1. STRUCTURAL – DESIGN

This Brief sets out the guidelines for design requirements of public cyclone shelters in the Northern Territory.

These guidelines are based on the “Design Guidelines for Queensland Public Cyclone Shelters” and incorporate the additional requirements of the NTG.

1.1 ACTS, CODES AND STANDARDS

Structural engineering design of the building work is to comply with the relevant requirements of the current National Construction Code (NCC), the NT Building Act 1993, the Work Health and Safety (National Uniform Legislation) Act 2011, all current relevant Australian Standards and other statutory requirements.

The following standards shall be used as a minimum in the design of the building structure:-

- AS 1170.0 Structural Design Actions Part 0: General Principles
- AS 1170.1 Structural Design Actions Part 1: Permanent, Imposed and Other Actions
- AS 1170.2 Structural Design Actions Part 2: Wind Actions
- AS 1170.4 Structural Design Actions Part 4: Earthquake Loads
- AS 1657 Fixed Platforms, Stairways, Walkways and Ladders
- AS 2159 Piling – Design and Installation
- AS 2312.1 Guide to the Protection of Structural Steel Part 1: Paint Coatings
- AS 2312.2 Guide to the Protection of Structural Steel Part 2: Hot Dip Galvanising
- AS 2870 Residential Slabs and Footings
- AS 3600 Concrete Structures
- AS 3700 Masonry Structures
- AS 3798 Guidelines on Earthworks for Commercial and Residential Developments
- AS 3850 Tilt-Up Concrete Construction
- AS 4100 Steel Structures
- AS 4600 Cold Formed Steel Structures
- AS 4678 Earth Retaining Structures

The above are the minimum standards that should be considered. All other relevant standards and codes must be adopted as deemed necessary.

2. ADDITIONAL DESIGN REQUIREMENTS

In addition to compliance with that listed in Clause 1, the design is also required to comply with the following additional specific requirements:

2.1 DEFINITION

For the purpose of this document, the word ‘shall’ indicates that a statement is mandatory.

2.2 DESIGN LIFE

The building design life for the primary structure (floor foundations, walls and structural framing and roof structure) is defined to be 50 years as per the requirements of the Building Code, AS 1170.0 and AS 3600.

2.3 DESIGN LOADS

The design of the building structure (for stability, strength and serviceability) and external fabric, including windows and doors, shall be capable of resisting the loads listed below. As a minimum the following information shall be noted in tabular form on the structural drawings approved for construction:

- Design superimposed dead loads
- Design live loads
- Special design live loads in localised areas such as compactus storage
- Design wind loads
- Design earthquake loads
- Design bearing pressures for foundation material
- Any other relevant loadings

All design loads and their parameters relevant to the project shall be fully stated on drawings.

2.4 DEAD AND LIVE LOADS

The dead loads shall be calculated in accordance with the principles of AS 11 70.0 and AS 1170.1 and utilise a gravity constant of 9.81m/s^2.

Superimposed Dead and Live Loads are to be calculated in accordance with the minimum loads described below (unless exceeded by the loads described in AS 1170 in which case the design must be for the higher load).

AREA/USE	LOAD	LOAD (kPa)	LOAD (kN)	COMMENTS
Roof	Live Load	0.25 4.0 for accessible roofs	- 1.8	-
Typical Suspended Floor Level	Dead Load	0.5	-	-
	Live Load	3.0	2.7	Offices for general use, hospital wards.
Basement Level Slab	Surcharge Load	Refer Geotechnical Report	-	-

	Live Load	2.5	13	Light traffic.
Stairs/Landings/Foyers	Dead Load	0.5	-	-
	Live Load	4.0	4.5	-
Plant Rooms	Dead Load	Plant Loads	-	-
	Live Load	5.0	4.5	-
Basement Walls	Surcharge Load	Varies	-	This will vary depending on the methodology chosen to deal with ground water.

Areas of floor designed to support specific localised heavy loads (e.g. from compactus storage or mechanical plant equipment or vehicles) shall be noted and shaded on the structural floor plans.

2.5 WIND LOADS

The wind forces applied to the building are determined in accordance with AS 1170.2 based on the criteria below.

