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Project 40596.08/1
30 January 2012
RJH

Hansen Yuncken Pty Ltd
PO Box 7514
MELBORNE VIC 8004

Attention: Mr Andrew Campbell

Email: ACampbell@hansenyuncken.com.au

Dear Sirs

Proposed Vehicle Access Ramp - West Keira Project
71 Market Street, Wollongong

1. Introduction

This report presents the results of a preliminary geotechnical assessment undertaken for a proposed ramp at 71 Market Street, Wollongong that will provide vehicle access into the West Keira shopping centre development. The assessment was requested by Hansen Yuncken Pty Ltd, head construction contractors for the project.

The construction of a new vehicle access ramp linking Market Street and the West Keira Project car park is proposed. The ramp will extend down from Market Street, through the subject site and the western end of Richardson Lane into the lower basement level of the proposed car park. The geotechnical assessment is required to provide preliminary information on the subsurface conditions and to accompany the amended development application.

The assessment included a site inspection followed by review of geotechnical information available from nearby sites including the main West Keira Project site and 73 Market Street, Wollongong (refer Section 2 of this report), together with review of preliminary plans provided. Details of the work are given in this report together with preliminary comments relating to design and construction practice.

2. Background

Douglas Partners Pty Ltd has previously undertaken detailed geotechnical investigations for developments on adjacent sites including the main West Keira Project development area (Project 40596, dated May 2006) and 73 Market Street Wollongong (Project SSI/1 – 7227, dated 17 July 1981).

The main West Keira Project development area is located to the south of the subject site. Two boreholes (Bores 101 and 102) positioned near the northern boundary of West Keira site are in close

proximity to the subject site. In summary, the boreholes were drilled to depths of approximately 13 m with the typical profile comprising filling and clayey overburden soils then sandstone bedrock from depths of less than 1 m. The sandstone was initially weathered and of extremely low to very low strength to depths of up to 1.5 m grading into very high strength sandstone below a depth of about 2.5 m. A standpipe installed in Bore 102 indicated a standing water table at 3.2 m.

The 73 Market Street site is located directly to west of the subject site. In summary, six boreholes were drilled in 1981 to depths in the range of up to 4 m. The typical subsurface profile comprised topsoil and clayey overburden soils to depths of up to 1 m then sandstone bedrock. The sandstone comprised weathered sandstone of extremely low to low strength to depths of up to 2.2 m overlying very high strength sandstone. No free ground water was encountered during auger drilling in the overburden soils.

3. Site Description and Regional Geology

The site, which includes Lot 1 in Deposit Plan 197138 and part of Richardson Lane is a rectangular shaped area of some 370 m^2 with maximum plan dimensions of approximately 43 m by 10 m (refer Drawing 1, attached). Site improvements at 71 Market Street at the time of the geotechnical assessment comprise a single storey weatherboard and brick cottage on the northern part of the site and a gravel car park on the southern part of the site which is accessed from Richardson Lane. Other site improvements include low retaining walls (less than 1 m high), concrete footpaths and stairs. The site is bounded to the north by Market Street, to the south by Richardson Lane and to the east and west by multi-storey commercial buildings.

Site levels, relative to Australian Height Datum (AHD), fall in the northerly direction (i.e. towards Market Street) from approximately RL 25 at the rear boundary to approximately RL 20 at the front boundary at an overall grade of approximately 1 in 20 increasing to 1 in 12 towards the front of the site.

Reference to the Wollongong Port Hacking 1:100 000 Geological Series Sheet (Ref 1) indicates that the site is underlain by Budgong Sandstone belonging to the Shoalhaven Group of Permian age. This formation typically comprises red, brown and grey, lithic sandstone which weathers to form clays of high plasticity. Previous DP investigations on neighbouring sites confirmed the geological mapping, with residual soils overlying tuffaceous sandstone encountered.

4. Proposed Development

It is understood that as part of the West Keira Project, a revised concept for the development includes the construction of a new ramp to provide vehicle access to the basement car parking associated with the development. Preliminary plans provided indicate the ramp will extend from Market Street to the proposed basement level car park. Excavations up to about 11 m deep will be required to achieve design levels. It is further understood the proposed ramp profiles from street level (RL 19.5) to the basement floor level (RL 13.8) at grades of 1 in 10.

