Slope Stability Report

at

16 Terry Road, Eastwood

for

Dongliang Yang

LAY CONSULTING
GEOTECHNICAL ENGINEERING

9 April 2016

Ref: 15002aRev1

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Slope Stability Assessment
16 Terry Road,
Eastwood NSW

1. Introduction

At your request we have carried out a geotechnical investigation at the above site. The purpose of the report was to provide a slope stability risk assessment for the subject site in accordance with the methodology set out in the Australian Geomechanics Society Landslide Taskforce “Practice Note Guidelines for Landslide Risk Management” March 2007. This report provides details of the investigation, stability assessment and development recommendations.

This report must be read in conjunction with Lay Consulting report "15002 - Geotechnical Investigation - Eastwood - 9.03.2015".

This report should be read in conjunction with the attached “General Notes”.

2. Slope Stability & Development Guidelines

2.1 Risk Assessment

An assessment of the risk to both property and life as a result of failure mechanisms on the site has been undertaken with reference to the Australian Geomechanics Society Landslide Taskforce “Practice Note Guidelines for Landslide Risk Management” March 2007.

2.1.1 Risk to Property

A summary of the results of Lay Consulting's site risk assessment, together with a qualitative assessment of the likelihood of occurrence of a landslide or mass ground movements and its consequence and risk to post construction structures on the site and neighbouring properties is presented in **Table 1** below.

Table 1 – Assessment of Risk to Property

Hazard		Likelihood	Consequence to Development	Risk to Development
1	Creep failure of colluvial or residual soils under existing residence	Rare	Major	Low
2	Creep failure of fill under existing residence	Rare	Major	Low
3	Rotational or Translational landslide failure of colluvial or residual soils under existing residence	Rare	Major	Low
4	Rotational or Translational landslide failure of fill under existing residence	Rare	Major	Low
5	Creep failure of colluvial or residual soils after future development	Rare	Major	Low
6	Creep failure of fill after future development	Rare	Medium	Low
7	Rotational or Translational landslide failure of colluvial or residual soils after future development	Rare	Major	Low
8	Rotational or Translational landslide failure of fill after future development	Rare	Medium	Low
9	Failure of natural or fill materials at rear of yard after construction of proposed retaining wall	Rare	Major	Low
10	Failure of proposed stormwater detention tank during and after construction	Unlikely	Medium	Low

Hazard 1 through to Hazard 4 has been assessed as having a ‘Rare’ likelihood. This was due to the existing residence displaying no movement. Failures for hazards 1 through 4 were assessed as having a 'Major'' consequence as the area is directly below existing development. A risk rating of ‘Low' has been applied to these hazards.

Hazard 5 has been assessed as having a 'Rare' likelihood. This was due to the site displaying no signs of mass movement of natural materials. Creep failure was assessed as having a ‘Major’ consequence as the area will be directly below future development. A risk rating of ‘Low' has been applied to this hazard.

Hazard 6 has been assessed as having a 'Rare' likelihood. This was due to the nature of the existing fill and the insignificant development noted on this area. Creep failure was assessed as having a ‘Medium’ consequence as the area will be directly below future development but

development is only minor in the noted fill area or fill will be removed. A risk rating of ‘Low' has been applied to this hazard.

Hazard 7 has been assessed as having a ‘Rare’ likelihood. This was due to the site displaying no signs of mass movement of natural materials. Rotational or Translational failure was assessed as having a ‘Major’ consequence as the area will be directly below future development. A risk rating of ‘Low' has been applied to this hazard.

Hazard 8 has been assessed as having a 'Rare' likelihood. This was due to the nature of the existing fill and the insignificant development noted on this area. Creep failure was assessed as having a ‘Medium’ consequence as the area will be directly below future development but development is only minor in the noted fill area or fill will be removed. A risk rating of ‘Low' has been applied to this hazard.

Hazard 9 has been assessed as having a 'Rare' likelihood. A likelihood of rare only applies if the retaining wall is sufficiently designed by a suitably qualified Structural Engineer. Failure was assessed as having a ‘Major’ consequence as failure of the retaining wall will greatly affect surrounding development. A risk rating of ‘Low' has been applied to this hazard.

