STRUCTURAL

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

DESIGN STANDARDS

Document Register

Issue	Date	Description	Initials
Revision 1	18/10/2021	Project Use	LI

Contents

Disclaimer
Refer to the Disclaimer within the UQ Design Standards.

Reference Documents
Refer to the UQ Design Standards for the list of documents and associated standards to be referenced for design work.
The designer is to coordinate between disciplines and standards

01 Structural Design Standard

1.1 General

This design standard is provided to outline structural engineering design criteria and requirements specific to UQ which meet or exceed the minimum requirements imposed by Australian Standards and National Construction Code (NCC).

1.1.1 Principles

The structural design of University Buildings or ancillary structures shall consider:

1. Quality. The structure shall be designed to a high level of serviceability with consideration of the end user experience and the aesthetic impacts of the structure.
2. Flexibility and Robustness. Allowance shall be given for future changes in occupancy loadings such as conversions from laboratories to lecture/seminar rooms, or vice versa. Allowance shall be given for future floor or wall penetrations for service penetrations, doorways, dumb-waiters or stairways.
3. Whole of Life. The structural design shall account for environmental effects, and other durability factors and requirements to provide a low maintenance profile.
4. Sustainability. Create new buildings that can be adapted and re-used in the future or refurbish existing buildings using sustainably sourced materials in construction.

1.1.2 Documentation

The basis of structural design and design parameters must be explicit on As Built structural drawings. This would include, but not be limited to:

1. Importance Level.
2. Design loadings – superimposed dead loads, live loads, barrier loads, wind loads and earthquake loads.
3. Structural dimensions and member sizes.
4. Founding level of foundations and design parameters for shallow and deep foundations.
5. Design serviceability limits including deflections and floor vibrations.
6. Cambers to beams and slabs.
7. Compactus loading or other heavy loads are to be clearly indicated on the floor plan.
8. All load bearing walls are to be clearly indicated.
9. Design and Construct (D&C) elements by others (e.g stud walls, retention systems).
10. Fire resistance.
11. Allowance for future flexibility or expansion (vertical by additional floors or horizontal by floor extensions).
12. Alterations to existing structure (refurbishments or fitouts).

The Structural Engineer is to provide a basis of determination of Importance Level, with reference to AS1170.0 and NCC, to UQ and relevant stakeholders for review and approval prior to Schematic Design.

Structural drawings must also clearly nominate the design and certification responsibilities of non-structural parts and components to comply with AS1170.4. The structural drawings must provide earthquake design criteria for sub-contractors to adopt in the design of non-structural components (e.g. walls and partitions, ceilings and bulkheads, mechanical, electrical and hydraulic components) to ensure selected systems have the required performance characteristics to accommodate the expected earthquake actions.

1.1.3 Safety In Design

The consultant must ensure, in carrying out their designs that, so far as is reasonably practicable, the project is designed to be without risks to anyone who constructs, uses, maintains, modifies or demolishes the proposed works. When undertaking the design, the consultant must carry out any calculations, analysis, testing or examination that may be necessary to eliminate or minimise risks. The consultant must provide current relevant information on any risks arising from the design to anyone who constructs the proposed works.

Safety is a core value for the University. Safety in this context refers to all aspects of the work, safe construction, safe operation, safe maintenance, safe modification and safe demolition. The entire project team has a duty to comply with Section s22 of the Work Health and Safety Act 2011, and amendments to same contained in the Work Health and Safety Act and other Legislation Amendment Act 2017 (Qld), and the associated Regulations.

In doing so, consultants shall ensure, so far as is reasonably practicable, that the design is without risk to health and safety, and that the requirements of the WH+S Act are met. A Safety In Design Report detailing all matters identified and addressed during the design and technical documentation phases shall be provided to the Project Manager/University with the documentation issued for construction purposes.

