structex

Date: 11 June 2012

AIRWAYS – Andy Herd Building

Quantitative Detailed Engineering Evaluation Report

ACENZ

strategy • engineering • design

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Limitations of Report

Findings presented as part of this report are for the sole use of our client, as addressed above. The findings are not intended for use by other parties, and may not contain sufficient information for the purposes of other parties or other uses. Our professional services are performed using a degree of care and skill normally exercised, 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.

Executive Summary and Recommendations

Structex has been engaged to complete a detailed engineering evaluation of the Andy Herd Building in the Airways Business Park, 20 Sir William Pickering Drive, Christchurch. This report summarises our quantitative assessment of the building, which supersedes our previous qualitative assessment, dated 07-02-2012.

A seismic assessment of the building has been carried out in accordance with New Zealand Society for Earthquake Engineering (NZSEE) guidelines, considering multiple importance categories that the building could potentially fall into. Refer to our letter of 16 March 2012, conveying how importance levels apply to this building. The building as it currently stands has a seismic strength of:

- At Importance level 2: **74% NBS**
- At Importance level 3: **56% NBS**
- At Importance level 4: **41% NBS**

Based on our assessment, we consider that the building is not considered earthquake prone.

From a review of existing drawings and visual inspections of the building, the following critical structural weaknesses were identified:

- None

There is some evidence of minor damage due to earthquake loading which does not have adverse effects on the overall strength of the structure. The overall observed damage is described fully in the previously released Interim Damage Report for the Airways Buildings, dated 06-07-2011. In summary, damage includes:

- Minor cracking of structural concrete elements including shearwalls and first floor topping
- Cracking and crushing of corners on precast concrete façade panels
- Concrete blockwall damage including opening of the movement joint on the rear west wall, and loose blocks on the top section of the south wall of the lift shaft
- Interior lining damage to GIB board, ceiling tiles and glazing
- Entry canopy connection damage

Options to repair the building have been outlined in the Interim Report and further recommended in section 5. These include injecting cracks to concrete elements with an appropriate epoxy, plus general internal lining repairs. Some repairs and shoring have been scoped, such as the exterior walkway connection replacement and the removal of the hazard created by the loose blocks at the top of the liftshaft.

Structex have been engaged to provide full specification of repairs, including some which require Building Consent.

Strengthening is not necessary to meet code requirements and will not be required in any subsequent future building consent. However, strengthening could be adopted, with the desired level to be discussed with the building owner, insurer and Christchurch City Council. Once the level of strengthening has been agreed and any other specified alteration work has been defined, we can finalise the design and document the work for Building Consent.

Contents

1 Introduction

1.1 Report Outline

Structex has been engaged to complete a detailed engineering evaluation for the Airways Andy Herd Building, Sir William Pickering Drive, Christchurch. The evaluation was undertaken in accordance with guidelines prepared by the Post-Canterbury earthquake Engineering Advisory Group (EAG). This report summarises our quantitative assessment, which supersedes our previous qualitative assessment outlined in the Earthquake Damage Report dated 30-11-2012. More specifically this report:

(a) Highlights Building Act requirements and the Christchurch City Council policy for earthquake-prone buildings

(b) Describes the existing building, its construction, and structural system

(c) Outlines the level of investigation undertaken and where information was obtained

(d) Assesses the building's seismic strength relative to New Building Standard (NBS), commonly referred to as "current code"

(e) Identifies critical structural weaknesses

(f) Summarises earthquake damage caused by the recent Canterbury earthquakes

(g) Reviews the building's performance in the recent Canterbury earthquakes

(h) Outlines conceptual repairs to restore the building to its pre-earthquake condition

(i) Makes recommendations for any further investigations

1.2 Scope of Investigation

Our detailed engineering evaluation has been undertaken in accordance with Engineering Advisory Group (EAG) guidelines "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury". At the time of writing this report, these guidelines were in draft format (revision 5, released through CSG, 19th July 2011) and under review with the Department of Building and Housing (DBH).

Our building evaluation has been based on the following information:

(a) A number of visual inspections of the building carried out in 2010, 2011 and 2012, which collectively included:

- The exterior from ground level
- The interior where accessible
- The floor slab after removal of raised floor sections
- The interior of the lift shaft walls

(b) Full structural and architectural drawings obtained from the council property file.

(c) Discussions with the tenant, Raewyn James of Airways.

(d) Previous reports including:

- Interim Damage Report by Structex, dated 06 July 2011.
- Multiple Level 2 rapid assessments by Structex, first dated 08 September 2010.