Hazard 10 has been assessed as having an 'Unlikely' likelihood. A likelihood of unlikely was applied based on the following restrictions. If total depth of excavation exceeds 1.0m then the excavation walls must be battered at no steeper than 1H:1V during excavation. If total depth of excavation is less than 1.0m than a vertical wall will be sufficient during excavation. The retention tank must be designed by a suitably qualified structural engineer to sufficiently retain the earth pressures and added stress from the carpark above for the length of the design life. Failure was assessed as having a ‘Medium’ consequence as failure of the retention tank walls may result in a vehicle above being damaged. A risk rating of ‘Low' has been applied to this hazard.

Reference to the Australian Geomechanics Society guidelines indicates that sites which have been deemed to have a Low Risk level or less are usually acceptable to regulators.

2.1.2 Risk to Life

The Australian Geomechanics Society Practice Note Guidelines also provides a framework for landslide risk management, guidance on risk analysis methods and information on acceptable or tolerable risks for loss of life.

Risk analysis can be broken up into four components, namely:

- Hazard identification
- Frequency analysis
- Consequence analysis, and
- Risk estimation.

For the loss of life, the individual risk can be calculated using:

$$R_{LOL} = P_H \times P_{S:H} \times P_{T:S} \times V_{D:T}$$

Where,

R_{LOL} is the risk, or annual probability of death of an individual
P_H is the annual probability of the hazardous event
$P_{S:H}$ is the probability of spatial impact by the hazard given the event
$P_{T:S}$ is the temporal probability given the spatial impact, and
$V_{D:T}$ is the vulnerability of the individual

A summary of the results of the assessment undertaken in relation to risk to life of the hazards identified at this site is presented in **Table 2** below.

Table 2 – Assessment of Risk to Life

Hazard		$P_{(H)}$	$P_{(S:H)}$	$P_{(T:S)}$	$V_{(D:T)}$	Risk $R_{(LOL)}$
1	Creep failure of colluvial or residual soils under existing residence	1×10^{-5}	1.0	1.0	0.5	5×10^{-6}
2	Creep failure of fill under existing residence	1×10^{-5}	1.0	1.0	0.5	5×10^{-6}
3	Rotational or Translational landslide failure of colluvial or residual soils under existing residence	1×10^{-5}	1.0	1.0	0.5	5×10^{-6}
4	Rotational or Translational landslide failure of fill under existing residence	1×10^{-5}	1.0	1.0	0.5	5×10^{-6}
5	Creep failure of colluvial or residual soils after future development	1×10^{-5}	1.0	1.0	0.5	5×10^{-6}
6	Creep failure of fill under existing after future development	1×10^{-5}	0.5	1.0	0.5	2.5×10^{-6}
7	Rotational or Translational landslide failure of colluvial or residual soils after future development	1×10^{-5}	1.0	1.0	0.5	5×10^{-6}
8	Rotational or Translational landslide failure of fill after future development	1×10^{-5}	0.5	1.0	0.5	2.5×10^{-6}
9	Failure of natural or fill materials at rear of yard after construction of proposed retaining wall	1×10^{-5}	1.0	1.0	0.5	5×10^{-6}
10	Failure of proposed stormwater detention tank during and after construction tank	1×10^{-4}	0.1	0.3	0.05	1.5×10^{-7}

The Australian Geomechanics Society's "Practice Note Guidelines" details tolerable risk levels for loss of life. **Table 3** below shows tolerable risk levels for existing and new developments.

Table 3 – Australian Geomechanics Society Tolerable Risk for Loss of Life

Situation	Suggested Tolerable Loss of Life Risk for the person most at risk
Existing Slope[1] / Existing Development[2]	10^{-4} / annum
New Constructed Slope[3] /New Development[4] /Existing Landslide[5]	10^{-5} / annum

Notes:
1. "Existing Slopes" in this context are slopes that are not part of a recognizable landslide and have demonstrated nonfailure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.
2. "Existing Development" includes existing structures, and slopes that have been modified by cut and fill, that are not located on or part of a recognizable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.
3. "New Constructed Slope" includes any change to existing slopes by cut or fill or changes to existing slopes by new stabilisation works (including replacement of existing retaining walls or replacement of existing stabilization measures, such as rock bolts or catch fences).
4. "New Development" includes any new structure or change to an existing slope or structure. Where changes to an existing structure or slope result in any cut or fill of less than 1.0m vertical height from the toe to the crest and this change does not increase the risk, then the Existing Slope / Existing Structure criterion may be adopted. Where changes to an existing structure do not increase the building footprint or do not result in an overall change in footing loads, then the Existing Development criterion may be adopted.
5. "Existing Landslides" have been considered likely to require remedial works and hence would become a New Constructed Slope and require the lower risk. Even where remedial works are not required per se, it would be reasonable expectation of the public for a known landslide to be assessed to the lower risk category as a matter of "public safety".

