

Revision history

2	23/01/2019	Minor grammar corrections
1	16/01/2019	Section 4.2 added for clarity
0	15/01/2019	Report issued for Heritage Manager

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Attention:

Dear

Windsor Bridge - Heritage Brick Barrel Drain Stage 1 - Test Piles Vibration Monitoring Results 15 January 2019

1 Introduction

VMS Australia Pty Ltd (VMS) was engaged by Georgiou Group to undertake vibration measurements during the excavation of Test Piles 41 and 43 on 15 January 2019.

The purpose of the measurements was to determine the range of vibration emission levels from the piling activity, based on varying rotational speed and thrust (torque) being applied during the pile excavation. Based on the measured vibration levels, nominate vibration limits to be applied on the Heritage Brick Barrel Drain and identification of vibration minimising pile excavation techniques.

2 Site Description and Work Operations

Pile excavation works were undertaken using an Enteco E300 Drilling Rig. The nominated test piles were located approximately 10m east of the Heritage Brick Barrel Drain. Piles 41 and 43 were excavated for this testing.

Vibration measurements were carried out in the ground at various offset distances from the drilling activity. Two vibration monitors were used during the trial. Monitor One was set in the ground at fixed distance of 1.5 m from the centreline of the drilling auger, which corresponds to the centreline offset distance of the piles adjoining the Heritage Brick Barrel Drain to the near-point of the drain. Monitor Two was progressively relocated to measure the attenuation of the vibration with distance from the drilling activity.

A photograph showing the location of the test piles is shown in **Figure 1**.

Figure 1 Test Pile Locations



3 Vibration Monitoring Results

Table 2 and **Table 3** present a summary of the measured maximum vibration velocity levels (in any orthogonal direction) for the two test piles.

Table 1 Summary of Maximum Vibration Levels – Test Pile 43

Auger Depth from Surface	Monitor One (1.5m offset)		Monitor Two		
	Measured Maximum Vibration Level	Frequency	Offset	Measured Maximum Vibration Level	Frequency
0m-0.5m	1.6 mm/s	28 Hz	3.0m	1.7 mm/s	25 Hz
0.5m-1.0m	1.6 mm/s	42 Hz		0.8 mm/s	36 Hz
1.0m-1.5m	1.6 mm/s	42 Hz		0.7 mm/s	25 Hz
1.5m-2.0m	0.4 mm/s	50 Hz		0.6 mm/s	31 Hz
2.0m-2.5m	0.6 mm/s	31 Hz	4.5m	1.0 mm/s	36 Hz
2.5m-3.0m	0.5 mm/s	28 Hz		1.0 mm/s	42 Hz
3.0m-3.5m	1.6 mm/s	21 Hz		1.0 mm/s	50 Hz
3.5m-4.0m	1.0 mm/s	50 Hz	6.0m	0.6 mm/s	42 Hz

Auger Depth from Surface	Monitor One (1.5m offset)		Monitor Two		
	Measured Maximum Vibration Level	Frequency	Offset	Measured Maximum Vibration Level	Frequency
4.0m-4.5m	0.9 mm/s	21 Hz		0.9 mm/s	50 Hz
4.5m-5.0m	N/A ¹	N/A ¹		N/A ¹	N/A ¹
5.0m-5.5m	N/A ¹	N/A ¹		N/A ¹	N/A ¹
5.5m-6.0m	1.2 mm/s	25 Hz		0.8 mm/s	14 Hz
6.0m-6.5m	1.5 mm/s	31 Hz		0.2 mm/s	83 Hz

Note 1: No data available due to drilling resuming prior to vibration monitoring equipment and personnel being available to recommence monitoring during scheduled break.

Table 2 Summary of Maximum Vibration Levels – Test Pile 41

Auger Depth from Surface	Monitor One (1.5m offset)		Monitor Two		
	Measured Maximum Vibration Level	Frequency	Offset	Measured Maximum Vibration Level	Frequency
0m-1.2m	1.6 mm/s	31 Hz	3.0m	1.3 mm/s	50 Hz
1.2m-2.0m	2.0 mm/s	21 Hz		0.5 mm/s	50 Hz
2.0m-3.7m	0.5 mm/s	83 Hz		1.4 mm/s	42 Hz
3.7m-4.5m	1.0 mm/s	83 Hz	4.5m	0.8 mm/s	42 Hz
4.5m-5.0m	0.9 mm/s	21 Hz		2.1 mm/s	42 Hz
5.0m-5.5m	0.9 mm/s	25 Hz		1.4 mm/s	42 Hz
5.5m-6.0m	1.2 mm/s	36 Hz		0.9 mm/s	36 Hz
6.0m-6.5m	1.0 mm/s	18 Hz		1.5 mm/s	50 Hz
6.5m-7.0m	1.1 mm/s	42 Hz		1.5 mm/s	50 Hz
7.0m-7.4m	1.0 mm/s	36 Hz	1.6 mm/s	20Hz	