It is expected that the report will address the following, as a minimum:

1. The purpose for which the structure or plant is being designed
2. The identification of all design, material, construction, operational and maintenance hazards and assessments of the risks to WH+S associated with these hazards;
3. Actions to be taken to remove or mitigate the risk, such as design changes, particular construction methods or procedures, and the like;
4. The results of any testing and analysis;
5. Requirements to ensure that the project is so far as is reasonably practicable, without risk when carrying out construction, operation, maintenance, modification and demolition;

1.1.4 Certification Requirements

The consultant is to ensure all project documentation is designed and certified by a Registered Professional Engineer of Queensland with specific experience relating to the appropriate field of expertise.

As Constructed drawings, when required by the University or project manager, are to be provided with RPEQ certification.

Form 15s and 16s, when required by the University or project manager, are to be provided by an RPEQ.

1.2 Design Criteria

1.2.1 Design Loadings

Beyond AS1170 code requirements for imposed floor actions, the following minimum design loadings are required:

1. Superimposed Dead Loads:
    a) Lightweight partitions 0.5 kPa
    b) Ceiling and services 0.3 kPa
2. Live Loads:
    a) General areas, laboratories, class rooms (to allow for future change of use) 4 kPa and 4.5kN
    b) Library stack areas (maximum shelf height 2.3m) 6 kPa and 7.0kN
    c) Archives, compactus or heavy equipment areas are to be specific to the application and based on calculations by Structural Engineer, but 10kPa as a minimum.
    d) Balustrade loadings are to consider crowd loading or impact loading from vehicles where applicable. Balustrade uprights and base connections are to be designed and detailed by the Structural Engineer. The Structural Engineer shall adopt design loading in accordance with AS1170.1 Occupancy Type C for areas susceptible to overcrowding.
    e) Roofs where inaccessible except for normal maintenance 0.25kPa and 1.8kN

f) Wall loadings are to consider support of equipment, shelving, etc specific to the application.

3. Facades shall be designed for barrier loadings, maintenance loading, impact loading, abseiling loads and anchor loads (where required) and wind and earthquake loading. Façade system shall be able to resist any hail loading (50 years – recurrence).

1.2.2 Design Life

The minimum design life of the structure to ensure durability and to minimise maintenance is to be as follows:

1. Concrete Structures: 50 years
2. Paint systems on external steel structures: 15 minimum years to first maintenance. External steel work to be hot dip galvanised.
3. Engineered Façade Systems:

   a) Mullions, transoms, structural steel framing members, screw/bolted connection and brackets, metal sheeting and sandwich panels: 20 years (warranty) with expected service life of 50 years with maintenance

   b) Glass units: 10 years (warranty) with expected service life of 20 years.

   c) Sealants: 10 years (warranty).

   d) Flashings: 10 years (warranty) with expected service life of 20 years.

1.2.3 Serviceability

1.2.3.1 Deflection

Vertical and lateral deflections of structural elements are to be within recommended serviceability limits provided in AS1170 and AS3600, whichever is stricter. The below are minimum acceptable standards and the Structural Engineer shall satisfy themsef that the predicted deflections calculated are suitable for the buildings intended use. Stricter deflections should be considered, in combination with the vibration criteria for sensitive floor areas (e.g. laboratories). Any deviation from the below is to be approved by UQ.

Suspended Floor Deflection Limits

Element	Limits	
	Incremental *	Long Term
Slab	Span/500	Span/250 30mm Max.
Edge Beams	Span/500	Span/360 30mm Max.
Internal Beams	Span/500	Span/250 30mm Max.
Transfer Beams	Span/700 10mm Max.	Span/500 15mm Max.

* Typically for members supporting brittle or deflection sensitive framing (e.g. masonry partitions, glass facades) where provision is made to minimise the effect of movement, otherwise Span/1000.

