Our Ref: 1605

31 July 2011

Insight Unlimited Ltd
P.O Box 1219
GISBORNE 4040

Attention: John Radburn

Dear John,

Re: Mona Vale Homestead – POST-EARTHQUAKE INSPECTION

Scope of this Report

This report covers our assessment of the structural condition of the Mona Vale Homestead building at Fendalton Road, Fendalton, Christchurch, following the magnitude 6.3 earthquakes on 2nd February 2011 and that of the 13 June 2011. Our assessment is based on a visual inspection of the outside and inside where it was deemed to be safe to enter. This was carried out on the 22nd June 2011 and 28th July 2011.

This report describes the damage observed, and comments on remedial work options for both temporary securing of the building, and long term repair where appropriate. This report is preliminary only and does not cover a detailed structural strength assessment or detailed specification of remedial works but does provide some investigation and assumptions that will allow an assessment to be made as to whether to reconstruct or demolish.

1. Scope of Investigation

On the 22nd June 2011 and 28th July 2011, we visually inspected the building including:
The exterior from ground level
The interior

This report is based on our assessment of the building at the time stated. Photos attached in Appendix A are indicative of the damage. Any subsequent loading by aftershocks, or high winds, may initiate further damage.

2. Building Description

General description:
The Mona Vale Homestead is a two storey gable roof structure consisting of double skin unreinforced brick walls with timber framed floors to the lower level, solid plaster walls on

timber framing with timber framed floors to the upper level, and timber framed roof structure with clay tile roofing. The building is constructed in an "L" shape structural form. The building is shown in the attached plans in appendix C and is approximately 280m2 first floor and 390m2 ground floor.
The building was first constructed 1910.

The building was being used as a Restaurant, but is currently unoccupied due to earthquake damage. The main occupancy classification in NZS1170 is C1 (Restaurants) and B (Communal Kitchens) and importance level of 2. The occupant load is calculated at 170 as classified by the Building Code Clause C table 2.2.

Roof construction:
Clay Tiles on sarking on timber framing.

First Floor External Wall construction:
Solid Plaster walls on timber framed walls with sarking and plaster board over to inside face.

First Floor Internal Wall construction:
Light timber framed walls with plaster linings.

First Floor Floor construction:
T&G Flooring on timber floor joists supported on timber beams, timber walls and brick walls.

Ground Floor External Wall construction:
Double skin unreinforced brick walls with sarking and plaster board over to inside face.

Ground Floor Internal Wall construction:
Unreinforced brick walls with sarking and plaster board over plus light timber framed walls with plaster linings.

Ground Floor Floor and Foundation construction:
T&G Flooring on timber floor joists supported on timber bearers on piles, with a concrete perimeter foundation wall (assumed unreinforced).

Structural System:
The gravity structural system can be described as simple beam and post/wall support
The structural system can be described as face loaded unreinforced masonry supported at foundation level and ceiling/roof level with nominal diaphragms taking loads back to unreinforced masonry walls acting in-plane. Load then transfers to mass concrete foundations to the ground.

3. Strength
The strength of the building has been determined as a % NBS using methodologies provided by NZSEE.

Before September 2010:
The strength of the building before September 2010 is estimated as

Dining Wing
First Floor
Hazard factor 0.22 (pre 19th May 2011) 56% NBS
Hazard factor 0.3 (post 19th May 2011) 41% NBS
Ground Floor
Hazard factor 0.22 (pre 19th May 2011) 45% NBS
Hazard factor 0.3 (post 19th May 2011) 33% NBS

Office Wing
First Floor
Hazard factor 0.22 (pre 19th May 2011) 65% NBS
Hazard factor 0.3 (post 19th May 2011) 88% NBS
Ground Floor
Hazard factor 0.22 (pre 19th May 2011) 57% NBS (governed by face loading on brick walls)
Hazard factor 0.3 (post 19th May 2011) 42% NBS (governed by face loading on brick walls)

On day of inspection:
The strength of the building on the day of inspection is estimated as

Dining Wing
First Floor
Hazard factor 0.3 (post 19th May 2011) 35% NBS (estimated only)
Ground Floor
Hazard factor 0.3 (post 19th May 2011) 5% NBS (estimated only)

Office Wing
First Floor
Hazard factor 0.3 (post 19th May 2011) 50% NBS (estimated only)
Ground Floor
Hazard factor 0.3 (post 19th May 2011) 35% NBS (estimated only)

It must be understood that this strength is based on the overall building strength and not individual elements. It is clear that some individual elements in fact have an even lower strength due to local cracking etc and as low as 0% in places. Furthermore this estimate is based on the fact that there is now significant cracking and lose of adhesion between bricks thus making the structure vulnerable as was shown on the north west wall of the dining wing with the continual collapse of the wall veneer and structural wall.

3. Damage Description

Damage caused by the February earthquake to the Mona Vale Homestead is described below. Damage described is that observed on the day and indicated on the L2 reports. Refer to Appendix B for marked-up drawings and sketches from the L2 reports indicating damaged locations.

i. General Damage to Exterior Walls:
General damage includes cracking of masonry walls, foundations and columns.

ii. Damage to Dining Wing:
This Section has suffered severe cracking to the brick walls both in the veneer and structural elements. The northwest wall veneer has partially collapsed and the structural wall has bricks dislodging. This section of wall is at high risk of collapse. The stair outer wall has partially collapsed.
The other walls have diagonal cracking with widths of up to 10mm to 20mm in places.
Bricks have become dislodged in some arch areas.
Ceilings have large cracks and are significantly damaged.

iii. Damage to Office Wing:
The brick walls have general cracking only with plaster walls also suffering general damage. Ceilings have general cracking.

iv. Damage to Internal Walls:
There is severe cracking to all internal brick walls in the Dining wing in the north south direction. The fire place and toilet block walls have large structural cracks. Plastered timber framed walls have suffered general damage.

v. Damage to Ceilings:
Ceilings have been significantly damaged at the Dining wing of the building with a lesser degree of damage occurring to ceilings in the Office wing. Damage ranges from severe across the whole ceiling to severe around edges to minor cracking.

vi. Collapse of brick chimneys:
The brick chimneys have collapsed or are damaged and have been removed. The chimneys have caused significant damage to the roof immediately adjacent where they pass through same.

vii. Damage to Roof:
The roof has remained relatively undamaged to the naked eye. However with the amount of relative movement in the walls some damaged is likely to have occurred.

viii. Other damage:
Cracked glass to some windows.
Minor cracking was found in the ring foundation.

4. Immediate Securing of the Building

The following works are required to mitigate immediate hazards, temporarily secure the building, and provide weather tightness:
Fence of site completely and restrict access up to 10m from exterior face of gables and 6m from eaves.
Provide temporary support and bracing to the Northern end of the dining wing to the where walls have fallen away. Remove remainder of bricks.
Provide temporary support and bracing to the roof to the stairwell exterior wall where bricks have dislodged or fallen away. Remove remainder of bricks.
This wall is to be either deconstructed or propped temporarily as described in the L2 report.
Provide temporary support and bracing to the upper floor where there support is collapsing.

Further calculations and detail confirming this is still required and should be discussed in conjunction with the Contractor who will carrying out this work and yourselves.

Due care, safety equipment and precautions must be taken when carrying out the above work. Maintain awareness of fall hazards and escape routes if entering the building.

5. Long Term Repair

This section of the report outlines options for repair to restore the building to a minimum 67% NBS. In most areas over 100%NBS is obtained especially where we have added new elements. We are of the opinion that if the repair costs were within acceptable budget and the building was deemed significant enough to repair then this is possible. However we are of the opinion that the internal masonry walls and structural portions of the exterior masonry walls need to be replaced in the Dining area to remove these hazards. Options for repair and/or strengthening will ultimately need to be discussed with the owner, and will be subject to revised local authority legislation.

i. Exterior Walls:

Two options are available

1. Strengthening could be successfully completed by removing the internal brick skin and replacing it with a new timber framed wall. Tying the external skin to the new framing. Install new linings to provide any bracing required. Install conventional ceiling diaphragms. Steel studs will be required adjacent windows to support any concrete lintels. This option is likely to bring the building back up to 100%NBS by default.

2. Strengthening could be completed the installation of ceiling diaphragms and substantial fixings between diaphragm and walls. Walls will require strengthening for face loading via ties being installed between the brick skins (e.g. Helifix Cemtie)

and either filling the cavity or installing steel mullions internally. This option is likely to bring the building back up to 67%NBS without.

The exterior brick veneer is heavily damaged in places and repair would be by complete deconstruction of these section and reconstruction using modern methods and design tying properly to new or strengthened structural walls either timber or strengthened masonry. Where crack widths are less than 3mm then these can be stitching outer masonry veneer skin to the main inner structural brickwall or new timber framed wall with Helifix Helibars and Cemties in accordance with Helifix specifications at 400mm vertically by 600mm horizontally. All ties to be grouted both sides. Install ties through mortar lines on exterior face so that this can be easily re-plastered over to match original surface.

ii. Interior Walls:

Two options are available

1. Strengthening could be completed the installation of ceiling diaphragms and substantial fixings between diaphragm and walls. Walls will require strengthening for face loading via ties being installed between the brick skins (e.g. Helifix Cemtie) and either filling the cavity or installing steel mullions internally.

2. Strengthening could be successfully completed by completely removing the brick walls and replacing them with new timber framed walls. Install new linings to provide any bracing required. Install conventional ceiling diaphragms. Steel studs will be required to support any internal concrete beams.

   Either option is likely to bring the building back up to 100%NBS by default.

We recommend that all internal Brick walls be demolished and reconstructed using modern materials and design.

iii. Foundations General Cracking:

Seal all cracks in concrete foundation wall larger than 0.2mm with a pressure injected epoxy (e.g. Sikadur injectokit and Sikadur52[0]), or similar). Seal smaller cracks by painting over with a brushable crack filler (e.g. Resene Brushable Crack Filler).

iv. Veneer Face of Masonry walls General and Office Wing Masonry Walls:

Repair cracks that are less than 3mm width by filling cracks with grout and stitching with Helifix Helibars in accordance with Helifix specifications. Repair all cracked arch lintels by stitching with Helifix Helibars and Cemties in accordance with Helifix specifications. Stitch outer masonry veneer skin to the main inner structural brickwall with Helifix Helibars and Cemties in accordance with Helifix specifications at 600mm vertically by 800mm horizontally. All ties to be grouted both sides. Install ties through mortar lines on exterior face so that this can be easily re-plastered over to match original surface.

v. General cracks to plaster Walls and Ceilings generally:

Remove cracked/peeling/bubbled wallpaper to expose damaged Internal walls linings. Repair as appropriate using one of the following: Grind-out v-shape into cracked plaster. Re-plaster and overlay crack with fibreglass reinforcing mesh. Re-plaster over to provide a smooth finish. Remove lath and plaster walls and replace with Braceline GIB, or plaster over corru-lath/rib-lath.
In all cases, wall ties and hold-down straps should be installed in accordance with GIB braced wall and ceiling diaphragm specifications.
Realign, re-fix and re-paint racked door frames and architraves.

Reducing the weight of the building will assist in the above options so replacement of the structural and internal brickwalls will play an important part in these decisions.

The costs associated with the repairs would require the appropriate professional to visit the site to view the extent of damage. At this stage we have not provided any specific detailing for repair works but can so at your request.

7. Elements Not Inspected

The following is a list of elements not specifically inspected:

- Subfloor construction
- Piles
- Soils (Geotechnical preliminary report by others was reviewed)

8. Limitations

Findings presented in this report are for the sole use of the client. The findings may not contain sufficient information for use by other parties, and as such should not be relied upon unless discussed with Structural Concepts Ltd. We have exercised our services in a professional manner using a degree of care and skill normally, under similar circumstances, by reputable consultants practicing in this field at this time. No other warranty, expressed or implied, is made as to the professional advice presented in this report.

Yours faithfully
STRUCTURAL CONCEPTS LTD

Garry Newton
BE (Civil), MIPENZ(Civil, Structural), CPEng, IntPE(NZ)

Director

55 DUNLOP ROAD, PO BOX 3315, NAPIER, 4142, NEW ZEALAND – P (06) 842 0111 – F (06) 842 0113 – E info@structuralconcepts.co.nz

APPENDIX A. PHOTOGRAPHS

Please note that the photographs provided in this report are not high quality and are for providing information that shows the indicative damage found around the building for structural engineering assessment only.


