

Southern Response
C/- Arrow International (NZ) Ltd

26 June 2014

RE: Geotechnical Investigation of 20 Dunarnan Street, Avonside, Christchurch (D3430254)

1 Introduction

Geoscience Consulting (NZ) Ltd (Geoscience) was requested by Arrow International (NZ) Ltd to undertake a geotechnical investigation of the subject property (herein referred to as 'the site').

We understand the dwelling at the site sustained damage as a result of the 2010-2011 Canterbury earthquake sequence and that you require a geotechnical assessment of the ground conditions to determine a suitable foundation option for the proposed foundation rebuild.

The scope of this study consists of:

- Desktop study of relevant publically available geotechnical and geological data;
- Geotechnical observation of the site to identify land damage caused by the 2010-2011 Canterbury earthquake sequence;
- Review of Earthquake Commission (EQC) and Environment Canterbury (ECan) geotechnical data;
- Perform shallow soil testing to characterise ground conditions on site;
- Prepare a report outlining our findings on the ground conditions and provide geotechnical recommendations for the proposed foundation solution.

Our scope of works does not include assessment of the structural integrity of the dwelling.

2 Site Description

The site is located in Avonside, Christchurch, on a relatively flat section of 612 m² (Figure 1). It is bound to the north by Dunarnan Street, to the east and west by residential properties and to the south by Linwood North School. The site is 210 m southeast of the Avon River.

Figure 1: Site Location Plan and Investigation Locations

3 Area Wide Information

3.1 CERA Land Classification

The Canterbury Earthquake Recovery Authority (CERA) has mapped the site within the 'Green Zone' where buildings are typically considered suitable for repair or rebuilding. The Ministry of Business, Innovation and Employment (MBIE) has divided the CERA 'Green Zone' into Technical Categories. This site is currently classified as TC2, where "minor to moderate land damage from liquefaction is possible in future large earthquakes" and "shallow soil strength testing standard for all homes" is required. Therefore, a site specific liquefaction analysis was not undertaken in our investigation.

3.2 Regional Geology

The site has been regionally mapped by GNS (Brown, 1992) to be underlain by dominantly alluvial sand and silt overbank deposits of the Springston Formation and by Forsyth (2008) as being underlain by river alluvium.

3.3 Canterbury Geotechnical Database

We have reviewed the Canterbury Geotechnical Database in preparation of this report and the relevant findings are presented and discussed herein.

Subsurface and Earthquake Specific Data

We have reviewed the Canterbury Geotechnical Database and summarised the data relevant to this site in Tables 1 and 2.

Table 1: Summary of Subsurface Data

CPT/Borehole Identifier	Position Relative to Site	Depth of Exploration (m)
BH_17908	30 m northwest of site	10.5
CPT_28987	45 m west of site	15
CPT_24039	30 m northwest of site	10

Table 2: Summary of Earthquake Specific Data

	Events			
	4 Sept 2010 (Mw 7.1)	22 Feb 2011 (Mw 6.2)	13 Jun 2011 (Mw 6.0)	23 Dec 2011 (Mw 5.9)
Median PGA (g)	0.21	0.54	0.31	0.28
PGA Probable Range (g)*	0.16 to 0.28	0.40 to 0.73	0.23 to 0.42	0.19 to 0.42
PGA7.5 (g)**	0.19	0.38	0.21	0.18
Regional Liquefaction and Lateral Spreading Observations (EQC)	None Observed	Moderate	Moderate	No Data available
Site Specific Aerial Photograph Liquefaction Interpretation***	None Observed	Minor	Minor	Minor
Mapped Ground Cracks	No ground cracks mapped on site or within 50 m.			

*Range for one standard deviation either side of the mean.

**Using Idriss and Boulanger (2008) magnitude scaling factor.

***Interpreted by Geoscience.

Groundwater

Groundwater is regionally mapped by GNS Science (GNS) between 1.0 m and 2.0 m depth, with the nearest GNS well is located approximately 200 m northwest of the site. EQC has mapped groundwater between 1.0 m and 2.0 m depth at the time of the 2010-2011 Canterbury earthquake sequence. The closest EQC piezometer measurement is approximately 650 m southeast of the site.

