ASSESSMENT OF LOW VIBRATION TECHNIQUES IN THE CONSTRUCTION OF A DIAPHRAGM WALL USING A HYDROMILL

D Prasad Marshall Day Acoustics, London, United Kingdom

1 INTRODUCTION

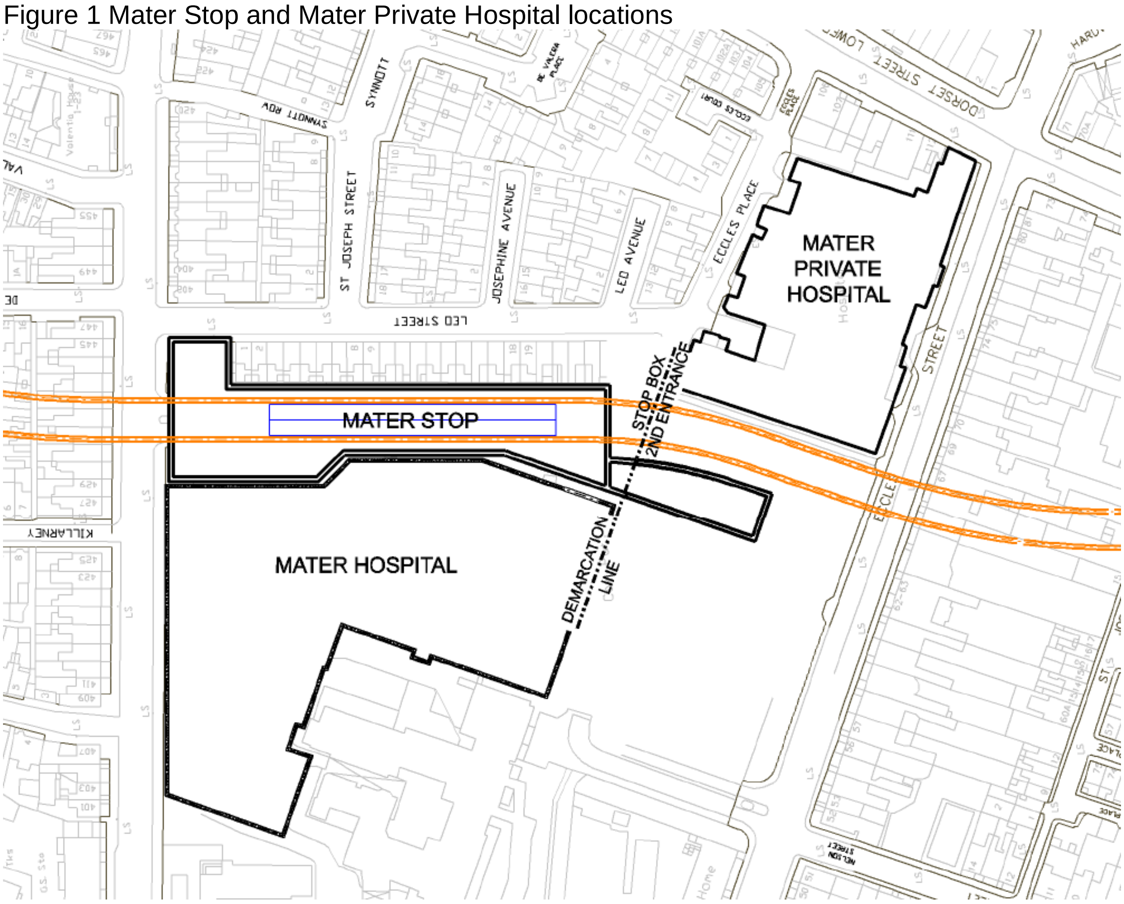
The proposed Metro North railway, will create a 7 km underground line that will connect the centre of Dublin to the airport. This assessment relates to the construction of the diaphragm wall of the Mater Stop, one of a number of underground stations to be built along the railway.