ITEM	DESCRIPTION	SYMBOL	VALUE	COMMENT
Wind Data	Terrain category	-	2	Design for worst case direction.
	Region	-	C	-
	Reference probability of exceedance	-	10,000	-
	Regional wind speed (ultimate)	$V_{10,000}$	85 m/s (306 km/hr)	-
	Regional wind speed (serviceability)	V_{25}	47.0m/s	-
	Topographic factor	M_t	>1.0	Refer Contour Survey to determine.
	Site shielding factor	M_s	1.0	Applies for worst case direction
	Wind direction multiplier	M_d	1.0	Applies for worst case direction.
	Internal pressure coefficient (ultimate)	C_{pi}	+0.7, -0.65	The internal pressure is determined on the basis that localised failure of cladding element may occur due to a load larger than the design debris load or that use of the natural ventilation system may result in full internal pressure

2.6 DEBRIS LOADS

The external building fabric (including, but not limited to, debris screens, walls, cladding, windows, doors, roller shutters, plant room louvres, mechanical dampers, and ventilation grills) shall be capable of resisting wind borne debris loads based on the criteria below.

ITEM	TRAJECTORIES	DESCRIPTION	IMPACT SPEED (m/s)	COMMENT
Wind Borne Debris	Horizontal	A spherical 8mm steel ball of 2g impacting at 0.4 x $V_{10,000}$, normal to wall surfaces, and roof surfaces greater than 35° pitch	34	-
		A 100mm x 50 mm piece of timber of 4 kg (of a density of at least 600kg/m3) impacting end-on at 0.4 x $V_{10,000}$, normal to wall surfaces, and roof surfaces greater than 15° pitch	34	
	Vertical	A spherical 8mm steel ball of 2g impacting at 0.3 x $V_{10,000}$, normal to roof surfaces less than, or equal to, 35° pitch	25.5	Roof cladding up to 15° pitch shall have a minimum of 18mm plywood protection against windborne debris irrespective of test results.
		A 100mm x 50 mm piece of timber of 4 kg (of a density of at least 600kg/m3) impacting end-on at 0.1 x $V_{10,000}$, normal to roof surfaces less than, or equal to, 15° pitch	8.5	

The shelter shall be located away from taller structures defined by a plane that is 1 vertical to 1 (minimum) horizontal.

External walls shall be of reinforced blockwork or concrete.

Reinforced blockwork shall be concrete filled all cores for all external walls.

Roof with a slope 15° or less shall have debris protection lining of no less than 18mm structural plywood regardless of the test results of vertical trajectory test.

Roof with a slope greater than 15° shall be designed as a wall and must satisfy the horizontal trajectory debris impact loads.

Do not use stainless steel woven wire mesh as cyclone debris screen.

Test method for debris tests shall be in accordance with *'2006 Design Guidelines for Queensland Public Cyclone Shelter - Appendix I: Specifications and Guidelines – External fabric of Public Cyclone Shelters - Specification of test criteria and procedures, and Debris resistant screens for Public Cyclone Shelter Specifications'*.

Fabric materials compliance must be verified with a NATA test compliance report, certified by a Registered Professional Engineer, to the specified criteria, and approved by DIPL.

2.7 EARTHQUAKE LOADS

The building is to be designed to resist earthquake loads for a building of Importance Level 4 as defined by the NCC and AS1170.4.

2.8 STRUCTURAL ROBUSTNESS

Comply with the requirements of AS 1170.0, and ABCB Structural Robustness Handbook (2016).

The structure and its fabric shall be designed and constructed so that they will not be damaged to an extent disproportionate to the original cause, by unforeseen events such as localised cladding failures, or opening failures, or due to the consequences of human error, during the disaster event.

2.9 FOUNDATION DESIGN

Foundation design shall be based on the recommendations of the Geotechnical Report prepared for the project. Fill material shall be select fill and compacting to 95% (min) MMDD. Depth of footings to be determined by Structural Engineer.

The project title, consultant / author, report number and issue date of the Geotechnical Report shall be clearly noted on the drawings.

2.10 EARTH PRESSURE

Any designed structure, including retaining walls, shall be designed to resist earth pressures in accordance with the recommendations from the Geotechnical Investigation. Basement walls and floors must be protected via subsoil drains.

2.11 FIRE RESISTANCE

The structure and its component members shall be designed for the appropriate fire resistance in accordance with the relevant Australian Standards and the requirements of the NCC.