5. Comments

5.1 Excavation Conditions

Based on the design details provided, the proposed ramp excavations are likely to be in the range of 1.5 m at the northern boundary of 71 Market Street increasing to 9.5 m beneath Richardson Lane. The ramp will continue into the West Keira site where the basement excavation will be around 11.3 m deep. The previous investigations indicate that the excavation will probably encounter filling, topsoil and overburden clay to depths of about 1 m then sandstone bedrock, increasing in strength and reducing in weathering with depth. Most of the excavation will probably be in fresh high to very high strength sandstone.

The filling, overburden soils and fractured rock to depths of up to approximately 2.5 m should be readily excavated using conventional earthmoving plant. Recommendations previously provided by DP for the main West Keira Project site (Project 40596, dated 31 May 2006) in Section 6.2.1: *Excavation Equipment Requirements* are considered appropriate for the excavation of slightly fractured to unbroken, very high strength sandstone at depths below about 2.5 m.

5.2 Groundwater Inflow

There is potential for groundwater inflow into the excavation through open fractures (principally jointing) in the bedrock. Based on standing water levels in the nearby standpipe, inflow will probably occur from a depth of about 3 m. It should be noted that groundwater levels will fluctuate with changes in climatic conditions and soil permeability. Comments previously provided for the main West Keira Project site (Project 40596, dated 31 May 2006) in Sections 6.2.2: *Groundwater* are considered relevant for the access ramp excavation.

5.3 Ground Vibrations

Recommendations provide by DP (Project 40596, dated 31 May 2006) in Sections 6.2.3: *Ground Vibrations Induced by Excavation Plant* are considered appropriate for the access ramp excavation due to the close proximity of adjacent buildings and their occupants.

From current knowledge of site conditions and proposed works, and subject to the results of building condition surveys and on-site vibration trials (including vibration attenuation rates and dominant vibration frequencies of excavation plant), the standards, guidelines and limits detailed in the attached notes are considered appropriate for management of ground vibrations generated by proposed works.

5.4 Excavation Support

Preliminary concept design details were available at the time of the geotechnical assessment. The proposed excavation varies in depth along the profile of the access ramp (1.5 – 9.5 m) and in distance

from existing adjacent structures on either side of the excavation (estimated to be 0.0 m and 1.6 m from the boundary on the eastern and western side respectively).

Due care will obviously be required when working adjacent to existing structures. It is recommended dilapidation surveys of adjacent properties be undertaken to provide baseline conditions of structures for assessment of possible claims of damage.

Recommendations previously provided by DP for the main West Keira Project site (Project 40596, dated 31 May 2006) in Sections 6.3: *Excavation Support* and in Section 6.4: *Retaining Structures* are also considered appropriate for the access ramp excavation.

5.5 Foundations

Based on the results of the geotechnical assessment, it is anticipated weathered sandstone grading into fresh, unbroken sandstone will be exposed in the access ramp excavation.

Recommendations previously provided by DP for the main West Keira Project site (Project 40596, dated 31 May 2006) in Sections 6.5: *Foundations* and in Section 6.6 *Ground Slabs* are also considered appropriate for the access ramp.

5.6 Additional Investigation and Testing

Notwithstanding this information provided in the Sections above, it is recommended that one additional cored borehole be drilled within the deeper area of proposed access ramp footprint once the site is accessible to confirm the subsurface conditions. The borehole should be extended to a depth below the likely maximum depth of excavation (say 12 m). A detailed proposal and scope of work for detailed geotechnical investigation of the site has been provided by DP to Hansen Yuncken (WOL110471 dated 17 November 2011).

The information provided in this report would be reviewed and updated based on the results of the investigation prior to works commencing on site.

6. References

1. Stroud WL, Sherwin L, Ray HN and Baker CJ (1985) *Wollongong – Port Hacking 1:100 000 Geological Series Sheet*, Sheet 9029 – 9129, Geological Survey of New South Wales, Department of Mineral Resources, Sydney.

7. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report Hansen Yuncken Pty Ltd for this project at 71 Market Street in accordance with DP's proposal dated 17 November 2011 and acceptance received from Mr Andrew Campbell dated 15 December 2011. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Hansen Yuncken Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions at the specific sampling and testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Please contact either of the undersigned for clarification of the above as necessary.