LiDAR and Ground Movement

EQC has prepared maps showing the change in surface elevation and horizontal deformation, as measured by a series of aerial LiDAR surveys. These LiDAR surveys capture surface deformation other than liquefaction-induced deformation, such as tectonic movement. GNS has created a “dislocated tectonic contour model” which shows the tectonic uplift or subsidence on a regional level based on survey of discrete benchmarks on bedrock outcrops across the Canterbury region. Subtracting the tectonic component of vertical deformation from surveyed ground levels gives an indication of vertical deformation from soil subsidence.

LiDAR maps prepared for the EQC show a cumulative subsidence of approximately 310 mm.

3.4 Historic Maps and Photography

We reviewed limited aerial photographs of the site dating back to 1941. As it relates to potentially significant geotechnical engineering issues, we describe relevant observations from our aerial photograph review below:

- The site was paddocks from 1941 to 1946 and was residentially developed between 1946 and 1955.
- A sleep out was added to the southeast of the site between 1984 and 1994.

3.5 Floor Levels

The Christchurch City Council (CCC) and CERA have released updated recommended floor levels for flood avoidance for properties in the Avon, Heathcote and Styx river catchments, as well as Sumner.

The following data is reported for the site:

- Interim Floor Level: 11.82 m above the Christchurch City Datum;
- Average Ground Level: 11.53 m above the Christchurch City Datum;
- 50 Year Flood Level: 11.82 m above the Christchurch City Datum; and
- Modelled 200 Year Flood level: 11.45 m above the Christchurch City Datum.

The site is located outside the “CCC City Plan – Flood Management Area” but within the “50 Year Flood Extent” and the “50 Year Floor Level Control Area”. The most current CCC flood levels should be taken into consideration when establishing floor elevations for the rebuilt foundation.

4 Site Investigation

Geoscience visited the site on the 22nd of May 2014 and made the following observations:

- The dwelling is a timber framed structure with heavy cladding on a perimeter concrete foundation with internal piles (Type B2, as defined by MBIE). The site has a separate single garage with light/medium cladding founded on a concrete slab to the southwest of the dwelling and a tin shed to the south of the single garage. There is a separate double garage in the southeast area of the site, with the eastern half of the garage converted into a sleep out.

There is also a timber lean to carport east of the dwelling and a brick patio in the southwest corner of the site. There is a timber deck that extends off the south side of the dwelling.

- The perimeter foundation has cracks up to 10 mm wide in the north, east and west sides of the dwelling. One of the perimeter cracks in the north continues up through the cladding to the window. A 10 mm wide crack extends up from the foundation into the cladding leading to the two nearby windows. The entrance way in the west has a 5 mm horizontal crack that runs along the south wall of the entranceway and under the door.
- The site has remnant ejecta behind the single garage and undulations within the southwest patio of up to 50 mm. The patio and concrete in the southwest side of the site has multiple cracks up to 5 mm wide and vertical offsets of 30 mm due to undulations. The tenant states that the concrete slab behind the single garage was level before the earthquakes implying that it has lifted up to 60 mm as a result of the earthquakes. The driveway has cracks up to 10 mm wide and separations of up to 10 mm wide; the driveway also has vertical offsets of 15 mm due to undulations

Site photographs are presented in Figure 2.

Figure 2: Site Photographs



Photo 1: Perimeter crack in the north foundation.



Photo 2: Perimeter and cladding crack in the east side.

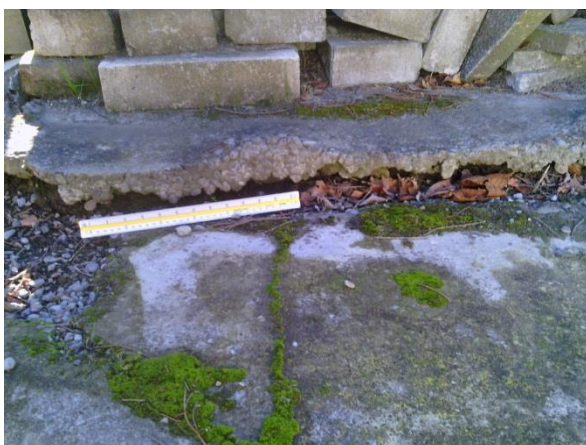


Photo 3: Damage to slab south of the single garage and remnant ejecta.



