

SAFE DESIGN OF STRUCTURES

Code of Practice

This DRAFT Code has been approved by Safe Work Australia Members and is ready for approval by the Select Council on Workplace Relations (Ministerial Council). This Code will become a model WHS Code of Practice under the Inter-Governmental Agreement for Regulatory and Operational reform in OHS when it is approved by the Ministerial Council.

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1. FOREWORD

This Code of Practice on the safe design of 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 Select Council for Workplace Relations on [*to be completed*].

SCOPE AND APPLICATION

The Code provides practical guidance to persons conducting a business or undertaking who design structures that will be used, or could reasonably be expected to be used, as a workplace. This includes architects, building designers and engineers.

This Code is also relevant for anyone making decisions that influence the design outcome, such as clients, developers and builders.

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, roads, bridges, rail 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.

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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.

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2. INTRODUCTION

Eliminating hazards at the design or planning stage is often easier and cheaper to achieve than making changes later when the hazards become real risks in the workplace.

Safe design can result in many benefits, including:

- more effective 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
- innovation, in that safe design can demand new thinking to resolve hazards that occur in the construction phase and in end use.

Design, in relation to a structure, includes the design of all or part of the structure and the redesign or modification of 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.

2.1 What is safe design?

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.

The safe design of a 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 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, demolition or dismantling and disposal
- what legislation, codes of practice and standards need to be considered and complied with.

2.2 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.

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

- preparing sketches, plans or drawings for a structure, including variations to a plan or changes to a structure

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- making decisions for incorporation into a design that may affect the health or safety of persons who construct, use or carry out other activities in relation to the structure.
- They include:
 - architects, building designers, engineers, building surveyors, interior designers, landscape architects, town planners 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 firms or others designing services that are part of the structure such as ventilation, 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
 - persons who specify how structural alteration, demolition or dismantling work is to be carried out.

A person conducting a business or undertaking who alters or modifies a design without consulting the original or subsequent designer will assume the duties of a designer. Any changes to the design of a structure may affect the health and safety of those who work on or use the structure and must be considered by the person altering or modifying a design.

The duties also apply to designers of domestic residences, only to the extent that at some stages in the lifecycle the residence may become a workplace and the design could affect the health and safety of workers who will carry out work on the building, such as construction, maintenance and demolition.

A person conducting a business or undertaking that commissions construction work (the client) has specific duties under the WHS Regulations 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.

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

The principal contractor has 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. Further guidance on managing risks for construction projects and principal contractor duties is available in the *Code of Practice: Construction Work*.

A person conducting a business or undertaking who commissions a design or construction work or a construction project is referred to in this Code as the 'client'.

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2.3 What is 'reasonably practicable' in relation to the designer's duty?

The duty of a person conducting a business or undertaking to ensure health and safety 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 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 structure.

In the process of designing 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 the 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:

- 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
- providing guidance on how a structure might be constructed safely
- carrying out the above in collaboration 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.

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3. KEY ELEMENTS OF SAFE DESIGN

3.1 Use a risk management approach

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 steps outlined in Chapter 3 of this Code:

- identify reasonably foreseeable hazards associated with the design of the structure
- if necessary, assess the risks arising from the hazards
- eliminate or minimise the risk by designing 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*.

3.2 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 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, proper demolition or 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 design solutions for reasonably foreseeable hazards that may occur as the structure is built, 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.

3.3 Knowledge and capability

In addition to core design capabilities relevant to the designer's role, a designer should also have:

- knowledge of work health and safety legislation, codes of practice and other regulatory requirements
- an understanding of the intended purpose of the structure
- knowledge of risk management processes
- knowledge of technical design standards
- an appreciation of construction methods and their impact on the design
- 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.

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3.4 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, 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.

So far as is reasonably practicable, the duty holders involved must consult each other on the hazards and risks associated with the building and work together on appropriate design solutions. This would include a client co-operating with a designer in changing a design to address a health and safety risk identified in the design process.

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

Appendix A provides examples of consultation, co-operation and co-ordination between duty holders in various contractual relationships.

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

3.5 Information transfer

Key information about identified hazards and action taken or required to control risks should be recorded and transferred from the design phase to those involved in later stages of the lifecycle. Communicating this information to other duty holders will make them aware of any residual risks and minimise the likelihood of safety features incorporated into the design being altered or removed by those engaged in subsequent work on or around the building or structure.

The WHS Act requires designers to give adequate information to each person who is provided with the design in order to give effect to it concerning:

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- 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.

Points for designers to consider when providing information include:

- making notes on drawings, as these will be immediately available to construction workers
- 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
 - any parts of the design where risks have been minimised but not eliminated
 - noise and vibration hazards from plant.

Methods of transferring information

Safety report

The WHS Regulations require a designer to provide a written report to the person conducting a business or undertaking who commissioned the design that specifies 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 safety report applies to designs of structures that have unusual or atypical features which present hazards and risks during the construction phase that are unique to the particular design.

The 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 those risks, for example changes to the design.