DANGER

55 DUNLOP ROAD, PO BOX 3315, NAPIER, 4142, NEW ZEALAND – P (06) 842 0111 – F (06) 842 0113 – E info@structuralconcepts.co.nz

APPENDIX B. L2 REPORT & MARKED-UP DRAWING INDICATING DAMAGED LOCATIONS

Christchurch Eq RAPID Assessment Form - LEVEL 2

Inspector Initials: SG
Territorial Authority: Christchurch City
Date: 3/3/2011
Time: 3:30pm
Final Posting (e.g. UNSAFE): R1 UNSAFE

Building Name: Mona Vale Homestead
Short Name:
Address: Fendalton Rd.
GPS Co-ordinates: S° E°
Contact Name: Greg Ward
Contact Phone: 021 2217022
Storeys at and above ground level: 2
Below ground level: 0
Total gross floor area (m²):
Year built: 1899-1903
No of residential Units: Nil
Photo Taken: Yes No

Type of Construction

- [x] Timber frame (1st floor)
- [ ] Steel frame
- [ ] Tilt-up concrete
- [ ] Concrete frame
- [ ] RC frame with masonry infill
- [ ] Concrete shear wall
- [x] Unreinforced masonry (ground floor)
- [ ] Reinforced masonry
- [ ] Confined masonry
- [ ] Other:

Primary Occupancy

- [ ] Dwelling
- [ ] Other residential
- [ ] Public assembly
- [ ] School
- [ ] Religious
- [x] Commercial/ Offices
- [ ] Industrial
- [ ] Government
- [x] Heritage Listed
- [ ] Other

Investigate the building for the conditions listed on page 1 and 2, and check the appropriate column. A sketch may be added on page 3

Overall Hazards / Damage	Minor/None	Moderate	Severe	Comments
Collapse, partial collapse, off foundation	☑	☐	☐	
Building or storey leaning	☑	☐	☐	
Wall or other structural damage	☐	☐	☑	
Overhead falling hazard	☐	☐	☑	
Ground movement, settlement, slips	☑	☐	☐	
Neighbouring building hazard	☑	☐	☐	
Electrical, gas, sewerage, water, hazmats	☑	☐	☐	

Record any existing placard on this building:

Existing Placard Type (e.g. UNSAFE): INSPECTED.

Choose a new posting based on the new evaluation and team judgement. Severe conditions affecting the whole building are grounds for an UNSAFE posting. Localised Severe and overall Moderate conditions may require a RESTRICTED USE. Place INSPECTED placard at main entrance. Post all other placards at every significant entrance. Transfer the chosen posting to the top of this page.

INSPECTED			RESTRICTED USE			UNSAFE			
GREEN	G1	G2	YELLOW	Y1	Y2	RED	R1	R2	R3

Record any restriction on use or entry

Further Action Recommended

Tick the boxes below only if further actions are recommended

- [x] Barricades are needed (state location): In place.
- [x] Detailed engineering evaluation recommended
  - [x] Structural
  - [ ] Geotechnical
  - [ ] Other:
- [ ] Other recommendations:

Estimated Overall Building Damage (Exclude Contents)

None	☐		
0-1 %	☐	31-60 %	☑
2-10 %	☐	61-99 %	☐
11-30 %	☐	100 %	☐

Sign here on completion

Date & Time: 3/3/2011 3:50pm
ID: SG - Structex 021 462 723

Inspection ID: ________ *(Office Use Only)*

Structural Hazards/ Damage		Minor/None	Moderate	Severe
Foundations		☑	☐	☐
Roofs, floors (vertical load)		☒	☑	☐
Columns, pilasters, corbels		☐	☑	☐
Diaphragms, horizontal bracing		☐	☐	☑
Pre-cast connections	N/A	☒	☐	☐
Beam		☑	☐	☐
Non-structural Hazards / Damage				
Parapets, ornamentation		☑	☐	☐
Cladding, glazing		☑	☐	☐
Ceilings, light fixtures		☐	☑	☐
Interior walls, partitions		☑	☐	☐
Elevators	N/A	☐	☐	☐
Stairs/ Exits		☑	☐	☐
Utilities (eg. gas, electricity, water)		☑	☐	☐
Other		☐	☐	☐
Geotechnical Hazards / Damage				
Slope failure, debris		☑	☐	☐
Ground movement, fissures		☑	☐	☐
Soil bulging, liquefaction		☑	☐	☐

Comments

Minor cracking to foundation wall at isolated locations.
Brick arches supporting first floor cracked and leaning outwards.
Severe damage to brick bay window adjacent stair-well. - wall partially collapsed.
Moderate to severe cracking to brick walls around restaurant area.
Chimneys taken down. Several loose roof tiles.
Cracked window panes around restaurant.
Cracking to lath & plaster ceilings in places
Minor cracking to internal walls
Brick pillar supporting balcony dislocated at top and on lean.

General Comment

Usability Category

Damage Intensity	Posting	Usability Category	Remarks
Light damage *Low risk*	Inspected (Green)	G1. Occupiable, no immediate further investigation required	
		G2. Occupiable, repairs required	
Medium damage *Medium risk*	Restricted Use (Yellow)	Y1. Short term entry	
		Y2. No entry to parts until repaired or demolished	
Heavy damage *High risk*	Unsafe (Red)	R1. Significant damage: repairs, strengthening possible	
		R2. Severe damage: demolition likely	
		R3. At risk from adjacent premises or from ground failure	

 Inspection ID: ________ *(Office Use Only)*

Sketch (optional)
Provide a sketch of the entire building or damage points. Indicate damage points.

Recommendations for ~~Repair and Reconstruction or Demolition (Optional)~~ temporary remedial works

- Take photos of building to allow accurate reconstruction.
- Prop brick archways
- Prop balcony
- Remove outer ~~top~~ bricks of leaning balcony column. Attempt to push balcony column back into place
- ~~Attempt to push~~ Clear debris between cracks in adjacent entrance arch. brick wall. Attempt to push brick ~~ar~~ archway and wall back in place.
- Remove outer brick veneer at restaurant walls which are diagonally cracked to expose interior structural walls for engineer to view. Further works to then be advised
- Remove exterior brick veneer from damaged bay window. Prop roof with forklift/rack loader. Expose damaged brick wall behind for engineer to view.
- Engineer to complete detailed seismic assessment and strengthening report.

Note: In all cases, retain existing brick for re-use.


damage to walls to drawing room


damage to walls to drawing room


damage to walls to dining room


damage to walls to drawing room


damage to chimney in entry lobby


damage to columns to patio area


damage to wall around stair lobby


damage to wall in office

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF
MONAVALE HOMESTEAD CHRISTCHURCH
Reference Plan Ground Floor

emajineer
Structural Concepts

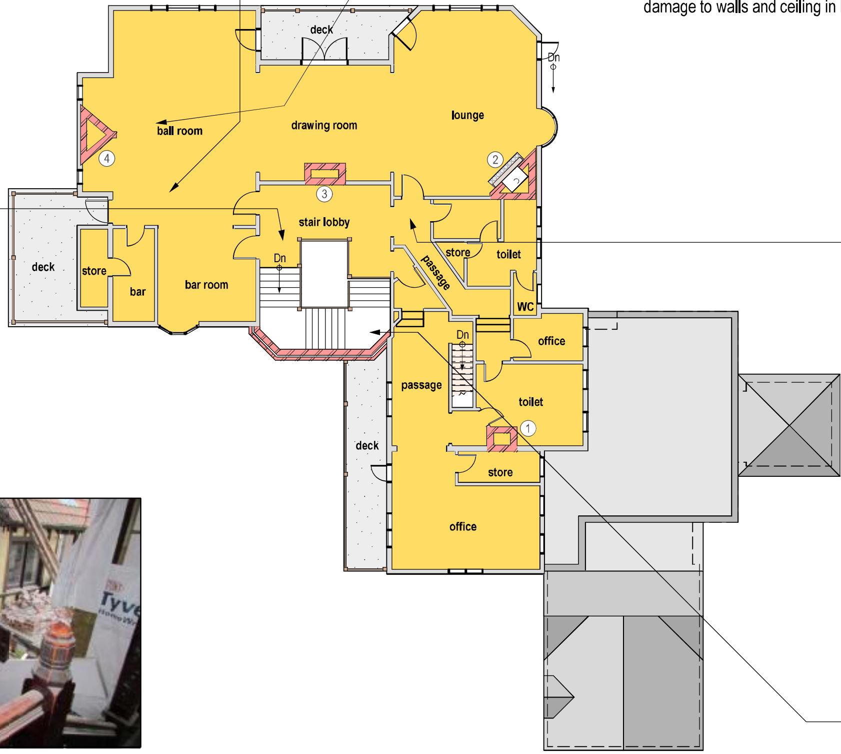
PRELIMINARY for client approval 19th August 2011

SC NUMBER 1605
SHEET S03
REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA | STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |

damage to ceiling in bar

damage to walls and ceiling in ball room



damage to walls in passage

damage to walls in stair lobby

damage to walls in stair lobby

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF MONAVALE HOMESTEAD CHRISTCHURCH

Reference Plan First Floor

emajineer
Structural Concepts

PRELIMINARY for client approval 19th August 2011

SCL NUMBER 1605
SHEET S04
REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |

APPENDIX C. FLOOR PLANS

Existing Ground Floor

Scale 1:200 @ A3

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF
MONAVALE HOMESTEAD CHRISTCHURCH
Existing Ground Floor Plans

PRELIMINARY
for client approval
19th August 2011

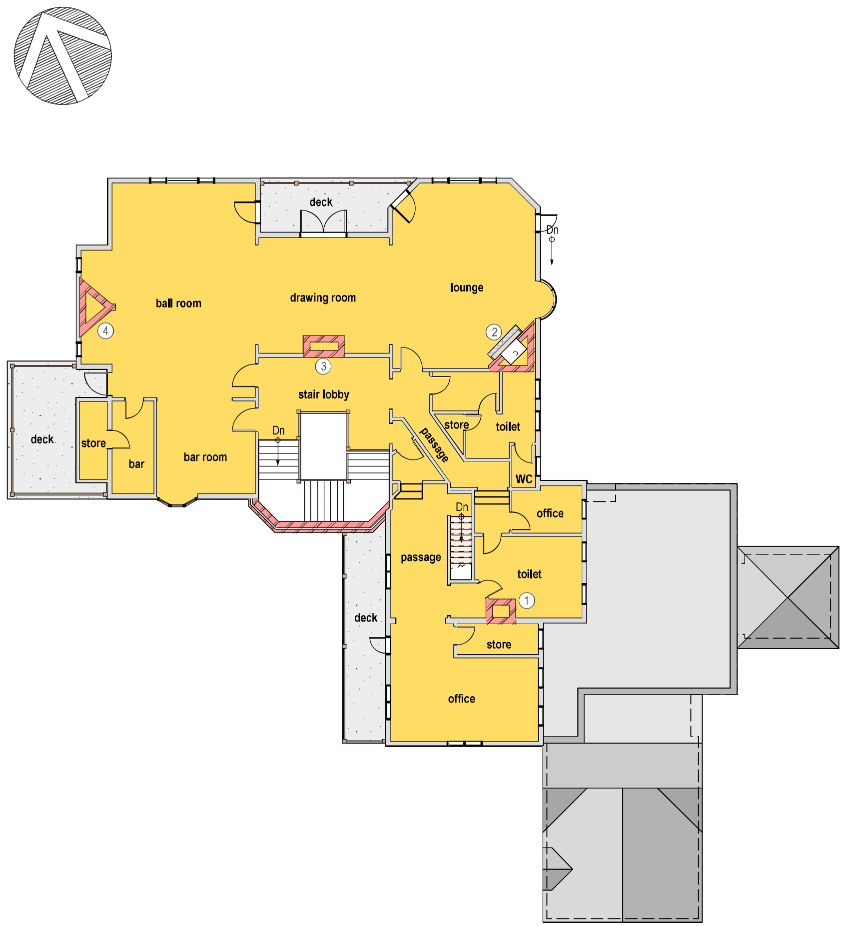
emajineer

Structural Concepts

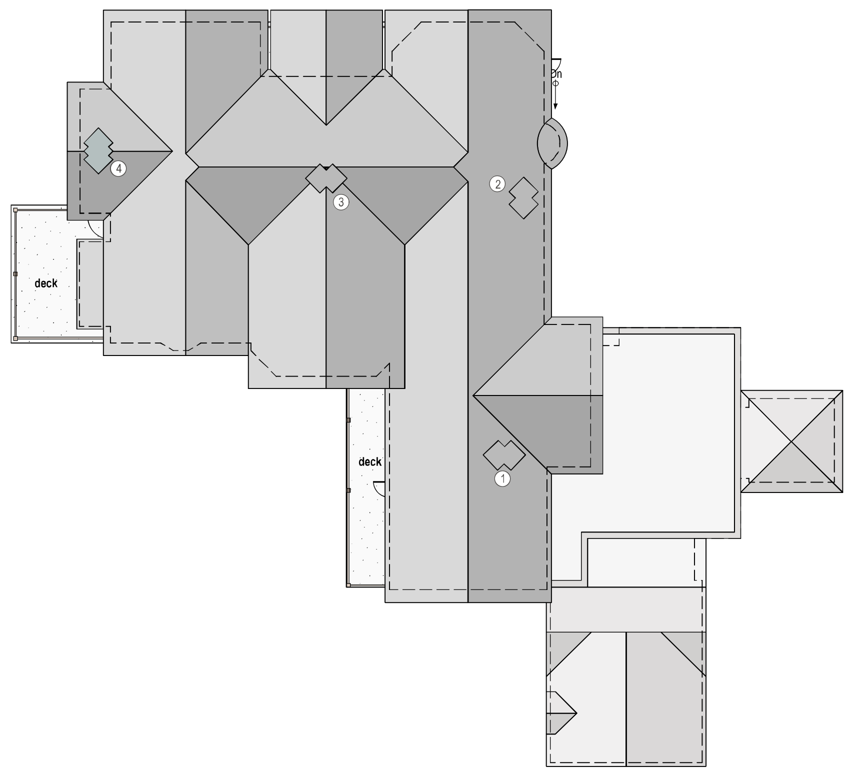
SCL NUMBER 1605
SHEET S01
REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |



Existing First Floor Scale 1:200 @ A3



Existing Roof Plan Scale 1:200 @ A3

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF MONAVALE HOMESTEAD CHRISTCHURCH

Existing First Floor and Roof Plans

PRELIMINARY for client approval 19th August 2011

emajineer

Structural Concepts

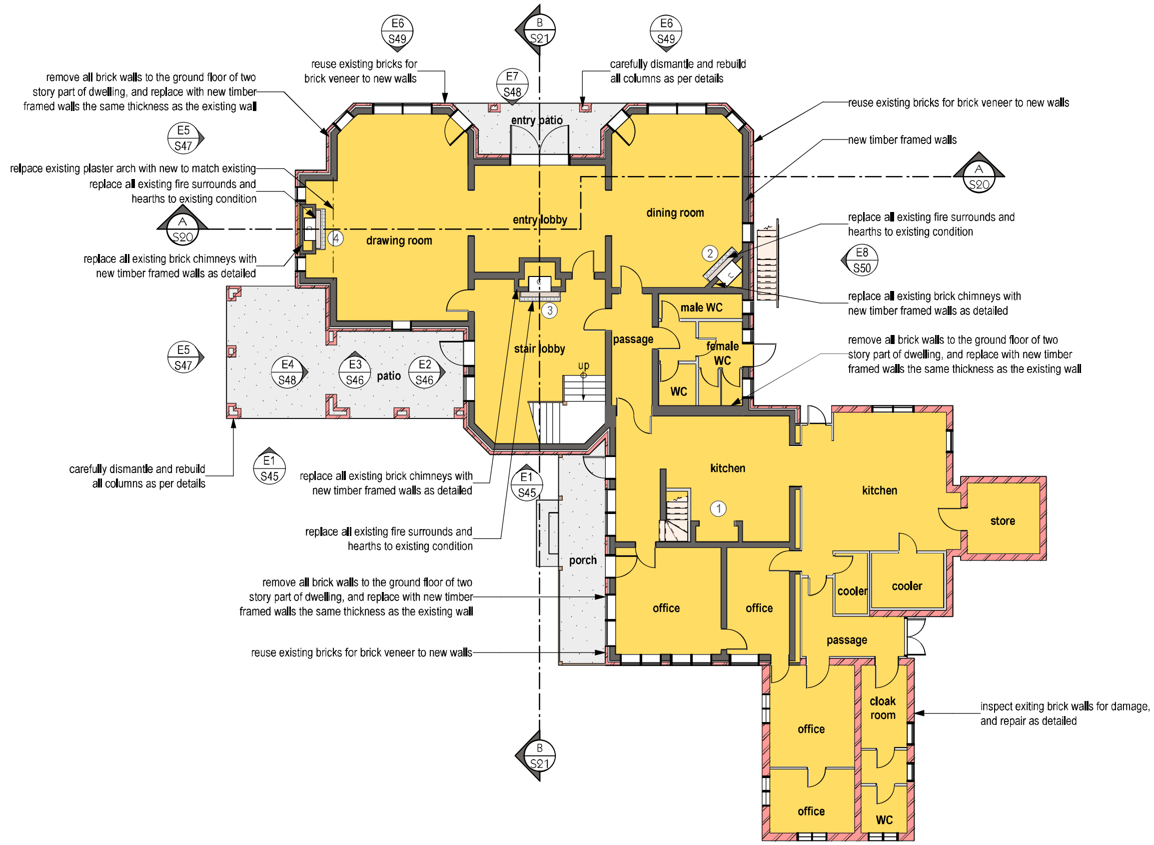
SCL NUMBER 1605
SHEET S02
REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |

55 DUNLOP ROAD, PO BOX 3315, NAPIER, 4142, NEW ZEALAND – P (06) 842 0111 – F (06) 842 0113 – E info@structuralconcepts.co.nz

APPENDIX D. NEW WORKS EXAMPLES



Proposed Ground Floor Scale 1:200 @ A3

GENERAL SCOPE OF WORKS:

This is not an exhaustive list of work to be done, confirm full extent of work with Architect prior to commencement of construction:

- remove all internal and external brick walls to lower floor supporting first floor, retaining brick as for re-use
- Remove and re-construct columns and arches to match existing with new structural support.
- Rebuild all existing brick walls as above with timber framed walls as shown, with brick veneer cladding to external walls to match existing, taking care to replace brick window lintels to match existing
- install crack stitching (Helibar system) to cracking of bricks to exterior and interior brick walls. Contractor to assess all damage on site to determine extent of damage to brick walls not being replaced
- generally repair all cracked plaster to timber walls on the first floor. finish of all walls and ceilings to be confirmed with client.
- remove chimney to floor level of ground floor, and replace with timber framed walls as detailed.
- inspect existing roof tile, replace damaged and broken roof tiles, install new roof tiles and roof structure to roof as required. ensure all tiles are held in place firmly, ensure roof is weather-tight.
- carefully remove and retain all timber wall paneling, skirting, scotia and doors, along with all architraves to doors and windows, to all existing brick walls being replaced. reinstall after new timber walls are constructed.
- ensure all doors and windows open and close properly, repair if required. replace broken glass as required.
- generally ensure all structure, finishes, plumbing and drainage, electrical, gas, and joinery items are repaired or replaced as required. Any existing exposed pipework and services shall be hidden inside the new timber framed walls.
- contractor to determine extent of work and damage to all items on site, in accordance to the direction of the heritage Architect.

| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

PRELIMINARY for client approval 19th August 2011

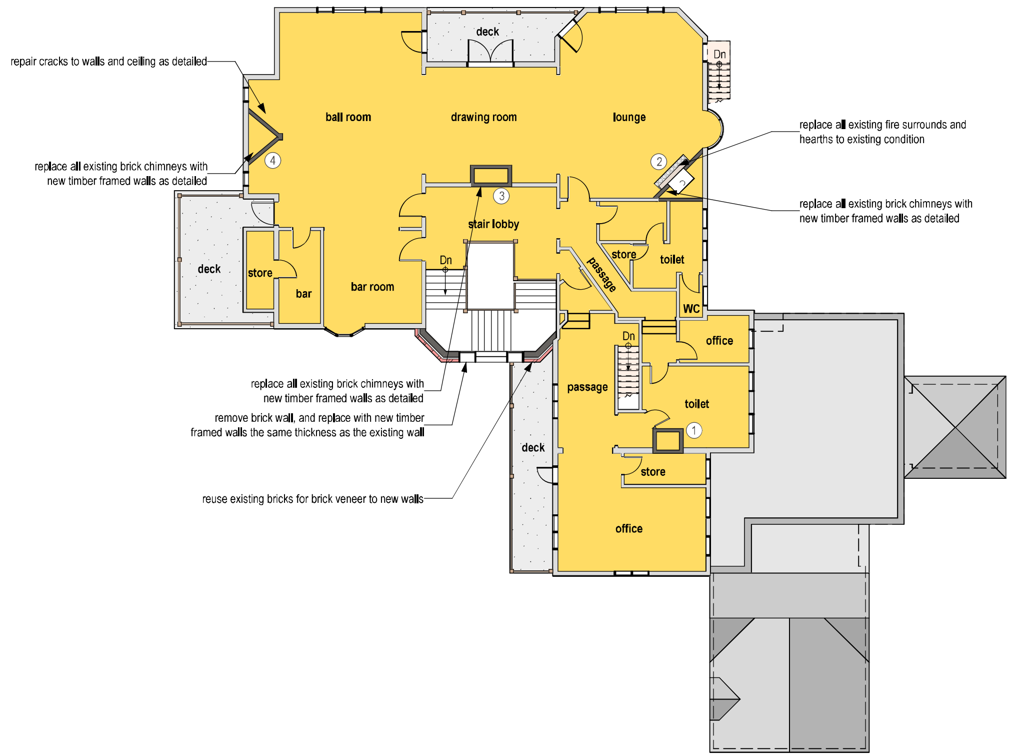
REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF
MONAVALE HOMESTEAD CHRISTCHURCH
Proposed Ground Floor Plans

emajineer
Structural Concepts

SCL NUMBER 1605
SHEET S09
REV 0



Proposed First Floor Scale 1:200 @ A3

GENERAL SCOPE OF WORKS:

This is not an exhaustive list of work to be done, confirm full extent of work with Architect prior to commencement of construction:

- remove all internal and external brick walls to lower floor supporting first floor, retaining brick as for re-use
- Remove and re-construct columns and arches to match existing with new structural support.
- Rebuild all existing brick walls as above with timber framed walls as shown, with brick veneer cladding to external walls to match existing, taking care to replace brick window lintels to match existing
- install crack stitching (Helibar system) to cracking of bricks to exterior and interior brick walls. Contractor to assess all damage on site to determine extent of damage to brick walls not being replaced
- generally repair all cracked plaster to timber walls on the first floor. finish of all walls and ceilings to be confirmed with client.
- remove chimney to floor level of ground floor, and replace with timber framed walls as detailed.
- inspect existing roof tile, replace damaged and broken roof tiles, install new roof tiles and roof structure to roof as required. ensure all tiles are held in place firmly, ensure roof is weather-tight.
- carefully remove and retain all timber wall paneling, skirting, scotia and doors, along with all architraves to doors and windows, to all existing brick walls being replaced. reinstall after new timber walls are constructed.
- ensure all doors and windows open and close properly, repair if required. replace broken glass as required.
- generally ensure all structure, finishes, plumbing and drainage, electrical, gas, and joinery items are repaired or replaced as required. Any existing exposed pipework and services shall be hidden inside the new timber framed walls.
- contractor to determine extent of work and damage to all items on site, in accordance to the direction of the heritage Architect.

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

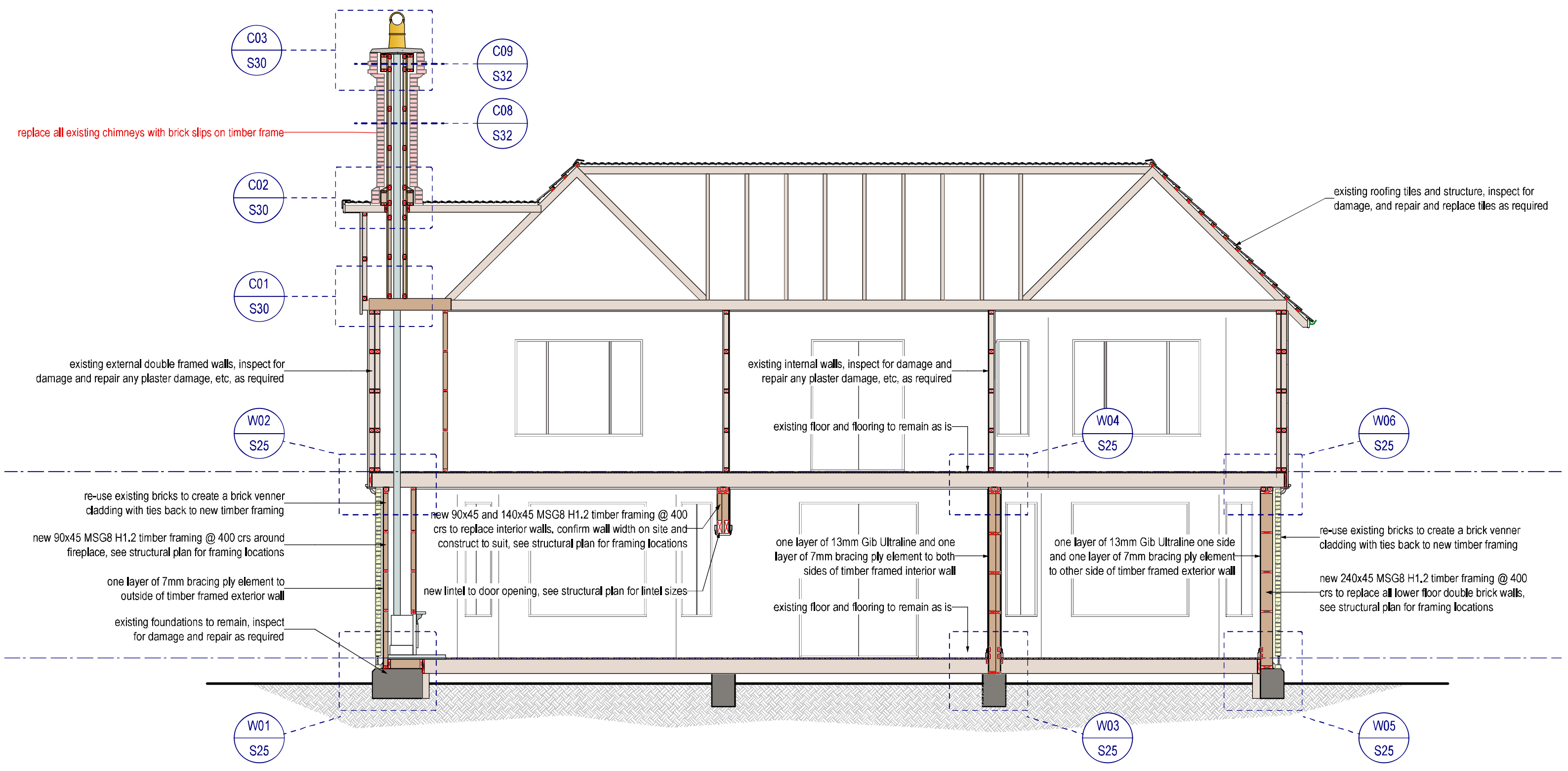
SEISMIC STRENGTHENING OF
MONAVALE HOMESTEAD CHRISTCHURCH
Proposed First Floor Plans