Lateral Element Deflection Limits

Element	Limits	Applied Action
Wall elements (including headers)	Height/200 (vertical element) Span/200 (horizontal element)	Serviceability Wind, Ws
Windows/facades/curtain walls	Span/250	Ws
Wall/façade elements supporting brittle elements (granite, brick)	Span/400 or 5mm	Ws
Glazing systems	Span/400	Ws
Internal Partition Walls	Height/200	Ws
Handrails and balustrades	Height/100 + Span/240	Live load, Q = 1.5kN/m

Vertical Rafter Deflection Limits

Type of Loading	Limits	
Dead loads	Span/360 Span/500	For roof pitches > 3 degrees For roof pitches < 3 degrees, check for ponding
Live loads	Span/250	
Wind loads	Span/180 Span/250 Span/500	If no ceilings in the building With ceilings (drop in tile) With ceilings (set plasterboard)
Operable wall	Span/500 or 5mm	For incremental deflection. Refer below.

* Structural steel supporting proprietary operable walls are to be designed with deflection limits to prevent sagging, distortion and movement (5mm or manufacturer tolerances, whichever is less).

1.2.3.2 Vibration

All floors are to be designed to an appropriate footfall vibration criterion suited to the application. The generic vibration criteria in accordance with base curves for human perception specified in BS 6472-1 and ISO2631 shall be followed. A maximum response factor (R) for stairs of 32 shall be adopted for light use (e.g. offices) and 24 for heavy use (e.g. public buildings). A maximum response factor of 8 shall be adopted for general areas and maximum response factor of 4 adopted for offices. Stricter vibration criterion is required for sensitive equipment in laboratories or other specialist areas, with a response factor of 1 acceptable for most instances for microscopes to 100x and of other equipment of low sensitivity and response factor of 0.5 acceptable for optical microscopes to 100x, microbalances, optical balances, proximity and projection aligners, etc. The performance requirements of laboratories, confirmation of equipment to be used and its potential sensitivity to floor vibrations should be agreed upon and coordinated with the University. Acoustic requirements shall also be coordinated with the Acoustic Consultant.

Vibrations from plant and other equipment is to be addressed by isolation at the source.

1.2.4 Flexibility

Structural framing and systems shall consider that the building may be refurbished and designed with the potential for a future change of use to occur. Regular column grids, large and efficient floor spans and minimal load bearing walls shall be adopted where possible.

Allowance for future expansion, vertically or horizontally, is to be agreed upon with the University. The allowance of additional loads on the structure is to be clearly noted on structural documentation for future reference. Adequate structural redundancy is to be allowed for to avoid unnecessary demolition and/or strengthening during future works.

1.2.5 Constructability

Where surrounded by existing buildings, the construction methodology and sequencing must be sympathetic to the environment to ensure construction stage disruption is minimised and is safe to build around staff and students. Off-site fabrication techniques where possible are to be considered to reduce disruption where limited site access is available.

Early contractor involvement in the form of pre-planning construction activities and verification of onsite processes and D&C structural elements is encouraged for projects where site congestion is an issue or staged decanting is required.

1.2.6 Sustainability

The University aims to address the consumption of resources for each project, by encouraging the selection of low-impact materials in accordance with the Green Building Council of Australia guidelines. It is encouraged that one or more of the following sustainability initiatives are incorporated into the project specification:

1. Portland Cement Reduction – A 30-40% reduction of Portland cement content, measured by mass across all concrete used in the project, compared to the reference case shall be specified for the project.
2. Water Reduction – Using captured or reclaimed water in concrete mix (at least 50% of the mix water of all concrete) shall be specified if available and of suitable quality.
3. Aggregate Reduction – At least 40% of coarse aggregate in concrete shall be replaced with crushed slag aggregate or alternative material OR at least 25% of fine aggregate in concrete shall be replaced with manufactured sand or alternative material.
4. Responsible Building Materials – Structural steel, reinforcing steel or timber that are responsibility sourced or have a sustainable supply chain shall be specified if available.