The information requirements under the WHS Act may be incorporated into the safety report prepared under the WHS Regulations.

The client must provide a copy of the safety report to the principal contractor.

Work health and safety file

The development of a work health and safety (WHS) file for a structure could assist the designer meet the duty to provide information to others. It could include copies of all relevant health and safety information the designer prepared and used in the design process, such as the safety report, risk register, safety data sheets, manuals and procedures for safe maintenance, dismantling or eventual demolition.

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4. INTEGRATING DESIGN AND RISK MANAGEMENT

A systems approach that integrates the risk management process in the design phases and encourages collaboration between a client, designer and constructor is recommended (see Figure 1).

4.1 Pre-design phase

This stage of the process involves:

- Establishing the design context in terms of the purpose of the structure, as well as the scope and complexity of the project
- Establishing the risk management context by identifying the breadth of workplace hazards and relevant legislation, codes of practice and standards that need to be considered
- Identifying the required design disciplines, skills and competencies
- Identifying the roles and responsibilities of various parties in relation to the project, and establishing collaborative relationships with clients and others who influence the design outcome
- Conducting consultation and research to assist in identifying hazards, assessing and controlling risks

Consultation

The client should prepare a project brief that includes the safety requirements and objectives for the project. This will enable a shared understanding of safety expectations between the client and designer.

The client must give the designer all available information relating to the site that may affect health and safety.

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.

Research

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 statistics regarding injuries and incidents
- hazard alerts or other reports from relevant statutory authorities, unions and employer associations, specialists, professional bodies representing designers and engineers
- research and testing done on similar designs.

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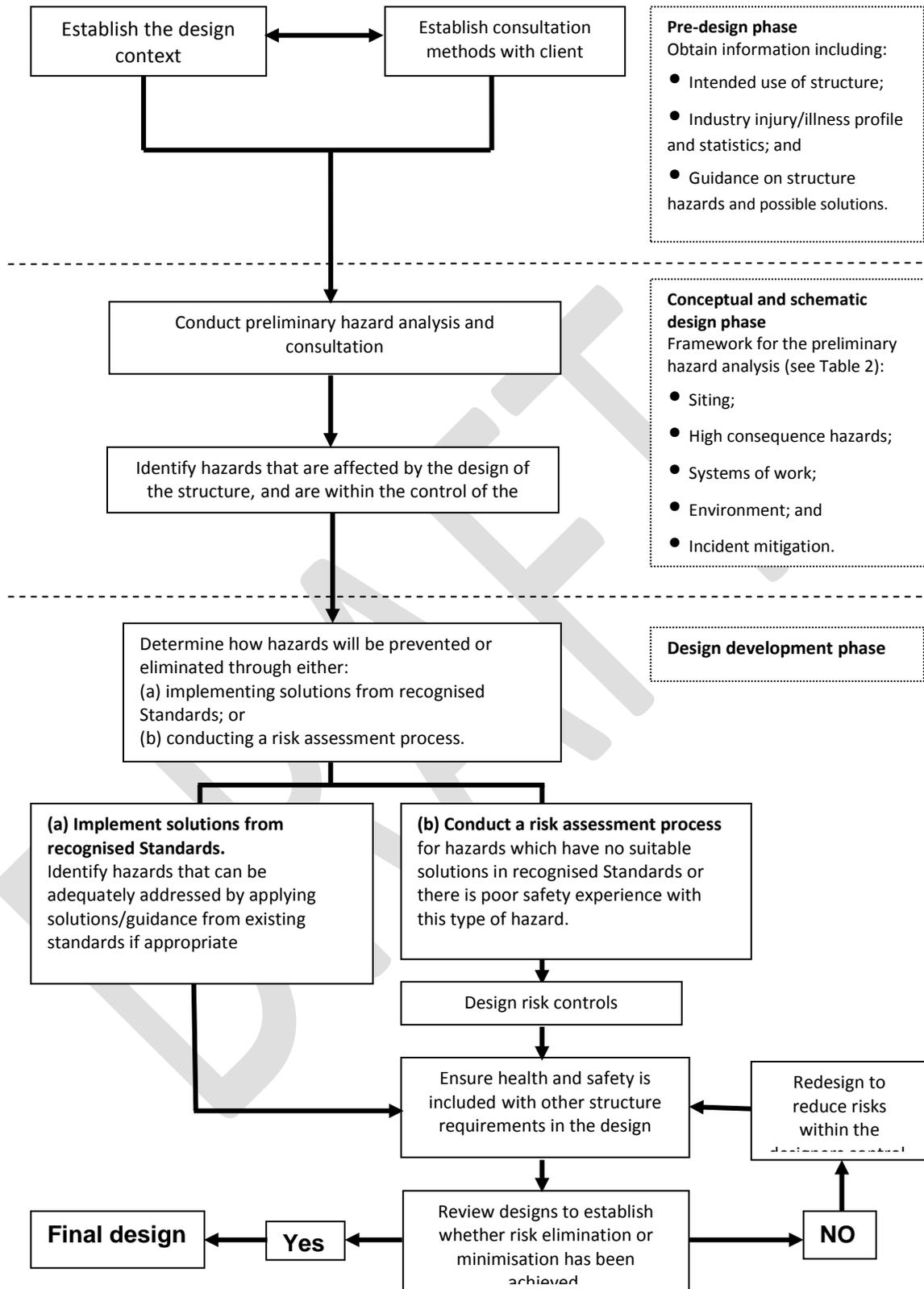