2.12 STRENGTH

The structure and its component members shall be designed such that their design strength exceeds the appropriate design actions in accordance with the NCC and the relevant Australian Standards.

2.13 STABILITY

The structure as a whole and its parts shall be designed to prevent instability due to overturning, uplift and sliding in accordance with the NCC and the relevant Australian Standards.

2.14 SERVICEABILITY

The structure and its component members shall be designed for serviceability by controlling or limiting deflection, lateral drift, cracking, and vibration in accordance with the relevant Australian Standards unless noted below.

Unreinforced blockwork is not permitted.

2.15 DEFLECTION LIMITS

Generally, deflection limits shall be as per AS 1170.0.

ITEM	DESCRIPTION	APPLIED ACTION	CRITERIA ADOPTED
Roof supporting elements	Mid-span deflection	$G + \Psi_l Q + W_s$ $G + W_s$	Span/300
Floors and floor supports	Mid-span deflection	$G + \Psi_l Q$	Span/350 or 30mm Span/500 (under blockwork walls / glazing)
Wall elements	Mid-height deflection	W_s	Height/250
Transfer structures	Mid-span deflection	$G + \Psi_l Q$	Span/500

2.16 CONCRETE DURABILITY

All concrete elements of the structure shall be designed for durability in accordance with Table 4.3 of AS 3600, the exposure classification of particular concrete surfaces shall be detailed below;

ITEM	DESCRIPTION	VALUE	COMMENT
Concrete Durability	Design life	50 years	-
	Concrete exposure classification	A2	Surfaces in interior environments / surfaces in contact with ground protected by damp proof membrane
		B1	Near coastal / surfaces in above-ground exterior environments (1km to 50km from coast or tidal estuaries)
		32MPa (f'c) minimum	Vehicle pavements in any location

2.17 CRACK CONTROL

Reinforcement for crack control shall be provided at, or better than, the ratios stipulated in AS 3600. This requirement does not replace any requirement for reinforcement specified for structural integrity.

2.18 POST TENSIONED OR PRECAST CONCRETE SLAB

The adoption of post tensioned or precast concrete system for slab or beam is not allowed without the approval of DIPL.

If post tensioned slabs are installed, the location of all tendons must be marked on the underside of the slab to ensure that any future core holes cut in the slab do not intersect any stressing cables.

2.19 WATERPROOFING AND WEATHERPROOFING

The exterior building fabric shall be resistant to water penetration. The fabric shall not permit penetration of uncontrolled water when tested in accordance with AS2047 under a water penetration resistance test pressure of 630 Pa.

Floors, walls and lift pits shall be fully tanked where below grade or subject to hydrostatic pressure.

2.20 STEEL PROTECTIVE COATING

Durability

The steel protection system shall satisfy the requirement of very long term durability of 25 years to first major maintenance and be warranted for a minimum of 20 years. Name the Principal as the warrantee.

Coating damage caused by welding or flame cutting, or during handling, transport, or erection shall be reinstated in accordance with the provisions of AS/NZS 4680 - Repair after Galvanizing.

Bases of all external structural steel columns must be coated with “Epireze 215”, coated 100mm below slab level or top of base plate, and extend to 100mm above finished concrete slab or above concrete collar surface level at the steel.

External steel columns / stumps surrounded by natural ground shall be encased with a reinforced concrete collar. The collars must extend horizontally a minimum of 100mm from the steel. The collars must be sloped down away from the column and finish not less than 100mm above natural ground level at the highest ground level point adjacent to the concrete collar.

Guide Notes

The steel protective coating/s for the project is to be selected from the following Table with options of inorganic zinc silicate (IZS), hot dip galvanised (HDG), or polyurethane system. Following the identification of the building location and the finish required, select and specify the appropriate coating/s from the Table. The selection of coating is to be read in conjunction with the associated NOTES below the table.

Do not use other protective coatings without approval.

Coating required is HDG, IZS, or polyurethane system (subject to the building location and finish required by the design architect), for all structural steelwork. The selection of coating is to be read in conjunction with the NOTES below the table.

