

Design Guidelines
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Section 20 Structural and Seismic.



Design Guidelines Index:

- 01 General
- 02 Architecture
- 03 Audio Visual
- 04 Civil
- 05 Communication Cabling
- 06 Design for Access & Mobility
- 07 Documentation Standards
- 08 Electrical
- 09 Environmentally Sustainable Design (ESD)
- 10 Fire and Life Safety
- 11 Interior Design
- 12 Hydraulics
- 13 Infrastructure
- 14 Landscaping
- 15 Lifts
- 16 Mechanical
- 17 Metering and Controls
- 18 Security
- 19 Signage and Wayfinding

 20 Structural and Seismic

Document Control

Revision History








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Key Updates from Previous Issue

Revision Item	Details
<i>20.1.6.3 Building Assessment Process</i>	<i>Amended and new content</i>
<i>20.3.12 Secondary Steel and Seismic Bracing</i>	<i>New clause</i>
<i>Appendix B</i>	<i>Removed</i>

	<u>20.1 Overview</u>	<u>1</u>
	20.1.1 Purpose	1
	20.1.2 Key Design Principles	1
	20.1.3 Seismic Policy	1
	20.1.4 Reporting and Documentation	1
	20.1.5 Structural Peer Review	1
	20.1.6 Assessment of Existing Structures	2
	20.1.7 Strengthening of Existing Structures	2
	20.1.8 Coordination with other Consultants	3
	<u>20.2 Design Concepts</u>	<u>4</u>
	20.2.1 General	4
	20.2.2 Durability	4
	20.2.3 Future proofing	4
	20.2.4 Acoustics	4
	20.2.5 Structure borne floor vibration	4
	20.2.6 Structural fire design	4
	20.2.7 Structural Materials	4
	20.2.8 Interstorey Floor Heights	4
	20.2.9 Seismic Design	4
	20.2.10 Geotechnical Performance Requirements	6
	<u>20.3 Building Elements</u>	<u>7</u>
	20.3.1 Floor Systems	7
	20.3.2 Foundations	7
	20.3.3 Façade and Cladding	7
	20.3.4 Columns & Column Elements within Walls	8
	20.3.5 Walls	8
	20.3.6 Beams	8
	20.3.7 Connection Detailing	8
	20.3.8 Stairs and Lifts	8
	20.3.9 Roofs and Parapets	8
	20.3.10 Balustrades etc.	8
	20.3.11 Retaining walls	8
	20.3.12 Secondary Steel and Seismic Bracing	9
	<u>20.4 Contractor/Installation Requirements</u>	<u>10</u>
	20.4.1 Contractor Deliverables and Information	10
	<u>Appendix A - Peer Review Requirements</u>	<u>11</u>
	<u>Appendix B - Earthquake Damage Repair Specification</u>	<u>Error! Bookmark not defined.</u>
	<u>Compliance Checklist</u>	<u>13</u>

20.1 Overview

20.1.1 Purpose

The Structure section of the Design Standard Requirements provides a reference document to support consistency across design and engineering objectives. The document provides guidance on the minimum performance standards for structural and geotechnical design, and ultimately aims to maximise the ability of the campus building stock to support the University's long term objectives.

These requirements recognise that the knowledge, science, and practice of structural and earthquake engineering are evolving. The requirements do not preclude an engineer from utilising other analysis or design approaches that may better address the specific structural characteristics and needs of a building - provided these are clearly communicated and appropriately reviewed.

This section of the Design Standard Requirements is intended to be read and applied in conjunction with **Section 01 – General** and any project specific brief and agreements.

20.1.2 Key Design Principles

The Structural Engineer should recognise that the University is not a conventional property developer, as it will typically own a building from design, through refurbishment and or extension, through to demolition. As such the University will directly benefit from all consideration of these additional phases of the buildings life cycle. With this in mind, the general design principles which should be at the forefront of decision making are:

- Consideration of safety from the outset - including during all foreseeable aspects of construction, commissioning, maintenance, and demolition.
- Recognition of the need to design spaces with intrinsic flexibility in use and potential for cost-effective alteration.
- Balancing of capital, operating, and maintenance costs over the full lifecycle of the building.

20.1.2.1 Seismic Design Objectives

The University's fundamental goal for seismic design is to ensure the provision of inherent resilience to the structure, and where possible its contents - aiming to minimise the potential risks to building occupants and the severity of future disturbance due to repairs or maintenance.

This applies in the assessment, refurbishment, re-purposing, and strengthening of existing buildings as well as the design of new buildings. The goal can be broken down into the following objectives:

- Protect life safety of the University community
- Secure the University's critical infrastructure and facilities
- Permit rapid resumption of teaching and research programs

20.1.3 Seismic Policy

All building work at the University must consider the overall University of Canterbury Campus Seismic Policy in relation to legislative earthquake prone building policy and target strengthening levels. This documents should be referred to in full, however two key requirements of the policy are:

- Buildings identified as earthquake prone in accordance with the New Zealand Building Act (NZBA) shall remain unoccupied until strengthened or demolished.

- Earthquake strengthening shall target a minimum earthquake strength of at least 67% that required for an equivalent new building, or 67% of the New Building Standard (67% NBS).

20.1.3.1 Existing Building & Site Information

The University has a large collection of existing building information including drawings, specifications, geotechnical reports, detailed seismic assessments and engineering evaluations. This information is available to design teams at the discretion of the University of Canterbury Project Manager.

Note that actual construction may not necessarily have matched the original detailing, and over time various undocumented alterations and additions are likely to have occurred. All existing information should be verified by on site review, and material testing if considered necessary.

20.1.4 Reporting and Documentation

20.1.4.1 Design Features Report

In addition to the requirements outlined in **Section 07 - Documentation Standards** the Structural Engineer is required to submit a Design Features Report (DFR) to convey all assumptions and limitations affecting use, resilience, and compliance with this design guideline. The DFR shall be initially submitted at the Concept Design stage, and updated at key milestone documentation issues throughout the project.