Figure 1: A systematic approach to integrating design and risk management

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Table 1: Designer - client consultation

Step	Possible techniques
Initial discussions	Obtain information on the: <ul style="list-style-type: none"> • Purpose of the structure, including plant, ancillary equipment and tasks; • Industry injury profile and statistics and common hazards and safety issues • Guidance from health and safety authorities and relevant associations, and standards. • Establish the breadth of hazards and the consultation arrangements between the client and designer.
Pre-design preliminary hazard analysis	Useful techniques may include a combination of the following actions by the client: <ul style="list-style-type: none"> • Conduct workshops and discussions with personnel using or working on 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 • Conduct workshops with specialist consultants and experts in the hazards.
Determine what hazards are 'in-scope'	Workshops/discussions to determine which hazards are affected, introduced or increased by the design of the structure.

4.2 Conceptual and schematic design phase

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.

Broad groupings of hazards should be identified before design scoping begins. **Appendix B** provides a checklist 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 eliminated or minimised.

Where there are systems of work which are foreseeable as part of the construction method and 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 project 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, acoustic environment in a call centre, 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.

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A structure must be designed to eliminate the need to carry out a hazardous manual task and, where this is not reasonably practicable, the risks of musculoskeletal disorders arising from hazardous manual tasks must be minimised.

Refer to the *Code of Practice: Hazardous Manual Tasks* for further guidance.

Table 2 outlines a framework for the preliminary hazard identification.

Table 2: Framework for the preliminary hazard identification

Siting of structure	<p>Potential design issues that may affect safety include:</p> <ul style="list-style-type: none"> • proximity to adjacent property or nearby roads • surrounding land use • clearances required for construction equipment and techniques • demolition of existing assets • proximity to underground or overhead services — especially electric lines • exposure of workers to adjacent traffic or other hazards • site conditions — including foundations, and construction over other assets or over water • safety of the public • use of adjacent streets.
High consequence hazards	<p>The storage and handling of dangerous goods, or work with high energy hazards (for example, pressure) and health hazards such as biological materials.</p>
Systems of work (involving the interaction of persons with the structure)	<p>The systems of work (including cleaning and maintenance activities) that pose risks, for example:</p> <ul style="list-style-type: none"> • rapid construction techniques, i.e. prefabrication versus in situ construction • materials to be used in construction • staging and coordination with other works • inadequate pedestrian or vehicle separation • restricted access for building and plant maintenance • hazardous manual tasks • working at height • exposure to occupational violence. <p>Consider both technical and human factors, including humans' ability to change behaviour to compensate for design changes. Anticipate misuse throughout the lifecycle.</p>
Environmental conditions	<p>Impact of adverse natural events such as cyclones, floods and earthquakes, inadequate ventilation or lighting, high background noise levels and welfare facilities that do not meet workplace needs.</p>
Incident mitigation	<p>The possibility of the structure to exacerbate the consequences after an incident due to inadequate egress, siting of assembly areas, inadequate emergency services access.</p>

4.3 Design development phase

In this phase the design concepts for the structure are converted into detailed drawings and technical specifications. Control measures are decided and construction documentation is prepared. The design is completed and handed to the client.

Control measures for common hazards may be chosen from known solutions. For other new or complex hazards a risk assessment may be necessary to assist in determining the most effective control measures. The design development phase should involve (see Table 3):

- Developing a set of design options in accordance with the hierarchy of control

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- Selecting the optimum solution. Balance the direct and indirect costs of implementing the design against the benefits derived.
- Testing, trialling or evaluating the design solution
- Redesigning to control any residual risks
- Finalising the design, preparing the safety report and other risk control information needed for the structure's lifecycle.

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 C** for examples).

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. The NCCA also does not provide guidance for some specialised structures such as major hazard facilities (for example, refineries).

Assessing risk

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
- 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

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assess risks; consulting directly with other experts, for example specialist engineers, 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.

Table 3: Design process

Step	Possible techniques	By whom
Identify solutions from <u>regulations, codes of practice</u> and recognise 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 risk management techniques	Further detailed information may be required on hazards, for example by: using checklists and referring to codes of practice and guidance material 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 influence risks when discussing 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 and may introduce risks in cleaning work.	Construction team in consultation with designer and client.

The hierarchy of control

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

- *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:

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- *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 risks that a competent builder or user would not be expected to be aware of
- 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 lifecycle of the 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.

4.4 Reviewing control measures

As the design progresses and design decisions become more fine-tuned and detailed, there are still opportunities for either eliminating or minimising risks. At various points in the design process, designers should review design solutions to confirm the effectiveness of risk controls and if necessary, redesign to minimise the risks so far as is reasonably practicable.