Yours faithfully
Douglas Partners Pty Ltd

R J Haselden
Engineering Geologist

Reviewed by

G W McIntosh
Principal

Attachments:
About this Report
Site Drawing
Photoplates (2 No.)
Previous Borehole Logs (8 No.)
Vibration Guidelines

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on 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 on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the 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.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole 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 weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. 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 this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

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, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Hansen Yuncken Pty Ltd	
OFFICE: Wollongong	DRAWN BY: RJH
SCALE: 1:250 @ A3	DATE: 23 January 2012

TITLE: **Borehole Locations - Previous Investigations**
Proposed Vehicle Access Ramp - West Keira Project
71 Market Street, Wollongong

N
MGA

PROJECT No:	40596.08/1
DRAWING No:	1
REVISION:	A

Photo 1: View from Market Street looking south

Photo 2: View of Market Street looking south west

Photo 3: View of retaining walls on eastern boundary

Photo 4: View of site looking north

TEST BORE REPORT

BORE No. 1

CLIENT PAYNTER & DIXON PTY. LTD.

DATE 8th July, 1981

SITE 73 MARKET STREET

CONTRACT No. SSI/1-7227

LOCATION WOLLONGONG

SURFACE LEVEL

Description of Strata	Depth metres	Sampling and in-situ Testing			
		Type	Depth	'N' value	Core recovery
	S.L.				%
TOPSOIL	0.30				
GRAVELLY CLAY - stiff brown clay with abundant rock fragments to 5 mm		A	0.50		
	0.70				
DECOMPOSED ROCK - extremely weak and very weak brown sandy decomposed rock		S	1.00 - 1.30 Refusal after 150 mm	21	
	1.50				
SANDSTONE - very weak and weak brown and grey sandstone, becoming weak to medium strong		S	2.00 - 2.01 Refusal in first 150 mm	10	
	2.01				
JACRO AUGER REFUSAL AT 2.01 METRES					

RIG Jacro DRILLER Simpson CASING

TYPE OF BORING Flight auger

WATER LEVEL OBSERVATIONS

REMARKS

TYPE

A — auger sample
S — standard penetration test sample
U — mm diameter undisturbed sample
C — continuous diamond core
V — field vane shear test

"N" VALUE

blows of a 63.5 kg hammer falling 760 mm to drive a standard 50 mm O.D. split penetrometer for the last 300 mm of test (where thin walled undisturbed sample tubes are driven in the same manner, the values are shown bracketed).

GROUND TEST PTY. LIMITED

TEST BORE REPORT

BORE No. 2

CLIENT PAYNTER & DIXON PTY. LTD.

DATE 8th July, 1981

SITE 73 MARKET STREET

CONTRACT No. SSI/1-7227

LOCATION WOLLONGONG

SURFACE LEVEL

Description of Strata	Depth metres	Sampling and in-situ Testing			
		Type	Depth	'N' value	Core recovery
	S.L.				%
TOPSOIL	0.30				
GRAVELLY CLAY - stiff brown clay with abundant rock fragments to 5 mm		A	0.50		
		S	1.00 - 1.30	21 for 150 mm	
	1.10				
DECOMPOSED ROCK - extremely weak brown clayey decomposed rock	1.50				
SANDSTONE - very weak and weak brown and grey sandstone, becoming weak to medium strong					
	2.20	S	2.20 -	10 Refusal no penetration	
JACRO AUGER REFUSAL AT 2.20 METRES					

RIG Jacro DRILLER Simpson CASING

TYPE OF BORING Flight auger

WATER LEVEL OBSERVATIONS

REMARKS

TYPE

A — auger sample
S — standard penetration test sample
U — mm diameter undisturbed sample
C — continuous diamond core
V — field vane shear test

"N" VALUE

blows of a 63.5 kg hammer falling 760 mm to drive a standard 50 mm O.D. split penetrometer for the last 300 mm of test (where thin walled undisturbed sample tubes are driven in the same manner, the values are shown bracketed).

GROUND TEST PTY. LIMITED

TEST BORE REPORT

BORE No. 3

CLIENT PAYNTER & DIXON PTY. LTD.