A geotechnical assessment of the ground conditions at the Airways site has not been conducted, but there are no visible signs of liquefaction or any significant ground movement.

Non-structural aspects fall outside the scope of this report and have not been covered by this investigation and assessment, including:

- An electrical safety review
- A fire safety review

These items should be inspected and assessed by qualified trades people or specialists prior to any repair or strengthening works being carried out. We request such persons be instructed to identify loose and/or inadequate fixings, and to notify the engineers if these are found.

2 Building Description

2.1 Details

Building name:	Andy Herd Building
Address:	26 Sir William Pickering Drive, Christchurch
Building use:	Commercial
Storeys above ground:	2
Storeys below ground:	N/A
Roof construction	Precast concrete double T units with topping, spanning onto steel trusses and beams
Wall construction:	Cast in-situ 300mm reinforced concrete shearwalls, non-structural blockwalls at west fire exit and surrounding lift shaft. Timber/light gauge steel interior partitions clad in GIB.
Floor construction:	Precast concrete double T floor units with concrete edge beams spanning between steel support beams with topping slab and edge beam tied into shearwall panel steel.
Subfloor construction:	Concrete slab-on-grade.
Year built:	1989
Approx. floor area:	1050m^2 per floor
Building Importance:	2 or 3(NZS1170.0) – building assessed for multiple importance levels
Alterations:	None apparent

2.2 Structural System

- Gravity system: Heavy concrete double-T roof system spans onto north-south direction steel trusses to steel UB columns. A similar double-T first floor system spans onto steel beams which are supported also by the exterior steel columns and additional interior columns at regular centres. The foundation system consists of significant perimeter strip footings and isolated concrete pads.

- Lateral system: Concrete shearwall action in both directions via cast in-situ doubly reinforced concrete shearwalls on each perimeter wall, sitting on significant extended strip footing beams. Liftshaft core and western structure blockwalls are not considered part of the lateral system due to a lack of shear flow connection.

3 Seismic Assessment

3.1 Qualitative Assessment

Our previous qualitative assessment estimated the building strength as 61% of NBS for the Andy Herd building, indicating that it is unlikely to be earthquake prone. This estimate was based on the Initial Evaluation Procedure (IEP) from the New Zealand Society for Earthquake Engineering (NZSEE), assuming an importance level 2 building. A copy of the IEP form has been included in Appendix D.

Due to the economical value and commercial importance as a priority airport communications building, a quantitative assessment was recommended and requested by Airways and the building owner, Commercial Investment Properties Limited, to confirm the IEP's assessment. This is summarised in the following section.

3.2 Quantitative Assessment

A seismic assessment of the building has been carried out in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" guidelines (June 2006).

AS/NZS1170.5:2005 was used to determine the applied loads to the building, assuming the following:

- A zone factor (Z) of 0.3 in accordance with changes to Section B1 of the Building Code, on the 19th May 2011
- A comparison of Importance Levels 2, 3 & 4
- Subsoil class D
- Structural ductility factor of 2 for in-plane bending and shear evaluation of the lateral panel system, owing to the robust detailing, 1.25 for diaphragm to wall connection

A 2-dimensional analysis was carried out. We consider this assessment sufficiently accurate for the purposes of confirming that the building is not earthquake-prone, or identifying elements requiring strengthening.

NZSEE guidelines (June 2006), and standards AS/NZS3101:2006 and AS/NZS3404:1997 have been used to assess the building capacity; along with the following material assumptions:

- Yield strength of 300MPa for steel members
- Concrete compressive strength of 30MPa
- Deformed bar strength of 430MPa

We note that while the Building Act "deems a building earthquake prone if its ultimate strength capacity is exceeded in a moderate earthquake, and the building would be likely to collapse", the NZSEE guidelines and CCC policy refer to a percentage of New Building Standard (%NBS). Currently 33% of NBS has been adopted as the threshold below which a building is considered earthquake-prone. The ultimate limit state capacity of the building has been assessed as a percentage of NBS to allow comparison.

The following table summarises the results of our assessment. Elements that have less than 33% of current code strength are regarded as being earthquake prone and will be highlighted in bold.

Note that the table compares evaluated strengths to loading demands of importance level 2 (normal), 3 (buildings subject to crowds) and 4 (post-disaster function).