An extensive checklist is available from the Structural Engineering Society New Zealand (SESOC) website. However, as a minimum the report shall outline:

- Basic information on the building and foundations
- Foundation investigation and design methods, including a graphical representation of the site geotechnical model
- Building design methods, load assumptions, load paths, and assumed structural ductility demand
- Expected building deformations and design actions/requirements for secondary elements and non-structural elements (to be designed by others)
- Expected failure mechanisms, and load levels at which failure is expected
- Key structural elements for construction monitoring
- Maintenance requirements during the building life
- Anticipated repair or reinstatement strategies and methodologies.
- All safety considerations identified during the design, any mitigation methods implemented, and the residual risks.

20.1.4.2 Producer Statements

Irrespective of City Council requirements for a particular project the Structural Engineer shall provide a Producer Statement - Design (PS1) and Producer Statement - Construction Review (PS4) encompassing all aspects of their design responsibility.

Where the Structural Engineer intends to explicitly omit a portion of the structure or an associated component from their Producer Statement this shall be clearly communicated to the University at the outset of the design.

20.1.5 Structural Peer Review

The University requires the use of Structural Design Peer Review on all new build and strengthening projects. The peer review process should be defined prior to the concept design phase, and commence during the concept design phase and continue throughout the design.



20.1 Overview

The degree of peer review for each project will be determined by the University for each individual project and may include the preparation of a Producer Statement - Design Review (PS2). Refer to Appendix A - Peer Review Requirements for further details.

20.1.6 Assessment of Existing Structures

20.1.6.1 Current Building Assessments

Seismic assessments of all existing University buildings have been carried out following the 2010/2011 Canterbury earthquakes, and shall be reviewed by the project design team when existing buildings are being assessed during building projects such as earthquake damage remediation, strengthening for previously identified seismic concerns, refurbishment or alterations, function re-tasking etc.

The current building assessment reports generally include a description of the extent of investigation carried out for building damage, and a description of the extent and type of damage observed, and expected to be found within the building.

These reports shall be used as a basis for any proposed earthquake damage remediation, noting that typically, only a small portion of the structural components of the buildings may have been exposed and reviewed - and additional investigation will likely be required.

Based on a review of the existing assessment report, the existing structural drawings, and an initial building inspection, the structural engineer should select an analysis approach appropriate for the building.

20.1.6.2 Further Assessments Required

Further assessment shall be carried out as necessary to ensure that all aspects of the building that require strengthening to meet the strengthening target for the building are identified and addressed in strengthening concept designs.

However, all assessment, analysis, design parameters and configurations, and all assumptions should be clearly communicated in the Design Features Report (DFR) and other design documents.

20.1.6.3 Building Assessment Process

Future quantitative assessments of University buildings should be based on the guidance document, "[The Seismic Assessment of Existing Buildings, 2018](#)", or the appropriate updated version of this document.

For existing University buildings that have experienced the shaking associated with the 2010/2011 Canterbury earthquake sequence, the University encourages the incorporation of past seismic performance data into current assessments as part of the design process. The University maintains records that detail known damage incurred, remediation measures undertaken, costs and timeframes needed for full recovery following these earthquakes.

This information shall be used by the design team to benchmark performance, assist in identification of appropriate remediation measures, and provide a reality check on methods that might otherwise be recommended.

[The Structural Engineer is to advise the University as to which assessment approach in Section C5 of the guidance document is considered most appropriate to apply on a case-by-case basis.](#)

20.1.6.4 Remedial Actions

The University will develop a remedial action plan for all buildings where the seismic assessment has determined that the building's performance does not meet its

performance objective, or some form of action is mandated by law.

20.1.6.5 Scope of Damage to be Remediated

Determining the full scope of earthquake damage within any specific building may not be possible until the remediation project for the building is underway and detailed inspections of all critical structural elements can be carried out.

While it is essential that all major damage to buildings be remediated, there may be minor or moderate damage that does not affect the building's structural strength or serviceability that may not need to be repaired.

Design consultants shall take all practical steps to determine or estimate the full scope of earthquake damage repair required, such that accurate project budgets can be developed prior to project confirmation and initiation. Where the full scope is not identifiable during project planning stages, assumptions made in scope determination shall be clearly identified in the project documentation, and appropriate contingency allowances shall be made during budget costing exercises.

20.1.6.6 Damage Remediation Specification

During the course of the earthquake damage remediation carried out since the 2010/2011 Canterbury earthquakes, a generic repair specification has been developed to cover the general types of repairs required to structural elements. This specification shall form the basis of all project specific specifications for earthquake damage remediation. Where additions or alterations to the base specification are considered necessary, the specification shall be subject to peer review. Refer to Appendix B for full details.

20.1.7 Strengthening of Existing Structures

Buildings that are earthquake prone or have an existing earthquake strength less than 67% NBS, and require seismic strengthening, shall be strengthened in full accordance with the Design Standard Requirements.

20.1.7.1 Minimum Acceptable Strengthening Targets

It is the University's preference that all buildings undergoing strengthening be strengthened to 100% NBS in all respects. Where this is not considered reasonably practicable, the following minimum targets apply:

The minimum target strength for all University buildings is 67%NBS, and higher if practicable within the bounds of the project budget and considering the degree of intervention within the building spaces. The design engineer shall propose for review, any reasonable options identified that may achieve strengthening targets higher than 67% NBS.

Strengthening shall address all building components that have an earthquake strength less than 67%NBS, noting that existing assessment reports may only report the strength of the weakest structural component, with other structural components also being less than 67% and not specifically noted within the report. It shall be the responsibility of the design team to review and identify all such building components.

Strengthening shall address any critical structural weaknesses (CSW) as defined by published NZSEE and DEE requirements. Any proposed strengthening should not alter the load distribution such that other elements become critical at less than 67%, or other CSW's are introduced.



20.1 Overview

20.1.8 Coordination with other Consultants

The Structural Engineer is to coordinate with other design consultants to ensure that the performance of the primary and secondary structural elements is comparable to that of all other building components, including services, at both the Ultimate Limit State and any project specific or generic Serviceability Limit State.



20.2 Design Concepts

20.2.1 General

The following general design parameters should be considered during the structural design of any new build or alterations undertaken at the University. Where designs for alterations of existing structures identify limitations to these parameters due to constraints from the existing structure these should be clearly communicated to the University.