SITE 73 MARKET STREET

LOCATION WOLLONGONG

DATE 29th June, 1981

CONTRACT No. SSI/1-7227

SURFACE LEVEL

Description of Strata	Depth metres	Sampling and in-situ Testing			
		Type	Depth	'N' value	Core recovery
	S.L.				%
TOPSOIL -	0.20				
CLAY - firm to stiff yellow brown clay, becoming slightly sandy		A	0.50		
	1.00	(U)	1.00 - 1.40	(24)	
DECOMPOSED ROCK - extremely weak and very weak brown clayey decomposed rock	1.30				
SANDSTONE - very weak brown and grey clayey sandstone	1.50	A	1.50		
		(S)	1.50 - 1.55	20	
			Refusal in first 150 mm		
SANDSTONE - very strong fractured to slightly fractured grey fossiliferous fine grained tuffaceous lithic sandstone. Joints dip at 0^{o} to 5^{o} along bedding planes		C	1.60 - 2.90		100
		C	2.90 - 4.00		100
	4.00				
BORE DISCONTINUED AT 4.00 METRES					

RIG B40 DRILLER Bannister CASING

TYPE OF BORING Flight auger to 1.6 m then NMLC core drilling.

WATER LEVEL OBSERVATIONS

REMARKS

TYPE

A — auger sample
S — standard penetration test sample
U — mm diameter undisturbed sample
C — continuous diamond core
V — field vane shear test

"N" VALUE

blows of a 63.5 kg hammer falling 760 mm to drive a standard 50 mm O.D. split penetrometer for the last 300 mm of test (where thin walled undisturbed sample tubes are driven in the same manner, the values are shown bracketed).

GROUND TEST PTY. LIMITED

TEST BORE REPORT

BORE No. 4

CLIENT PAYNTER & DIXON PTY. LTD.

DATE 29th June, 1981

SITE 73 MARKET STREET

CONTRACT No. SSI/1-7227

LOCATION WOLLONGONG

SURFACE LEVEL

Description of Strata	Depth metres	Sampling and in-situ Testing			
		Type	Depth	'N' value	Core recovery
	S.L.				%
TOPSOIL	0.30				
SANDY CLAY - firm grey brown silty fine grained sandy clay		A	0.50		
	0.80				
DECOMPOSED ROCK - extremely weak and very weak brown clayey fine grained sandstone		S	1.00 - 1.10 Refusal in first 100 mm	30	
	1.20	C	1.20 - 4.00		86
SANDSTONE - very strong slightly fractured to unbroken grey fossiliferous fine grained tuffaceous lithic sandstone. * 1.56 m - 2 mm wide calcite veined joint dips at 70°.					
	4.00				
BORE DISCONTINUED AT 4.00 METRES					

RIG B40 DRILLER Bannister CASING

TYPE OF BORING Flight auger to 1.2m, then NMLC core drilling.

WATER LEVEL OBSERVATIONS

REMARKS

TYPE

A — auger sample
S — standard penetration test sample
U — mm diameter undisturbed sample
C — continuous diamond core
V — field vane shear test

"N" VALUE

blows of a 63.5 kg hammer falling 760 mm to drive a standard 50 mm O.D. split penetrometer for the last 300 mm of test (where thin walled undisturbed sample tubes are driven in the same manner, the values are shown bracketed).

GROUND TEST PTY. LIMITED

TEST BORE REPORT

BORE No. 5

CLIENT PAYNTER & DIXON PTY. LTD.

DATE 8th July, 1981

SITE 73 MARKET STREET

CONTRACT No. SSI/1-7227

LOCATION WOLLONGONG

SURFACE LEVEL

Description of Strata	Depth metres	Sampling and in-situ Testing			
		Type	Depth	'N' value	Core recovery
	S.L.				%
TOPSOIL	0.30				
SILTY CLAY - firm brown silty clay	0.80	A	0.50		
		S	1.00 - 1.17 Refusal after 20 mm		
DECOMPOSED ROCK - extremely weak and very weak brown decomposed rock	1.17	C	1.17 - 2.17		90
SANDSTONE - very weak highly fractured brown clayey sandstone with bands to 75 mm of weak to medium strong sandstone at about 100 mm intervals	2.17	C	2.17 - 3.34		100
SANDSTONE - very strong unbroken grey fossiliferous fine grained tuffaceous lithic sandstone	3.34				
BORE DISCONTINUED AT 3.34 METRES					

RIG Jacro DRILLER Simpson CASING

TYPE OF BORING Flight auger to 1.17 m then NMLC core drilling

WATER LEVEL OBSERVATIONS

REMARKS

TYPE

A — auger sample
S — standard penetration test sample
U — mm diameter undisturbed sample
C — continuous diamond core
V — field vane shear test

"N" VALUE

blows of a 63.5 kg hammer falling 760 mm to drive a standard 50 mm O.D. split penetrometer for the last 300 mm of test (where thin walled undisturbed sample tubes are driven in the same manner, the values are shown bracketed).