The diaphragm wall will form the station box and is to be constructed immediately adjacent to several vibration sensitive properties. These being the:

- Mater Private Hospital (MPH);
- Leo Street Residences, and;
- the Mater Misericordiae University Hospital (MMUH).

A general plan is shown in Figure 1 below with the MMUH denoted as the Mater Hospital. Noise and vibration assessments were made to all sensitive properties. Of most significance is the Mater Private Hospital, which houses various medical equipment (e.g. MRI, Linac, CT scanners) that are particularly sensitive to vibration.

Figure 1 Mater Stop and Mater Private Hospital locations



Each room, or piece of equipment, has been assigned vibration limits to ensure both patient and staff safety is not compromised during construction. Limits as low as 12 μm/s, in one-third octave bands, have been imposed in rooms close to the diaphragm wall.

2 CONSTRUCTION EQUIPMENT

There are two main vibration sources that will be used in the construction of the diaphragm wall, these being:

- a diaphragm wall grab, and;
- a hydromill (hydrofraise) trench cutter.

These are shown in Figure 2 below.

Figure 2 Hydromill (left), Grab (right)

The hydromill is a milling machine that uses two counter rotating heads to grind earth into slurry to be pumped away. The diaphragm wall grab is only effective in soils and is usually at refusal in rock. The hydromill is more effective in rock as soil tends to clog the suction pipework, which leads to continual downtime for maintenance.

2.1 Ground Conditions

A number of borehole tests have been taken around the Mater Stop site. Generally they have indicated an upper layer of glacial till with a limestone rock head located approximately 20-25 metres below ground level.

3 PUBLISHED SOURCE DATA

At tender stage we were required to provide a detailed assessment of the resultant vibration levels from the construction of the diaphragm wall. Hydromills are relatively rare pieces of equipment. At this stage we had no vibration data for hydromills nor was it possible to locate one in operation to measure the groundborne vibration.

Even if one was located it is quite possible that it would be operating in different ground conditions to that of the Mater Stop. Vibration propagation is directly linked to the ground conditions and as such it may not be possible to directly translate these measurements.

Published data was found within Table 12-2 of the Federal Transit Administration (FTA) guidelines[1]. This is reproduced in Figure 3 below.

Figure 3 FTA Source Data

Table 12-2 Vibration Source Levels for Construction Equipment (From measured data.[(8)(9)(10)(11)])

Equipment		PPV at 25 ft (in/sec)	Approximate L_v† at 25 ft
Pile Driver (impact)	upper range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	typical	0.170	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

† RMS velocity in decibels (VdB) re 1 μinch/second

Further research found data from the South Ferry Terminal Project, New York[2], as shown in Figure 4 below. We are unsure if this is measured data. It appears that this data might be an interpolation from the original values published in the FTA guidelines however we cannot confirm this.

We do not know information about the ground conditions where this data may have been measured. Data has been provided in terms of 'soil' and 'rock' although the nature and mechanical properties of these are not defined.

There is also no information on the frequency content from either of these pieces of machinery making it difficult to assess the vibration levels in one-third octave bands as required.

At this stage we had to make a number of conservative assumptions in the assessment. The results indicated a significant number of days of disruption to a number of clinical areas.