1.3 Structural Design

The structural design shall be based on proven methods, materials and technology. All structures shall be designed in accordance with accepted engineering practices to current relevant Australian Standards, the National Construction Code and incorporate safety in design principles.

1.3.1 Geotechnical Investigation

A geotechnical site investigation must be carried out for all new buildings. A Certified Geotechnical Engineer is to provide a comprehensive report that includes sufficient information to inform the foundation design, retaining structures and pavement design. The geotechnical brief is to be prepared by the Structural Engineer and Civil Engineer. For D&C projects, it is the responsibility of the Head Contractor to procure the geotechnical investigation with the brief and obtain a minimum of three competitive quotes for final approval by UQ. The geotechnical site investigation is to be undertaken in the preliminary phase of project, so the final report is available to the design team prior to Developed Design stage. The geotechnical report shall include as a minimum:

1. Assessment of soil strata/profiles, depth to rock/suitable bearing strata;
2. Groundwater conditions;
3. Building slab / foundation recommendations with allowable bearing pressures, shaft friction and estimated foundation settlements;
4. Site classification;
5. Retaining wall design parameters; and allowable short / long term batters;
6. Earthworks recommendations;
7. Pavement recommendations;
8. Construction and site management recommendations; and
9. Civil Engineering geotechnical requirements, including pavement CBR, dispersivity/Emerson Class and ASS/PASS where necessary. The impacts of flooding shall be considered if applicable. Refer to Civil Design Standard.

1.3.2 Floor Slabs

Suspended floor slabs are to be designed to the preceding design criteria for the most economical and flexible construction. Suspended floor slabs shall account for future flexibility in terms of services reticulation underneath the slab/beams and consider the impact of future floor penetrations up to 200mm diameter on long term deflections and structural integrity of the floor slabs.

The use of post-tensioned slabs or precast concrete systems is subject to approval by UQ. If post-tensioned slabs are installed, the final as constructed setout of tendons must be recorded on as-built documentation and provided to UQ for their records. Signage indicating that the building floor slabs and beams containing post-tensioning tendons are to be installed throughout the building in accordance with the Architectural Design Standard. The setout location of tendons may also be clearly marked on the underside of slabs to easily locate for coordination – but only on the underside of slabs where slab and beam soffits are concealed by ceilings. Tendons shall be designed to be located away from columns to allow a future zone for floor penetrations near columns. Penetrations at column heads shall be allowed for in floor slabs, either by way of providing in-situ fire-rated, boxed out services zones or nominate allowable service zones at column locations on structural drawings.

If penetrations or overhead fixings are required to be introduced in existing floor slabs, the location of reinforcement and tendons shall be confirmed by concrete x-ray investigation by a qualified Contractor. The final setout of any penetration shall be approved by the Structural Engineer prior to cutting existing slabs. The fire rating of the slab shall be restored by fire rated sealing of all penetrations in accordance with the requirements of the NCC and AS4072.1.

1.3.3 Columns and Walls

Columns shall preferably be located on a regular column grid to utilise consistent floor framing. Columns within internal functional spaces should be avoided (e.g. lecture theatres).

Load bearing walls shall be avoided where possible to allow future flexibility. Load bearing walls shall be restricted to building stair cores, lift shafts and plant rooms unless approved by UQ. Concrete or masonry walls required for bracing purposes shall be located to not impact on future proposed internal modifications.

The structural design shall avoid the use of corbels, Double structure (e.g. beams and columns) shall be used if required.

1.3.4 **Basement**

The preferred method for basement water proofing is the dry wall system with access to the face of the wall and suitable surface drain. Inaccessible waterproofing membranes for basement walls shall be avoided as leaks are impossible to locate and repair. Concrete blockwork retaining walls in basement retention systems shall be avoided unless approved by UQ, as it is difficult to maintain the correct concrete cover.