PRELIMINARY
for client approval
19th August 2011

emajineer
Structural Concepts
SCL NUMBER 1605
SHEET S10
REV 0

| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA



Section A-A Scale 1:100 @ A3

REV	DATE	DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF MONAVALE HOMESTEAD CHRISTCHURCH
Section

emajineer

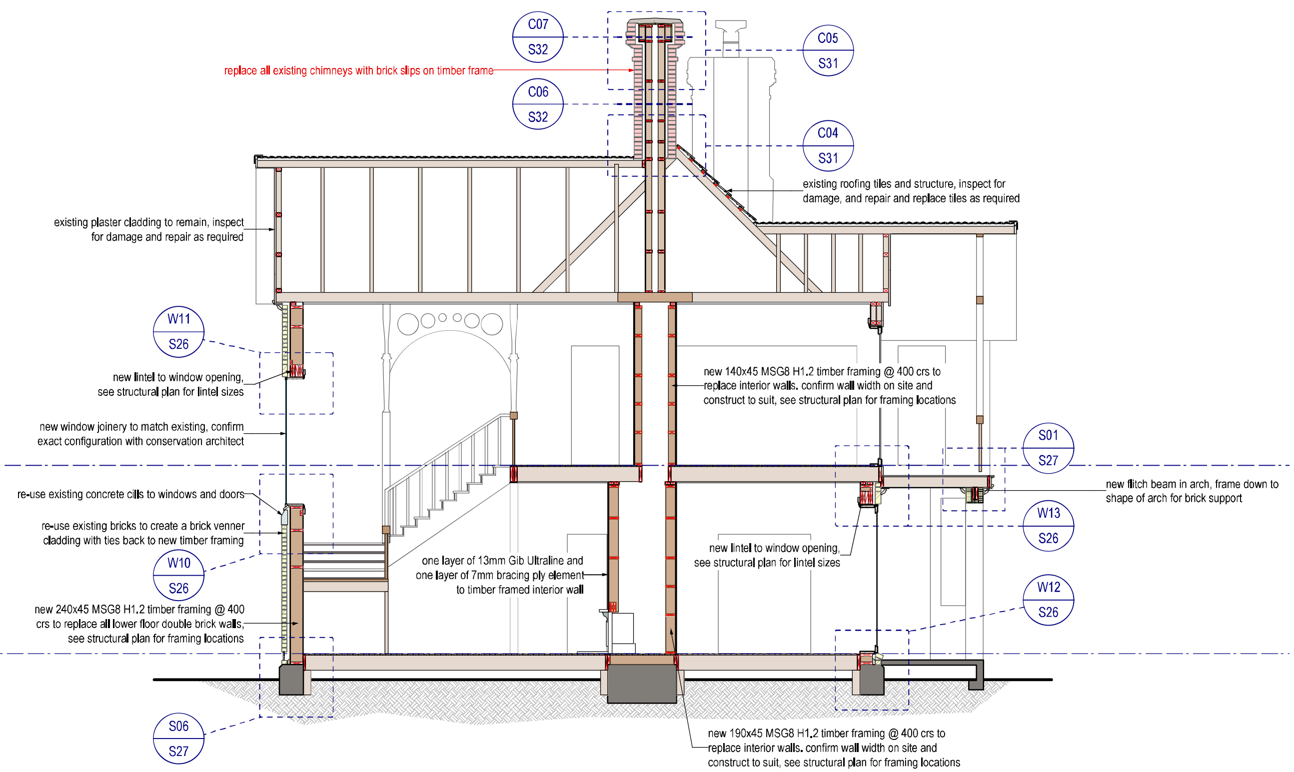
Structural Concepts

PRELIMINARY for client approval 19th August 2011

SCL NUMBER 1605
SHEET S20
REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |



Section B-B Scale 1:100 @ A3

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF
MONAVALE HOMESTEAD CHRISTCHURCH
Section

emajineer

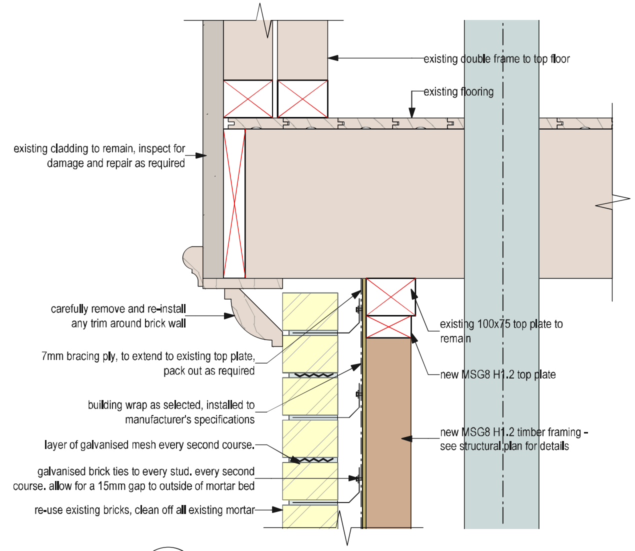
PRELIMINARY
for client approval
19th August 2011

Structural Concepts

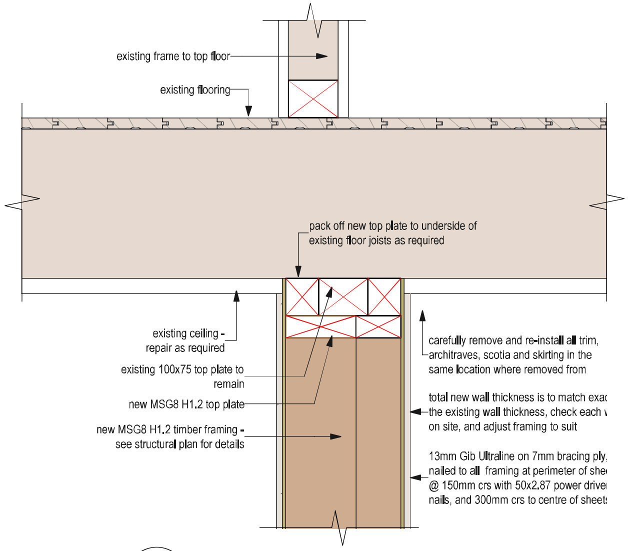
SCL NUMBER 1605
SHEET S21
REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

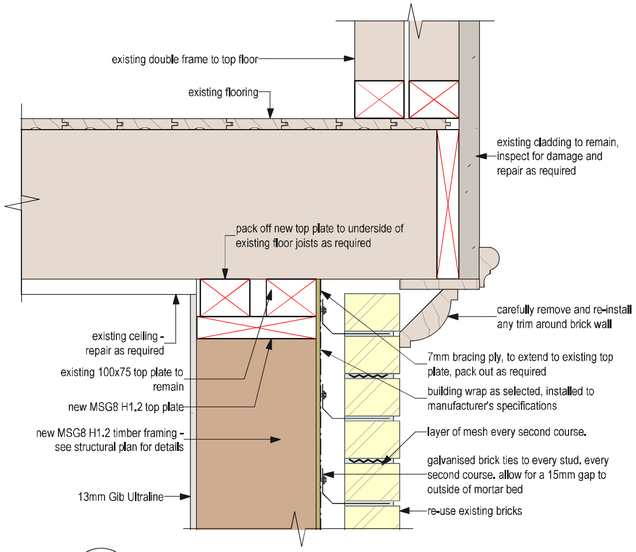
| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |



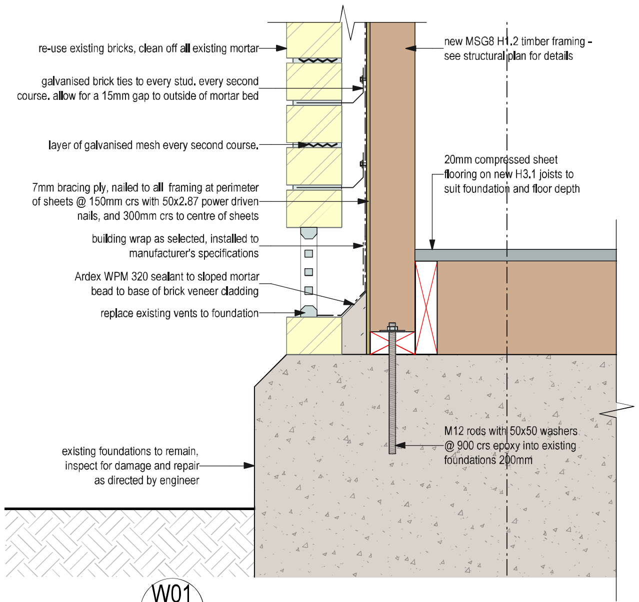
W02 S20 External Wall Mid Floor Detail Scale 1:10 @ A3



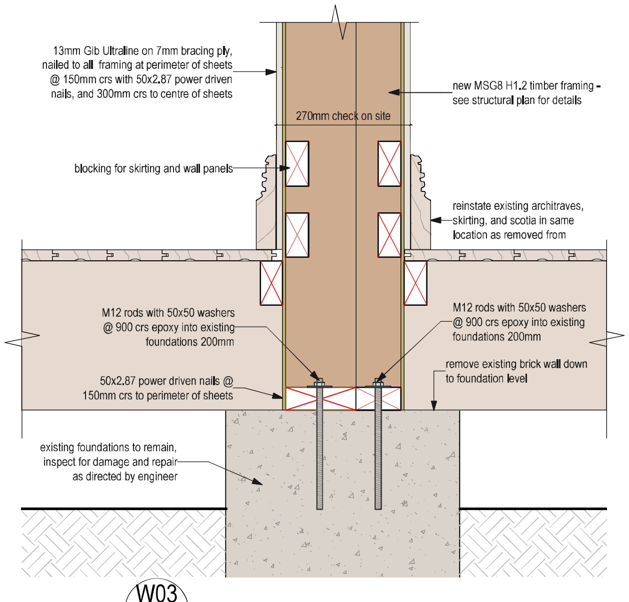
W04 S20 Internal Wall Mid Floor Detail Scale 1:10 @ A3



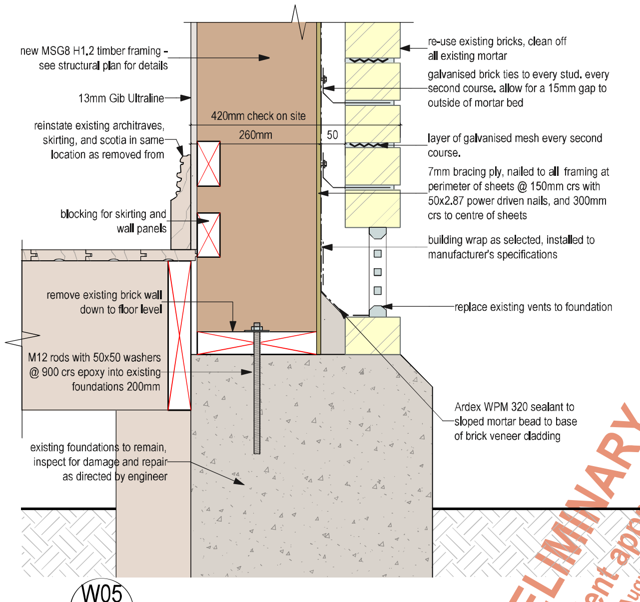
W06 S20 External Wall Mid Floor Detail Scale 1:10 @ A3



W01 S20 External Wall Foundation Detail Scale 1:10 @ A3



W03 S20 Internal Wall Foundation Detail Scale 1:10 @ A3



W05 S20 External Wall Foundation Detail Scale 1:10 @ A3

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF MONAVALE HOMESTEAD CHRISTCHURCH
Structural Details