Table – Steel protective coating selection

BUILDING LOCATION	COATING	COMMENT
Inland tropical (areas more than 0.5km from coast or estuary)	Hot dip galvanised (HDG) - As per Table 1 of AS/NZS 4680	Steelwork to be galvanised shall be prepared and pre-treated to the requirements of AS 1627.4 and hot dip galvanized in accordance with AS/NZS 2312.2, AS 4650, AS/NZS 4680, and with the Standard Specification for Hot Dip Galvanizing, published by the Galvanizers Association of Australia, accessible via https://gaa.com.au/standard-specification-for-hot-dip-galvanizing/ .
	Inorganic zinc silicate (IZS) - 75 µm DFT (min)	All non-galvanised steelwork is to be blast cleaned to a class 2½ finish and primed with 75 microns inorganic zinc silicate. Top or finish coat to be as per architectural specification.

Marine (areas 0.5km from coast or less)	Polyurethane System, total DFT 325 µm - Consists of 75 µm IZS primer, 200 µm high build epoxy (2 pack) intermediate coat, and 50 µm polyurethane (2 pack) topcoat	Prepared and primed as above. Colour to be as per architectural specification.

NOTES:

1. For this Guide, durability is defined as the time elapsed before the first major maintenance (recoating) of a coating system becomes necessary, to arrest corrosion.

2. The objective is to achieve maximum durability compatible with the 50 years design life of the structural steelwork, or equal to the expected service life of the structure as defined in the Brief or NCC.

3. The design of the structure influences the choice of a protective coating. As a general rule, important, difficult to access, and complicated structures should be given long-life systems to reduce the amount of costly maintenance. More durable coating at the beginning is more sustainable and this will lead to cost saving in the long run with less or no recoating required (lower lifecycle cost).

4. Any components of the structure which are not accessible after assembly should be provided with a corrosion protection system that will remain effective for the service life of the structure. If this cannot be achieved by means of a protective coating system, other measures, such as manufacturing from corrosion-resistant material, designing for replacement, or specification of a corrosion allowance, should be taken.

5. IZS and HDG have been chosen as the preferred steel protective coating systems due to their proven performance, superior durability and less maintenance (lower frequency of recoating required) than other products. Both have been shown to have a very long life to first maintenance in most environments and often no maintenance will be required during the entire life of the project.

6. As a guide, colour or architectural paint coated finish steel shall have a protective coating of IZS. Buildings located within the tropical, arid and more than 0.5km from the coast or tidal estuaries shall be coated with IZS or HDG. Steel surfaces vulnerable to corrosion in the coastal fringe would require a polyurethane coating system. Coastal fringe includes areas up to 0.5km from the coast or tidal estuaries.

7. The coating systems apply to all structural steelworks of the project, including internal and external (exposed) located steel members. This standardised approach minimises confusion and errors in design and fabrication, easier for quality control in verification and inspection, and provides consistency among all DIPL projects.

8. Specifiers to nominate the coating systems suitable for the project based on the coating options and criteria from the Table as well as other criteria stated in this Guide.

9. For works associated with refurbishment of existing steelwork, minor and temporary structures, or if only a shorter working life is required, a cheaper, less durable system may be sufficient. However, this will need to be assessed on a case by case basis, and be subject to approval by DIPL.

10. For this Guide, the atmospheric corrosivity category has been assessed as C5 for the areas of Coastal fringes, Tropical Inland or C4 for the areas north of Tennant Creek and up to the Top End, and C3 for the arid areas south of Tennant Creek to Central Australia.

2.21 DISSIMILAR METALS

Contact between dissimilar metals shall be avoided to prevent galvanic corrosion. Special attention is required to reliably achieve isolation between dissimilar metal surfaces using marine-grade stainless steel inert spacers or washers.

2.22 GEOTECHNICAL INVESTIGATION

Prepare a written geotechnical investigation report of the site including any car parking areas.

The report shall provide information on subsurface conditions across the site, including but not limited to:

- Provide assessment of soil materials encountered across the site
- Site classification in accordance with AS 2870
- Recommendations on site preparation and earthworks requirements, including suitability of in-situ material for re-use as fill, placement of fill, compaction criteria and testing requirements
- Recommendations on suitable foundation systems
- Provide foundation design parameters, including allowable soil bearing pressures and estimated soil settlements
- Assessment of the site factor for earthquake design in accordance with AS 1170.4
- Assess pavement requirements and provide pavement subgrade design parameters, including CBR
- Provide comments on site drainage and groundwater
- Identify anticipated construction difficulties and provide possible solutions

The investigation shall be carried out by an experienced and qualified Geotechnical Engineer.

