structex

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AIRWAYS – ADC1 Building

Quantitative Detailed Engineering Evaluation Report

ACENZ

strategy • engineering • design

Project number: 3473

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A	17/09/2012	GBu	Client Issue

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 ADC1 Building in the Airways Business Park, 26 Sir William Pickering Drive, Christchurch. This report summarises our quantitative assessment of the building, which supersedes our previous qualitative IEP assessment, dated 17 February 2012.

A seismic assessment of the building has been carried out in accordance with New Zealand Society for Earthquake Engineering (NZSEE) guidelines. Following discussion with Airways, it is agreed that this building be assessed as Importance Level 2. The building as it currently stands has a seismic strength of at least 70% NBS.

At this stage, this estimate is based on the strength of the lower sections of the structural columns in bending action, where the worst cases of seismic action have been assessed only. We would expect higher overall strength if we are to consider some elements of load shedding to other column components, which would generally happen for a system like this in reality. Updates on the overall strength will be issued in due course.

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 buildings, 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 to moderate cracking evident in the top of the first floor concrete waffle slab
- General cracking/crushing damage of façade concrete panels
- Extensive lining damage around the seismic separating joint at the interface with the ADC2 building
- Interior lining damage to light steel/timber fit-out partitions, GIB plasterboard linings and the ceiling tile system
- Window frame damage, leading to minor water-tightness issues

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 have already been scoped, such as the floor cracking epoxy injection repair method. 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 ADC1 Building, Sir William Pickering Drive, Christchurch. 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 buildings, their construction, and structural systems

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

(d) Estimates 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 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 7, released through CSG, 16 May 2012) 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 waffle floor slab after removal of floor covers and sections of raised floor
- The underside of the first floor slab via removal of ground floor ceiling tiles

(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
- A weather tightness assessment

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:	ADC1
Address:	26 Sir William Pickering Drive, Christchurch
Building use:	Commercial
Storeys above ground:	2
Storeys below ground:	N/A
Roof construction	Lightweight cold formed DHS steel purlins spanning onto UB rafters and a large intermediate UB frame running north-south
Wall construction:	Precast concrete wall panels and spandrels, plus a large amount of Aluminium framed glazing
Floor construction:	Cast-in-situ reinforced concrete waffle slab supported by internal and edge concrete beams spanning between reinforced concrete columns
Subfloor construction:	N/A - Concrete slab-on-grade
Foundation Construction:	Reinforced concrete foundation bearing pads and reinforced concrete tie beams
Year built:	1999
Approx. floor area:	600m^2 per floor
Building Importance:	2 (NZS1170.0)
Alterations:	None apparent

2.2 Structural System

- Gravity System:

  The lightweight steel framed roof and heavier reinforced concrete waffle slab are supported by a series of cantilevered concrete columns to foundation pad/tie beam level. Some intermediate steel framing is present which assists in supporting gravity loads.

- Lateral System:

  The Reinforced concrete columns resist lateral loads in both directions via a combination of cantilever action and bending in the first floor beam/column joint. The foundation tie-beams resist bending action provided by the columns at base level.

3 Seismic Assessment

3.1 Qualitative Assessment

Our previous qualitative assessment estimated the building strength as 64% of NBS for the ADC1 Building, indicating that it is unlikely to be considered earthquake prone. This estimate was based on the Initial Evaluation Procedure (IEP) from the New Zealand Society for Earthquake Engineering (NZSEE) "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" guidelines (June 2006), assuming an importance level 2 building.

This procedure provides an estimate of building seismic strength, relative to New Building Standard (NBS), based upon the buildings age, type of construction, and any known structural deficiencies. This procedure is used primarily for the purposes of assessing whether a further quantitative assessment is required.

Due to the economic 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 Importance Levels 2
- Subsoil class D
- Structural ductility factor of 2 for in-plane bending evaluation of the column system, owing to the robust detailing, 1.25 for shear strength evaluation and diaphragm to column 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 rolled steel members
- Concrete compressive strength of 35MPa
- Deformed bar strength of 500MPa

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.

Note that the table compares evaluated strengths to loading demands in both orthogonal directions of earthquake shaking. A summary of the quantitative analysis calculations is included in Appendix D attached.