Key requirements have been included wherever possible, however it is the responsibility of the structural consultant to identify any areas of ambiguity or omission and ensure that the overall design meets the overall performance intentions identified in this guideline.

20.2.2 Durability

The general site and building exposure classification in accordance with relevant New Zealand material standards such as NZS 3101 shall be recorded in the Design Features Report, and form the basis of durability design and provisions within the structural elements and systems.

Where special and specific environmental conditions are to be catered for by the building design as part of the client brief, the local exposure classification shall be adjusted accordingly and due allowances made to ensure the structural elements are designed with appropriate durability to meet the underlying performance requirements specified by the building code, and any specific performance requirements specified in the brief.

Where specialist treatments are required to enhance the natural durability of structural elements, these shall be clearly highlighted within the structural documentation, including the design features report, to allow appropriate review and coordination with the architectural design, and other services requirements.

20.2.3 Future proofing

The University prefers large, open plan buildings spaces with flexibility to alter internal space planning and future usage without requiring significant alterations to primary structure or the building envelope.

20.2.4 Acoustics

While acoustic design does not form part of the traditional scope of works of the structural engineer, appropriate allowance for acoustic treatment required to elements such as floors and walls shall be considered early in the design process. Where space planning requires higher than "normal" acoustic performance between adjacent spaces, additional mass and weight of materials is often added to meet these requirements.

Acoustic treatment shall be considered in the concept design phase of the project. Coordination between the University, the architect and/or the acoustic engineer, and the structural engineer shall be carried out to determine any relevant increases to superimposed dead or dead load provisions required within the design parameters.

High acoustic performance requirements may lead to the selection of alternative structural systems than otherwise might normally be utilised, e.g. more solid floor systems or floor thickness.

20.2.5 Structure borne floor vibration

Floor vibration shall be considered in the design of suspended floor systems, particularly if high floor vibration performance requirements have been specified as part of the design brief.

Situations that may require specific review include:

- composite steel floors with spans > 8 m
- concrete floors with spans > 12 m
- areas of floors supported on significant cantilevers
- aerobic/dance/sport activities within the building
- laboratory spaces
- feature stairs / footbridges
- mixed use areas with high volume foot traffic next to quiet zones such as library and study areas

Appropriate guidance documents for considering floor vibration include the current versions of **SCI publication P354, Design of Floors for Vibration: A New Approach**, and **CCIP-016, A Design Guide for Footfall Induced Vibration of Structures**.

20.2.6 Structural fire design

The structural engineer shall coordinate his design and documentation with the fire rating requirements of the building design as specified in the fire report or assumed in the architectural design. Structural members and their connections that support or form part of fire rated boundaries such as floors or walls shall achieve the appropriate fire resistance rating.

Where structural elements require additional treatment to achieve the required fire resistance rating, these elements shall be clearly highlighted on the structural drawings such that appropriate coordination of fire resisting treatments may occur between the structural engineer, the architect, and the fire engineering consultant.

20.2.7 Structural Materials

The University has no preference with respect to steel, concrete or timber framed structures - provided the structural design meets the criteria and performance expressed in the Design Standard Requirements - including environmental and seismic design considerations.

20.2.8 Interstorey Floor Heights

Floor-to-floor heights and the depth of structural floor systems should be sufficient to allow services to be reticulated beneath the structural elements rather than through isolated penetrations.

Where this is not achievable consideration shall be given to providing a suitable quantity and location of supplementary penetrations to facilitate ease of future services reticulation.

20.2.9 Seismic Design

The University requires building configurations with a definable and continuous lateral load-resisting path with little or no lateral system irregularities, and seeks buildings with regular distribution of mass and stiffness in plan and elevation. Programme and other design guidelines may however, result in buildings with irregular load resisting systems. During the concept design phase the design team shall present the rationale for any such irregular building configurations, and reasons why such irregularities are unavoidable, to University for review and approval as part of the peer review process.

The University recommends the use of structural systems with demonstrated improved seismic performance in their buildings. Innovative structural systems may be proposed, but they need to be supported by sound analytical research and testing and be accepted by the territorial authority as an "alternative solution" in accordance with Building Code requirements.



20.2 Design Concepts

20.2.9.1 Building Shape & Configuration

Regular building shapes of smaller footprint area will generally provide better overall building and foundation performance under seismic shaking. However, this must be balanced against the use of larger footprint buildings to increase the ratio of floor to cladding area, which is can be more cost-effective. Re-entrant corners and floor plans that 'neck' between larger areas should be avoided.

Footprint areas are encouraged to be kept small if buildings are sited on ground that is liquefiable and/or subject to lateral spread. This will minimise the impact of differential settlement and spreading that has caused significant issues for many larger footprint buildings in Canterbury that were otherwise relatively undamaged.

If large floor plates are unavoidable, movement joints should be installed to control the effects of long-term shrinkage and expansion; and to control the impact of potential differential settlements and/or lateral spread. Joints should be located in areas where the concentrated movement may be most easily dealt with but in general, excessive slab panel aspect ratios should be avoided.

Lighter-weight building materials should be used where possible to promote the use of shallow foundation systems and reduce seismic demand.

The University prefers structural systems which allow bracing elements to be confined to the perimeter of the building or contained within localised services cores.

Seismic joints in floor slabs and foundations should in all cases be coordinated with structural movement joints or seismic separations in the superstructure. Dual lateral and vertical support lines may be required in order to maintain stability in the event of large seismic movements, and any seismic separations within the superstructure shall be appropriately sized for expected building drifts to eliminate or minimise potential "pounding" between portions of the structure. It is noted that appropriate detailing for construction joints and shrinkage control may provide beneficial foundation flexibility and facilitate readily repairable and cost-efficient structures.

20.2.9.2 Displacement compatibility

Stiff elements that are not separated from the surrounding structure will almost certainly govern the seismic response of a building, whether the designer intended this or not. Designers need to consider this and detail carefully for the implied movement of structures, including foundation rotation if this is significant. Non-structural elements that are stiff and/or brittle should be provided with adequate movement allowance. Engineering analysis shall explicitly consider actual and proposed geometries, and the manner in which elements of different systems may interact.