GROUND TEST PTY. LIMITED

TEST BORE REPORT

BORE No. 6

CLIENT PAYNTER & DIXON PTY. LTD

SITE 73 MARKET STREET

LOCATION WOLLONGONG

DATE 9th July, 1981

CONTRACT No. SSI/1-7227

SURFACE LEVEL

Description of Strata	Depth metres	Sampling and in-situ Testing			
		Type	Depth	'N' value	Core recovery
	S.L.				%
TOPSOIL	0.30				
SILTY CLAY - firm to stiff brown silty clay		A	0.50		
	0.80				
DECOMPOSED ROCK - extremely weak and very weak brown clayey decomposed rock		S	1.00 - 1.30 Refusal after 150 mm	24	
	1.35	C	1.35 - 2.85		100
SANDSTONE - very strong slightly fractured grey fossiliferous fine grained tuffaceous lithic sandstone. Joints are subhorizontal and fresh		C	2.85 - 3.45		100
	3.45				
BORE DISCONTINUED AT 3.45 METRES					

RIG Jacro DRILLER Simpson CASING

TYPE OF BORING Flight auger to 1.35 m then NMLC core drilling

WATER LEVEL OBSERVATIONS

REMARKS

TYPE

A — auger sample
S — standard penetration test sample
U — mm diameter undisturbed sample
C — continuous diamond core
V — field vane shear test

"N" VALUE

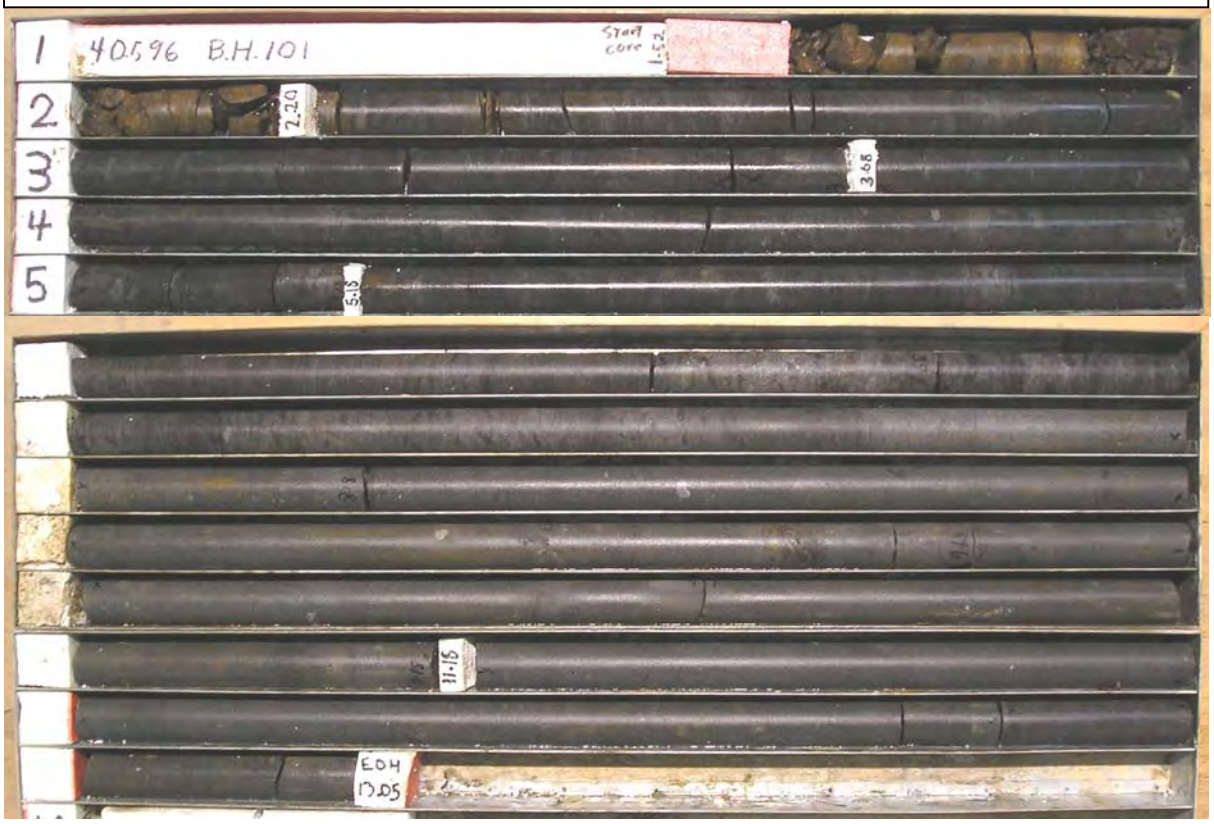
blows of a 63.5 kg hammer falling 760 mm to drive a standard 50 mm O.D. split penetrometer for the last 300 mm of test (where thin walled undisturbed sample tubes are driven in the same manner, the values are shown bracketed).