ITEM	%NBS N-S	%NBS E-W
Upper Level Column Bending strength (weighted average):	108%	110%
Lower Level Column Bending Strength:	70-90%	73-101%
Lower Level Column Shear Strength:	108%	111%
Foundation Beam strength:	109%	109%
Beam/Column Joint and detailing	Not assessed -TBC	Not assessed -TBC

Overall, the building strength classification appears to be governed by in-plane bending of the cantilever column sections, and at this stage is limited by the worst-case scenarios assessed for the lower sections of these columns. If we were to consider a certain amount of load shedding to other areas, a weighted average could be adopted which could prove the building to have an overall higher percentage comparison to current code standards. Therefore, we would consider the overall strength indications below to be the lower bound.

Our assessment indicates that the building strength is at least 70% 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.

3.3 Expected Damage

From a review of our schematic drawings (wall geometry) and our understanding of the structural system based on visual non-intrusive inspections we would expect damage to the following areas of these units after a major seismic event:

- Cracking of reinforced concrete sidewall cladding panels, possibly in a diagonal shear crack manner, flexural out-of-plane action or around restraint points
- Crushing of concrete at interfaces between spandrel panels and piers due to rotational incompatibility
- Flexural cracking of the structural concrete columns, mainly at the base
- The opening of shrinkage cracks in the first floor waffle slab
- Ceiling tiles falling due to grid buckling, as previously seen
- General internal lining cracking as currently seen
- Possible damage or miss-alignment of the ground floor slab

3.4 Critical Structural Weaknesses

From a review of the structural drawings and visual inspections of these buildings, no critical structural weaknesses were identified.

As this building is of light roof construction, basic geometry and utilises newer design techniques due to the young age, it could be considered to have good resilience to earthquakes by way of ability to deform beyond ULS displacements (e.g. during a maximum credible design earthquake).

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 plus an associated photo record.

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

- Minor to moderate cracking observed in concrete structural elements, mainly the top of the first floor waffle slab and external concrete wall panels. The extent of cracking observed would not significantly impact the structural strength of the building.
- Minor movement and cracking of external "C" corner panels over foundations.
- Cracking of connections to the "red" panel over the main entry.
- Moderate to minor damage to interior fit-out walls, GIB linings and ceiling systems as a result of the movements occurring during shaking.
- Major damage to the linings in the region of the seismic movement joint at the first floor corridor.
- Minor damage and buckling issues in the aluminium window frames.

Some intrusive investigation has been carried out by removing linings around perimeter columns and the removal of carpet tiling on 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.

Inspection of the first floor has revealed noticeable cracking to the top side of the waffle floor slab. It is possible that these cracks have been present since construction due to normal drying shrinkage and restraint of supports or formwork.

The recent earthquake events may have resulted in further opening of these cracks making their appearance more obvious. 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. Structex have also observed selected areas of the soffit of the waffle slab via removal of the ground floor ceiling tiles. Overall, less cracking was found and almost no cracking detected around major structural columns supporting the floor. From what we have observed in the ADC1 Building, these cracks do not pose a loss of strength issue, rather a change on response frequency, and can be repaired via epoxy injection to restore stiffness to an appropriate level. Structex have only become aware of these cracks after release of the Interim Damage Report, and have since tested and proposed a suitable repair method.

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 around Christchurch with this type of hanging grid system. The predicament occurs due to the lack of compatibility between the ceiling grid frame and the movement response of the buildings structure, leading to crushing or buckling of the grid and tiles popping out. These tiles can be replaced with lightweight alternatives.

General internal fit-out walls have shown movement and associated damage to linings, particularly to the western quadrants of the upper floor. These are non-structural and do not affect the overall integrity of the building.

Extensive damage occurred to the linings around or over the seismic joint between the ADC1 and ADC2 buildings. This is to be expected as these linings are subject to the independent movements of both buildings simultaneously. Severe superficial lining damage is typical of seismic gap detailing and is difficult to avoid. New linings have been installed in the vicinity of the seismic gap.