Photo 4: Damage in driveway west of dwelling showing cracks with vertical offset.

4.1 Hand Auger Borehole and Scala Penetrometer Testing

Geoscience completed three hand auger boreholes and associated Scala Penetrometer (Scala) tests to depths between 2.7 m and 3.9 m. Standing water was encountered at 2.0 m depth in the hand auger boreholes.

Full logs are presented as attachments to this letter report and are written in general accordance with the New Zealand Geotechnical Society field classification guidelines (NZGS, 2005).

4.2 Summary of Subsurface Conditions

The material encountered in our subsurface investigations is broadly consistent with published mapping. Table 3 below provides a generalised summary of the subsurface conditions; consult the boring logs for specific subsurface conditions at each location.

Table 3: Summary of Subsurface Conditions

Depth (m)	Soil Type	Density/Consistency
0.0 to 0.4	TOPSOIL / FILL	Very Loose / Soft to Firm
0.4 to 3.0	ALLUVIUM	Loose to Dense / Stiff to Hard
3.0 to 5.5*	Interbedded SAND and GRAVEL	Medium Dense
5.5 to 10.5*	SAND	Medium Dense to Dense

*soil types below 3 m were inferred from nearby soil borings.

4.3 Soil Classification

For the purpose of seismic design, we consider the soil classification in line with NZS 1170.5:2004 to be 'Class D – Deep or Soft Soil'.

5 Geotechnical Recommendations

As outlined in the MBIE guidance, expected settlements for TC2 sites under Ultimate Limit State (ULS) and Serviceability Limit State (SLS) design loads are up to 100 mm and up to 50 mm, respectively. In accordance with the MBIE guidance, we recommend designing foundations to handle these anticipated settlements.

We consider the following solutions to be suitable for the proposed foundation rebuild as outlined below. Your Structural Engineer may have alternative options capable of tolerating the settlements anticipated for this site.

5.1 New Foundations

For construction of new foundations on this site we recommend the following:

For concrete slab foundations in accordance with Section 5 of the MBIE guidance, we consider TC2 'Options 1 to 4' to be appropriate for this site. Foundations should bear on native silt or engineered fill placed on the native silt present beneath the topsoil and fill anticipated below a depth of 0.4 m, and be designed for a geotechnical Ultimate Bearing Capacity of 200 kPa. Additionally, slab on grade foundations should be designed to span 2 m at the perimeter and 4 m within the interior.

For Timber Floor construction in accordance with Section 5 of the MBIE guidance, we recommend specifically designing for a geotechnical Ultimate Bearing Capacity of 200 kPa below 0.5 m depth assuming a 300 mm pile diameter.

For concrete slab foundations or foundations that incorporate a gravel raft, all grass and topsoil should be undercut from within the building footprint plus a minimum of 0.5 m beyond the perimeter foundation line. Grass and topsoil beneath pile supported timber floors may harbour moisture and we recommend this is taken into consideration during foundation design. Removal of grass and placement of a moisture barrier or removal of grass and the upper 100 mm topsoil and replacement with free draining granular fill may be suitable mitigation options; however, this should be confirmed by your foundation design team.

5.2 Additional Considerations

- Foundations should be designed by a Chartered Professional Engineer practising in foundation design;
- We advise that future building work takes into consideration the recommendations of the MBIE guidance. We recommend referring to Table 7.2 of the MBIE guidance for the maximum recommended weights for wall and roof cladding; and
- Geoscience should be given the opportunity to review the foundation design drawings prior to submitting for Building Consent and observe the foundation excavation in order to verify that the recommendations presented in this report have been interpreted as intended.

6 References

- Brown, L.J. & Weeber, J.H. (1992). Geology of the Christchurch Urban Area 1:250,000. *CGD5122*. Institute of Geological and Nuclear Sciences.
- Canterbury Earthquake Recovery Authority (2013). Canterbury Geotechnical Database. Retrieved May 2014, from <https://canterburyrecovery.projectorbit.com/cgd>
- Canterbury Regional Council (2007). Christchurch City Waterways Survey Maps.
- Christchurch City Council. Floor Levels in Residential Homes in Christchurch. Retrieved May 2014, from <http://www.ccc.govt.nz/homeliving/buildingplanning/floorlevels/index.aspx>
- Christchurch City Council. Rates Information. Retrieved May 2014, from <http://www.ccc.govt.nz/CCC.Web.RatesInfo/homeliving/ratesvaluations/ratesinfo/index.aspx>
- Forsyth, P., Barrell, D. J., & Jongens, R. (2008). Sheet 16 - Geology of the Christchurch Area 1:250,000. Institute of Geological and Nuclear Sciences.