PRELIMINARY for client approval 19th August 2011

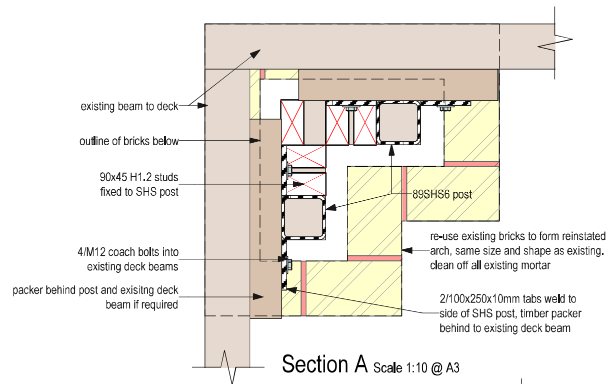
emajineer

Structural Concepts

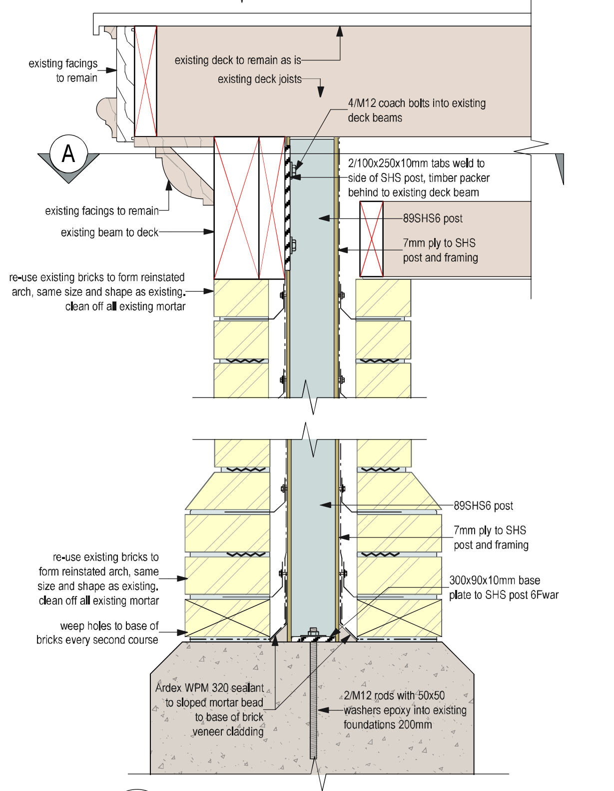
SCL NUMBER 1605
SHEET S25
REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

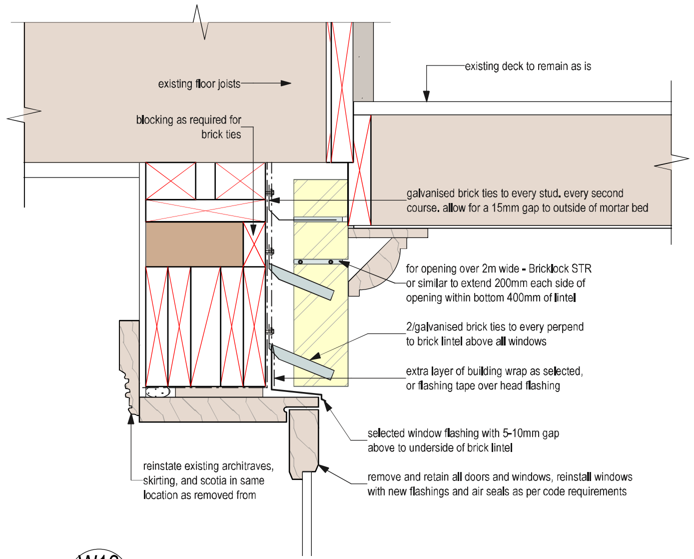
| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |



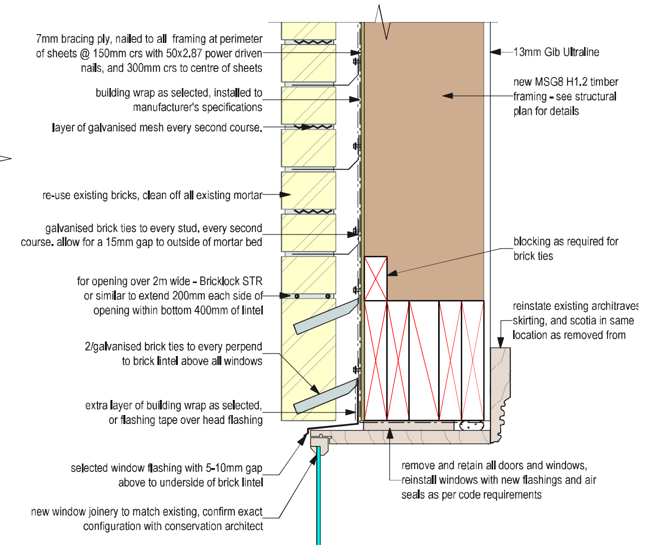
Section A Scale 1:10 @ A3



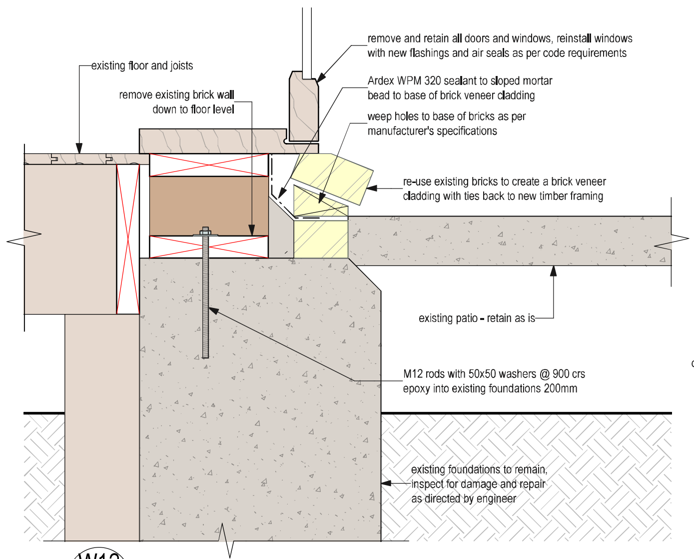
S05 / S12 Typical Column Post Section Detail Scale 1:10 @ A3



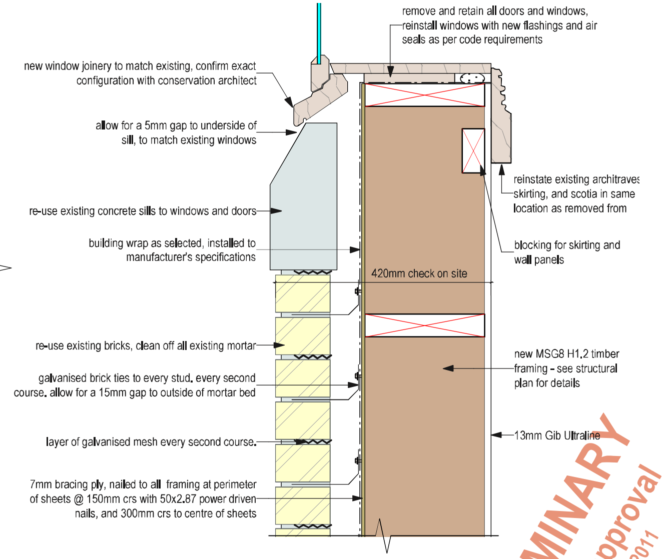
W13 / S21 Typical Door Head Detail Scale 1:10 @ A3



W11 / S21 Typical Window Head Detail Scale 1:10 @ A3



W12 / S21 Typical Door Sill Detail Scale 1:10 @ A3



W10 / S21 Typical Window Sill Detail Scale 1:10 @ A3

PRELIMINARY for client approval 19th August 2011

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

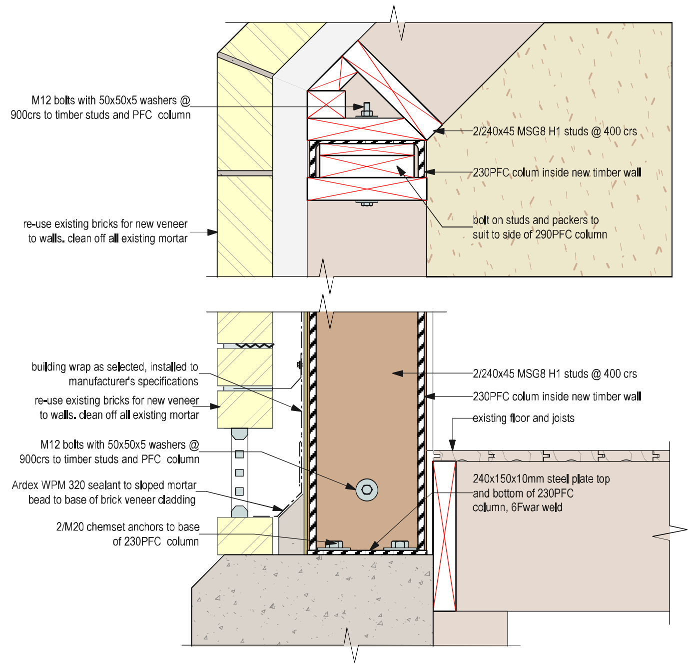
SEISMIC STRENGTHENING OF MONAVALE HOMESTEAD CHRISTCHURCH
Structural Details

emajineer
Structural Concepts

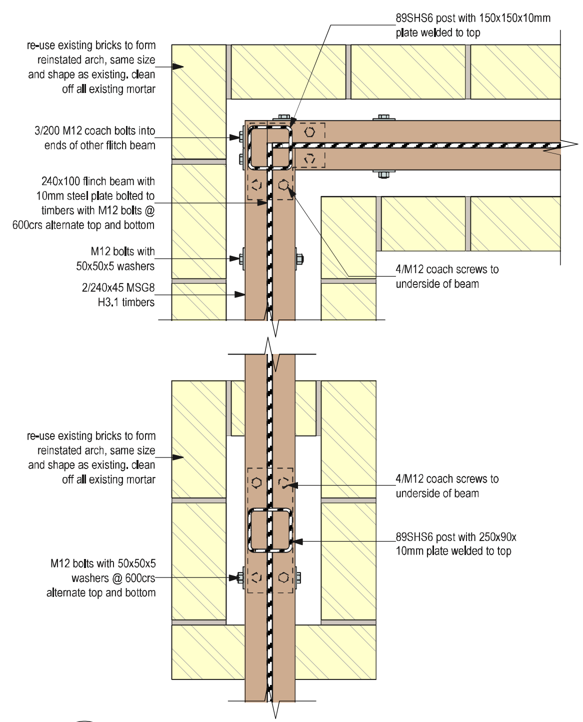
SCL NUMBER 1605
SHEET S26 REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

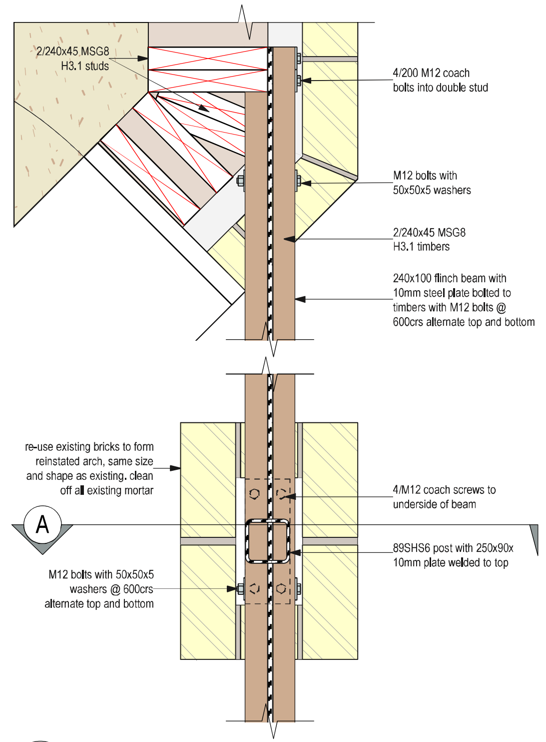
| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |



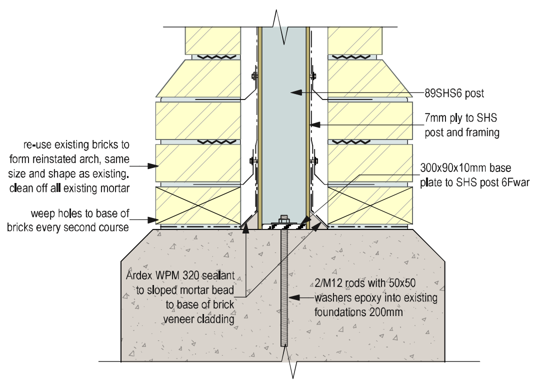
S06 S12 290PFC Column in Wall Detail Scale 1:10 @ A3



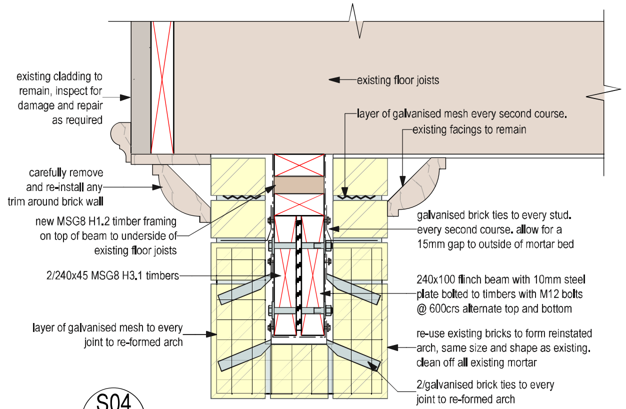
S03 S12 Flinch Beam Over Arch Detail Scale 1:10 @ A3



