment that may be used.</p> <p>Consider whether the structure may be exposed to specific hazards, such as manual tasks in health facilities, occupational violence in banks or dangerous goods storage in warehouses.</p> <p>In addition to the requirements of the <i>National Construction Code of Australia</i>, risks relating to the function of a structure can be controlled by:</p> <ul style="list-style-type: none"> • Designing traffic areas to separate vehicles and pedestrians. • Using non-slip materials on floor surfaces. • Providing sufficient space to safely install, operate and maintain plant and machinery. • Designing spaces which accommodate or incorporate mechanical devices and therefore reducing manual task risks. • Designing floor loadings to accommodate heavy machinery that may be used in the building.
<p>Design for safe maintenance</p>	<p>Risks relating to cleaning, servicing and maintaining a structure can be controlled by:</p> <ul style="list-style-type: none"> • Designing the structure so that maintenance can be performed at ground level or safely from the structure, for example, window cleaning bays or gangways integrated into the structural frame. • Designing features which use non-corrosive materials to avoid dirt traps and the use of abseiling methods or long ladders for cleaning windows. • Designing and positioning permanent anchorage and hoisting points into structures where maintenance needs to be undertaken at height. • Designing safe access and sufficient space to undertake structure maintenance activities.