2.23 STEEL STUD WALL FRAME

Do not specify steel stud frames for external or structural walls.

Non-structural internal stud frames of light gauge “C” sections shall be no less than 1.6mm BMT and must be fully detailed. Drawing details shall include, but not be limited to, full elevation of every wall frame, member section sizes, welding connection, galvanised hold-down bolt information, and specification of Alcor flashing between base of bottom plate and concrete.

Do not specify manufacturer proprietary systems.

Do not specify manufacturer to design, manufacture, and certify for structural stud wall frames.

2.24 PROPRIETARY TRUSS

Do not use proprietary steel or timber trusses.

2.25 MASONRY

Drawings to specify clean out inspection holes at base course of all reinforced and core fill cores. Clean out all cores to be filled progressively as the work proceeds.

Drawings are required to show full elevations of all external and internal shear blockwork walls.

Window sills are required to be fixed to bond beam with galvanised N12 shear pins at 600mm centres and at each window mullion.

All external blockwork, wet area blockwork, blockwork below ground level and for the first 3 base courses above finished floor level shall be constructed using mortar with a damp-proof admixture such as “Cementaid Calblack” or similar. This needs to be clearly noted on the drawings.

All external blockwork walls shall be concrete filled all cores.

The use of unreinforced blockwork or brick masonry walls is prohibited.

Blockwork control joints shall be provided in walls to minimise the effects of linear shrinkage, temperature variations, creep, and subgrade movement. All joint locations to be clearly marked on slab plans and wall elevations.

2.26 METAL CAPPING AND FLASHING

All exposed parts of flashing and capping are to be screw fixed with No. 14 class 4 HH screws with EPDM seal. Fixing distances to be fully detailed and in accordance with AS 1562.1:2018 for cyclonic regions. This needs to be noted on the drawings.

2.27 METAL ROOF AND WALL SHEETING

All metal sheeting to be colorbond steel.

Sheeting thickness to be 0.48mm BMT minimum with Class 4 finish fixing screws.

Ceiling sheeting thickness can be 0.42mm BMT.

2.28 HOLD-DOWN ANCHOR

All vertical hold-down anchors are to be cast-in system.

Do not use other mechanical, nor chemical anchors as column or stub column hold-downs without approval.

2.29 LOCATION OF WALLS, COLUMNS AND WALL BRACING

The design of the structure shall incorporate flexibility for future changes in internal layout or use. This requirement should be reflected in the design of the building structure. The use of internal walls as load bearing or structural walls is to be avoided where possible.

Careful consideration must be given to the location of columns within the building. Columns within the body of a functional space should be avoided wherever possible.

Walls required for bracing purposes should be carefully located so as not to impact severely on flexibility to rearrange the internal layout in the future.

2.30 GROUND SLAB MOISTURE BARRIER AND BEDDING SAND

All floor slabs on ground shall be placed on moisture barrier equivalent to 300 micron thick ‘Fortecon’ polythene membrane, turned up at the perimeter and with all joints and penetrations sealed.

The use of 200 or 300 µm termite barrier polymer sheet (e.g. HomeGuard or similar product) as moisture barrier or damp proof membrane is prohibited.

Bedding sand shall be a naturally occurring material that has a high clay/fine silt content to ensure the material can hold its shape when used under concrete slabs. The specification or use of manufactured quarry sand as bedding sand is prohibited. This needs to be clearly noted on the drawings.

2.31 EXTERNAL SLAB

External slabs associated with buildings are to be documented as part of structural documentation. This includes slabs for under cover walkways, verandahs, carports, and path slabs linking between buildings.

Do not document external slabs of buildings as part of civil design documentation.

2.32 SLAB JOINTS

Slab joints whether for contraction, expansion, or construction must be considered and documented as part of structural documentation. All joint locations to be clearly shown on the slab plans.

Slabs with architectural significance or visible surfaces must be carefully designed to minimise cracking.

Do not document joint locations and details of building slabs as part of architectural or civil documentation.

2.33 WINDOWS, DOORS, LOUVRES, DAMPERS, DEBRIS SCREENS AND ROLLER SHUTTERS

External doors, windows, louvres, mechanical dampers and roller shutters shall comply with the requirements of wind and debris loads. Evidence of debris testing for compliance is required.