20.2.9.3 Importance level recommendations

As a fundamental aspect in the determination of earthquake and other loads, the building importance level for the University's buildings shall generally be determined from Table 3.2 of AS/NZS1170.0.

It is expected that the majority of the University's buildings, existing or new, will be Importance Level 2, or of normal importance. Where buildings have a capacity of greater than 500 occupants, or if more than 300 occupants can congregate in any one area within the building, the building shall be Importance Level 3.

Specific buildings that form part of critical service infrastructure systems, or other designated essential facilities, may be designated as Importance Level 4, or have specific Serviceability Limit State performance requirements. This will be defined in the project specific brief.

If not defined in the project brief, design teams shall consult with the University at the outset of every project to determine the building Importance Level before beginning any seismic assessment or structural design.

20.2.9.4 Serviceability Limit State

The University may choose to impose additional serviceability limit state criteria on the design. This may involve an intermediary serviceability limit state, similar in nature to the SLS2 criteria for an Importance Level 4 structure, with load levels and performance criteria specific to the University's needs.

This will generally be in accordance with the annual probability of exceedance table below. However, where existing building capacity or behaviour, or site specific conditions such as liquefiable soils, drive change in building performance at a particular level of design loading - this should be clearly communicated so the associated risks can be considered from a campus wide perspective.

20.2.9.5 Probability of Exceedance for Seismic Design

The following table illustrates the University's minimum requirements for return period earthquakes to be used in design in accordance with NZS1170.0. Additional University preferences for building classifications and importance levels are also summarised in the table. Note this table assumes a 50 year design life, and alternative measures may be required if this assumption changes.

Building Use	IL	SLS1	SLS2	ULS
Small (<30m ²) ancillary buildings that are not usually occupied	IL1	1/25	n/a	1/100
Larger ancillary buildings	IL2	1/25	n/a	1/500
Buildings with capacity less than 500 occupants	IL2	1/25	n/a	1/500
Buildings with capacity more than 500 occupants, or where more than 300 can congregate	IL3	1/25	n/a	1/1000
Designated "operationally essential" facilities	IL3	1/25	1/250*	1/1000
Designated critical facilities	IL4	1/25	1/500	1/2500

*In some circumstances it may be appropriate to use a 1/100 return period for these facilities. This should be discussed with the University if high levels of seismic are not interpreted to be a key driver in the project brief.

20.2.9.6 Additional Seismic Resilience Requirements

The following additional seismic resilience requirements shall be incorporated into the structural design:

- Capacity design is to be used regardless of the ductility used in design. This shall apply for the design of both the superstructure and the foundation elements.
- Redundancy in the primary structural systems is required where failure of one element could result in a disproportionate risk of global collapse of the structure.
- Where building inter storey drifts are expected to exceed 0.5%, consideration shall be given to isolating non-structural building elements such as internal partition walls etc. from drift effects to mitigate the risk of drift related damage to linings. This is particularly relevant to fire rated partitions where damage to fire rated linings may compromise the required fire rating.



20.2 Design Concepts

20.2.10 Geotechnical Performance Requirements

20.2.10.1 Coordination with Geotech

It is the Structural Engineers responsibility to coordinate with the Geotechnical Engineer to achieve the design outcomes outlined in these requirements.

In particular, the design shall be coordinated to ensure the foundation performance is comparable to that of the superstructure, and that expected settlements are within tolerable limits.

20.2.10.2 Site Selection Implications

Prudent site planning and foundation design is required to reduce future damage to buildings due to ground movement. Subject to a detailed assessment of the geotechnical conditions at a particular site, planners/designers should consider locating buildings on the most stable areas of sites. In particular, buildings should be located as far as practicably possible from watercourses (existing or historic, naturally filled or infilled, where known) and potentially unstable slopes. Geotechnical investigation shall be undertaken to locate historic watercourses and sedimentary features that may contribute to detrimental performance. To the degree that the proposed structure cannot avoid such features, adequate means to address these features in the design shall be proposed during the concept design phase.

One of the first elements of this is to establish the broad ground classification of the site, in accordance with the following table:

Site Class	Land performance expectation	Nominal SLS land settlement	Nominal ULS land settlement	Nominal ULS lateral spread
Good ground	Refer to NZS3604 Settlement [1] or liquefaction damage from a future large earthquake is unlikely	0-15mm	0-25mm	Generally not expected
Poor ground	Settlement [1] or liquefaction damage from a future large earthquake is possible	<=50mm	<=100mm	<=500mm
Poor with lateral spread [2]	Settlement [1] or liquefaction and lateral spread damage from a future large earthquake are likely	>50mm	>100mm	>500mm

1. Settlement refers to ground movement that may result under seismic or non-seismic "loading" conditions, such as might be expected in compressible or expansive soils (e.g. peat or reactive clays)
2. Lateral Spread is the flow or stretching effect that is experienced by some soils during ground shaking, typically in liquefaction-prone areas, and often accompanied by settlement. This is often, but not always, alongside watercourses.

In considering the vulnerability of soils to liquefaction and consequent effects, designers may refer to the Ministry of Building, Innovation and Employment (MBIE) Residential

Building Guidance, in particular the foundation technical categories (TC1, TC2, and TC3).

Although the Technical Categories are restricted to residential properties in the Canterbury Earthquake region, the TCs may further inform the assessment of likely site performance for University sites. In addition, the TC assessment procedures may assist in the assessment and ready communication of the general geotechnical nature of University sites outside the Christchurch area.

20.2.10.3 Allowable Building Settlements

The geotechnical engineer and structural engineer should work together to develop a robust foundation solution that matches the ground conditions and is compatible with the structural form and use of the proposed building.

It should be noted that the 25mm in 6m differential settlement guidance given in Appendix B of NZBC B1/VM4 is informative only, and that this may be exceeded if the structure is specifically designed to manage damage under a greater level of settlement.