GROUND TEST PTY. LIMITED

DOUGLAS PARTNERS PTY LTD

PROPOSED RETAIL DEVELOPMENT – CNR CROWN & KEIRA STREETS, WOLLONGONG

BORE: 101 DEPTH: 1.52m – 13.05m PROJECT: 40596 APR 2006



BOREHOLE LOG

CLIENT: Bovis Lend Lease
PROJECT: Proposed Retail Development
LOCATION: Cnr Crown Lane & Keira Street, Wollongong

SURFACE LEVEL: 26.66 m AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 101
PROJECT No: 40596
DATE: 27 Apr 06
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Type	Core Rec. %	RQD %	Test Results & Comments
26	0.2	BITUMEN AND ROADBASE						Note: Unless otherwise stated, rock is fractured along rough, undulating, ironstained bedding planes dipping at 0-10°				
		FILLING - gravelly sandy clay										
25	0.8	SANDSTONE - extremely low to very low strength, extremely to highly weathered sandstone										
	1.52	SANDSTONE - medium to high then very high strength, moderately to slightly weathered, fresh stained then fresh, fractured then unbroken, grey fine to medium grained sandstone						1.52m: CORE LOSS: 110mm 1.63-2.24m: number of discontinuities spaced at 10-80mm 1.7m: J, R, I, FeS 1.77m: J, 30°, R, U, FeS 1.9 & 2.05m: J, 90°, R, U, FeS 2.13m: J, 85°, R, U, FeS 2.45m: J, 40°, R, U	C	84	0	PL(A) = 0.9MPa
24									C	100	91	PL(A) = 3.5MPa PL(A) = 4.8MPa PL(A) = 3.7MPa
23									C	100	100	PL(A) = 4.6MPa PL(A) = 5.6MPa
22									C	100	100	PL(A) = 5.8MPa
21									C	100	100	PL(A) = 4.2MPa
20									C	100	100	
19									C	100	100	PL(A) = 4.2MPa
18									C	100	100	
17									C	100	100	PL(A) = 4.9MPa
16									C	100	100	
15									C	100	100	
14												
13	13.05	Bore discontinued at 13.05m										
12												
11												

RIG: Gemco 210B **DRILLER:** Boers **LOGGED:** McKenzie **CASING:** -

TYPE OF BORING: Spiral flight auger to 1.52m; NQ coring to 13.05m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧗ Water level

CHECKED	
Initials:	
Date:	

Douglas Partners
Geotechnics · Environment · Groundwater

DOUGLAS PARTNERS PTY LTD

PROPOSED RETAIL DEVELOPMENT – CNR CROWN & KEIRA STREETS, WOLLONGONG

BORE: 102 DEPTH: 1.00m – 13.00m PROJECT: 40596 APR 2006

BOREHOLE LOG

CLIENT: Bovis Lend Lease
PROJECT: Proposed Retail Development
LOCATION: Cnr Crown Lane & Keira Street, Wollongong