The concrete cladding panels have presented typical problems after earthquake shaking. Rotation of the bottom sections of the 'C' shaped panels in the north-east and south-west corners has occurred resulting in angular cracking patterns at the 90 degree knee and overall shifting on the foundations. The lack of out-of-plane restraint and hold down connection at the base of these panels could account for this. Structex have previously designed and monitored the installation of tie-back connections to the main columns behind to limit further damage in these areas. Other panels have shown crushing damage due to rotation incompatibility between spandrel and pier claddings, similar to what has been observed on the Andy Herd Building. Movement of cladding sections has resulted in failure of the flexible sealant at the junctions of panels, which will require reinstatement to avoid durability issues.

Non-structural damage has occurred to some of the aluminium window framing resulting in a water-tightness issue which has been raised by Airways. Closer inspection has revealed a combination of slight buckling of the frame componentry and the non-earthquake related deterioration of the seals has accounted for this. Structex have been involved in the investigation of window damage issues and the arrangement of a replacement system as part of the overall repair specifications for ADC1.

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.

Structex are aware that maintaining functionality of the ADC1 Building as an Airways facility is of premium importance. 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 Earthquake Repairs and Temporary Support

5.1 Temporary Securing Measures

No areas were observed that require temporary securing measures for aspects of the buildings that present an immediate hazard or limit further damage. Therefore, this section addresses only the permanent repair issues for the ADC1 Building.

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.

Some repairs have already been undertaken, including securing the base of the C-shaped concrete cladding panels at the north-east and south-west corners of the building as well as temporary re-establishment of the linings around the seismic joint at the interface of the neighbouring ADC2 building.

A building consent or exemption may be required for repair work. 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 general, repairs include:

Repair to concrete slab-on-grade:

- Grind out and seal cracks using Sikaflex 11FC(A).
- Alternatively, seal using a pressure-injected epoxy such as Sikadur Injectokit TH(A).

Repair to damaged internal wall and ceiling linings:

- Repair and/or replace damaged GIB wall and ceiling linings in accordance with GIB recommendations. Refer GIB Bulletin "Guidelines for repairing GIB plasterboard linings in wind or earthquake damaged properties" (November 2011). This can be found online at www.gib.co.nz/earthquakebulletin.
- In addition we make the comment that owners have commented that their timber framed houses have become noisier and more susceptible to outside vibrations since the earthquakes. This is due to a stiffness reduction from pull-out of wall lining fixings. 80% of this stiffness can be reinstated by re-fixing the perimeter of GIB sheets to wall framing.
- For minor isolated cracks to plaster linings (smaller than 300mm in any direction), grind-out V-shaped groove along crack. Re-plaster over groove, utilising fibreglass mesh reinforcement across the crack.
- For larger cracks/fractures to plaster linings, remove and replace with GIB in accordance with GIB literature.
- Sand, prime and repaint over to match existing.

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.
- Where cracks are subject to significant thermal effects (e.g. north facing and/or dark painted), even smaller cracks may require epoxy injection to limit future damage to paintwork or sealants. Confirm with the engineer prior to repair.

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-Structural Mortar and Sika MonoTop 910N-Primer, in accordance with Sika specifications(A). 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.

Repairs to the suspended waffle slab floor:

- Repairs for the floor have been specified previously, subject to the results of the crack injection method testing and considerations of the operation of the ADC1 building.

Other non-structural repairs:

- Ease and adjust any jammed/catching doors/windows/etc.
- Replace or re-fix any damage ceiling tiles
- Realign and re-fix any dislodged timber architraves, frames, skirting boards and trims.
- Sand, prime and repaint over to match existing.
- Repair/replace broken windows and frames as required.
- We suggest replacing heavy suspended ceiling panels in the office areas with a lightweight system.

(A) Refer attached SIKA specification, in Appendix F, to confirm most suitable product for specific application and for information on product installation. For further information, contact SIKA on 0800 745 269.

5.3 Strengthening to 67% or 100% NBS

The repairs noted above are required to restore the buildings to their pre-earthquake damaged condition. Any seismic strengthening would be additional to this and is beyond the scope of this quantitative assessment.

The results of the quantitative analysis in section 3.2 above indicate that strengthening will not be required as part of any future building consent. However, strengthening could be adopted, with the desired level to be discussed with the building owner, insurer and Christchurch City Council.

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. We 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 suspended floor and internal partitions / floor lining / ceiling. Refer Section 4 for further details.

As the building is considered not earthquake-prone , 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 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 beam - column connections and the bases of the cantilever columns.

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.