There are no established individual or societal risk acceptance criteria for the loss of life due to a hazardous event such as a landslide or rock fall. Australian Geoguide LR7 discusses "acceptable" and "tolerable" levels of risk which have been proposed by several authorities including the ANCOLD Guidelines for Risks from Large Dams.

2.1.3 Discussion of Risk Assessment

Based on Risk Assessment in Table 2 the existing development is acceptable as per the suggested tolerable limits described in Table 3. Based on the Risk Assessment in Table 2 future development on the site constructed on the existing fill will not be acceptable as per the suggested tolerable limits described in Table 3, however it will be acceptable if the future development is founded in natural material.

2.1.4 Council's Development Guidelines

Council's development guidelines should be reviewed during site planning as development guidelines may impose height limitations on site cuts and fills.

2.1.5 Retaining Walls

Engineer designed retaining walls should be designed in accordance with the requirements of AS4678 "Earth-retaining Structures" to support, where appropriate, surcharge loading due to the upslope battered surface level above the retaining walls and the depth of cut or fill material. Retaining walls should be constructed with adequate surface and subsurface drainage to the Engineer's and Council's requirements.

2.1.6 Site Drainage

The effective drainage from the site of surface and subsurface water is important to ensure the stability of the surface soil and the long term performance of any footing system and retaining walls.

The property should be developed and maintained in accordance with the guidelines set out in Section 3 of the BCA and Appendix B of AS 2870 – 2011.

In particular the following measures are recommended:

- Catch/dish drains formed at the top of all batters.
- Dish and rubble drains installed at the toe of all batters.
- Subsoil drains installed behind new retaining walls.
- Cut areas sloped to fall away from buildings and water not allowed to pond around buildings.
- The site graded to prevent water from ponding on any compacted fills.
- Surface stormwater and subsoil water collected and disposed of to Council's requirements.
- Erosion control measures to be undertaken during construction to Council's requirements.
- It is recommended that a subsoil drain be constructed immediately upslope of any proposed residence to intercept and dispose of any groundwater seepage.
- Infiltration of collected stormwater is not recommended on the site.

3. Further Investigation

It is highly recommended that a site inspection be made by a suitably qualified Geotechnical Engineer post excavation and prior to construction to confirm site conditions.

4. Report Limitations

The extent of testing associated with this assessment is limited to the visual assessment of the site and surrounding area and the borehole and Dynamic Cone Penetrometer logs and variations in ground conditions may occur. Lay Consulting should be contacted immediately should subsurface conditions be found to differ from those described in this report.

Matthew Lay
Geotechnical Engineer
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ATTACHMENTS

- General Notes

Matthew Lay Consulting Engineers Pty Ltd.

General Notes

Introduction
These notes are supplied with all geotechnical reports from **Matthew Lay Consulting Engineers Pty Ltd** and therefore may contain information not necessarily relevant to this report.

The purpose of the report is set out in the introduction section of this report. It should not be used by any other party, or for any other purpose, as it may not contain adequate or appropriate information in these events.

Engineering Reports
Matthew Lay Consulting Engineers Pty Ltd engineering reports are prepared by qualified personnel and are based on information obtained, and on modern engineering standards of interpretation and analysis of that information. Where the report has been prepared for a specific design proposal the information and interpretation may not be relevant if the design proposal is changed. If the design proposal or construction methods do change, **Matthew Lay Consulting Engineers Pty Ltd** request that it be notified and will be pleased to review the report and the sufficiency of the investigation work.

Geotechnical reports are based on information gained from limited subsurface excavation and sampling, supplemented by knowledge of local geology and experience. For this reason, the report must be regarded as interpretative, rather than a factual document, limited, to some extent, by the scope of information on which it relies.