SURFACE LEVEL: 24.74 m AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 102
PROJECT No: 40596
DATE: 28 Apr 06
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Type	Core Rec. %	RQD %	Test Results & Comments
24	0.15	BITUMEN						Note: Unless otherwise stated, rock is fractured along rough, undulating, ironstained bedding planes dipping at 0-10°				
	0.7	FILLING - slag roadbase										
	0.9	SANDY CLAY										
1	1.12	SANDSTONE - medium to high, high then very high strength, moderately to slightly weathered, fresh stained then fresh, fractured then unbroken, orange then grey fine to medium grained sandstone with clay band at 1.52m (40mm)						1.08m: J x 2, 40°, R, U, FeS 1.12m: CORE LOSS: 360mm	C	64	0	PL(A) = 0.8MPa
23								1.48m: J, 30°, R, U, FeS Clay 40mm	C	100	0	PL(A) = 2.1MPa
2								1.52-2.63m: discontinity spacing 20-80mm 1.58m: J, I, FeS 1.65m: B, V Cl 1.69m: J, 30°, R, U, FeS, Co Cl 2mm 1.74m: B, Co Cl 1mm 1.8m: B, Co Cl 2mm 1.93m: B, Co Cl 3mm 2.19m: J, 30°, R, U, FeS 2.4m: J x 2, 85°, R, U, FeS, spacing 40mm	C	100	91	PL(A) = 4.7MPa
22												
3												
21												
4									C	100	100	PL(A) = 3.6MPa PL(A) = 3.9MPa
20												
5												
19									C	100	100	PL(A) = 3.9MPa
6												
18												
7									C	100	100	PL(A) = 3.5MPa
17								>>				
8												
16									C	100	100	PL(A) = 3.8MPa
9												
15												
10									C	100	100	
14												
11												PL(A) = 4MPa
13												
12									C	100	100	
12												PL(A) = 4MPa
13	13.0	Bore discontinued at 13.0m										
11												
14												
10												
15												
9												

RIG: Gemco 210B **DRILLER:** Boers **LOGGED:** McKenzie **CASING:** to 1.0m

TYPE OF BORING: Spiral flight auger to 1.0m; NQ coring to 13.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Standpipe piezometer installed, Standing water level at 3.17m on 05/05/06

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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VIBRATIONS GUIDELINES

Ground vibrations can be described by measurement of the acceleration, velocity or displacement of the ground particles at one or more locations. Triaxial geophone sensors for example can measure the peak velocities of radial, transverse or vertical particle motion (designated PPVr, PPVt and PPVz respectively and PPVi for any directional component) within selected sample periods and peak velocities can also be determined in the resultant direction of particle motion, from calculations of instantaneous vector sums throughout the sample period. Vector sum velocities are designated VSPPV, or in many cases simply PPV.

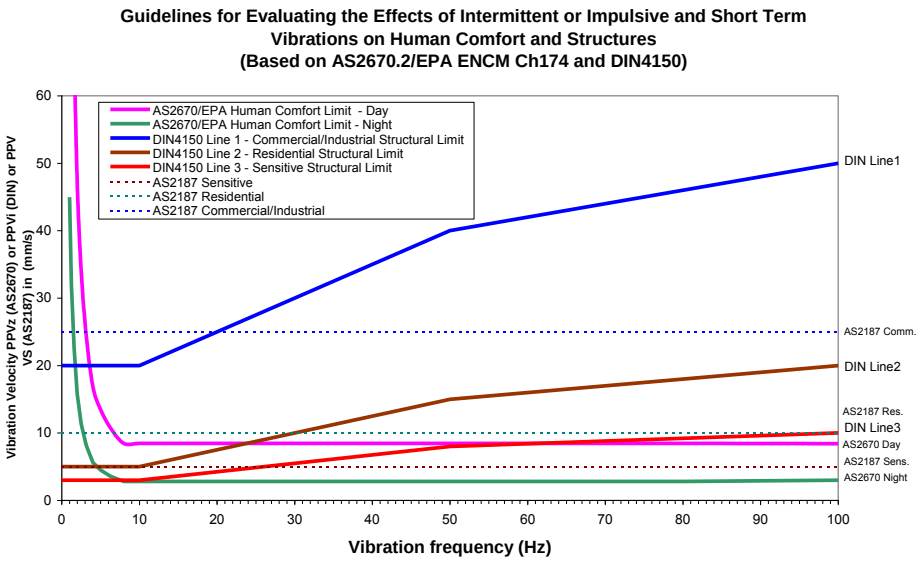
There are three aspects of vibrations which need to be assessed:

1. Effects on structures
2. Effects on architectural finishes
3. Effects on humans

Numerous standards and guidelines exist worldwide which provide a basis for these assessments. Their focus varies from structural damage to human comfort and from transient to intermittent to continuous vibrations. Most provide guideline vibration limits for protection against damage or human discomfort, however these limits are not always consistent and application of a particular standard or guideline should be based on the expected types of vibrations, the types and conditions of the potentially affected buildings and the potential for discomfort of their occupants.

