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18 August 2015

Greg Dewe
Land Development Manager
Fulton Hogan Land Development Limited
29 Sir William Pickering Drive
PO Box 39185
Christchurch 8545

Dear Greg

Geotechnical Completion Report – Longhurst Stage 10 Development (Lots 703, 710 to 730, 980, 981, 984 and 985)

This geotechnical completion report is submitted in accordance with Section 12.4.1 of the Christchurch City Council Infrastructure Design Standard.

Introduction

Fulton Hogan Land Development Limited (FHLD) is in the process of developing the Longhurst Residential development in Halswell in southwest Christchurch, with Stage 10 of the development nearing completion. During the geotechnical investigation stage of Stage 10 parts of development were identified as being susceptible to a varying degree to the effects of seismically induced liquefaction. See attached plan for the extent of Stage 10.

The liquefaction risk and associated lateral spreading risk was assessed as being variable across the site. As such a series of three rows of Deep Soil Mix (DSM) columns have been installed in the bank of the stormwater basin edge along Lots 703 and 710 to 718.

The conditions of Aurecon's engagement are as per our original agreement relating to initial geotechnical investigation carried in October 2010, and are set out in our letter of engagement dated 29 September 2010.

Previous Investigation

Aurecon undertook a geotechnical site investigation across the wider 117ha FHLD Halswell West residential development site in October 2010 to support a plan change application. This investigation is described in the Aurecon Report *Geotechnical Site Investigation and Liquefaction Assessment, Halswell West Rezoning, Rev1* dated 29 November 2010 prepared for Fulton Hogan Land Development Limited (Aurecon, 2010).

Aurecon undertook further geotechnical investigations to support a subdivision application for Stage 10 of the Longhurst development between September 2011 and April 2013. This included testing in areas that are now included in Stage 10. This investigation is described in the Aurecon Report *Halswell West Residential Development Longhurst Stage 10 Geotechnical Assessment, Rev1* dated 26 August 2013 (Aurecon, 2013).

Liquefaction Hazard Assessment

In the days immediately following the 4 September 2010 Darfield Earthquake and the 22 February 2011 Christchurch Earthquake Aurecon undertook a site walk over and mapping of surface manifestation of liquefaction across the entire Halswell West development (including Longhurst Stage 10). Surface manifestation of liquefaction was observed in parts of what is now Stage 10 after the Darfield Earthquake.

A liquefaction hazard assessment was carried out as part of the site assessments using the method prescribed in the Ministry of Business, Innovation, and Employment guidelines for residential development in Canterbury following the Canterbury earthquake sequence (MIBE, 2012). Based upon this assessment:

Lots 703 and 710 to 718

For Lots 703 to 718 the calculated liquefaction induced vertical ground deformations were within the limits of Technical Category 2 (TC2) classification. However, due to the orientation and depth of a sandier soil lenses these lots in their original form were unlikely to fulfil the requirements of TC2 classification from a lateral displacement criteria towards the stormwater basin to the west.

Lots 719 to 730

The calculated liquefaction induced ground deformations were within the limits of a TC2 classification.

Liquefaction Risk Mitigation

The following liquefaction hazard mitigation has been undertaken across the site:

Lots 703 and 710 to 718

In order to ensure a TC2 classification across the entire development stage and provide additional seismic resilience lateral spreading mitigation works have been undertaken to improve the seismic performance of Lots 703 and 710 to 718. This improvement works comprised of installing three rows of Deep Soil Mix (DSM) columns along the stormwater basin edge facing these properties to reduce lateral spreading in a major seismic event. With this ground improvement in place a TC2 foundation system can be used at these sites.

The DSM works comprise of three rows of 800mm diameter deep soil mix (DSM) columns on a nominal 2.4m triangular spacing. These have been installed approximately 1m into the underlying gravely soils at a depth of 6m or so. Plans showing the location and a cross-section of these DSM columns are appended to this report.

Technical Category Classification

We have assessed the liquefaction hazard at the site using the method recently prescribed by MBIE guidelines, observed site performance during the major seismic events in the Canterbury earthquake sequence. Based upon our geotechnical site investigations, the liquefaction hazard assessments and the implementation of a DSM works (in front of lots 703 to 718) we believe:

- **Lots 703 and 710 to 730 fulfil the requirements of TC2 Classification,**
- **Lots 980, 981, 984 and 985 are utility and drainage reserve areas; therefore no Technical Category Classification is applicable for these lots.**

A TC2 Classification effectively means that the MBIE believe that '*Minor to moderate land damage from liquefaction is possible in future significant earthquakes*'. House foundations and site specific geotechnical investigations are required in accordance with the MBIE (2012) guideline documents '*Repairing and rebuilding houses affected by the Canterbury earthquakes*' released in December 2012.