ITEM	IMPORTANCE LEVEL 2		IMPORTANCE LEVEL 3		IMPORTANCE LEVEL 4	
	%NBS N-S	%NBS E-W	%NBS N-S	%NBS E-W	%NBS N-S	%NBS E-W
Wall in plane lateral strength	74%	75%	56%	58%	41%	42%
Diaphragm-wall connection	74-78%	78-80%	57-63%	60-65%	41-44%	43-45%
Foundation Beam strength	>100%	>100%	>100%	>100%	84%	84%

The wall in-plane strengths listed above are governed by flexural in plane bending as opposed to wall overturning or shear failure.

Our assessment indicates that the building strength for each importance level considered is as follows:

- At Importance Level 2: **74% NBS**
- At Importance Level 3: **56% NBS**
- At Importance Level 4: **41% NBS**

The building is therefore assessed to be **not considered earthquake-prone** for any of the assessed importance level categories, and strengthening will not be required if a building consent is required for any repairs or future.

The importance level requirement of the building is somewhat inconclusive, but a level can effectively be selected by the tenant and building owner and subsequent recommendations for possible strengthening can be made. Refer also to our letter of March 16 2012 in Appendix G, describing importance catagories.

3.3 Expected Damage

From a review of the drawings and our understanding of the structural system we would expect damage to the following areas after a major seismic event:

- General diagonal cracking to concrete panel shearwalls
- Yielding of precast panel starter bars and associated cracking of concrete in these areas, possibly within the foundation
- Ceiling tiles falling due to grid buckling, as previously seen
- General internal lining cracking as currently seen
- External cladding panel damage at points of rotation due to incompatibility at the joints.
- Blockwork 'staircase cracking' through mortar planes

3.4 Critical Structural Weaknesses

From a review of existing drawings, visual inspections of the building, and the quantitative assessment; the following critical structural weaknesses (as defined by EAG guidelines) were identified:

- None

4 Building Performance in Recent Canterbury Earthquakes

4.1 Earthquake Damage

Structex has previously issued an Interim Damage Report, dated 30 November 2011, which describes typical damage observed in the three Airways buildings – ADC1, ADC2 and the Andy Herd Building. Please see this report for an in-depth description of damage to the building and surrounds and an associated photo record.

From our visual inspections, observed damage to the building includes:

- Minor cracking in structural reinforced concrete elements such as floor topping and shearwalls
- Cracking and general damage to concrete blockwalls including joint opening in the north-western stair blockwall, and loose blocks at the top of the lift shaft.
- Minor to moderate cosmetic damage to internal linings such as GIB plasterboard and glazing cracking
- Suspended ceiling grid damage, leading to tiles dropping
- Connection damage where the steel external walkway to the south cantilevers from the main building

Some intrusive investigation has been carried out by removing linings around perimeter columns above the first floor.

A selection of photos has been included in Appendix E, to indicate the nature of the observed damage. These photos are not meticulous or comprehensive records of all damage but have been included to provide an indication of the damage.

4.2 Review of Building Performance

Overall the building sustained minor damage considering the magnitude of the recent earthquakes. Hairline-minor cracking to concrete elements was expected damage, but was negligible compared to what would be expected during significant shaking. Cracking has been found in the first floor topping, which is likely to have been there as hairline cracking due to normal drying shrinkage but has opened up in recent shaking. This generally leads to a loss of stiffness and a change in the floor frequency, with tenants commonly experiencing what could be described as a 'bouncy' floor. From what we have observed in the Andy Herd Building, these cracks do not pose a loss of strength issue and can be repaired via epoxy injection to restore stiffness. A repair similar to this has previously been conducted on the ADC2 floor rib cracking.

Internal lining damage observed is typical of what has been experienced across the city, is minor in nature, and to be expected in the level of shaking. Falling ceiling tiles have proved a problem for all of the Airways buildings Structex is involved with, a problem that is shared in other buildings with this type of system. The predicament occurs due to the lack of compatibility between the ceiling grid frame and the response of the buildings structure, leading to crushing or buckling of the grid and tiles popping out.

The damage to the external walkway on the south façade seems to be caused by poor detailing of the cantilevered steel connection. The connection plate seems to be bolted to the non-structural column encasement concrete of approximately 100mm thickness. The plate was bolted in a manner that allowed bending of the bolt, and has caused spalling of the concrete in some areas. A repair detail has been specified by Structex and is awaiting building consent.

Loose blocks were found at the top section of the south wall of the lift shaft, a problem that seems to be have been created due to construction sequencing. The top course of blocks has been left unfilled and unreinforced because they could not be installed as specified simply because the Double-T roof units were already in place, restricting access. Structex have

instructed removal of these blocks as a safety precaution, which the contractor has already attended too. This section of wall is intended as a fire wall, therefore a replacement top section needs to be specified to maintain compliance.