Wherever possible, design safety reviews should involve the people who will eventually construct the structure. If this is not possible, the client and designer should make every effort to include people with knowledge and experience in the construction and maintenance processes in the design safety reviews. Their expertise will assist in identifying safety issues which may have been overlooked in the design.

Health and safety aspects of the design should be reflected in the requirements of contract documents for the construction stage and assist in the selection of suitable and competent contractors for the project.

Post-construction review

On completion of construction, the effectiveness of safety in design should be evaluated. This will enable identification of the most effective design practices and any design innovations that could be used on other projects. The review may be carried out in a post-construction workshop attended by all relevant parties involved in the project.

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Subsequent feedback from users to assist designers in improving their future designs may be provided through:

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

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5. DESIGN CONSIDERATIONS

This chapter provides examples of design options to control risks in various stages of the lifecycle.

5.1 Design for safe construction

Control measures for risks relating to the construction of a structure include:

- 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 that can be pre-fabricated 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, for example fixing windows in place at ground level prior to erection of panels.
- 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.
- Limiting the size of pre-fabricated wall panels where site access is restricted.
- Selecting paints or other finishes that emit low volatile organic compound emissions.
- Indicating, where practicable, the position and height of all electric lines to assist with site safety procedures.

5.2 Design to facilitate safe use

Consider the intended function of the structure, including the likely systems of use, and the type of machinery and equipment that may be used.

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.

Risks relating to the function of a structure can be controlled by:

- Designing traffic areas to separate vehicles and pedestrians.
- Using non-slip materials on floor surfaces in areas exposed to the weather or dedicated wet areas.
- Providing sufficient space to safely install, operate and maintain plant and machinery.
- Providing adequate lighting for intended tasks in the structure.
- Designing spaces which accommodate or incorporate mechanical devices to reduce manual task risks.
- Designing adequate access, for example, allowing wide enough corridors in hospitals and nursing homes for the movement of wheelchairs and beds.
- Designing effective noise barriers and acoustical treatments to walls and ceilings.

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- Specifying plant with low noise emissions or designing the structure to isolate noisy plant.
- Designing floor loadings to accommodate heavy machinery that may be used in the building and clearly indicating on documents design loads for the different parts of the structure.

5.3 Design for safe maintenance

Risks relating to cleaning, servicing and maintaining a structure can be controlled by:

- Designing the structure so that maintenance can be performed at ground level or safely from the structure, for example, positioning air-conditioning units and lift plant at ground level, designing inward opening windows, integrating window cleaning bays or gangways into the structural frame.
- Designing features to avoid dirt traps
- Designing and positioning permanent anchorage and hoisting points into structures where maintenance needs to be undertaken at height.
- Designing safe access, such as fixed ladders, and sufficient space to undertake structure maintenance activities.
- Eliminating or minimising the need for entry into confined spaces (refer to the Code of Practice: Confined Spaces for further guidance)
- Using durable materials that do not need to be re-coated or treated.

5.4 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 any new hazards and risks are identified and controlled, 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.

5.5 Demolition and dismantling

In relation to the proper demolition or disposal of a structure, designers also have a duty 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 health and 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.

A structure should be designed to enable demolition using existing techniques. The designer should provide information so that potential demolishers can understand the structure, load paths

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and any features incorporated to assist demolition, as well as any features that require unusual demolition techniques or sequencing.

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 *Code of Practice: Demolition Work*.