Figure 4 South Ferry Terminal Project Source Data

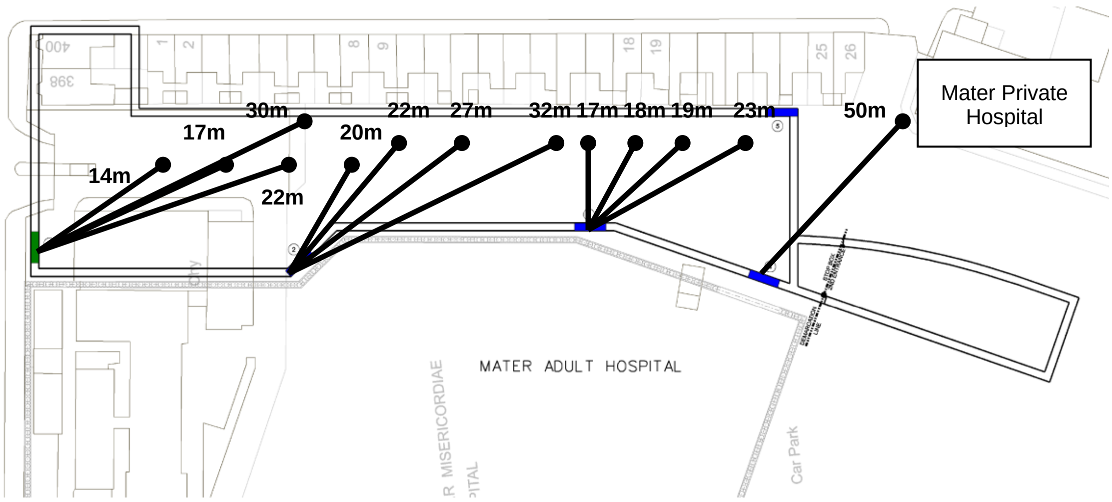
Equipment		PPV (ips)							
		5 ft	10 ft	25 ft	50 ft	100 ft	150 ft	200 ft	300 ft
Pile Driver (impact)	upper range	16.97	6.000	1.518	0.537	0.190	0.103	0.067	0.037
	typical	7.200	2.546	0.644	0.228	0.081	0.044	0.028	0.015
Pile Driver (sonic)	upper range	8.206	2.901	0.734	0.260	0.092	0.050	0.032	0.018
	typical	1.901	0.672	0.170	0.060	0.021	0.012	0.008	0.004
Clam shovel drop (slurry wall)		2.258	0.798	0.202	0.071	0.025	0.014	0.009	0.005
Hydromill (slurry mill)	in soil	0.089	0.032	0.008	0.003	0.001	0.001	0.000	0.000
	in rock	0.190	0.067	0.017	0.006	0.002	0.001	0.001	0.000
Large bulldozer		0.995	0.352	0.089	0.031	0.011	0.006	0.004	0.002
Caisson drilling		0.995	0.352	0.089	0.031	0.011	0.006	0.004	0.002
Loaded trucks		0.850	0.300	0.076	0.027	0.010	0.005	0.003	0.002
Jackhammer		0.391	0.138	0.035	0.012	0.004	0.002	0.002	0.001
Small bulldozer		0.034	0.012	0.003	0.001	0.000	0.000	0.000	0.000

4 TRIAL PANEL MEASUREMENTS

Prior to the construction of the diaphragm wall, a series of test panels were constructed. This provided an opportunity to evaluate the vibration levels of the construction equipment and re-evaluate the resultant vibration levels.

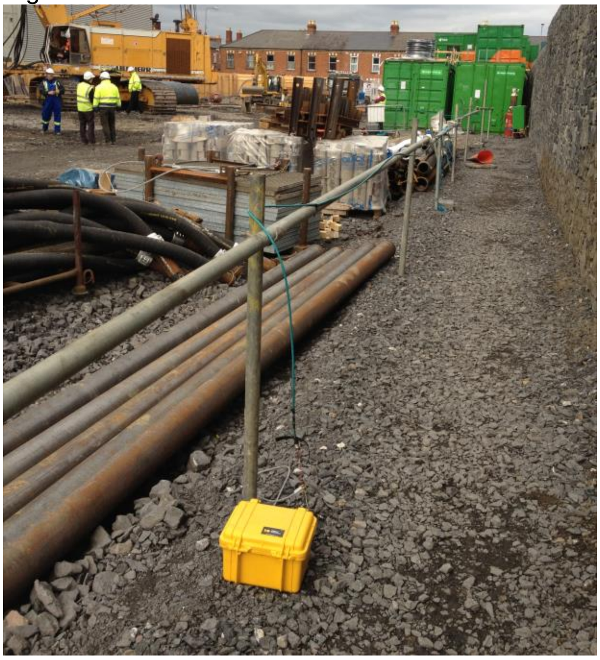
Vibration levels were measured from each of the test panels at distances ranging from 14 metres to 50 metres as shown in Figure 5 below.

