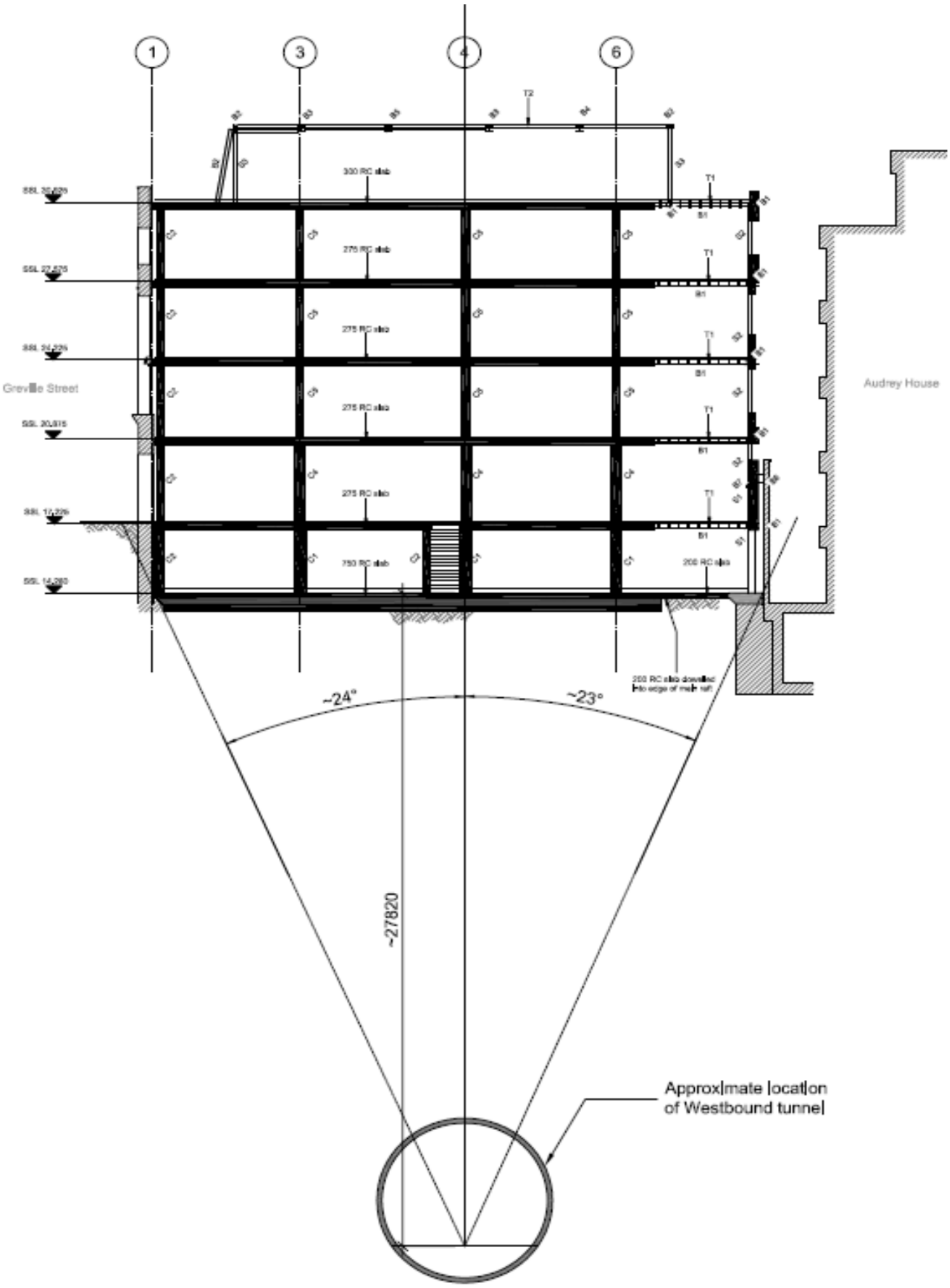
Introduction

These calculations will provide an assessment of the noise and vibration impact resulting from the Crossrail tunnel below the site. The Crossrail document *Information for Developers* dated December 2016 provides key information about Crossrail, predicted vibration and a methodology for determining noise and vibration levels in a new development.

Location of tunnel



Calculation

Crossrail requires that the ground borne noise level from the passage of trains in their tunnels in the centre of any noise-sensitive room is predicted in all reasonably foreseeable circumstances to not exceed the levels given in Table 1 in *Information for Developers*
The workshops in the basement will be assumed to be similar to office spaces and therefore the maximum sound pressure level, L_{ASmax} = 40 dB

The soil radial velocity will be calculated from a distance,r from the tunnel using the equation from section 5 of *Information for Developers* below:

$$L_r = L_t - 4.34\frac{\omega\eta r}{c_s} - 10\log_{10}\left[\frac{r_0 + r}{r_0}\right]$$

Where
L_t = the tunnel radio velocity for a tunnel radius of r_0
ω = angular frequency of each 1/3 octave band in radians per second
η = soil loss factor
c_s = phase speed of compression waves in soil
r = distance to room
r_0 = radius of tunnel

Below are the numerical values used and where they have been taken from:

η	0.1	from Crossrail *Groundborne Noise and Vibration Prediction Validation on DLR Greenwich technical report*
C_s	1611	from Crossrail *Groundborne Noise and Vibration Prediction Validation on DLR Greenwich technical report*
r	27.82	from page 1 of the calculations
r_0	3.5	from Crossrail *Information for Developers*

In reference to page 1 of the calculations the angle of visible levels to receiving vibration from Crossrail is approximately +/- 24°
In reference to drawing C122-OVE-R4-DDA-CR001_Z-11023 the speed limit is 80km/h in the tunnel directly beneath. Therefore the tunnel radio velocity values in table 1 in appendix A of *Information for Developers* will be used as below for +/- 28° and the corresponding L_r values for each frequency and position. For the appropriate frequencies the value of the 'A-weighting' has been applied in accordance with BS EN ISO 710-1 2013 for spectrum No. 1

L_t							**L_r**							
Hz	**332**	**346**	**360**	**0**	**14**	**28**	**w**	**332**	**346**	**360**	**0**	**14**	**28**	A-weighting
20	86	89	90	90	89	86	125.7	76	79	80	80	79	76	
25	85	90	91	91	90	85	157.1	74	79	80	80	79	74	
31.5	95	99	100	100	99	95	197.9	84	88	89	89	88	84	
40	96	102	103	103	102	96	251.3	85	91	92	92	91	85	
50	85	92	95	95	92	85	314.2	33	40	43	43	40	33	-40
63	83	90	92	92	90	83	395.8	35	42	44	44	42	35	-36
80	79	85	88	88	85	79	502.6	33	39	42	42	39	33	-33
100	82	86	90	90	86	82	628.3	39	43	47	47	43	39	-29
125	89	89	94	94	89	89	785.4	48	48	53	53	48	48	-26
160	84	83	88	88	83	84	1005.3	44	43	48	48	43	44	-23

Calculation of L_p, is the 1/3 octave band sound pressure to compare with the allowable maximum sound pressure is:

$$L_p = L_v - 27dB$$

Where L_v is the root mean square vibration velocity in dB re 1 nanometer second:

Calculation of L_v and L_p are calculate below for each frequency:

Frequency	L_v	L_p
20	78	51
25	78	51
31.5	87	60
40	89	62
50	39	12
63	40	13
80	38	11
100	43	16
125	49	22
160	45	18

Therefore the average value of the 1/3 octave band sound pressure level is 32 dB < 40dB, therefore within acceptable limits