New Zealand Geotechnical Society (2005). Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes.

Standards Association of New Zealand (2004). Structural Design Actions, Part 5: Earthquake Actions – New Zealand, NZS 1170.5:2004. Standards New Zealand, Wellington.

The Ministry of Business, Innovation, and Employment (2012). Guidance - Repairing and Rebuilding Houses affected by the Canterbury Earthquakes.

We further note that some of the data included in this report was extracted from the Canterbury Geotechnical Database (<https://canterburygeotechnicaldatabase.projectorbit.com>), which were prepared and/or compiled for the EQC to assist in assessing insurance claims made under the Earthquake Commission Act 1993. The source maps and data were not intended for any other purpose. EQC and its engineers, Tonkin & Taylor, have no liability for any use of the maps and data or for the consequences of any person relying on them in any way. This "Important notice" must be reproduced wherever this data or any derivatives are reproduced.

7 Limitations

- i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Southern Response, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.
- ii. The recommendations in this report are based on the ground conditions indicated from published sources, site inspections and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.
- iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.
- iv. This report is not to be reproduced either wholly or in part without our prior written permission.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on 03 328 9012 if you require any further information.

Report prepared by



Jacinta Morgan

Staff Geologist

Reviewed by



Don Bruggers, CPEng, IntPE (NZ); PE, GE (USA)

Principal Geotechnical Engineer

Attachments:

- Hand Auger Borehole Logs


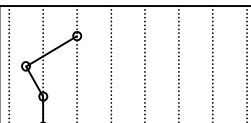

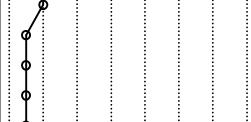

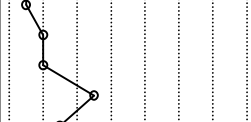


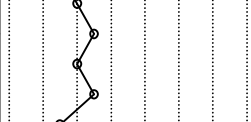
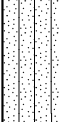
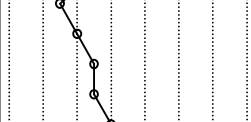
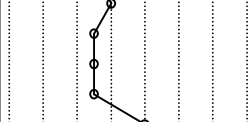
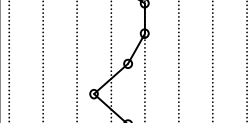
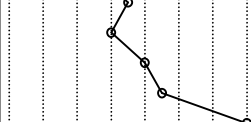
HAND AUGER BOREHOLE - HA01

20 Dunarnan Street

Avonside

D3430254

Client : Arrow International (NZ) Ltd **Date** : 15/05/14
Project : Southern Response **Hole Depth** : 3.7 m
Geoscience Ref. : 9653.000.2192 **Shear Vane No.** : 1362
Drilling Method : Hand auger **Logged By** : JC/AN
Hole Diameter : 50 mm **Reviewed By** : JM

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Log	Water Level	Moisture Condition	Shear Vane (kPa) Peak/Remolded	Consistency / Density Index	Scala Penetrometer Blows per 100 mm
0.0	FILL	ML	SILT with minor gravel, trace sand and brick; dark greyish brown. Low plasticity. Gravel, fine, poorly graded, subrounded to subangular [FILL].					S	
0.5			SILT; brownish grey with orange mottles. Low plasticity.				64/15		
1.0		ML	Trace clay encountered and becomes grey with orange mottles from 1.2 m depth.		W		152/30	St-H	
1.5	ALLUVIUM						212+		
2.0		SM	Silty fine to medium SAND; grey. Poorly graded, subrounded to subangular. Becomes saturated at 2.1 m depth.					MD	
2.5		SP	Fine to medium SAND with trace silt; grey. Poorly graded, subrounded to subangular.		S			MD	
3.0			EOH: 2.7 m						
3.5									
4.0									

Termination: Practical Refusal

Hand auger met practical refusal due to hole collapse at 2.7 m depth.