The external cladding panels have typically shown crushing at the interface of the spandrels and column encasements. This is due to the rotation of the spandrel pressing on the column section and subsequently crushing the concrete. These panels are not structural, and their connection to the steel structure has previously been viewed with no concern over the integrity.

The western perimeter blockwall housing a secondary stairwell has shown typical opening of the movement joint and some cracking through mortar planes at the top section. Viewed from the top, it also appears that the flashing has moved, suggesting that some out-of-plane motion has occurred, but internally there is no sign of this. Damage around the movement joint has been designed for and only minor in nature.

Overall, in consideration of the damage observed, we believe that the "earthquake life" of the building has not been significantly reduced as a result of the Christchurch earthquakes.

4.3 Safety & Occupancy

The damage observed does not appear to indicate any appreciable degradation in strength to the building and our quantitative assessment has confirmed the building to be not considered earthquake-prone. Imminent hazards such as the loose blocks in the lift shaft have been dealt with to date, and temporary shoring to the external walkway as it awaits repairs is in place. For these reasons we see no reason to restrict occupancy.

The Andy Herd Building is occupied 24 hours to maintain air traffic control facilities. Occupancy may be affected by the repair works as a result of the damage and will need to be discussed with the tenant and contractor to agree on a compatible construction schedule to limit disruption of Airways services.

Equivalent Civil Defence placard - Green G2: Light damage, low risk, occupiable, repairs required.

5.0 Earthquake Remedial Work

5.1 Temporary Securing Measures

To mitigate hazards, Structex have recommended the following temporary shoring measures which have previously been implemented:

- Removal of falling hazards created by loose blockwork at the top of the south wall of the liftshaft
- Propping of the south exterior walkway
- Removal of loose and potential falling hazard ceiling times where required

No other areas were observed that require temporary securing measures to remove an immediate hazard, or limit further damage. Therefore section 5.2 below addresses only permanent repair issues.

5.2 Repairs

This section describes options of repair to restore the building to its pre-earthquake condition. These repairs are subject to change as the works proceed and as further information regarding existing construction and the extent of damage is revealed. On-site correspondence with the contractor carrying out the works may be required and careful planning of construction methods and sequencing will be needed to limit disruption to normal building use.

Structex is currently compiling a full repair specification for specific damage areas and a corresponding building consent application.

Sika and GIB repair reference material in included in Appendix F attached.

In some instances, a building consent may be required to complete repair work.

In general:

Repair to cracked concrete panels:

- Seal cracks larger than 0.2mm using a pressure injected epoxy. We recommend engaging a Sika Approved contractor to advise on the most suitable product on a case by case basis. Literature in Appendix F will provide some guidance.
- For cracks smaller than 0.2mm, seal by painting over with Resene Brushable Crack Filler or similar.
- If required, repaint over to match existing.

Repair to spalled concrete:

- Break-out loose concrete.
- If reinforcement is exposed, allow engineer to inspect condition of reinforcement. Repairs may be required.
- For corroded reinforcement, wire brush off loose material and spray with a rust convertor.
- Patch repair spalled areas using Sika MonoTop-412N and Sika MonoTop-910N primer in accordance with Sika specifications. For smaller patch repairs, use Sikadur 41 with Sikadur 32 tie coat.
- Repaired surface could be concealed by re-rendering to match existing or painting.

Repair to cracked masonry block mortar:

- Rake-out cracked mortar and re-grout/re-point.
- Alternatively, seal cracks larger than 0.2mm using a pressure injected epoxy(A). If the masonry is not solid filled, Sikadur Injectokit TH is likely to be appropriate. If solid filled, Sikadur Injectokit LV or Sikadur 52 is likely to be appropriate.
- Reinstate rendered finish to match existing.

Repair to damaged internal wall and ceiling linings:

- Repair and/or replace damaged GIB wall and ceiling linings in accordance with GIB recommendations. Refer www.gib.co.nz/earthquakebulletin - this document outlines appropriate repairs depending on the specific type of damage encountered. Sand, prime and repaint over to match existing.
- We suggest replacing heavy suspended ceiling panels at the western end of the office area with a lightweight system.

6 Recommendations

6.1 Damage and Safety

Observed damage does not appear to indicate any appreciable degradation in strength, and our quantitative assessment has confirmed the building to be not considered earthquake-prone. W see no obvious reason to restrict occupancy in the buildings' current state, but recommend that occupancy be reassessed following any significant earthquakes.

We recommend decisions surrounding occupancy consider the results of our assessment.