Ground floor slabs shall have, as a minimum, a 0.2mm thick polyethylene film of high impact resistance, lapped and taped at all joints. Vapour barriers and damp-proofing membranes are not waterproofing membranes and shall not be used where water is present. Refer to Architectural Design Guide for Waterproofing membranes

For existing building refurbishments where trenching through existing ground slabs is required, reinstatement of existing waterproofing/damp-proofing membranes and water stops to slab infill is required to reinstatement watertightness.

1.3.5 **Engineered Façade Systems**

Engineered façade systems shall be designed and certified by a Façade Engineer or based on the production of performance-based design intent documentation produced by a Façade Design Specialist. Engineered façade systems include bespoke elements such as window walls, outer veils supported on structural steel framing, atrium skylights and architectural metal, glazing features, etc.

Refer also to Architectural Design Standard.

The engineered façade systems shall satisfy the following objections:

1. Functionality – be durable, weatherproof and include low maintenance finishes.
2. Buildability – have a clear methodology for construction sequencing.
3. Use of standardised systems – realise the design intent with industry proven systems and design techniques.
4. Coordinated design – shall consider the interactions of each of the façade systems with each other, and the primary and secondary structure.

The engineered façade system shall satisfy the following design criteria:

1. Loadings – Designed for wind pressures in accordance with AS1170.2, with allowance made for strengthened areas in local pressure zones and maintenance loading, impact loading, abseiling load (if required), earthquake loading. Façade system shall be able to resist any hail loading (50 years – recurrence)
2. Fixings – Façade and glazing systems shall have positive fixings to supports and not rely on sealants for structural fixing. Any anchor fixing used shall comply to AS5216, and be appropriate to be used in earthquake prone regions.
3. Maintenance – The engineered façade system shall incorporate a fixed building access system for safe access for maintenance and cleaning of external façade where possible.
4. Combustibility – Façade systems used shall be non-combustible in accordance with the NCC.
5. Waterproofing – Complete façade systems shall provide adequate water and air tightness. The façade system shall comply to AS/NZS 4284 water penetration test requirements.
6. Facades shall meet the required thermal and acoustic criteria in the NCC.
7. Thermal and Building Movement – Façade systems shall be designed to accommodate building and thermal movements. For external applications -5°C to +90°C shall be considered. For internal applications exposed to direct sunlight +10°C to + 40°C shall be considered. The façade systems shall be designed to accommodate building movement of structural framing as determined by the Structural Engineer.

1.4 Materials

1.4.1 Concrete

1.4.1.1 Durability

All reinforced concrete members shall be designed with cover to satisfy the requirements for durability in AS 3600 for minimum 50 years design life. All members in above ground exterior environments at St Lucia and Herston Campuses shall satisfy the provisions for Exposure Classification B1. All members in above ground exterior environments at Gatton shall satisfy the provisions for Exposure Classification A2. Other campuses are to be assessed on an individual basis in accordance with AS3600.

Concrete cover shall consider the level of fire protection required in accordance with NCC and nominated on the structural drawings.

Construction joints in concrete shall be specified with hot dipped galvanised reinforcement or dowel bars.

1.4.1.2 Crack Control

All reinforced concrete members shall be designed to satisfy the AS3600 minimum reinforcement requirements for a moderate degree of crack control as a minimum. A strong degree of control of cracking shall be provided for all exposed concrete surfaces or concrete slabs under brittle finishes.

Temporary construction joints in long slabs and permanent control / expansion joints in slabs and walls shall be located and detailed to minimise shrinkage cracking and accommodate long term movement of the structure. Construction joints shall nominate that the first cast concrete face is to be deliberately roughened (i.e. scabbled) for shear transfer via aggregate interlock, or mechanical shear keys specified.

1.4.1.3 Concrete Curing

Curing compounds shall conform to AS 3799. All concrete pavements, structural slabs, columns etc., shall be cured using an approved method. The curing method and curing compounds must be compatible with the final application of the member and any applied surface finishes.