Figure 5 Trial Panel and Measurement Locations



We would have liked to measure closer but due to deep excavations, and heavy machinery operating, this was not possible. The site was extremely narrow and safe working space was constrained. Measurement had to be restricted to the designated pedestrian routes (as shown in Figure 6).

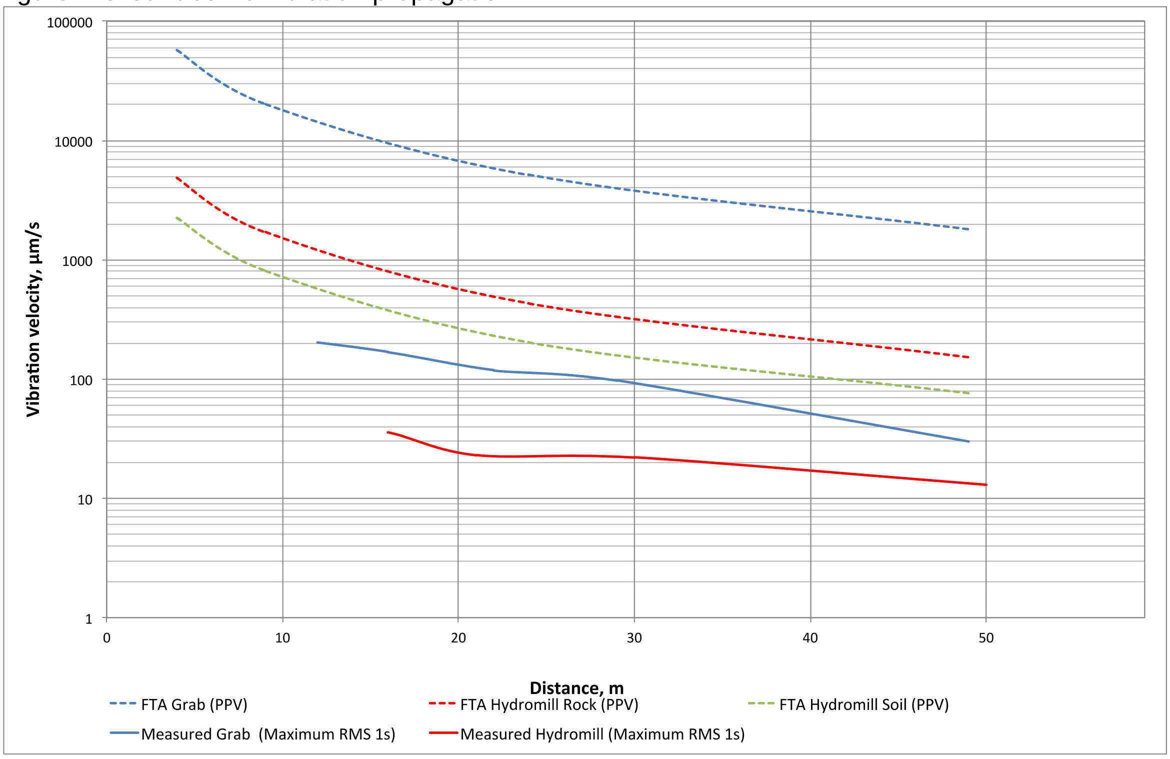
Figure 6 Trial Panel Measurement Locations



4.1 Results

A summary of the measured groundborne vibration propagation for the hydromill and diaphragm wall grab is shown in Figure 7 below. For reference these have been compared to the data published in the FTA Guidelines and the South Ferry Terminal Project.