6.2 Repairs, Strengthening and Temporary Support

Repairs are required to cracked precast cladding panels, structural concrete shearwalls and floor topping, concrete blockwalls and internal partitions / floor lining / ceiling. Refer Section 4 for further details.

As the building is considered not earthquake-prone in importance category 2, 3 and 4, any building consent required for repairs or future alterations will not need to include strengthening as required by the Christchurch City Council's Earthquake-Prone Building Policy.

Structex are currently compiling specification for all works requiring building consent, such as blockwall damage, crack injection and ceiling grid/tile replacement.

Strengthening is not necessary to comply with code but could be implemented. The level of any strengthening desired should be discussed with the building owner, insurer and Christchurch City Council. Once the level of strengthening has been agreed and any other specified alteration work has been defined, we can finalise the design and document the work for Building Consent.

6.3 Further Assessment and Investigations

If strengthening is considered, further geotechnical and structural investigation, including intrusive investigation, is required.

Some further investigation of structure may be needed to form a comprehensive earthquake damage schedule, such as the un-viewed floor-wall connections.

The quantitative analysis presented in this report assumes the site achieves "good Ground" 300KPa Ultimate Limit State bearing conditions as described by NZS3604. Whilst this is consistent with both our observations and understanding of typical soils in this area, a geotechnical survey of the site may be required to confirm this.

Structex have been engaged to visually inspect the building following any significant earthquakes, measuring M5.0 or greater and within 20km.

Appendix A: Statutory Regulations for Existing Earthquake-prone Buildings

This section highlights statutory requirements concerning existing and earthquake-prone buildings as laid out in the Building Act 2004, Building Code, and the Christchurch City Council's Earthquake-prone Building Policy 2010.

A.1 Building Act Requirements

The Building Act 2004 came into force on 31 March 2005 along with the Building Regulations. In considering the structure of existing buildings the relevant sections of the Act are as follows:

Section 124 – Powers of territorial authorities in respect of dangerous, earthquake-prone, or insanitary buildings

If the Territorial authority is satisfied that a building is dangerous or earthquake prone, the Territorial Authority may:

(a) Put up a hoarding or fence to prevent people approaching the building;
(b) Place a notice on the building warning people not to approach the building, or
(c) Give written notice requiring work to be carried out on the building to reduce or remove the danger.

Section 122 – Meaning of earthquake-prone building

This section of the Act deems a building earthquake prone if its ultimate strength capacity would be exceeded, and the building would be likely to collapse causing injury or death, in a "moderate earthquake". The size of a "moderate earthquake" is defined in the Building Regulations as one third the size of the earthquake used to design a new building at that site.

Section 112 – Alterations to Existing Buildings

This section requires that after any alterations, the building shall continue to comply with the structural provisions of the Building Code to at least the same extent as before the alteration. This means that alteration work cannot weaken the building. Additional building strength would therefore be required where structural elements are to be removed or weakened, or additional mass to be added. The building will also need to be assessed in terms of the egress from fire, and access for persons with disabilities provisions of the Building Code and upgraded to comply, as nearly as is reasonably practicable.

Section 67- Waivers and Modifications

This section allows the Territorial Authority to grant a Building Consent subject to waivers or modifications of the Building Code. The Territorial Authority may impose any conditions they deem appropriate with respect to the waivers or modifications.

The Building Act was also altered by the Canterbury Earthquake (Building Act) Order 2010, which, amongst other things, gave additional powers to the Territorial Authorities, extended the definition of a dangerous building and extended the Schedule 1 list of building work exempt from Building Consent.

A.2 Christchurch City Council (CCC) Requirements for Earthquake-Prone Buildings

The Christchurch City Council adopted a new policy for earthquake-prone buildings in September 2010.

The policy reflects the Christchurch City Council's determination to reduce earthquake risk to buildings and ensure that Christchurch "is a safe and healthy place to live in" and may be viewed on the CCC website.

In summary, the relevant items of the policy are as follows:

(a) Buildings are assessed using the New Zealand Society of Earthquake Engineering (NZSEE) guidelines with applied loadings from AS/NZS 1170.5 and are classed as earthquake prone if its strength is less than 33% of the applied loading from the loading standard AS/NZS 1170.5.

(b) It outlines the Council's approach to earthquake-prone buildings including identification, prioritisation, timeframes and implementation. In general, Importance Level 4 buildings (Post-disaster facilities, as defined by AS/NZS1170) will have 15 years from 1 July 2012 to either be strengthened or demolished. Importance Level 3 (crowd or high value) buildings will have 20 years and Importance Level 2 (normal) buildings will have 30 years. There are also additional triggers for requiring assessment and strengthening work to be undertaken at an earlier stage (including "significant" alterations or earthquake damage).