Greater levels of movement may be tolerated by the University, if the impacts can be managed. This may require firstly that the superstructure can be shown to receive only minor damage from the predicted movement, and then that the building may be re-levelled/ repaired within reasonable time and cost (say within a standard vacation period for the on-site implementation work, or otherwise without significant impact on the operation of the university).

In buildings with large floor-plates, absolute differential settlement limits may be unnecessarily restrictive, where a focus on utility only may determine that the floor slope is acceptable. In such cases, designers should consider the potential impact of large absolute settlements separately, in discussion with the University.

The University will work with designers to determine acceptable performance and re-levelling criteria (i.e. serviceability limit states) for sites where rigid adherence to the NZBC guidance may otherwise generate an inefficient solution, that is, where the foundation cost would otherwise be disproportionately high.



20.3 Building Elements

20.3.1 Floor Systems

Floor slabs shall be designed for the most economical construction and flexibility of use with due consideration to long-term deflections and the need to provide for penetrations both initially and during the course of the building's life. Designers shall consider:

- The need to core holes up to 200mm diameter or for penetrations up to 1200mm square in selected areas in the future should be taken into account during design.
- Topping slab thickness must address both fire and acoustic performance requirements - and in wet-use areas (such as laboratories and bathrooms) shall provide sufficient redundancy to accommodate future recesses and falls.
- Floor vibration characteristics as per section 20.2
- All floors are to be finished within a maximum tolerance of $\pm 3\text{mm}$ in 3000mm in any direction.
- It is preferred that floor systems not be designed as requiring propping during construction without input from the Contractor.
- The use of slab-on-grade floors within internal spaces shall only be considered where it can be demonstrated that potential settlement damage has been considered and appropriate and cost effective repair methodologies have been determined.

20.3.1.1 Design Loadings

In addition to statutory requirements the following minimum live load allowances shall apply:

Area	Minimum
Office Floor - General live load	5 kPa
Compactus areas	10 kPa
Computer equipment areas	6 kPa
Air handling, refrigeration, boiler plant rooms	8 kPa

In addition to the live load, a minimum superimposed dead load allowance of 1.0 kPa for suspended ceilings and services etc. shall be provided.

Heavily loaded areas shall be subject to specific calculation to determine applied loadings, e.g.

- Storage
- Libraries
- Machine Rooms, etc.

Any loading calculations that indicate loading less than the reference values specified in table 3.1 of the loading standard, AS/NZS 1170.1, shall be reviewed with the University. The intention is that table 3.1 provide minimum loading allowances.

Design allowance for heavy loadings, and Compactus areas in particular, shall be restricted to the areas specified in the briefing documents. If these are not clearly defined the Structural Engineer shall confirm the locations for design rather than providing a general allowance for these items. All design loading allowances shall be clearly indicated on the structural drawings for future reference.

20.3.2 Foundations

The University's preference is for shallow foundation solutions. However, foundations shall be appropriate for the applied building loads and ground conditions, as determined from the geotechnical investigation and recommendations within the geotechnical report.

Buildings with significantly different pile lengths or depths of foundation should be avoided.

It is best to avoid locating buildings in positions that cross boundaries between different soil types, or that have extreme variations in the depth of or to soils that are prone to settlement. Where this cannot be avoided, give consideration to foundation types that minimise the impact of these factors.

20.3.3 Façade and Cladding

Lightweight cladding is generally preferred, however alternative systems will be considered provided they meet the intent and requirements of the Design Guidelines.

Cladding

Heavy and potentially brittle cladding such as masonry or precast concrete shall not be located above or adjacent to locations where students may congregate, or above or adjacent to access and egress paths, except at low level.

When considering the use of heavy cladding, the architectural and structural engineering implications should be considered in a holistic fashion. Brick cladding is a robust durable system that has many advantages for buildings when considered over the whole building life, but it may not be suitable for all locations, with consideration of geotechnical conditions, seismic loads, and falling hazard.

It should be noted that the additional seismic mass of cladding systems may impose a considerable penalty on the design of lateral load systems, particularly in cases where the overall seismic load significantly exceeds the wind load. If comparing whole-of-life costing's for cladding systems, the added impact of heavy cladding systems should include a factor to allow for additional foundations and lateral bracing strength.

Where installation of stiff and/or heavy cladding systems are proposed, additional care shall be taken to ensure they are appropriately detailed to allow for seismic deflections and they do not alter the intended seismic load path.

Glazing

Glazing systems shall be designed in general accordance with the New Zealand standards for glazing in buildings, NZS 4223, incorporating the appropriate increases to the seismic design loads for the Canterbury region.

In addition, glazing systems shall be designed with sufficient clearance to accommodate the full lateral displacement implied by the ULS design level wind or earthquake loads, with allowance for inelastic drifts calculated in accordance with NZS1170.5.

Above Egress Routes

The use of pre-cast concrete or other heavy cladding systems over egress routes or external public spaces is prohibited unless specific study illustrates the suitability of these elements to sustain a suitable margin of performance beyond the Ultimate Limit State loadings and displacements.

Similarly, safety film should be applied to overhead glazing panels and glazing above egress ways in existing buildings and the fixings of these elements shall be detailed to accommodate the expected movements.



20.3 Building Elements

20.3.4 Columns & Column Elements within Walls

The University requires that significant load bearing elements in buildings of more than one storey are designed to be as robust as practicable, in order to provide a greater measure of protection against the damaging effects of seismic movement and to provide a greater level of protection to occupants. "Robust" in this context refers to structural performance and not "massiveness", which may be counterproductive to structural performance.

In buildings of more than one storey, all concrete columns (or column elements within walls of concrete and concrete masonry) shall be detailed for ductility in accordance with the additional provisions of the relevant standards, regardless of the building system ductility or capacity design procedures that the designer has elected to use.

In practice, this means that all affected columns and column elements within walls must be detailed with sufficient closed stirrups and links that the columns are capable of developing full ductility ($\mu \geq 3$). Designers may have elected to design the overall structure for elastic or nominally elastic actions ($\mu \leq 1.25$), but this University requirement recognises that displacements at these levels may be exceeded under a larger earthquake and that the additional ductility can be added for nominal increase in cost and may result in considerable savings for repairs, and a greater likelihood of the building remaining usable after a seismic event.