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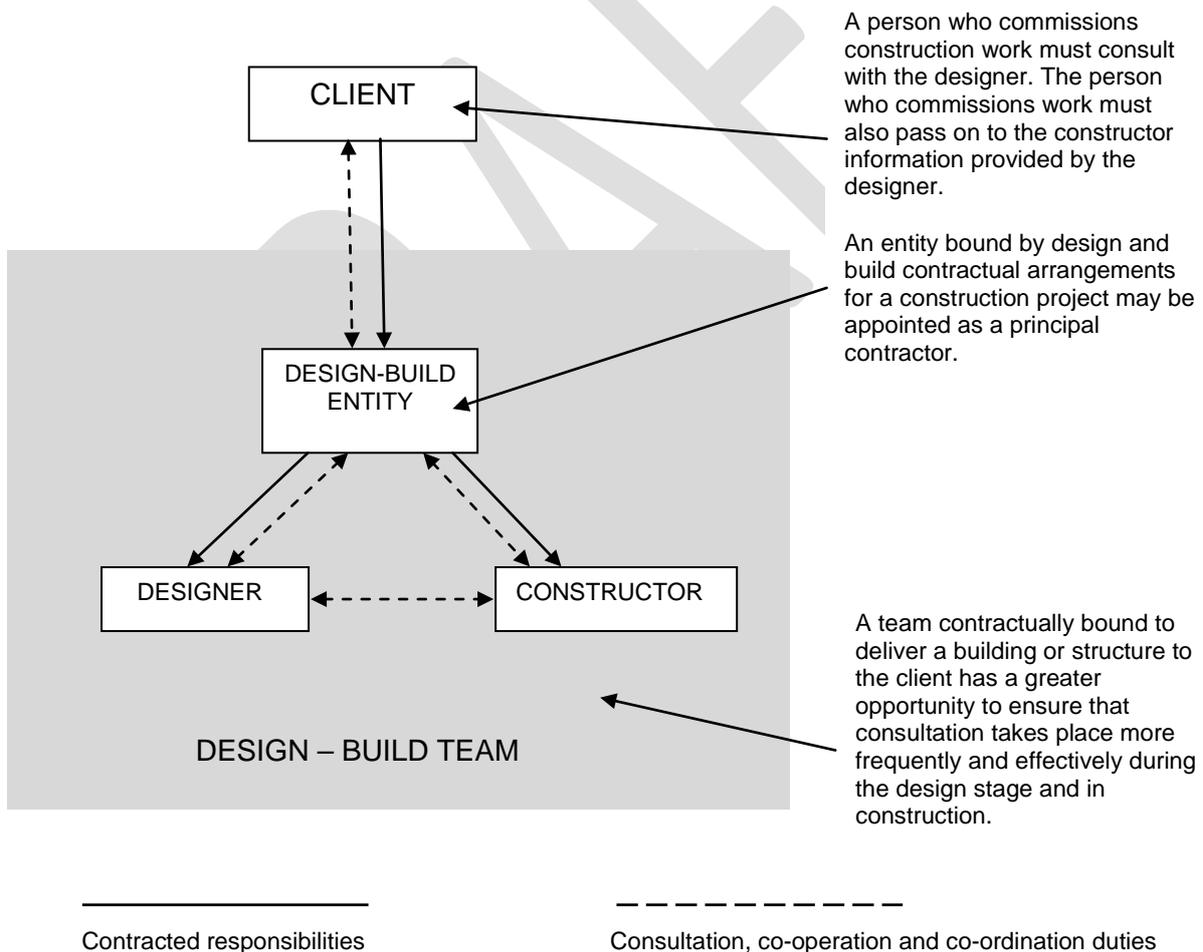
APPENDIX A – ROLES AND RESPONSIBILITIES

Some design tasks, although related, may be controlled by different parties due to contractual arrangements. For a traditional project delivery model — where the client directly engages a designer to undertake detailed design — the project safety decisions during the design stage are the result of collaboration between the designer and the client. However, in a design and construct or a collaborative project delivery model, the primary collaboration will be between the constructor and the client, with participation of the designer subject to the terms of their engagement.

Figures 2a-e show some of the often complex arrangements established for construction projects, and how the parties can consult, co-operate and co-ordinate with each other in relation to safe design.

Note: A construction project is a project where the cost of the construction work is \$250 000 or more. There can only be one principal contractor for a construction project. The client may appoint the Construction Manager or one of the contractors as the Principal Contractor depending on who will have management and control of the workplace.

Figure 2a – This model represents design and build arrangements where all parties are contractually bound



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Figure 2b – This model may apply where design and construction are carried out separately, for example when a client is seeking to finance construction at a later date