(c) The Council has a commitment to maintaining the intrinsic heritage values of Heritage buildings and has some discretion with regards to strengthening levels and methods. Each building will require discussion with Council Heritage team and Resource Consent prior to any strengthening or repair works being undertaken.

To date the Council has identified 67% of New Building Standard (NBS), or current Code, as the required level for strengthening of earthquake-prone buildings. However, the council may allow strengthening to levels between 33% and 67%, on a case by case basis, taking into account the following:

- The cost of strengthening
- Building use
- Level of danger presented by the building
- How much the building has been damaged

For buildings with a damaged building strength >33% of current code, it is recommended (but not required) that the building also be strengthened.

A.3 Recent Seismicity Changes for Christchurch

As a result of new information from the recent Canterbury earthquakes, changes have been made to Section B1 of the Building Code, increasing seismic code levels within areas covered by the Christchurch City, Selwyn District and Waimakariri District Councils. Such changes include:

- Increasing the zone hazard factor (Z) in AS/NZS1170.5 from 0.22 to 0.3, and serviceability limit state risk factor (R_s) from 1.25 to 1.33.
- Replacing Section 5 of NZS3604:1999 with NZS3604:2011 Section 5, adopting Earthquake Zone 2.

These changes came into effect on the 19th May 2011 and are interim code levels pending further seismological study and investigation. For further information on other changes refer: http://www.dbh.govt.nz/information-sheet-seismicity-changes.

A.4 CERA Requirements

The CCC Earthquake Prone Building Policy has been somewhat superseded by CERA who have wide-ranging powers on these matters. CERA have currently given us verbal advice that the period within which they would require reporting of strength via a detailed engineering assessment (DEE) is no later than 30 June 2014. Official requirements for supplying a DEE to CERA will be contained in a letter sent to building owners in due course.

Appendix B: Recent Seismic Events

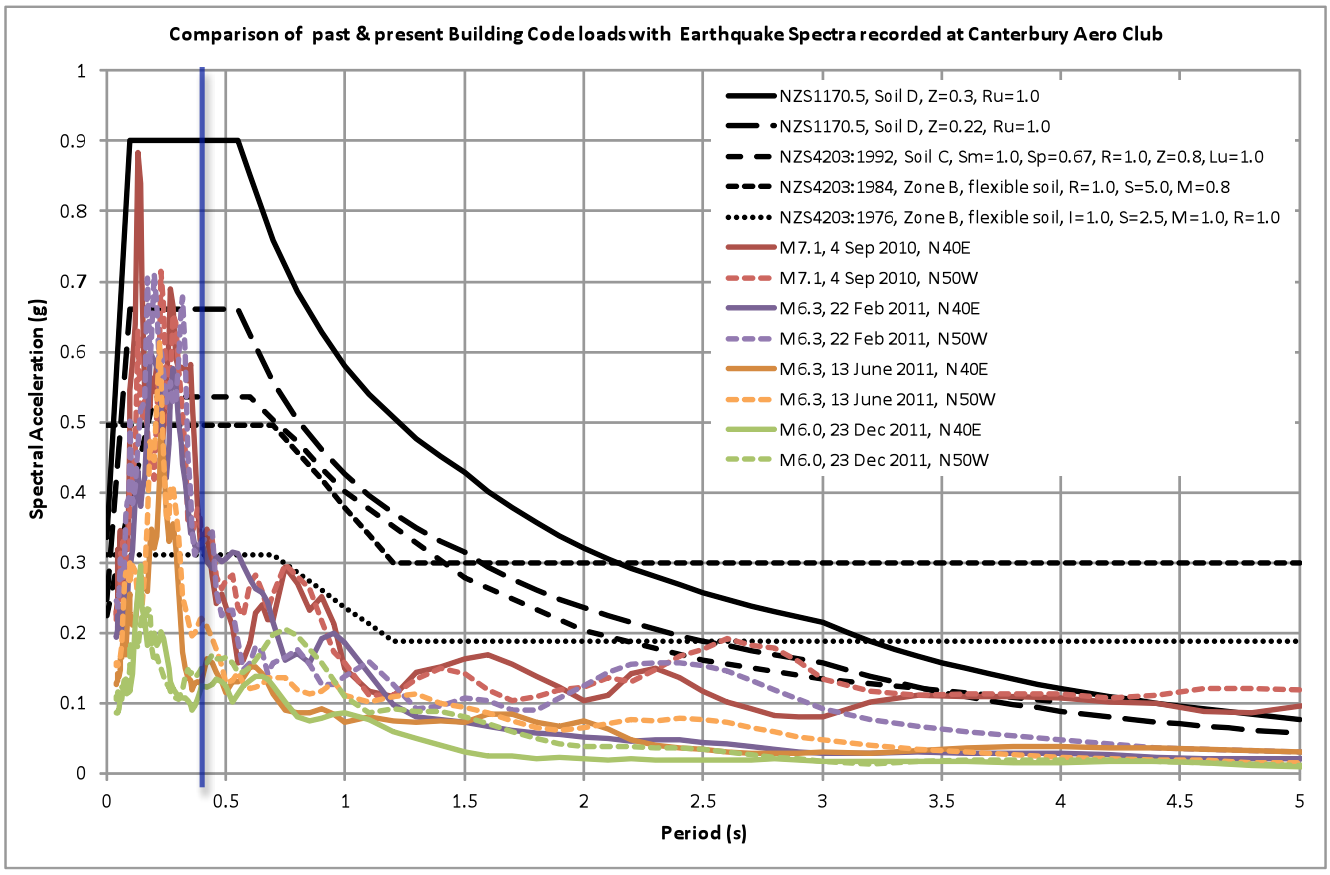
The table below lists the magnitude 5.0 and greater earthquakes within the Canterbury region since 4th September 2010 until the time of writing.