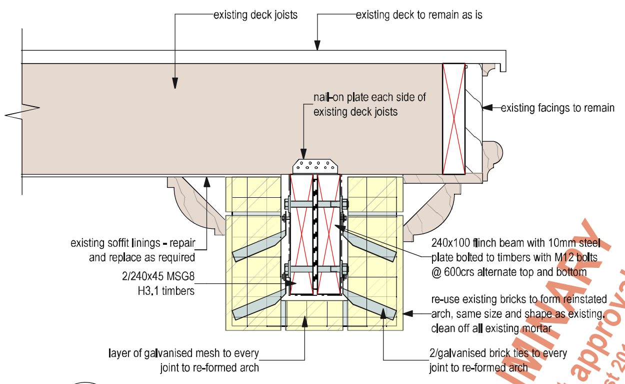
S02 S12 Flinch Beam Over Arch Detail Scale 1:10 @ A3



Section A - Typical SHS Post Base Scale 1:10 @ A3



S04 S12 Typical Arch Beam Section Detail Scale 1:10 @ A3



S01 S12 Typical Arch Beam Section Detail Scale 1:10 @ A3

REV DATE DESCRIPTION

CLIENT
Christchurch City Council
PROJECT ADDRESS
63 Fendalton Road, Christchurch

SEISMIC STRENGTHENING OF
MONAVALE HOMESTEAD CHRISTCHURCH
Structural Details

PRELIMINARY
for client approval
19th August 2011

emajineer
Structural Concepts

SCL NUMBER 1605
SHEET S27
REV 0

DATE Aug 2011 ACA2011 A3 | DES - | DRG TT/DJA

| STRUCTURAL CONCEPTS | E: info@structuralconcepts.co.nz | P: +64 6 8420111 | F: +64 6 8420113 | 55 DUNLOP RD, PO BOX 3315, ONEKAWA, NAPIER 4142, NEW ZEALAND |

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315, NAPIER, 4142, NEW ZEALAND, P (06) 842 0111 F (06) 842 0113, E info@structuralconcepts.co.nz

Client: Christchurch City Council

Project: Mona Vale Homestead
63 Fendalton Road, Christchurch

Ref: 1605 prelim

Date: 23-Jun-11

CALCULATIONS

BY GARRY NEWTON
BE (Civil) , MIPENZ(Civil, Structural), CPEng, IntPE(NZ)

CONTENTS

STRUCTURAL CONCEPTS LIMITED
55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Gravity Loads		

Loads

Roof	
Clay tiles	0.670
Timber 20.6	0.092
Purlins 05 .4	0.034
Battens 05 1.2	0.011
Rockwool Insu.	0.002
Gib Board 13	0.120
Timber 15.6	0.069
	0.998 kPa

Upper External Walls	
Portland Plaster	0.290
Timber 15.4	0.103
140. Nogs & plates	0.104
Rockwool Insu.	0.002
Gib Board 13	0.120
	0.619 kPa

Timber floor	
25mm Pine deck	0.138
Timber 20.6	0.092
90. Nogs & plates	0.067
Battens 05 1.2	0.011
Rockwool Insu.	0.002
Gib Board 13	0.120
	0.429 kPa

Partitions	
Timber 15.4	0.103
140. Nogs & plates	0.104
Gib Board 13	0.120
Gib Board 13	0.120
	0.447 kPa

Lower Exterior Brick Walls	
100 Brick veneer	1.900
215 Med Brick	4.600
	6.500 kPa

Live loads		
A2 other rooms	2.00	kPa
Office Utility	3.00	kPa
Com. Kitchens	3.00	kPa
R2 Roofs	0.25	kPa

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Loads

Interior Brick Walls

215 Med Brick 4.600

4.600 kPa

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Seismic loads to NZS1170 - Office areas		

Seismic Loads to NZS 1170.5 — Sheet No.: 4

Ref: | Design | Output

Design working live — 50 Years

Importance level — 2

Annual Probability of exceedance (inverse) Ultimate — 500

Annual Probability of exceedance (inverse) Service — 25

Element			Area/length	Load Kpa	Total kN
Roof			80.00	1.00	79.86
Partitions			20.00	0.45	8.94
Upper External Walls			42.00	0.62	26.00
			0.00	0.00	0.00
			0.00	0.00	0.00
			0.00	0.00	0.00
	1.00	0.40	0.00	0.00	0.00
					114.80 kN

Live load reduction

Total floor area 270.0

$$.3+\frac{3}{\sqrt{A}} = 0.500$$

But not less than .5

Element			Area/length	Load Kpa	Total kN
Timber floor			80.00	0.43	34.36
Upper External Walls			42.00	0.62	26.00
Lower Exterior Brick Walls			72.00	6.50	468.00
Roof			105.00	1.00	104.82
Interior Brick Walls			36.00	4.60	165.60
Partitions			36.00	0.45	16.09
Office Utility	0.50	0.40	80.00	3.00	240.00
	0.50	0.40	0.00	0.00	0.00
					862.87 kN

Total building weight
977.67 kN

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead 63 Fendalton Road, Christchurch	Date:	23/6/11
		BY:	GN
Subject:	Seismic loads to NZS1170 - Office areas		

Sheet No.: 5

Ref:	Design				Output
	Soil type				
	D. Deep or soft soil				
	<u>Across the building</u>				
	Period of building across the building		0.40		
	Does the seismic bracing have ductile capabilities but is designed as nominally ductile				☑
	Structural ductility factor (Ultimate)	m =	2.00		
	Structural ductility factor (Service SLS1)	m =	1.25		
	Hazard Factor Christchurch	Z =	0.3		
	Return period factor	Ru =	1.00		
	Return period factor	Rs =	0.25		
	Structural Performance factor (Ultimate)	Sp =	0.70		
	Structural Performance factor (Service)	Sp =	0.70		
	Spectral Shape Factor (across)	Ch(T) =	3.00		
	Near Fault factor	N(T,D) =	1.0	n/a	
	Elastic site spectra (Ultimate)	C(T) =	0.90		
	Elastic site spectra (Service)	C(T) =	0.23		
	Ultimate	km =	1.57		
	Service	km =	1.14		
	<u>Ultimate</u>				
	Horizontal design action coefficients (Across)	Cd(T1) =	0.40	But not less than 0.030Ru	
	Ultimate force across the building	Cd(T1) x Wi =	391.96	kN Total	
	<u>Service</u>				
	Horizontal design action coefficients (Across)	Cd(T1) =	0.14		
	Service force across the building	Cd(T1) x Wi =	134.74	kN Total	
	<u>Along the building</u>				
	Period of building along the building		0.40		
	Does the seismic bracing have ductile capabilities but is designed as nominally ductile				☑
	Structural ductility factor (Ultimate)	m =	2.00		
	Structural ductility factor (Service SLS1)	m =	1.25		
	Structural Performance factor (Ultimate)	Sp =	0.70		
	Spectral Shape Factor (across)	Ch(T) =	3.00		
	Near Fault factor	N(T,D) =	1.0		
	Elastic site spectra (Ultimate)	C(T) =	0.90		
	Elastic site spectra (Service)	C(T) =	0.23		
	Ultimate	km =	1.57		
	Service	km =	1.14		
	<u>Ultimate</u>				
	Horizontal design action coefficients (Across)	Cd(T1) =	0.40	But not less than 0.030Ru	
	Ultimate force along the building	Cd(T1) x Wi =	391.96	kN Total	
	<u>Service</u>				
	Horizontal design action coefficients (Across)	Cd(T1) =	0.14		
	Service force across the building	Cd(T1) x Wi =	134.74	kN Total	

STRUCTURAL CONCEPTS LIMITED
55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Seismic Forces		

Seismic Loads to NZS 1170.5 — Sheet No.: 6

Ref:	Design				Output	
	Seismic weight at level i	Wi	114.80	kN		
	Height at level i	hi	6.0	m		
	Seismic weight at level I	Wi	862.87	kN		
	Height at level I	hi	3.0	m		
	Sum of Wihi		3277.4			
	Base shear ultimate		391.96	kN		
	Base shear service		134.74	kN		
	8% of base shear to be applied at top level		31.36	kN		
	8% of base shear to be applied at top level		10.78	kN		

$$Fi = .92V \frac{Wihi}{\sum(Wihi)}$$

Ultimate

Equivalent Lateral force at level i (Roof)	107.14		2143
Equivalent Lateral force at level i	284.81		
Equivalent Lateral force at level i	0.00		
Equivalent Lateral force at level i	0.00		
Equivalent Lateral force at level i	0.00		
Equivalent Lateral force at level i	0.00		
	391.96	kN base V	
	7839.14	BU's	

Service

Equivalent Lateral force at level i (Roof)	36.83	
Equivalent Lateral force at level i	97.90	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
	134.74	kN base V

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Bracing Capacity - Upper Office Wing		

Ref:	Design	Output

All walls have been lined with gypsum wall boards (Fixing at nominal 300 spacings) therefore utilising the allowable strength values determined by NZSEE Table 11.1 we have assessed the strength of the walls independent of the Gib manual.
From table 11.1 a strength value of 3 kN/m per side with a strength reduction factor of 0.7 can be used.

R = 3 kN/m per side
∅ = 1

∅ R = 3 kN/m per side
60 BU's/m

Along

length of wall available

6 one side
10 two sides
Rtotal = 6 x 60 x 2.4/2.7+10 x 60 x 2.4/2.7 x 2
= 1387 BU's
69.33 kN OK

required
2143 BU's
provided
1387 BU's

65 %NBS z = 0.3
88 %NBS z=0.22

Across

length of wall available

7 one side
12.5 two sides
Rtotal = 7 x 60 x 2.4/2.7+12.5 x 60 x 2.4/2.7 x 2
= 1707 BU's
85.33 kN OK

required
2143 BU's
provided
1707 BU's

80 %NBS z = 0.3
100 %NBS z=0.22

Therefore it is determined that the wall linings will provide the strength required without necessarily strictly complying with the Gib brace requirements
Also it is noted that the main building stucture is also capable of carrying some of this load and therefore reduce the requirements of the gypsum wall strength.

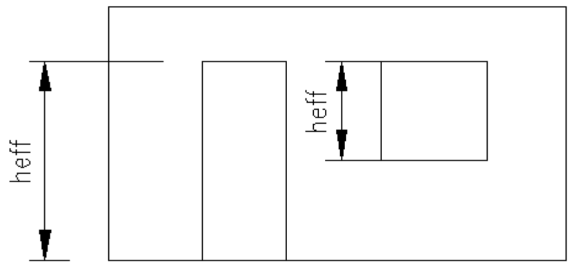
STRUCTURAL CONCEPTS LIMITED
55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead 63 Fendalton Road, Christchurch	Date:	23/6/11
		BY:	GN
Subject:	Office Wing Masonry Walls In Plane		

In-Plane strength of walls and piers to FEMA URM seismic guidelines — Sheet No.: 8

Ref:	Design				Output

The following calculation follows the FEMA 273 guild lines for seismic rehabilitation of existing unreinforced masonry buildings (URM). This calculation is for piers or walls between window and door openings. Typically these piers are limited by diagonal tension in the panel or toe compressive stress, but bed-joint sliding shear or expected rocking strength can also limit the capacity.