Similar consideration of ductile performance shall also be made for load bearing structural steel columns within buildings, such that category 1 performance in accordance with the New Zealand Steel Structures Standard, NZS3404, will be achieved.

20.3.5 Walls

Slender structural walls with single layer reinforcing shall be avoided as part of structural design solutions, unless appropriate ductility and out-of-plane performance during earthquake shaking can be demonstrated.

Non-structural walls shall be appropriately isolated from earthquake induced building drifts, unless drifts at the prescribed serviceability limit states are sufficiently low as to not initiate damage.

20.3.6 Beams

Beams that form part of moment-resisting frame systems shall be appropriately detailed for ductility, with particular attention to the potential plastic-hinge zones that may develop away from support or columns lines as a result of the combination of earthquake and gravity load moment patterns.

20.3.7 Connection Detailing

Connections between structural elements, and between non-structural elements and their supporting structure, shall make due allowance for expected building movement and earthquake induced drifts.

A common performance issue observed following the 2010/2011 Canterbury earthquakes related to insufficient movement allowance, or movement allowance that was designed and documented, but not implemented appropriately during construction.

Connections of critical or particularly hazardous elements shall consider drifts at and beyond the ultimate limit state (ULS) while non-critical connections shall perform adequately at any specified serviceability limit states.

20.3.8 Stairs and Lifts

Failure of existing lifts during the 2010/2011 Canterbury earthquakes highlighted deficiencies with lift performance, particularly with the performance of the counterweights and counterweight guide rails, and the seismic restraint of lift machinery.

During remediation or strengthening projects for existing University buildings, consideration shall be given to upgrading existing guide rails and fixings within lift shafts. Generally this has been achieved to date by increasing the number of guide rail fixings by installing additional fixings between the existing fixings, with appropriate secondary supporting structure as necessary.

Design of upgraded lift components, and new lift installations, shall comply with the appropriate requirements of the New Zealand standard for non-domestic passenger and goods lifts, NZS 4332, incorporating the appropriate increases to the seismic design loads for the Canterbury region, and building specific displacements.

20.3.9 Roofs and Parapets

Roofs shall be detailed with adequate falls to prevent ponding. If "flat" structural systems are proposed, adequate allowance for non-structural screeds or fall build-up, and weather protection shall be included in the design parameters of the system.

Consideration of roof access and safety of maintenance personal shall form part of the design process. A suitable harness system shall be provided if compliant edge protection does not form part of the design. All harness system connection loads shall be transferred to the primary roof structure, and design loads for these connections shall be as specified in the appropriate New Zealand guidance, such as the Ministry of Business, Innovation & Employment Best practice requirements for working at heights in New Zealand.

Parapets and other compliant edge protection shall be connected to the primary roof structure and designed for the minimum imposed actions from table 3.3 on AS/NZS 1170.1 for the appropriate occupancy type considering the building use and level of access to the roof.

20.3.10 Balustrades etc.

Balustrades and other barriers shall be connected to the primary building structure and as a minimum level, designed for the imposed actions from table 3.3 of AS/NZS 1170.1 for occupancy type C3, or larger as appropriate.

20.3.11 Retaining Walls

Retaining walls shall be separate from buildings wherever possible.



20.3 Building Elements

20.3.12 Secondary Steel and Seismic Bracing

The University's preference is for the secondary seismic steel and seismic bracing to be designed concurrently with the rest of the design elements, rather than for the full scope of this work to be passed entirely to the contractor in the form of a performance specification without due consideration.

As a minimum it is expected that the Design Team document a solution to a level of detail within the structural drawings which allows for detailed cost estimation and spatial coordination activities to occur, particularly for critical junctions and highly serviced areas. The specific design deliverables in this space are to be discussed with the University on a case-by-case basis.

20.3.12.1 General Provisions

Non-structural systems and components shall be considered during projects involving either existing University buildings or new building designs. The design team shall address seismic bracing and anchorage of all non-structural systems and components within the building, including heavy or unstable contents that may not otherwise be restrained against seismic actions. This should include mechanical, electrical, and plumbing (MEP) systems (such as sprinklers, ducts, pipes, conduits, HVAC and other mechanical and electrical equipment), racks, shelves, optical tables, benches, tables, cold rooms, fume hoods, etc., as well as architectural components (such as partition walls and ceilings, ornaments, heavy joinery units, screens, curtain walls, light fixtures, roof tiles, etc.).

The design team should also provide support systems, such as uni-strut rails, in areas of the building that may support laboratory functions and which are intended for storage of heavy equipment (e.g., freezers, incubators, etc.) to enable the bracing of furnishings and laboratory equipment. Such bracing shall be placed at heights and locations that are most appropriate for the type of content intended for that particular location.

In general, the non-structural systems of University buildings should meet the same performance requirements as required of the building as a whole. This means that:

- After an SLS1 earthquake, all aspects of the building should be fully operational, needing only readily implemented repairs that do not materially impact operation of the building.
- After an SLS2 earthquake, a building should be able to be used as intended, but with repairable damage that may be completed over limited periods such as scheduled breaks.
- After a ULS earthquake, damage to non-structural systems and components shall not be disproportionate to structural damage, with remediation able to be effected within the time frames required to remediate structural damage and re-occupy the building.

All non-structural systems, but in particular those which may impact on the continued use of the building, must be appropriately detailed in accordance with the relevant standards or good practice for the required loads and/or movements calculated from NZ1170.

The Structural Engineer should either include bracing and anchorage requirements on the structural documents or review and approve Architectural/MEP documents, which address these issues.

The Structural Engineer should also review typical anchorage and bracing installation details during construction site visits and work with the general contractor and any special inspection and testing agency to develop a quality assurance plan that ensures that all bracing is installed correctly. The structural engineer

should also review all attachment details of non-structural components, equipment, and content to ensure they do not impact the performance of the building's structural system. Design and anchoring of non-structural systems is also subject to peer review.