Table 1-Recent Seismic Events

Date	Time	Magnitude	Location	Depth (km)
25-05-2012	14:42	5.2	20km East of Christchurch	12
15-01-2012	2:47	5.0	10km East of Christchurch	9
07-01-2012	1:21	5.2	20km East of Christchurch	15
06-01-2012	14:20	5.0	10km North-East of Christchurch	15
02-01-2012	5:45	5.5	20km East of Christchurch	15
02-01-2012	1:27	5.1	20km North-East of Lyttelton	15
24-12-2011	6:37	5.1	10km East of Diamond Harbour	8
23-12-2011	16:50	5.0	20km North-East of Diamond Harbour	10
23-12-2011	15:18	6.0	10km East of Christchurch	6
23-12-2011	14:06	5.3	20km East of Christchurch	10
23-12-2011	13:58	5.8	20km East of Christchurch	8
09-10-2011	20:34	5.5	10km North-East of Diamond Harbour	12
22-07-2011	5:39	5.1	40km West of Christchurch	12
21-06-2011	22:34	5.4	10km South-West of Christchurch	8
15-06-2011	6:27	5.0	20km South-East of Christchurch	6
13-06-2011	14:20	6.3	10km South-East of Christchurch	6
13-06-2011	13:00	5.6	10km East of Christchurch	9
06-06-2011	9:09	5.5	20km South-West of Christchurch	15
10-05-2011	3:04	5.3	20km West of Christchurch	15
30-04-2011	7:08	5.2	60km North-West of Christchurch	9
16-04-2011	17:49	5.3	20km South-East of Christchurch	11
20-03-2011	21:47	5.1	10km East of Christchurch	10
22-02-2011	19:43	5.0	20km South-East of Christchurch	12
22-02-2011	16:04	5.0	Within 5km of Christchurch	12
22-02-2011	14:50	5.5	Within 5km of Lyttelton	5
22-02-2011	13:04	5.7	10km South of Christchurch	6
22-02-2011	12:51	6.3	10km South-East of Christchurch	5
20-01-2011	6:03	5.1	10km South-West of Christchurch	10
19-10-2010	11:32	5.0	10km South-West of Christchurch	9
13-10-2010	16:42	5.0	20km West of Christchurch	15
04-10-2010	22:21	5.0	30km East of Darfield	12
08-09-2010	7:49	5.1	10km North-West of Diamond Harbour	6
07-09-2010	3:24	5.4	20km South-East of Darfield	15
06-09-2010	23:40	5.4	20km South-West of Darfield	9
06-09-2010	23:24	5.2	20km South-East of Darfield	9
04-09-2010	16:55	5.4	10km South-West of Darfield	10
04-09-2010	11:14	5.3	10km South-East of Darfield	6
04-09-2010	11:12	5.3	10km East of Darfield	12
04-09-2010	7:56	5.2	20km West of Christchurch	7
04-09-2010	4:56	5.3	30km West of Christchurch	8
04-09-2010	4:35	7.1	40km West of Christchurch	11

The figure below plots earthquake acceleration spectra recorded at the Canterbury Aero Club for the four largest magnitude earthquakes. To allow comparison with past and present Building Code seismic loads, elastic design spectra from NZS4203:1976, NZS4203:1984, NZS4203:1992 and NZS1170.5:2005 have also been plotted. The figure gives an indication of the level of load experienced by buildings during the recent earthquakes compared to loads they would have been designed to, as a function of building period. Low rise structures generally would have a period between 0.4 to 1 second.