Both the guideline and the vibration limits should be determined on a case by case basis and the adopted limits (damage and human comfort or the lower of the two) may vary from guideline values, according to the experience of the vibration consultant, due to the sensitivity of the building or the activities of its occupants. Some applicable guidelines are summarised in the graph below.

Depending on site conditions, proposed works, results of building condition surveys and on-site vibration trials (indicating vibration attenuation rates and dominant vibration frequencies of excavation plant), the standards, guidelines and limits discussed below are considered appropriate for management of ground vibrations generated during rock excavation.



Effects on Structures

The German Standard DIN4150-3 (1999) "Structural vibration – effects of vibrations on structures", recommends that ground vibrations at foundation level of residential buildings, in good condition bearing on sound rock foundations, be limited to 5 - 15 – 20 mm/s PPVi (at vibration frequencies of 10 - 50 – 100 Hz typical of excavation plant), in order to reduce the potential for structural damage. Higher limits (20 - 40 – 50 mm/s PPVi) and lower limits (3 - 8 - 10 mm/s PPVi) are recommended for commercial/industrial and sensitive buildings respectively. From DP experience where buildings are bearing on loose sand, maximum vibration levels should be significantly reduced to the order of 5 - 7 mm/s VSPPV to reduce the risk of vibration-induced sand densification and settlement.

Effects on Architectural Finishes

It has been found from experience that even with buildings bearing on rock, vibration levels as low as 10 mm/s VSPPV may cause minor defects such as cracks through rendering, cornices and skirtings. Management of vibrations may require a lowering of structural damage criteria to this architectural damage criterion, or negotiations with owners of affected buildings.

Effects on Humans

Ground vibration can be strongly perceptible to humans at levels above 2.5 mm/s VSPPV and can be disturbing at levels above 5 mm/s VSPPV. Complaints from residents and building occupants are sometimes received when levels are as low as 1 mm/s VSPPV.

The Australian Standard AS 2670.2 - 1990 “Evaluation of human exposure to whole-body vibrations – continuous and shock induced vibrations in buildings (1-80 Hz)” indicates an acceptable day time limit of 8 mm/s PPVz for human comfort. Management of vibrations may require a lowering of damage criteria to this human comfort criterion, or negotiations with occupants of affected buildings.

Vibration Dosage

A vibration limit based on a particle velocity allows real time control of excavation using warning systems (eg flashing lights) attached to vibration monitors. Occasional exceedances (vibration levels exceeding the allowed limit) are not damaging or disturbing and can be allowed but frequent exceedances should be avoided by changes in excavation methods. The difference between occasional and frequent is difficult to gauge on site but can be assessed using recorded vibration data, on the basis of experience or by application of a vibration dosage criterion.

A vibration dosage value (VDV) can be used to assess the affect of intermittent vibrations (eg from bursts of rock hammering) on humans over a defined period. Acceptable dosages (generally VDVz for vertical vibrations found most disturbing by humans) have been defined for occupants of residential, commercial and industrial buildings (“Assessing Vibration: a technical guideline”, Department of Environment and Conservation, 2006). Estimates of VDV (eVDV) can be calculated from recorded vibration data and can be compared with recommended maxima of 0.4, 0.8 and 1.6 m/s for residential, commercial and industrial locations respectively, to assess the need to change excavation methods to restore human comfort.

The vibration dosage guideline does not relate VDV to structural damage however it is considered that if the VDV is acceptable from a human comfort viewpoint, vibrations leading to that VDV would be unlikely to cause damage to the corresponding residential, commercial or industrial structure. Management of vibrations may require addition of these vibration dosage criteria to other human comfort or damage criteria, if the frequency of vibration exceedances becomes difficult to assess on site or by experienced-based data review.