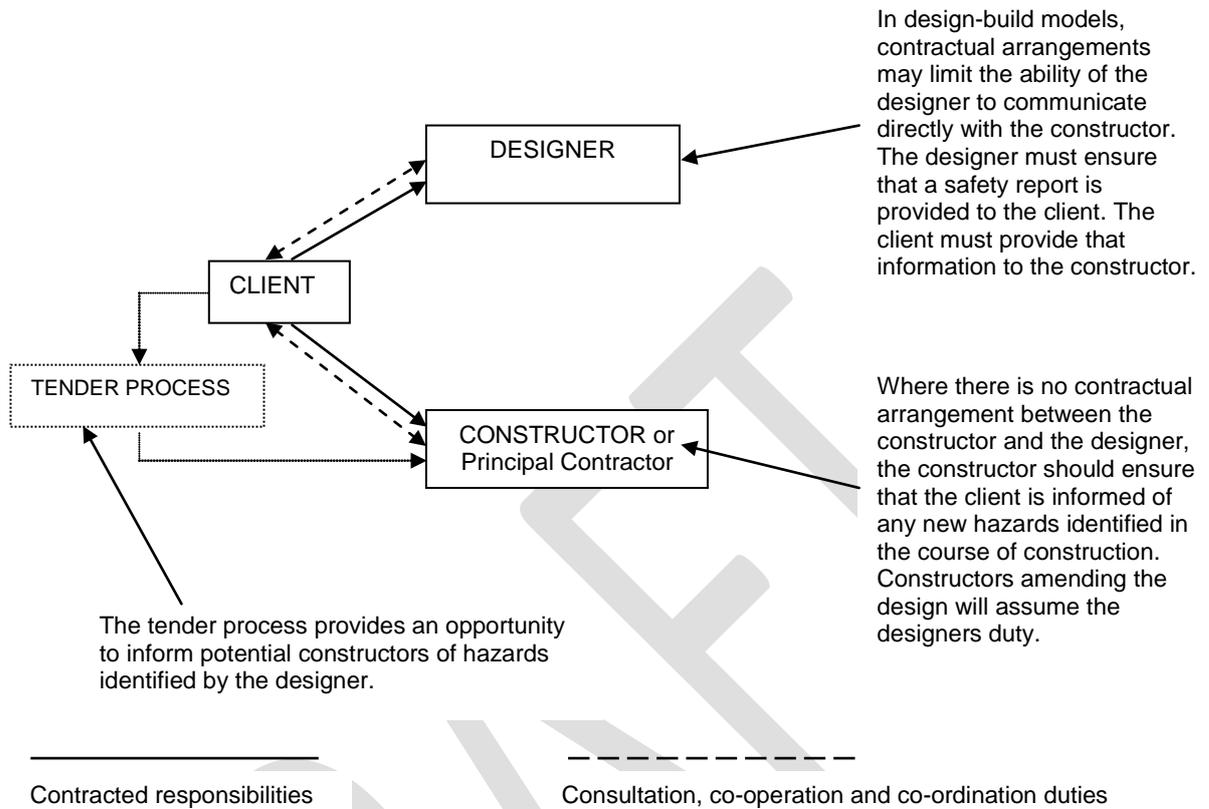
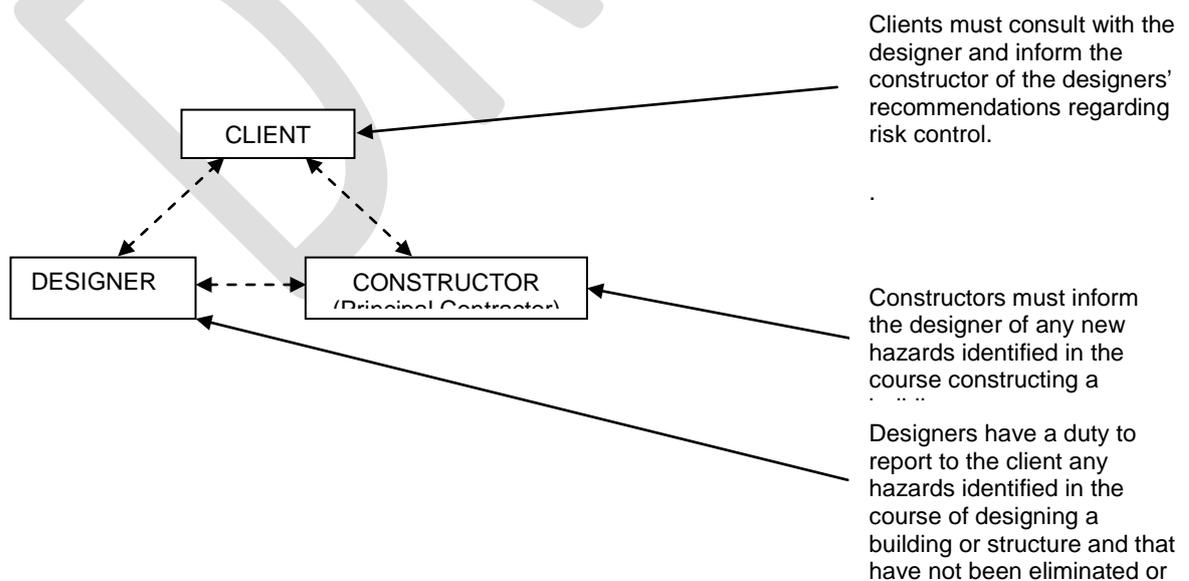


Figure 2c – This model may apply where the design and construction activities are integrated such as a domestic residence or apartment complex



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Figure 2d – This model may apply to a complex construction project such as a hospital or airport terminal where specialist contractors carry out large parts of the project