4 Comments and Recommendations

4.1 Discussion of Results

The maximum recorded vibration level which can be attributed directly to the drilling works was 2.0 mm/s, measured by Monitor One at centre offset distance of 1.5m. Away from the drilling, at Monitor Two, vibration levels reached 2.1mm/s. It was observed that the ground vibration levels in the near field (Monitor One) was generally associated with the force (or rate of change of the force) of drilling and interaction with varying soil conditions, particularly when rocks were encountered. At Monitor Two, away from the drilling, the ground vibration appeared to correlate with force transmission through the tracks of the drill rig, particularly the force transmission associated with changes in auger rotational and axial velocity.

It is anticipated that the vibration levels likely to be induced on the Heritage Brick Barrel Drain from the drilling works, at centre offset distance of 1.5m from the drain, would be comparable to those measured for the test piles at distance 1.5m.

4.2 Comparison Against Vibration Damage Criteria

There are numerous Australian and International Standards and Guidelines which nominate vibration damage criteria for various structures. In terms of the most stringent, applicable and recent vibration criteria which may be adopted for the protection of the Heritage Brick Barrel Drain from potential vibration induced damage associated with the piling activities, German Standard DIN4150 presents frequency dependent safe vibration limits for “Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order)” i.e. heritage structures. An extract of the relevant frequency dependent vibration limits for heritage structures is presented in **Table 3**. It is noted, however, that DIN51450 also nominates vibration limits for buried pipe works, including a safe vibration limit of 50 mm/s for masonry pipes.

Table 3 DIN 4150 Safe Vibration Limits for Heritage Structures

Group	Type of Structure	Peak Particle Velocity (mm/s)		
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz ¹
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order)	3	3 at 10 Hz increasing to 8 at 50 Hz	8 at 50 Hz increasing to 10 at 100 Hz and above

Review of the vibration limits presented in **Table 3** shows that the vibration criteria are more stringent at lower frequencies, with a minimum (most stringent) vibration limit of 3 mm/s for frequencies below 10 Hz. A comparison of the maximum measured vibration level (2.1 mm/s) from the test piles against the DIN4150 vibration limits has found that the likely vibration levels that are likely to be induced on the Heritage Brick Barrel Drain from the nearest proposed piles would be below even the most stringent vibration limit of 3 mm/s.

4.3 Recommend Vibration Limits for Heritage Brick Barrel Drain

For all attended monitoring, particularly for the piles being drilled adjacent to the Heritage Brick Barrel Drain (Stage 2 Test Piles), the DIN4150 frequency dependent vibration criteria for heritage structures (Table 3 above) will be adopted for the drain.

For all unattended monitoring (i.e. for piles not located adjacent to the drain, Stage 3 piles), two control limits are recommended:

- “Operator Warning Level” of 6 mm/s
- “Operator Halt Level” of 8 mm/s

4.4 Recommended Drilling Controls

The following operational controls are recommended in order to minimise the ground vibration when working adjacent to the Heritage Brick Barrel Drain:

- Maintain constant auger rotational velocity during drilling
- Ensure that the end of the drill hole is not rammed by the auger when reinserting into the hole
- Run the auger at the lowest constant speed when drilling through the top layer of engineered rocky fill

- Minimise aggressive manoeuvring of the drill rig, repeated raising and lowering of the auger and changes in rotation velocity (particularly rapid direction reversal) of the auger

4.5 Completion of Stage 1 Test Piles

It is noted that the two Test Piles were part of a set of five piles (as shown in **Figure 1**), Stage 1 Test Piles. The three remaining Stage 1 Test Piles can be drilled at any time, however, vibration monitoring must be undertaken on the Heritage Brick Barrel Drain during these works.

I trust the above meets your current requirements. Please feel free to contact me if you require any additional information.

Regards,



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