Figure 7 Groundborne vibration propagation



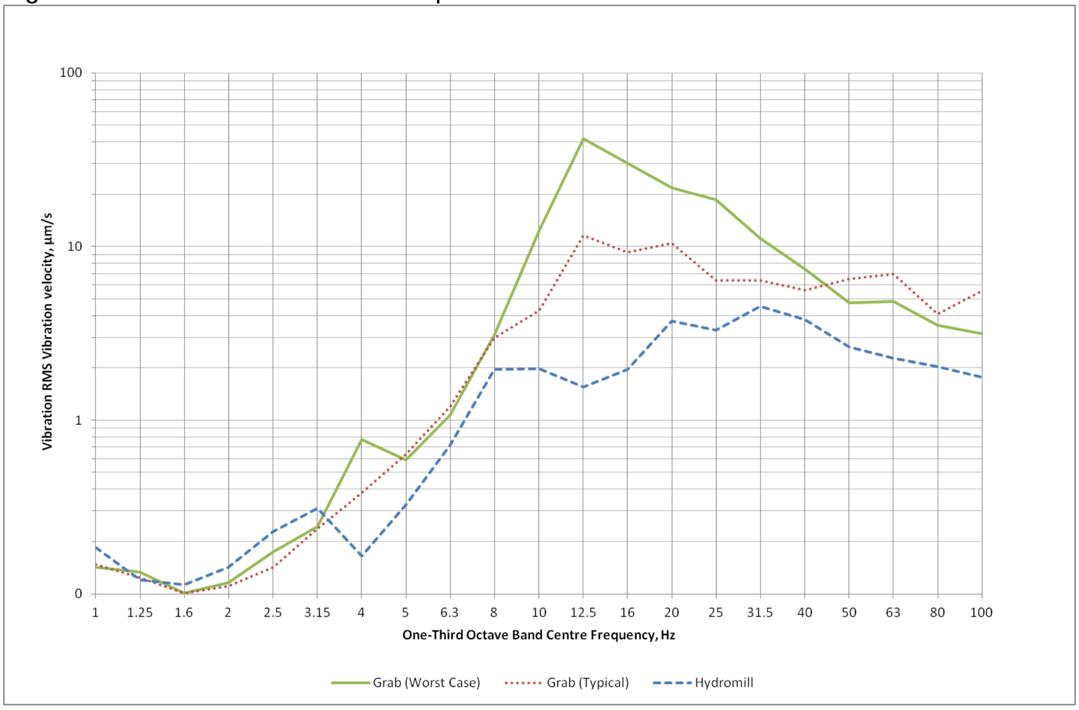
The hydromill generates a lower level of groundborne vibration than the diaphragm wall grab. It is also interesting to note that the measured vibration levels are significantly lower than those published in the FTA Guidelines and the South Ferry Terminal Project.

During the construction of Test Panel 4 an obstruction (old sewer) was encountered. To break through this obstruction the diaphragm wall grab was dropped from a great height. This resulted in a noticeably higher level of vibration.

We have shown the spectral information from the measured vibration levels from the hydromill and diaphragm wall grab in Figure 8 below. These are the results measured at the base of the Mater Private Hospital, some 50 metres away. These show the relative levels between a 'worst-case' drop (breaking through the sewer) and a more typical drop of the diaphragm wall grab.

These are the maximum one-third octave band levels over a number of events.

Figure 8 Relative maximum source spectra at 50 metres



Using this measured data we were able to re-evaluate the resultant vibration levels within the Hospital. Given that the actual source levels were significantly lower than the ones initially used, the impact on the Hospital was significantly reduced.

Although not presented in this paper, the measured vibration values showed a good correlation to the modelled results.

5 SUMMARY

- An assessment in the use of a hydromill and diaphragm wall grab has been made on the construction of the diaphragm wall at the Mater Stop.
- Measurements were made of both the diaphragm wall grab and hydromill operating on site.
- Results of the measurements have shown the hydromill produces a significantly lower level of vibration when compare to the diaphragm wall grab.

- The measured data is also significantly lower than the source data the FTA Guidelines and the South Ferry Terminal Project.

6 REFERENCES

1. Federal Transit Administration – *Transit noise and vibration – Impact Assessment*, April 1995
2. Metropolitan Transportation Authority/New York City Transit - *South Ferry Terminal Project* - 5.11 Noise and Vibration – May 2004