Foundation Recommendations

The following foundation recommendations are made for residential houses to be built at the site:

Lots 703 and 710 to 730

With Lots 703 and 710 to 730 enhanced TC2 foundation are required as outlined in Section 5 of the MBIE (2012) Guidelines. In accordance with the Guidelines standard shallow lot specific shallow geotechnical investigations will be required during the detailed house design to assess the lot specific ground conditions and bearing capacity values.

References

Aurecon, 2010. *Geotechnical Site Investigation and Liquefaction Assessment, Halswell West Rezoning, Fulton Hogan Land Development Limited, Revision 1* - dated 29 November 2011. Aurecon New Zealand Limited, Christchurch, New Zealand.

Aurecon, 2013. *Halswell West Residential Development Longhurst Stage 10 Geotechnical Assessment, Rev1* dated 26 August 2013. Aurecon New Zealand Limited, Christchurch, New Zealand.

MBIE, 2012. *Repairing and rebuilding houses affected by the Canterbury earthquakes*. Ministry of Business, Innovation and Employment, Wellington, New Zealand.

Limitations

We have prepared this report in accordance with the brief as provided. The contents of the report are for the sole use of the Client and no responsibility or liability will be accepted to any third party. Data or opinions contained within the report may not be used in other contexts or for any other purposes without our prior review and agreement.

The recommendations in this report are based on data collected at specific locations and by using suitable investigation techniques. Only a finite amount of information has been collected to meet the specific financial and technical 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.

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.

Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay.

This report is not to be reproduced either wholly or in part without our prior written permission.

This conclusions in this report draws on investigations, analysis and conclusions from various investigations stages and numerous reports. For specific details please refer to the above mentioned references or contact the writers.

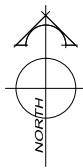
If you have any queries regarding the content of this letter, please do not hesitate to contact the undersigned.

Yours sincerely



Dr Jan Kupec
elect. sign
PhD MSc candIng MIPENZ CPEng IntPE MRSNZ | NZGS IGS ISSMGE NZSEE
Chartered Professional Geotechnical Engineer – Technical Director

Inc: Longhurst Stage 10 Site Layout Plan
DSM Layer Plan and Detail





Overall
SCALE: 1:1500@A1
1:3000@A3

- NOTES:
- 1) Areas and dimensions subject to final survey and deposit of plans.
 - 2) Service easements to be created as required.
 - 3) This plan has been prepared for subdivision concept purposes only. No liability is accepted if the plan is used for any other purpose.

BUILDING SETBACKS

No buildings are permitted within the areas marked D, E & F.

LEGEND

-  Density A
Development Lot
-  Density B
Total Lots: 21
Min Lot Size: 287m²
Max Lot Size: 390m²
Average Lot Size: 358m²

SCHEDULE OF EASEMENTS

Nature	Servient Tenement		Dominant Tenement
	Lot No.	Shown	
Right to drain Sewage in gross	980	A	Lots 703 & 710 - 730
	929 D.P.453318	B	
	985	C	
	913	D	Lots 714 & 715 Lot 715
	914	E	

SCHEDULE OF AREAS

Description	Area
Residential Lots (Lots 703, 710 - 730)	9540m ²
Local Purpose (Drainage) Reserve to Vest in Christchurch City Council (Lots 980, 984 & 985)	4.5743ha
Local Purpose (Utility) Reserve to Vest in Christchurch City Council (Lot 981)	300m ²

Total Area: 5.5583ha
Comprised in:



DAVIE LOVELL•SMITH
PLANNING SURVEYING ENGINEERING

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JOB TITLE:
**Fulton Hogan Ltd
Longhurst - Stage 10
Halswell Junction Road**

SHEET TITLE:
**Proposed Subdivision of
Lot 983 RMA 92021819**

DRAWING STATUS:
Subdivision Consent

SCALE: 1:500@A1
1:1000@A3
DATE: October 2013

CAD FILE: J:\16011\Subcon\LONGHURST\16011 Subcon Stg10_R1.dwg
DRAWING No: **S.16011**
SHEET No: **1 of 1**
REVISION: **R1**