Effective height and pier geometry may vary in the same wall assembly

Ref	Design	Symbol	Value	Unit
	Expected axial gravity force on pier	PCE	207	kN
	<u>Pier dimentions</u>			
	Effective height of pier	heff	3.00	m
	Pier length (net mortared length)	L	34.50	m
	Pier thickness (net mortared width)	Tm	200	mm
	Net mortared area		6900000	mm²
	Average bed-joint shear strength	Vte	1.00	Mpa
(7-1)	Expected shear strength			
	$\dfrac{0.75\left(0.75vte+\dfrac{Pce}{An}\right)}{1.5}$ =	Vme	0.390	Mpa
	Expected lateral strength is the lesser of:-			
(7-3)	Bed-joint shear strength Vme x An =	QCE	2691.0	kN
	a = 0.5 for cantilever or 1.0 for fixed pier	a	0.5	
(7-4)	Expected rocking strength $.9aPce\left(\dfrac{L}{heff}\right)$ =	QCE	1071.2	kN
	Masonry compressive strength	fm	4.0	Mpa
	Diagonal tension strength			
	Vme = fdt in eq. (7-5) only	fdt	0.390	Mpa
	Vertical axial compressive stress	fa	0.030	Mpa
	Aspect ratio (L / heff) =		11.50	

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

In-Plane strength of walls and piers continued

Ref:	Design	Output
	Expected lateral strength of pier is lesser of:-	
(7-5)	Diagonal tenson stress	
	$Vdt = fdt.An\left(\frac{L}{heff}\right)\sqrt{1+\frac{fa}{fdt}}$ = QCL 32114.7 kN	
(7-6)	Toe compressive stress	
	$Vtc = aPcl\left(\frac{L}{heff}\right)\left(1-\frac{fa}{0.7\,fm}\right)$ = QCL 1177.5 kN	
	The govening lateral force for this pier is 1071.2 kN	
	Actural force on pier is 392.0 kN	
	% of NBS, proportion of NZS1170.5 %NBS 273 %	
	Low Hazard	

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Internal Brick Walls Out of Plane		

Vertically spanning wall panel out-of-plane dynamic loads to NZSEE — Sheet No.: 10

Ref:	Design				Output
	Height of the upper most seismic mass	hn	6.0	m	
	Height of support for wall (from ground level)	hi	0.0	m	
	Mass of masonry used in design		22	kN/m³	
	Height of panel between supports	h	3.50	m	
	Length of panel between supporting walls	L	2.00	m	
	Thickness of wall	tnom	225	mm	
	Weight acting on top of the panel	P	6.0	kN	
	Assuming a hinge forms at mid height of the panel we have:-				
	Weight of top part of panel	Wt	17.3	kN	
	Weight of Bottom part of panel	Wb	17.3	kN	
(3)	Effective thickness of wall (.975 - 0.025P/W) =	t	218.4	mm	
	Eccentricities				
	Eccentricity of P measured from centroid of Wt	e_p	109.2	mm	
	Eccentricity of bott pivot measured from centroid of Wb	e_b	109.2	mm	
	Eccentricity of mid-height pivot measured centroid of Wt	e_t	109.2	mm	
	Eccentricity of mid-height pivot measured centroid of Wb	e_o	109.2	mm	
	Mid-Height deflection				
10(7)	$\frac{bh}{2a}$ = Di				
	Where:-				
	$b = W_b.e_b + W_t(e_o+e_b+e_t) + P(e_o+e_b+e_t+e_p) - C(W_b y_b + W_t Y_t)$				
	$a = W_b.y_b + W_t(h/2 + Y_t) + Ph$				
	Interstorey slope divided by storey height	C	0.01	% Drift	
	Vertical Eccentricity of Wt to top pivot	Y_t	875	mm	
	Vertical Eccentricity of Wb to bottom pivot	Y_b	875	mm	
10(8)	Coefficient for formula 10(8)	b	9885.2		
10(9)	Coefficient for formula 10(9)	a	81637.5		
10(7)	Instability deflection is:- $\frac{bh}{2a}$ =	Di	212	mm	
	Maximum usable deflection is	.6Di	127.1	mm	
10(10)	Approximate period of vibration	Tp	1.209	s	
	Seismic coefficient for elastically responding part				
	Design working live		50 Years		
	Importance level				
	Annual Probability of exceedance (inverse) Ultimate		500		
	Soil type: D. Deep or soft soil — Location: Christchurch				
	For Parts				
	Floor acceleration is such to causing yielding of part See table C8.2				
(8)	Structural ductility of part (Table C8.2)	mp=	1.00		NZSEE recommendation

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead 63 Fendalton Road, Christchurch	Date:	23/6/11
		BY:	GN
Subject:	Internal Brick Walls Out of Plane		

Vertically spanning wall panel out-of-plane continued — Sheet No.: 11

Ref:	Design				Output
T 3.3	Hazard Factor	Z =	0.3		
T 3.5	Return period factor	Ru =	1.00		
T 3.1	Spectral Shape Factor for parts	Ch(0) =	1.12		
T 3.7	Near Fault factor	N(T,D) =	1.0		
	Site Hazard coefficient Ch(0) x Z x R x N(T,D) =	C(0) =	0.34		
T. 8.1	Part risk factor	Rp	1.0		
8.3	Floor height coefficient				
	Eq 8.3(1) $\left(1+\frac{hi}{6}\right)$	Chi	1.000		
	Eq 8.3(2) $\left(1+10\frac{hi}{hn}\right)$	Chi	1.0		
		Chi	1.000		
	Period of part	Tp	1.21	Sec	
8.4	Part spectral shape coefficient	Ci(Tp)	1.1		
8.2	Design response coefficient for wall				
	C(0).Chi.Ci(Tp) =	Cp(Tp)	0.36		
(9)	Participation factor for rocking system				
	Rotational inertia of the mass				
	$Jbo+Jto+\frac{1}{g}\left[Wb\left[eb^2+yb^2\right]+Wt\left[(eo+eb+et)^2+yt^2\right]+P\left[(eo+eb+et+ep)^2\right]\right]+Janc$				
	And is:-	J	3036		
10(12)	Participation factor $\frac{(Wb.yb+Wt.yt)h}{2Jg}$ =	g	1.781		
	Displacement response $g\,(Tp/2p)^2.Dp(Tp).Rp.g$ =	Dph	0.229		
	% of NBS, proportion of NZS1170.5 $\left[(1.2)(0.6)\Delta i\right]/Dph$ =	%NBS	66.5	%	
	Low Hazard				NZSEE guidelines

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	External Brick Walls Out of Plane		

Vertically spanning wall panel out-of-plane dynamic loads to NZSEE — Sheet No.: 12

Ref:	Design				Output
	Height of the upper most seismic mass	hn	6.0	m	
	Height of support for wall (from ground level)	hi	0.0	m	
	Mass of masonry used in design		22	kN/m³	
	Height of panel between supports	h	3.50	m	
	Length of panel between supporting walls	L	2.00	m	
	Thickness of wall	t_{nom}	225	mm	
	Weight acting on top of the panel	P	6.0	kN	
	Assuming a hinge forms at mid height of the panel we have:-				
	Weight of top part of panel	Wt	17.3	kN	
	Weight of Bottom part of panel	Wb	17.3	kN	
(3)	Effective thickness of wall (.975 - 0.025P/W) =	t	218.4	mm	
	Eccentricities				
	Eccentricity of P measured from centroid of Wt	e_p	109.2	mm	
	Eccentricity of bott pivot measured from centroid of Wb	e_b	109.2	mm	
	Eccentricity of mid-height pivot measured centroid of Wt	e_t	109.2	mm	
	Eccentricity of mid-height pivot measured centroid of Wb	e_o	109.2	mm	

Mid-Height deflection

10(7) $$\frac{bh}{2a} = Di$$

Where:-

$b = W_b.e_b + W_t(e_o+e_b+e_t) + P(e_o+e_b+e_t+e_p) - C(W_b y_b + W_t Y_t)$

$a = W_b.y_b + W_t(h/2 + Y_t) + Ph$

Ref:	Design				Output
	Interstorey slope divided by storey height	C	0.01	% Drift	
	Vertical Eccentricity of Wt to top pivot	Y_t	875	mm	
	Vertical Eccentricity of Wb to bottom pivot	Y_b	875	mm	
10(8)	Coefficient for formula 10(8)	b	9885.2		
10(9)	Coefficient for formula 10(9)	a	81637.5		
10(7)	Instability deflection is:- $\frac{bh}{2a}$ =	Di	212	mm	
	Maximum usable deflection is	.6Di	127.1	mm	
10(10)	Approximate period of vibration	Tp	1.209	s	

Seismic coefficient for elastically responding part

Design working live: 50 Years

Importance level: 2

Annual Probability of exceedance (inverse) Ultimate: 500

Soil type: D. Deep or soft soil

Location: Christchurch

For Parts

Floor acceleration is such to causing yielding of part See table C8.2

(8) Structural ductility of part (Table C8.2) μ_p= 1.00 — NZSEE recommendation

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	External Brick Walls Out of Plane		

Vertically spanning wall panel out-of-plane continued

Sheet No.: 13

Ref:	Design				Output
T 3.3	Hazard Factor	Z =	0.3		
T 3.5	Return period factor	Ru =	1.00		
T 3.1	Spectral Shape Factor for parts	Ch(0) =	1.12		
T 3.7	Near Fault factor	N(T,D) =	1.0		
	Site Hazard coefficient Ch(0) x Z x R x N(T,D) =	C(0) =	0.34		
T. 8.1	Part risk factor	Rp	1.0		
8.3	Floor height coefficient				
	Eq 8.3(1) $\left(1+\frac{hi}{6}\right)$	Chi	1.000		
	Eq 8.3(2) $\left(1+10\frac{hi}{hn}\right)$	Chi	1.0		
		Chi	1.000		
	Period of part	Tp	1.21	Sec	
8.4	Part spectral shape coefficient	Ci(Tp)	1.1		
8.2	Design response coefficient for wall				
	C(0).Chi.Ci(Tp) =	Cp(Tp)	0.36		
(9)	Participation factor for rocking system				
	Rotational inertia of the mass				
	$Jbo+Jto+\frac{1}{g}\left[Wb\left[eb^2+yb^2\right]+Wt\left[(eo+eb+et)^2+yt^2\right]+P\left[(eo+eb+et+ep)^2\right]\right]+Janc$				
	And is:-	J	3036		
10(12)	Participation factor $\frac{(Wb.yb+Wt.yt)h}{2Jg}$ =	g	2.652		
	Displacement response $g\,(Tp/2p)^2.Dp(Tp).Rp.g$ =	Dph	0.341		
	% of NBS, proportion of NZS1170.5 $[(1.2)(0.6)\Delta i]/Dph$ =	%NBS	44.7	%	
	Moderate hazard				NZSEE guidelines

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Stir Brick wall		

Vertically spanning wall panel out-of-plane dynamic loads to NZSEE — Sheet No.: 14

Ref:	Design				Output
	Height of the upper most seismic mass	hn	6.0	m	
	Height of support for wall (from ground level)	hi	0.0	m	
	Mass of masonry used in design		22	kN/m³	
	Height of panel between supports	h	6.00	m	
	Length of panel between supporting walls	L	1.00	m	
	Thickness of wall	tnom	225	mm	
	Weight acting on top of the panel	P	0.0	kN	
	Assuming a hinge forms at mid height of the panel we have:-				
	Weight of top part of panel	Wt	14.9	kN	
	Weight of Bottom part of panel	Wb	14.9	kN	
(3)	Effective thickness of wall (.975 - 0.025P/W) =	t	219.4	mm	
	Eccentricities				
	Eccentricity of P measured from centroid of Wt	e_p	109.7	mm	
	Eccentricity of bott pivot measured from centroid of Wb	e_b	109.7	mm	
	Eccentricity of mid-height pivot measured centroid of Wt	e_t	109.7	mm	
	Eccentricity of mid-height pivot measured centroid of Wb	e_o	109.7	mm	
	Mid-Height deflection				
10(7)	$\frac{bh}{2a}$ = Di				
	Where:-				
	$b = W_b.e_b + W_t(e_o+e_b+e_t) + P(e_o+e_b+e_t+e_p) - C(W_b y_b + W_t Y_t)$				
	$a = W_b.y_b + W_t(h/2 + Y_t) + Ph$				
	Interstorey slope divided by storey height	C	0.01	% Drift	
	Vertical Eccentricity of Wt to top pivot	Y_t	1500	mm	
	Vertical Eccentricity of Wb to bottom pivot	Y_b	1500	mm	
10(8)	Coefficient for formula 10(8)	b	6069.9		
10(9)	Coefficient for formula 10(9)	a	89100		
10(7)	Instability deflection is:- $\frac{bh}{2a}$ =	Di	204	mm	
	Maximum usable deflection is	.6Di	122.6	mm	
10(10)	Approximate period of vibration	Tp	1.758	s	
	Seismic coefficient for elastically responding part				
	Design working live		50 Years		
	Importance level		2		
	Annual Probability of exceedance (inverse) Ultimate		500		
	Soil type: D. Deep or soft soil — Location: Christchurch				
	For Parts				
	Floor acceleration is such to causing yielding of part See table C8.2				
(8)	Structural ductility of part (Table C8.2)	mp=	1.00		NZSEE recommendation

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead 63 Fendalton Road, Christchurch	Date:	23/6/11
		BY:	GN
Subject:	Stir Brick wall		

Vertically spanning wall panel out-of-plane continued — Sheet No.: 15

Ref:	Design				Output
T 3.3	Hazard Factor	Z =	0.3		
T 3.5	Return period factor	Ru =	1.00		
T 3.1	Spectral Shape Factor for parts	Ch(0) =	1.12		
T 3.7	Near Fault factor	N(T,D) =	1.0		
	Site Hazard coefficient Ch(0) x Z x R x N(T,D) =	C(0) =	0.34		
T. 8.1	Part risk factor	Rp	1.0		
8.3	Floor height coefficient				
	Eq 8.3(1) $\left(1+\frac{hi}{6}\right)$	Chi	1.000		
	Eq 8.3(2) $\left(1+10\frac{hi}{hn}\right)$	Chi	1.0		
		Chi	1.000		
	Period of part	Tp	1.76	Sec	
8.4	Part spectral shape coefficient	Ci(Tp)	0.5		
8.2	Design response coefficient for wall				
	C(0).Chi.Ci(Tp) =	Cp(Tp)	0.17		
(9)	Participation factor for rocking system				
	Rotational inertia of the mass				

$$Jbo+Jto+\frac{1}{g}\left[Wb\left[eb^2+yb^2\right]+Wt\left[(eo+eb+et)^2+yt^2\right]+P\left[(eo+eb+et+ep)^2\right]\right]+Janc$$