Details of debris screens, louvres, glazing, windows frames, door frames, door locks and associated fixings between frame members and walls shall be fully documented and structurally certified with Section 40 Structural Design Certificate. It is envisaged the design engineer will need to collaborate with the aluminium and glazing manufacturers suppliers (such as Capral and Glasshape) to complete the design of windows to satisfy the requirements.

Purposely made doors or proprietary doors (such as Sealeck doors) that have been tested, and satisfied the debris loads and test criteria are acceptable to be specified for this project.

Roller shutters thickness shall be 1mm BMT minimum. Fixing of roller shutters channel guide to wall must be fully detailed and certified as part of structural design documentation.

Do not refer to manufacturer's details or specifications for fixings. Fixing details shall be detailed as part of structural drawings.

Only the products that have been tested and meet the debris testing compliance should be specified.

Drawings shall specify design wind pressures (incorporating local pressure factors) and water penetration resistance pressure for glazing. Water penetration resistance test pressure shall be 630 Pa (minimum).

2.34 NON-STRUCTURAL PARTS AND COMPONENTS

Non-structural parts and components, including architectural, mechanical, and electrical components, and their fastenings, shall be designed for horizontal and vertical earthquake forces as per Section 8 of AS 1170.4. The design shall be fully detailed as part of the structural documentation and certified with Section 40 Structural Design Certificate by a NT Registered Certifying Engineer (Structural) with expertise in the design of the Non-structural Parts and Components to the code requirements.

2.35 TIMBER PRODUCTS

Do not use timber material for any part of the structural work without approval.

2.36 DESIGN ENGINEER

The structural engineer responsible for the design and certification shall be a NT Registered Building Practitioner (Structural) with extensive experience and proven track record in design and construction for buildings commensurate with the value, usage and complexity of the IL4 building or cyclone shelter works.

2.37 DRAWINGS

The drawings shall comply with the following principles/requirements.

The drawings shall comply with NTG Technical Drawings Part 1 and 3.

There should be no conflict between the Structural drawings and other discipline drawings.

Incomplete structural documentation is not acceptable.

Structural notes should not be excessive with only the notes that are relevant shall be shown. Notes that are not relevant shall not be included.

All graphical details shall be drawn to the right scales. The outlines and details of a representation should be proportional to the represented part.

Details shall be unambiguous and clear. For any feature of a drawing, there shall be only one interpretation. It should be easy to understand for each involved person. Details by description without actual graphical illustration is not acceptable.

Details of a specific nature and particular to an individual project need to be fully detailed in the drawings. It is important to ensure that the coverage is comprehensive. If a specific detail is required that is not similar to any other previously shown detail, it should be shown.

Details of specific nature based on standardise details are not acceptable. The details shall be purposely drawn to reflect and illustrate the detail envisaged.

Non-standard or typical details shall be clearly cross-referenced to the appropriate design layout/elevation/section. Poor or erroneous cross-referencing is not acceptable.

Standard details not relevant or applicable to the project shall not be included as part of the detailing.

Areas of floor designed to support specific localised heavy loads (e.g. mechanical equipment or compactus storage) shall be noted and highlighted on the structural floor plans.

Amendments when required on drawings should be shown clouded and tagged with an appropriate mark in accordance with NTG Technical Drawings Part 1. Additionally, the

amendment table within the title block of the drawing should be updated (with a brief description) to reflect the amendment.

2.38 SHOP DRAWINGS AND CONSTRUCTION RFIs

The Engineer engaged for the structural design is required to review Shop Drawings (precast concrete and/or steelwork) to ensure the intent of the design has been correctly interpreted. The review should include general arrangement, member sizes and connection details, but should not be regarded as a check of dimensions. In addition, the Design Engineer is also responsible for any Request for Information (RFIs) during construction phase by the contractor.

2.39 SAFETY IN DESIGN (SID)

Comply with the *Work Health and Safety (National Uniform Legislation) Act 2011.*

The design shall consider and incorporate design solutions that minimise the potential for danger during construction as well as during occupation and maintenance.

A SID report detailing the optimal solutions to minimise hazards and risk issues will need to be provided as part of the documentation work at the conclusion of the design project.