Scala Penetrometer met practical refusal at 3.7 m depth.

Dip test showed standing water at 2.0 m depth.


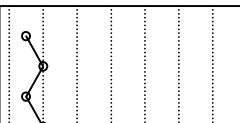

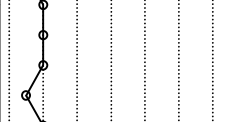
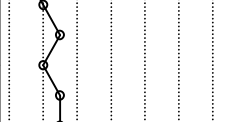

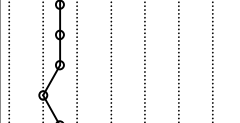

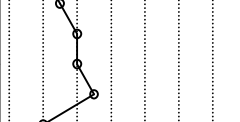
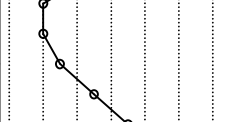
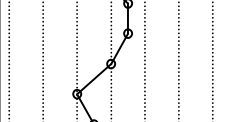
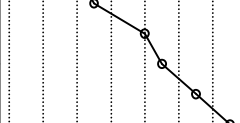

HAND AUGER BOREHOLE - HA02

20 Dunarnan Street

Avonside

D3430254

Client : Arrow International (NZ) Ltd **Date** : 15/5/14
Project : Southern Response **Hole Depth** : 3.2 m
Geoscience Ref. : 9653.000.2192 **Shear Vane No.** : 1362
Drilling Method : Hand auger **Logged By** : AN/JC
Hole Diameter : 50 mm **Reviewed By** : JM

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Log	Water Level	Moisture Condition	Shear Vane (kPa) Peak/Remolded	Consistency / Density Index	Scala Penetrometer Blows per 100 mm
0.0	TOPSOIL	ML	SILT with trace rootlets; dark brown. Low plasticity. [TOPSOIL]					S-F	
0.5			SILT; brownish grey with orange mottles. Low plasticity.				67/14	St	
1.0		ML				W	167/42	VSt	
1.5	ALLUVIUM		Trace sand encountered from 1.6 m depth.				123/42		
2.0			Silty fine to medium SAND; grey. Poorly graded, subrounded to subangular.					L-MD	
2.5		SP				S		MD-D	
3.0			EOH: 3.0 m						
3.5									
4.0									

Termination: Practical Refusal

Hand auger met practical refusal due to hole collapse at 3.0 m depth.

Scala Penetrometer met practical refusal at 3.2 m depth.

Dip test showed standing water at 2.0 m depth.



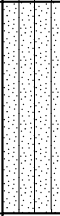
HAND AUGER BOREHOLE - HA03

20 Dunarnan Street

Avonside

D3430254

Client : Arrow International (NZ) Ltd **Date** : 15/05/14
Project : Southern Response **Hole Depth** : 3.9 m
Geoscience Ref. : 9653.000.2192 **Shear Vane No.** : 1362
Drilling Method : Hand auger **Logged By** : JC/AN
Hole Diameter : 50 mm **Reviewed By** : JM

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Log	Water Level	Moisture Condition	Shear Vane (kPa) Peak/Remolded	Consistency / Density Index	Scala Penetrometer Blows per 100 mm
0.0	TOPSOIL	SM	Silty fine to coarse SAND with trace gravel and rootlets; dark brown. Poorly graded, subrounded to subangular [TOPSOIL].					VL	
0.5	ALLUVIUM	ML	SILT; brownish grey with orange mottles. Low plasticity.		W		94/24	St-H	
1.0			Becomes grey with orange mottles at 1.0 m depth.				140/42		
1.5			Trace clay encountered from 1.2 m depth.				212+		
2.0	ALLUVIUM	SM	Trace sand encountered from 1.8 m depth.		S		88/17	MD	
2.5			Silty fine SAND; grey. Poorly graded, subrounded to subangular.						
3.0			EOH: 2.8 m						
3.5									
4.0									

Termination: Practical Refusal

Hand auger met practical refusal due to hole collapse at 2.8 m depth.

Scala Penetrometer met target depth at 3.9 m depth.

Dip test showed standing water at 2.0 m depth.