The vertical blue line indicates the approximate assessed period of the Andy Herd Building, at 0.4sec.



Appendix C: Sample Plans

Appendix D: Completed IEP Form

Appendix E: Photos

Photo 1: Building elevation showing tile damage

Photo 2: Spandrel / column cladding crushing

Photo 3: Suspended floor topping cracking

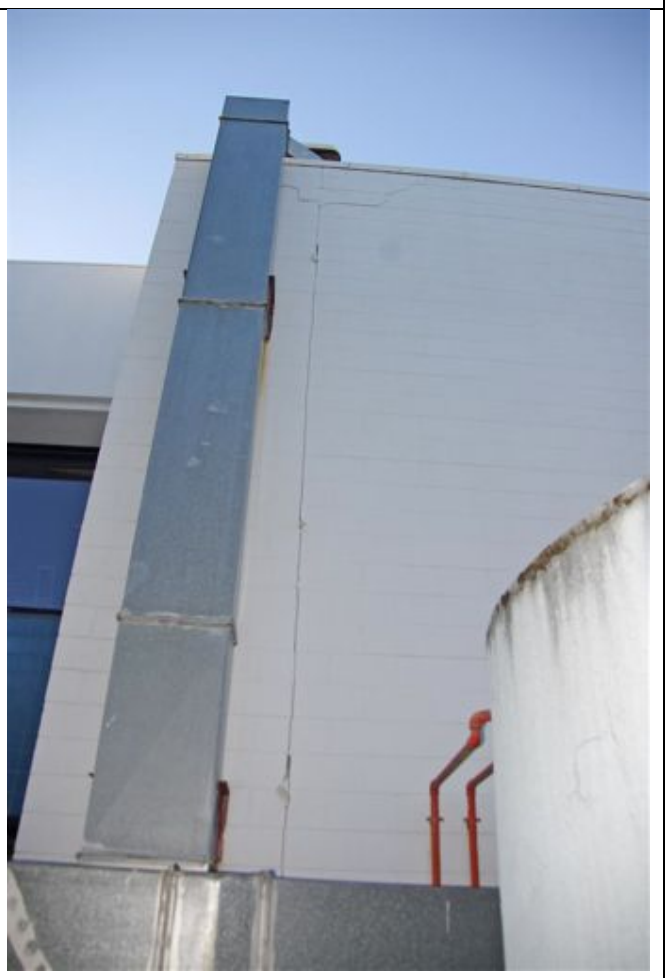


Photo 4: Western blockwall cracking

Photo 5: External walkway spalling of concrete at joint

Photo 6: Typical internal lining damage

Photo 7: Lift shaft Blockwall – loose blocks at top

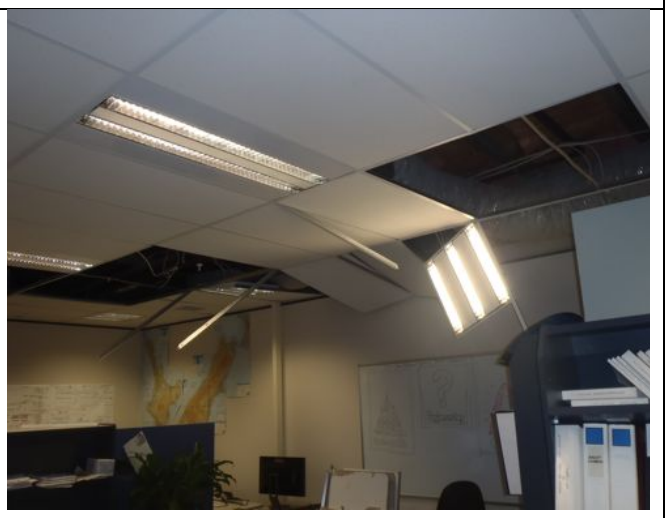


Photo 8: Typical suspended ceiling damage at Airways

Photo 9: South elevation showing external walkway

Photo 10: Further external tile cladding damage

Appendix F: Reference Material for Repair Works

Appendix G: AHB Importance Level Letter