Matthew Lay Consulting Engineers Pty Ltd cannot accept responsibility for problems which may develop if it is not consulted after factors considered in the report's development have changed.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, **Matthew Lay Consulting Engineers Pty Ltd** cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will depend partly on test location spacing and sampling frequency.
- The actions of contractors responding to commercial pressures.

If these occur, **Matthew Lay Consulting Engineers Pty Ltd** will be pleased to assist with investigation or advice to resolve the matter.

Misinterpretation of Reports
Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, **Matthew Lay Consulting Engineers Pty** Ltd should be retained to review the adequacy of plans and specifications relative to geotechnical issues.

Engineering Logs
Matthew Lay Consulting Engineers Pty Ltd uses subcontractors for fieldwork. Field logs are developed by accredited geotechnicians. Final engineering logs are developed by the Geotechnical Engineer based upon interpretation of field logs and laboratory evaluation of field samples. Only final engineering logs are included in geotechnical engineering reports. To minimize the likelihood of engineering log misinterpretation, give contractors ready access to the complete geotechnical engineering report.

Site Inspection
Matthew Lay Consulting Engineers Pty Ltd will always be pleased to provide inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit, to full time engineering presence on site.

Change in Conditions
Subsurface conditions may be modified by constantly changing natural forces. Because a geotechnical engineering report is based on conditions, which existed at the time of subsurface exploration, construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and thus, the continuing adequacy of a geotechnical report. **Matthew Lay Consulting Engineers Pty Ltd** should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, **Matthew Lay Consulting Engineers Pty Ltd** requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed during construction, than at some later stage, well after the event.

Ground Water
Unless otherwise indicated the water levels given on the engineering logs are levels of free water or seepage in the test hole recorded at the given time of measuring.

This may not accurately represent actual ground water levels, due to one or more of the following:

- In low permeability soils, ground water although present may enter the hole slowly, or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent prior weather changes. They may not be the same at the time of construction as indicated at the time of investigation.

Accurate confirmation of levels can only be made by appropriate instrumentation techniques and monitoring programs.

Foundation Depth
Where referred to in the report, the recommended depth of any foundation, (piles, caissons, footings etc) is an engineering estimate of the depth to which they should be constructed. The estimate is influenced and perhaps limited by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications based upon this report should provide for variations in the final depth depending upon the ground conditions at each point of support.

Engineering Logs
Engineering logs presented in the report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify economically. In any case, the boreholes or test pits represent only a very small sample of the subsurface profile.

Interpretation of information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling and the possibility of other than straight line variations between the test locations.

Investigation Methods
Matthew Lay Consulting Engineers Pty Ltd both conducts engineering fieldwork and outsources fieldwork to accredited subcontractors. All fieldwork is conducted as per AS 1726. The following is a summary of drilling methods currently used by **Matthew Lay Consulting Engineers Pty Ltd** and its subcontractors, and some comments on their use and application.

Test Pits: These are excavated using a backhoe or tracked excavator, allowing close examination of insitu soil if it is safe to descend into the pit.

Hand Auger: The soil sample is obtained by screwing a 75mm Auger into the ground by hand.

Continuous Spiral Flight Augers: The soil sample is obtained by using a 90 – 115mm diameter continuous spiral flight auger which is withdrawn at intervals to allow sampling or insitu testing.
This is a relatively economical means of drilling in clays, and in sands above the water table. Samples, returned to the surface, are very disturbed and may be contaminated. Information from the drilling is of relatively lower reliability. SPT's or undisturbed sampling may be combined with this method of drilling for reasonably satisfactory sampling.

Hand Penetrometers: Hand Penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and recording the number of blows for successive 100mm increments of penetration. Hand penetrometers tests are carried out as per AS 1289.5.3.2 and AS 1289.5.3.3

Sampling: Sampling is carried out during drilling or excavation to allow engineering examination, and laboratory testing of the soil or rock. Disturbed samples taken during drilling or excavation provide information on colour, type, inclusions and some information on strength and structure.

Undisturbed samples are taken by pushing a think walled sample tube into the soils and withdrawing this with a sample of soil in a relatively undisturbed state contained inside. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Laboratory Testing: Laboratory testing is carried out by NATA accredited laboratories.

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