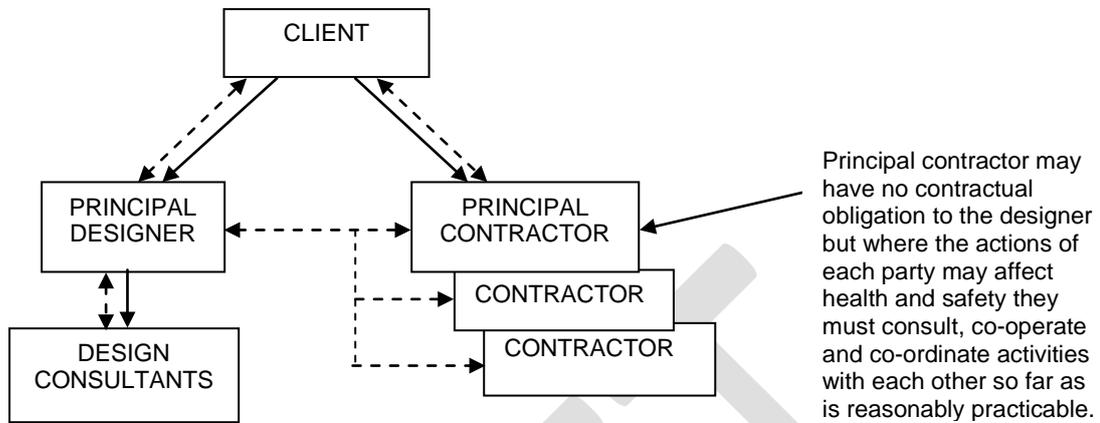
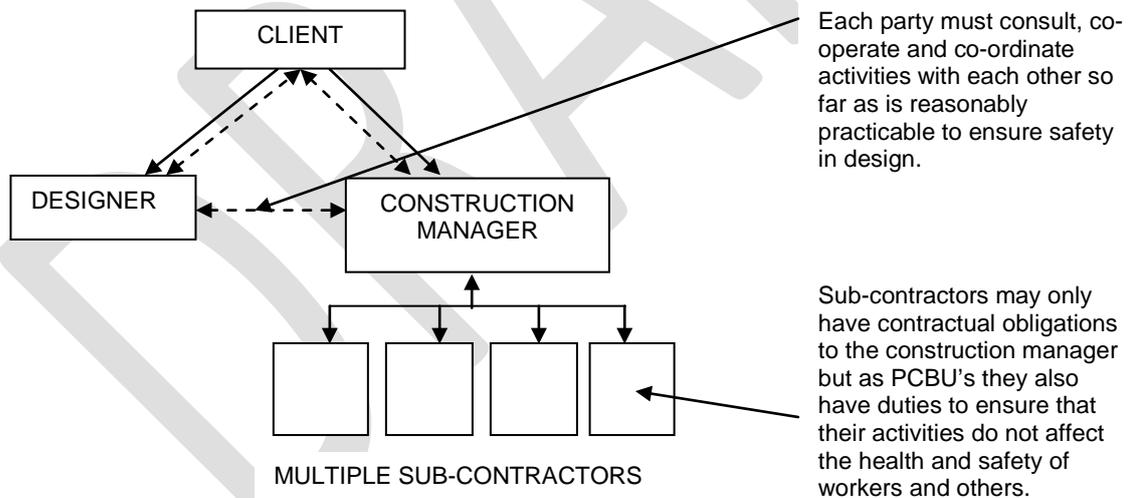


Figure 2e – This model may apply to large construction projects where the management role is carried out by a specialist construction manager



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APPENDIX B – SAFETY IN DESIGN CHECKLIST

The following list may be used to assist in identifying hazards and controlling risks associated with the design of a structure throughout its lifecycle.

Electrical safety

- Earthing of electrical installations
- Location of underground and overhead power cables
- Protection of leads/cables
- 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, including for people with disability
- Traffic management
- Loading bays and ramps
- Safe crossings
- Exclusion zones
- Site security

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 absorption
- Seating
- Floor surfaces to prevent slips and trips
- 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

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Earthworks

- Excavations (for example, risks from earth collapsing or engulfment)
- Location of underground services

Structural safety

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

Manual tasks

- Methods of material handling
- Accessibility of material handling
- Loading docks and storage facilities
- Workplace space and layout to prevent musculoskeletal disorders, including facilitating use of 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
- Storage and use of hazardous chemicals, including cleaning products

Falls prevention

- Guard rails
- 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 radiation, for example, electromagnetic radiation
- Exposure to biological hazards
- Fatigue
- Working alone
- Use of explosives
- Confined spaces
- Over and under water work, including diving and work in caissons with compressed air supply

Noise exposure

- Exposure to noise from plant or from surrounding area

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APPENDIX C - TECHNICAL STANDARDS AND OTHER REFERENCES

The following table is a list of published technical standards that provide guidance on the design of certain types of structures. These technical standards provide guidance only and compliance with them does not guarantee compliance with the WHS Act and Regulations in all instances. This list is not exhaustive.

Reference	Title
AS 1170 (set)	Structural design 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/NZS 1680.1	Interior and workplace lighting – General principles and recommendations
AS/NZS 2107	Acoustics – Recommended design sound levels and reverberation time for building interiors
AS 2436	Guide to noise and vibration control on construction, demolition maintenance sites
AS/NZS 1680.2.4	Interior lighting – Industrial tasks and processes
AS/NZS 1668 (set)	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 1428.1	Design for access and mobility: General requirements for access to new building work
AS 2601	The demolition of structures
AS/NZS 3000	Electrical installations (known as the Australian New Zealand wiring rules)
AS 3610	Formwork for concrete
AS 3600	Concrete structures
AS 3828	Guidelines for the erection of building steelwork
AS 3850	Tilt-up concrete construction
AS 4024.1 (set)	Safety of machinery
AS 4100	Steel structures
AS 5100 (set)	Bridge design
AS/NZS 4389	Safety mesh

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Reference	Title
AS/NZS 4576	Guidelines for scaffolding
AS/NZS 4994	Temporary edge protection – general requirements

Other References

Building Code of Australia, Australian Building Codes Board 2010

A Guide to designing workplaces for safer handling of people: For health, aged care, rehabilitation and disability facilities,

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

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APPENDIX D – CASE STUDIES

Example 1: Incorporating safety in design at the Alice Springs to Darwin Rail Link

This was a Build, Own, Operate and Transfer (BOOT) project to construct a railway from Alice Springs to Darwin and take over an existing railway from Tarcoola to Alice Springs. It was a design and construct contract. A design working group was developed by the client, and included representatives of the client, state and territory governments and other external stakeholders.