	And is:-	J	7004		
10(12)	Participation factor $\frac{(Wb.yb+Wt.yt)h}{2Jg}$ =	g	2.896		
	Displacement response $g\,(Tp/2p)^2.Dp(Tp).Rp.g$ =	Dph	0.364		
	% of NBS, proportion of NZS1170.5				
	$[(1.2)(0.6)\Delta i]/Dph$ =	%NBS	40.4	%	
	Moderate hazard				NZSEE guidelines

STRUCTURAL CONCEPTS LIMITED
55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Seismic loads to NZS1170 - dining areas		

Seismic Loads to NZS 1170.5 — Sheet No.: 16

Ref: | Design | Output

Design working live 50 Years

Importance level 2

Annual Probability of exceedance (inverse) Ultimate 500

Annual Probability of exceedance (inverse) Service 25

Element			Area/length	Load Kpa	Total kN
Roof			216.00	1.00	215.62
Partitions			45.00	0.45	20.12
Upper External Walls			81.00	0.62	50.15
			0.00	0.00	0.00
			0.00	0.00	0.00
			0.00	0.00	0.00
	1.00	0.40	0.00	0.00	0.00

285.89 kN

Element			Area/length	Load Kpa	Total kN
Timber floor			216.00	0.43	92.76
Upper External Walls			81.00	0.62	50.15
Lower Exterior Brick Walls			70.00	6.50	455.00
Roof			0.00	1.00	0.00
Interior Brick Walls			54.00	4.60	248.40
			0.00	0.00	0.00
A2 other rooms	0.50	0.60	216.00	2.00	432.00
	0.50	0.40	0.00	0.00	0.00

975.91 kN

Live load reduction

Total floor area 270.0

$$.3+\frac{3}{\sqrt{A}} = 0.500$$

But not less than .5

Total building weight
1261.79 kN

STRUCTURAL CONCEPTS LIMITED

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Seismic loads to NZS1170 - dining areas		

Sheet No.: 17

Ref:	Design				Output
	Soil type				
	D. Deep or soft soil				
	Across the building				
	Period of building across the building		0.40		☑
	Does the seismic bracing have ductile capabilities but is designed as nominally ductile				
	Structural ductility factor (Ultimate)	m =	2.00		
	Structural ductility factor (Service SLS1)	m =	1.25		
	Hazard Factor — Christchurch	Z =	0.3		
	Return period factor	Ru =	1.00		
	Return period factor	Rs =	0.25		
	Structural Performance factor (Ultimate)	Sp =	0.70		
	Structural Performance factor (Service)	Sp =	0.70		
	Spectral Shape Factor (across)	Ch(T) =	3.00		
	Near Fault factor	N(T,D) =	1.0	n/a	
	Elastic site spectra (Ultimate)	C(T) =	0.90		
	Elastic site spectra (Service)	C(T) =	0.23		
	Ultimate	km =	1.57		
	Service	km =	1.14		
	Ultimate				
	Horizontal design action coefficients (Across)	Cd(T1) =	0.40	But not less than 0.030Ru	
	Ultimate force across the building	Cd(T1) x Wi =	505.86	kN Total	
	Service				
	Horizontal design action coefficients (Across)	Cd(T1) =	0.14		
	Service force across the building	Cd(T1) x Wi =	173.89	kN Total	
	Along the building				
	Period of building along the building		0.40		☑
	Does the seismic bracing have ductile capabilities but is designed as nominally ductile				
	Structural ductility factor (Ultimate)	m =	2.00		
	Structural ductility factor (Service SLS1)	m =	1.25		
	Structural Performance factor (Ultimate)	Sp =	0.70		
	Spectral Shape Factor (across)	Ch(T) =	3.00		
	Near Fault factor	N(T,D) =	1.0		
	Elastic site spectra (Ultimate)	C(T) =	0.90		
	Elastic site spectra (Service)	C(T) =	0.23		
	Ultimate	km =	1.57		
	Service	km =	1.14		
	Ultimate				
	Horizontal design action coefficients (Across)	Cd(T1) =	0.40	But not less than 0.030Ru	
	Ultimate force along the building	Cd(T1) x Wi =	505.86	kN Total	
	Service				
	Horizontal design action coefficients (Across)	Cd(T1) =	0.14		
	Service force across the building	Cd(T1) x Wi =	173.89	kN Total	

STRUCTURAL CONCEPTS LIMITED
55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Seismic Forces - Dining Areas		

Seismic Loads to NZS 1170.5 — Sheet No.: 18

Ref:	Design				Output	
	Seismic weight at level i	Wi	285.89	kN		
	Height at level i	hi	6.0	m		
	Seismic weight at level I	Wi	975.91	kN		
	Height at level I	hi	3.0	m		
	Sum of Wihi		4643.0			
	Base shear ultimate		505.86	kN		
	Base shear service		173.89	kN		
	8% of base shear to be applied at top level		40.47	kN		
	8% of base shear to be applied at top level		13.91	kN		

$$Fi = .92V \frac{Wihi}{\sum(Wihi)}$$

Design	Output	
Ultimate		
Equivalent Lateral force at level i (Roof)	212.40	4249
Equivalent Lateral force at level i	293.46	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
	505.86	kN base V
	10117.20	
Service		
Equivalent Lateral force at level i (Roof)	73.01	
Equivalent Lateral force at level i	100.88	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
Equivalent Lateral force at level i	0.00	
	173.89	kN base V

STRUCTURAL CONCEPTS LIMITED
55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Bracing Capacity - Upper Dining Wing		

Ref:	Design	Output

All walls have been lined with gypsum wall boards (Fixing at nominal 300 spacings) therefore utilising the allowable strength values determined by NZSEE Table 11.1 we have assessed the strength of the walls independent of the Gib manual.
From table 11.1 a strength value of 3 kN/m per side with a strength reduction factor of 0.7 can be used.

$R =$ 3 kN/m per side
$\phi =$ 1

$\phi R =$ 3 kN/m per side
60 BU's/m

Along

length of wall available

11 one side
11 two sides
Rtotal = 11 x 60 x 2.4/2.7+11 x 60 x 2.4/2.7 x 2
= 1760 BU's
88.00 kN OK

required
4249 BU's
provided
1760 BU's

41 %NBS z = 0.3
56 %NBS z=0.22

Across

length of wall available

15 one side
10 two sides
Rtotal = 15 x 60 x 2.4/2.7+10 x 60 x 2.4/2.7 x 2
= 1867 BU's
93.33 kN OK

required
4249 BU's
provided
1867 BU's

44 %NBS z = 0.3
60 %NBS z=0.22

Therefore it is determined that the wall linings will provide the strength required without necessarily strictly complying with the Gib brace requirements
Also it is noted that the main building stucture is also capable of carrying some of this load and therefore reduce the requirements of the gypsum wall strength.

STRUCTURAL CONCEPTS LIMITED

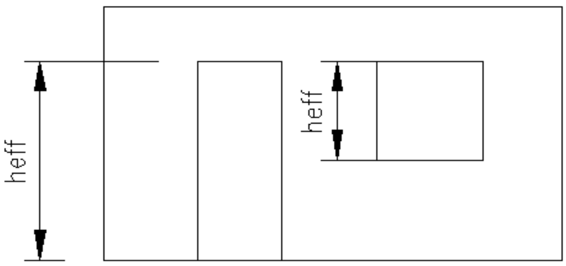
55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Dining Wing Masonry Walls In Plane Across		

In-Plane strength of walls and piers to FEMA URM seismic guidelines | Sheet No.: 20

Ref:	Design	Output

The following calculation follows the FEMA 273 guild lines for seismic rehabilitation of existing unreinforced masonry buildings (URM). This calculation is for piers or walls between window and door openings. Typically these piers are limited by diagonal tension in the panel or toe compressive stress, but bed-joint sliding shear or expected rocking strength can also limit the capacity.



Effective height and pier geometry may vary in the same wall assembly

Ref	Description		Symbol	Value	Unit
	Expected axial gravity force on pier		P_{CE}	100	kN
	Pier dimentions				
	Effective height of pier		h_{eff}	3.00	m
	Pier length (net mortared length)		L	17.00	m
	Pier thickness (net mortared width)		T_m	200	mm
	Net mortared area			3400000	mm²
	Average bed-joint shear strength		V_{te}	1.00	Mpa
(7-1)	Expected shear strength				
	$\dfrac{0.75\left(0.75vte+\dfrac{Pce}{An}\right)}{1.5}$	=	Vme	0.390	Mpa
	Expected lateral strength is the lesser of:-				
(7-3)	Bed-joint shear strength	Vme x An =	Q_{CE}	1325.0	kN
	a = 0.5 for cantilever or 1.0 for fixed pier		a	0.5	
(7-4)	Expected rocking strength $.9aPce\left(\dfrac{L}{heff}\right)$	=	Q_{CE}	255.0	kN
	Masonry compressive strength		f_m	4.0	Mpa
	Diagonal tension strength				
		Vme = f_{dt} in eq. (7-5) only	f_{dt}	0.390	Mpa
	Vertical axial compressive stress		f_a	0.029	Mpa
	Aspect ratio	(L / heff) =		5.67	

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

In-Plane strength of walls and piers continued

Ref:	Design	Output

Expected lateral strength of pier is lesser of:-

(7-5) Diagonal tenson stress

$$Vdt = fdt.An\left(\frac{L}{heff}\right)\sqrt{1+\frac{fa}{fdt}}$$ = QCL 7786.5 kN

(7-6) Toe compressive stress

$$Vtc = aPcl\left(\frac{L}{heff}\right)\left(1-\frac{fa}{0.7\,fm}\right)$$ = QCL 280.4 kN

The govening lateral force for this pier is 255.0 kN
Actural force on pier is 505.9 kN

% of NBS, proportion of NZS1170.5 %NBS 50 %

Moderate hazard

STRUCTURAL CONCEPTS LIMITED

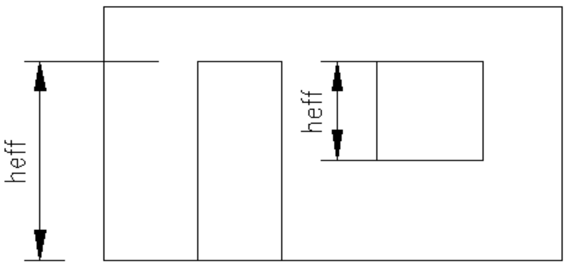
55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

Client:	Christchurch City Council	Ref:	1605 prelim
Project:	Mona Vale Homestead	Date:	23/6/11
	63 Fendalton Road, Christchurch	BY:	GN
Subject:	Dining Wing Masonry Walls In Plane Along		

In-Plane strength of walls and piers to FEMA URM seismic guidelines — Sheet No.: 22

Ref:	Design	Output

The following calculation follows the FEMA 273 guild lines for seismic rehabilitation of existing unreinforced masonry buildings (URM). This calculation is for piers or walls between window and door openings. Typically these piers are limited by diagonal tension in the panel or toe compressive stress, but bed-joint sliding shear or expected rocking strength can also limit the capacity.



Effective height and pier geometry may vary in the same wall assembly

Ref	Description		Symbol	Value	Unit
	Expected axial gravity force on pier		PCE	80	kN
	Pier dimentions				
	Effective height of pier		heff	3.00	m
	Pier length (net mortared length)		L	14.00	m
	Pier thickness (net mortared width)		Tm	200	mm
	Net mortared area			2800000	mm²
	Average bed-joint shear strength		Vte	1.00	Mpa
(7-1)	Expected shear strength				
	$\dfrac{0.75\left(0.75vte+\dfrac{Pce}{An}\right)}{1.5}$	=	Vme	0.389	Mpa
	Expected lateral strength is the lesser of:-				
(7-3)	Bed-joint shear strength	Vme x An =	QCE	1090.0	kN
	a = 0.5 for cantilever or 1.0 for fixed pier		a	0.5	
(7-4)	Expected rocking strength $.9aPce\left(\dfrac{L}{heff}\right)$	=	QCE	168.0	kN
	Masonry compressive strength		fm	4.0	Mpa
	Diagonal tension strength				
		Vme = fdt in eq. (7-5) only	fdt	0.389	Mpa
	Vertical axial compressive stress		fa	0.029	Mpa
	Aspect ratio	(L / heff) =		4.67	

55 DUNLOP ROAD, PO BOX 3315
NAPIER, 4142, NEW ZEALAND
P (06) 842 0111 F (06) 842 0113
E info@structuralconcepts.co.nz

In-Plane strength of walls and piers continued

Ref:	Design	Output

Expected lateral strength of pier is lesser of:-

(7-5) Diagonal tenson stress

$$Vdt = fdt.An\left(\frac{L}{heff}\right)\sqrt{1+\frac{fa}{fdt}}$$ = QCL 5270.0 kN

(7-6) Toe compressive stress

$$Vtc = aPcl\left(\frac{L}{heff}\right)\left(1-\frac{fa}{0.7\,fm}\right)$$ = QCL 184.8 kN

The govening lateral force for this pier is 168.0 kN
Actural force on pier is 505.9 kN

% of NBS, proportion of NZS1170.5 %NBS 33 %

Moderate hazard