20.3.12.2 Partitions

Partitions shall be protected from damage at SLS levels of shaking, either by limiting seismic drift of the primary structure to less than the drift which causes onset of damage for the partitions, or by providing seismic protection to the partitions (such as sliding head restraints and appropriate separation to primary building structure).

20.3.12.3 Ceiling Systems

In general, ceilings must be laterally secured and designers must consider deformation compatibility in the detailing of edges and junctions with structural elements; and where the ceiling may interact with other non-structural elements such as light fittings, sprinklers, and partitions.

Suspended ceiling systems, where used, shall be designed in accordance with AS/NZS 2785, for loads in accordance with NZS1170.5.

20.3.12.4 Building Services

Mechanical and electrical systems (including ICT and security system elements) shall be secured in accordance with NZS4219. Unless the design of ceiling systems has specifically considered the additional weight and behaviour of services in the design of lateral restraint, all suspended services elements shall

20.3.12.5 Building Services

Mechanical and electrical systems (including ICT and security system elements) shall be secured in accordance with NZS4219. Unless the design of ceiling systems has specifically considered the additional weight and behaviour of services in the design of lateral restraint, all suspended services elements shall have independent lateral and vertical restraint.

Deformation compatibility with other non-structural elements and with primary structure must be considered in the configuration and design of building services and supporting elements.

The potential interaction between buildings (and particularly their foundation elements) may impact building services. In this case the ability of services to tolerate differential movement must be addressed. Where necessary, potential repair strategies must be developed to cover the building services.

Fire sprinkler systems may require special attention to ensure that seismic induced building movements at SLS levels of shaking are accommodated within the pipework systems, and at junctions with structural or non-structural components, to reduce the risk of unintended seismic induced release of fire suppression water.



20.4 Contractor/Installation Requirements

20.4.1 Contractor Deliverables and Information

The Structural Engineer shall specify in the tender issue documentation any and all information they are likely to require from the Contractor to satisfy themselves at the end of the project that the work is completed in accordance with the Producer Statement - Design (PS1), and ultimately require in order to issue a Producer Statement - Construction (PS4).

- These requirements should be captured predominantly in a single section of the Structural Specification and should include reference to items such as
- Quality Assurance requirements for construction methods requiring pre-approval from the engineer. For example, curing of concrete elements, or protection to intumescent paint.
- Specific testing requirements. For example testing of site or shop welding, or the installation of embedded anchors
- Specific Contractor deliverables. For example pre-pour checklists, issue and distribution of site reports, notice for inspections, or requirements for photographic records.



Appendix A - Peer Review Requirements

A key part of successful project delivery at the University incorporates the use of Structural Design Peer Review early in the design process and through the finalisation of construction documentation. The peer reviewer reports to the University of Canterbury Project Manager and assists the design engineer in ensuring that the latest seismic engineering practices are incorporated as appropriate, that critical seismic deficiencies within existing buildings are addressed, that viable alternative options are explored, that design solutions are not overly conservative or wasteful, and that the design detailing is comprehensive and sound.

Process

The University requires that all new build and strengthening projects be subject to peer review by the University or their appointed peer review consultant. The peer review process should be defined prior to the concept design phase, and commence during or at the completion of the concept design phase, or otherwise when project criteria are being developed. The peer reviewer works closely with the project design engineer in confirming the structural design, methodologies, and compliance with these requirements.

The peer review will continue through the developed and detailed design phases. The degree of peer review for each project will be determined by the University in the project briefing and may include the preparation of a Producer Statement – Design Review (PS2) to be included with the building consent documentation.

Peer reviews are intended to improve structural design and provide a measure of additional assurance with respect to the seismic performance, safety, and efficiency of the structure. The University recognizes the value of peer review because building code provisions represent minimum requirements, and compliance with building code criteria alone does not necessarily meet the University's desired structural performance and acceptable level of safety.

The peer review serves as a different "set of eyes" that comprehensively examines the structural design for building code compliance, enhanced constructability, and increased assurance in cases where new and/or innovative solutions are proposed. The peer review may also be used for commenting on alternative solutions that may be used more cost effectively to achieve the performance objectives for the project.

A peer review does not replace normal design procedures and standards performed by the design engineer, such as using appropriate codes, internal checking and quality reviews.

Responsibilities

The responsibility for structural design remains fully with the design engineer, who is contractually obligated to prepare structural drawings and related documents.

Responsibility for adherence to the peer review process lies with the University Project Manager. After the project manager has retained the services of the peer reviewer, the design engineer contacts the peer reviewer, schedules meetings to discuss the project and peer review process, and provides structural documentation sufficiently in advance to facilitate timely peer review. The design engineer works with the peer reviewer and the project manager to establish a mutually agreeable peer review scope of work, schedule, and deliverables.

The peer reviewer transmits appropriate queries and recommendations, allowing adequate time to address and incorporate comments into the project design. The design

engineer ensures that final and complete documentation of the peer review process is obtained and copied to the project manager. The primary responsibility for communication and transmission of documents lies with the design engineer.

The design engineer is responsible for responding to, and providing appropriate documentation to answer and resolve peer review queries.

Qualifications

In order to render a thorough and impartial peer review, the peer reviewer should possess the following qualifications:

- "Peer(s)" of the project design professional(s) with a high level of technical expertise in seismic design and earthquake engineering
- Familiarity with local regulations for the project being reviewed and the Universities design guideline documents
- Independent from the project design team, with no conflict of interest with the design engineer
- Able to conduct peer review in an unbiased, objective, and constructive manner
- Cooperates with the full project team for overall benefit of the project and other parties
- Adequate resource availability to not delay appropriately developed project programmes
- A Chartered Professional Engineer registered in New Zealand.

Scope

The scope of the peer review shall be defined on a project-specific basis. The scope can vary but shall include the following:

- A definition of what is to be reviewed with an understanding of the building's function and performance objectives, including seismic design and vibration criteria. Impacts on budget and cost issues should also be addressed
- Meetings between the peer reviewer, the project manager, and the design engineer, and if necessary, a representative from Capital Projects. It is important that a meeting takes place prior to the concept phase of the design to review and agree on the review criteria and process.
- Acknowledgement of the review process to be followed (schedule, submittals, document formats, etc.).
- The peer review should consider value engineering opportunities, and the peer reviewer should assist the design engineer in identifying alternative systems, materials, and methods for the project to maximize structural efficiency, and reduce project cost. The peer review should confirm that the structural design meets, but does not unreasonably exceed, the project's established performance and design objectives.