Weekly meetings were held during the design stage to ensure that the design was both practical and safe to build and operate. An independent reviewer was engaged by the client to audit and certify all work performed by the design working group.

Monthly design reports were required, documenting (among other things) the safety aspects of the design. Members of the design working group were located on-site during the construction work and were able to be directly involved. All subcontractors were required to submit a safety plan describing how they would manage safety in the project. These plans were reviewed by the client, with input from the design and construct team.

Example 2: Construction Hazard Assessment Implication Review

A company managing a multi-million dollar construction project made design changes to improve safety after conducting a risk assessment using the CHAIR¹ (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
- air conditioners moved to ground level, with the ducts remaining in the originally planned position.

Example 3: Lightweight air distribution ductwork

The use of pre-insulated ductwork in a large nursing home project has assisted in the labour intensive installation process that took place in the congested roof spaces and ceiling cavities. The lightweight ductwork was only 15% of the weight of traditional sheet metal ductwork and could be easily handled by a single worker without the need for mechanical lifting equipment.

As the material was already insulated there was no need to for the ductwork to be lagged, as would have been the case with metal ductwork, resulting in a considerable saving in time and in the need for workers to manipulate mineral fibre insulation in already congested spaces.

Eliminating the need for mineral fibre insulation also eliminated the possible introduction of fibres into the ducting system should there be a leakage in a joint. This also means that the ductwork could be located some 200mm higher in a false ceiling.

The reduced time taken in installation meant that fewer workers were required on-site and that they worked at height for a minimum amount of time.

Example 4: Use of 3D modelling as a tool for designers

¹ **CHAIR** (*Construction Hazard Assessment Implication Review*) has been specifically developed for the construction industry by WorkCover New South Wales. *This DRAFT Code has been approved by Safe Work Australia Members and is ready for approval by the Select Council on Workplace Relations (Ministerial Council). This Code will become a model WHS Code of Practice under the Inter-Governmental Agreement for Regulatory and Operational reform in OHS when it is approved by the Ministerial Council.*

A building designer had traditionally used sketches and 2D drawings in early project discussions with clients. Not all clients could appreciate the three dimensional implications from 2D drawings and fewer could afford the expense of scale models.

With the advent of downloadable 3D modelling software it became possible (and feasible) to provide the client with a fully rendered, coloured, and three dimensional representation of their project. Capable of being submitted electronically, the file allows the client to view the proposal from any direction.

This software also allowed the designer to work with the client to explain the construction process as well as identifying safety issues such as excavations, work at heights and traffic movements that could be resolved by adjusting the design. The designers' clients are also better informed so that they can consider the use of the building after construction is completed and to make any adjustments to the design at the earliest possible stage.

Example 5: Pre-assembly of stair frames

An analysis of an early design for the steel framing for a multi-level stairway in a high rise car park revealed that the original design would not allow the framework to be pre-assembled and would require the framework to be assembled in small pieces while working at height. The original design called for a beam running the full width of the stairway at each landing and this prevented the structure from being pre-assembled.

The designer reviewed the original design in consultation with the steelwork fabricator and determined that by splitting the original tie-beam and replacing it with smaller beams tied via fin plates, that the stair flights could be pre-assembled at ground level and lifted into place as a whole including decks, stair treads and handrails. This small modification greatly reduced the amount of time spent by the framework erector at height and provided a greater level of safety for workers as the framework installation proceeded.

Example 6: Design changes to reduce risk for construction and maintenance

In a design and construct project in Melbourne, the design process identified a number of risks relating to the ongoing maintenance of the building under construction. As a result, design changes were made.

The building consisted of a glazed sawtooth roof with suspended lighting. Inside was a fully glazed atrium covering all nine floors. In the initial design, there had been some consideration given to the maintenance of all the glazing components and access to services installed on the roof. In the original design, protection from falling during maintenance work consisted of a railing with rope access. The design team deemed this to be unsuitable and designers investigated ways in which maintenance work could be performed more safely.

The final design included a purpose-designed gantry to be installed across the atrium. On top of the gantry was a safe working platform. The platform was installed on hydraulic lifts enabling safe access to the services located high in the ceiling space. When the platform was not in use it was retracted and positioned on top of the gantry. Another moveable working platform was suspended under the gantry, allowing access to the glazed atrium below. Not only did this arrangement provide a safe environment for routine maintenance, but the gantry, which was erected early in the construction process, was also used for access during the construction of the atrium and roofing. The gantry design also contributed to substantial cost savings and improved constructability of the atrium and roof, thus reducing construction time.

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