1.4.1.4 Tolerances

Specified tolerances shall reflect the requirements for the appearance and function of the concrete elements. Tolerances and structural specification shall meet or exceed the below minimum requirements

Concrete element	Tolerance on Surface Quality
Footings	Concealed – Class 4 in accordance with AS3610.1
Slabs	Exposed edges to be class 2 in accordance with AS3610.1 Maximum deviation from any specified height or cross-sectional dimension to be the greater of 1/200 times specified dimension or 5mm. Surface level – to be within +10mm of specified level. Flatness – maximum from a 3m straightedge placed anywhere on the surface 13mm for 90% of tests. This tolerance is consistent with AS3600 Section 17 which satisfies structural requirements. A tighter tolerance shall be required for some floor finishes (e.g. tiled, vinyl, polished concrete) where light reflecting from surface highlights undulations. A maximum variation of 6mm from a 3m straightedge would be reasonable for small areas (e.g. < $10m^2$), and 8mm for larger areas (> $10m^2$).
Columns and Walls	Concealed – Class 4 in accordance with AS3610.1 Exposed – Class 2 where viewed as a whole, and is to consider appropriate substrate
Architectural Element	Class 1, 2 or 3 in accordance with AS3610.1, depending on the application. Adopt tighter tolerances where required for floor finishes. Tolerances shall consider the appropriateness of components to be fitted, such as operable walls, precast cladding or façade framing.
External Pathways	Flatness – maximum from a 3m straightedge placed anywhere on the surface 16mm for 90% of tests.
Industrial Pavements	Flatness and levelness to specify F-numbers – finish process using a long straightedge tool. Refer to ACI-117.

1.4.2 Steel

1.4.2.1 External steel

All external structural steel, hold down bolts and connections exposed to the atmosphere or located in external masonry walls / cavities shall be hot dipped galvanized in accordance with AS 4680. External structural steel shall be specified to achieve a coating system with a minimum life to first maintenance of 15 years.

Contact between dissimilar metals can cause bi-metal corrosion and shall be avoided, or additional protective measures appled. Structural detailing shall avoid the need for on-site welding, particularly hot dipped galvanised members.

External steel framing shall be designed to deter birds from roosting or water ponding – utilise sealed hollow tube instead of open sections.

1.4.2.2 External stairs

Fit countersunk galvanised bolts to landing plates and trafficable areas to allow future inspections for corrosion where necessary. Provide for a lifting facility.

1.4.2.3 Connections (Bolts, Welds)

High strength structural bolts of category /TB or /TF shall be specified with load indicating washers.

All fillet welds shall be specified as weld category SP (Structural Purpose).

1.4.2.4 Mezzanines

Lightweight cold formed steel sections (C/Z purlin/girts) shall not be used for mezzanine floor framing. Hot rolled structural steel (or timber bearer joists where applicable) shall be used for lightweight floor framing.

1.4.3 Timber

Steel framing is preferred over timber framing in order to achieve construction utilising termite resistant materials.

1.4.3.1 Durability

All timber framing shall have the durability class 2 (minimum) or an appropriate level of preservative treatment in accordance with AS 1684.2.

Unseasoned timber framing shall not be used for internal framing.

1.4.3.2 Load Bearing Walls

The use of internal load bearing walls is to be avoided where possible.

1.4.4 Masonry

1.4.4.1 Durability

Construction joints in masonry shall be specified with a minimum of hot dipped galvanised masonry ties. Refer to Australian Standard for us of stainless steel masonry ties in harsh environments.

1.4.4.2 Core Filling

As a minimum for reinforcement concrete masonry, core fill and reinforce each core on either side of window or door openings in block-work walls and either side of all construction joints and change of direction.

1.4.4.3 Ties

Provide ties from masonry walls to supporting framework as a minimum at each floor level and at eaves.

1.4.4.4 Crack Control

Full height blockwork control joints are to be placed at maximum 8m centres to control cracking.