Specific elements of the Peer Reviewers scope of work may include:

Loading and structural systems with respect to:

- Architectural/functional requirements
- Geotechnical criteria including site topography, soils, settlement potential etc.
- Building or other adjacency issues
- Wind and earthquake forces; including seismic performance objectives

Performance Evaluation

- Structural serviceability including deflection and lateral drift
- Vibrations
- Crack control



- Settlement, total and differential
- Effects of deflection, lateral drift, and other movement on non-structural elements
- Response to wind and earthquakes

Structural System

- Ability of selected structural framing materials and systems to meet performance criteria
- Degree of redundancy, ductility, and compatibility
- Appropriateness of member sizes and locations
- Appropriateness of foundation type and design
- Compatibility of structural system and non-structural elements
- Detailing of structural system
- Basic constructability of structural elements and connections
- Appropriateness of inclusion of seismic separation in any portion of the system

Detailed Design

- Methodology and spot checking of structural calculations and/or independent calculations
- Review of structural design drawings and specifications for adequacy, clarity, basic constructability, and testing and inspection requirements

Safety in Design

- Due consideration of Safety in Design aspects during the buildings' life cycle including construction, operation, inspection and maintenance, and demolition and disposal.

Peer Review Report

The peer review is complete when the design engineer has satisfactorily addressed in writing all of the peer reviewer's comments. A single report format should be used to provide a comprehensive record of the completed peer review from start to finish. It shall identify all of the issues that were raised at each step of the process and how they were resolved. At the end of the project, all issues should be resolved with agreements reached between the peer reviewer and the design engineer. If there are any disagreements, they should be indicated in the form and brought to the attention of Capital Projects as soon as they arise. The final Peer Review Report Form remains in the project file and a copy is provided to Capital Projects.

Submittals

The following information is considered to be the minimum information submitted by the design engineer to ensure a proper peer review at each of the project phases required. More information may be deemed appropriate on large or complicated projects and should be discussed and mutually agreed upon by the University of Canterbury project manager, the design engineer, and the peer reviewer prior to commencement of the work.

- Project Schedule including key milestone delivery dates
- Structural System Design Features Report including:
 - Performance Objectives
 - Seismic and Geotechnical Design Criteria
 - Structural Systems Descriptions (Foundation, Gravity and Lateral Force Resisting Systems)
 - Analysis methods proposed to be used to achieve the design criteria
 - Relevant/current drawings and calculations appropriate to the project phases required

Review Comments

The peer reviewer is required to provide a professional opinion as to the compliance of the design with the Building Code, the University structure design guideline, and any specific performance criteria established for the building. The peer review process must be fully documented. Peer review comments are to be provided in writing to the design engineer and copied to the University project manager. Review comments shall be uniquely numbered and shall indicate the specification section or drawing number the comment references. As a minimum, each comment shall be identified by one of the following five categories:

- Type 1: Potential structural design concern or code violation
- Type 2: Missing information, coordination problem, or constructability concern
- Type 3: Suggestion, drawing error, or discrepancy (no response required)
- Type 4: Value Engineering opportunity
- Type 5: Seismic Performance Issue

The design engineer shall provide written responses to all Type 1, 2, 4 and 5 comments.

Resolution of Differences

While the responsibility of the structural design rests fully with the design engineer, the peer review should be one of teamwork and cooperation between the design engineer and the peer reviewer to produce a structural design that achieves the prescribed level of performance for the building. Direct and open communication between the design engineer and the peer reviewer is necessary to avoid misunderstanding. Despite this, honest differences may arise. The differences are expected to be worked out by extended consultation between all parties, including the University of Canterbury project manager where necessary. If irreconcilable differences arise between the peer reviewer and the design engineer, the University of Canterbury project manager shall resolve the matter internally with the assistance of Capital Projects.



Compliance Checklist

Project Name:

Date:

Submitting Consultant:

Design Stage:

Section 20 – Structure

Compliance Checklist

	Complies	Does Not Comply	Not Applicable	Comments:
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1.0 Section 01 – General

#	All Clauses	Complies	Does Not Comply	Not Applicable
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20.1 Overview

20.1.1	Purpose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.1.2	Key Design Principles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.1.3	Seismic Policy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.1.4	Reporting and Documentation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.1.5	Structural Peer Review	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.1.6	Assessment of Existing Structures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.1.7	Strengthening of Existing Structures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.1.8	Coordination with other Consultants	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20.2 Design Concepts

20.2.1	General	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.2	Durability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.3	Future proofing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.4	Acoustics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.5	Structure borne floor vibration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.6	Structural fire design	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.7	Structural Materials	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.8	Interstorey Floor Heights	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.9	Seismic Design	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.2.10	Geotechnical Performance Requirements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20.3 Building Elements

20.3.1	Floor Systems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.3.2	Foundations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.3.3	Facade and Cladding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.3.4	Columns & Column Elements within Walls	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.3.5	Walls	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.3.6	Beams	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.3.7	Connection Detailing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.3.8	Stairs and Lifts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Compliance Checklist

Project Name:

Date:

Submitting Consultant:

Design Stage:

Section 20 – Structure

Compliance Checklist

		Complies	Does Not Comply	Not Applicable	Comments:
20.3.9	Roofs and Parapets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
20.3.10	Balustrades etc.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
20.3.11	Retaining Walls	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Error! Reference source not found.	Secondary Steel and Seismic Bracing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
20.4	Contractor/Installation Requirements				
20.4.1	Contractor Deliverables and Information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Appendix A	Peer Review Requirements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Compliance Checklist

Project Name:

Date:

Submitting Consultant:

Design Stage:

Section 20 – Structure

Compliance Checklist

Complies

Does Not Comply

Not Applicable

Comments:

Date:

Acceptable

University Reviewer:

Acceptable subject to comments

Signed:

Resubmission required

