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Address:
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Norfolk NR14 8EJ

Appendix G

Ground-borne Noise and Vibration Assessment



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1.1 Assessment criteria

The assessment has been undertaken in accordance with Appendix B of the Crossrail 2 Information for Developers, April 2021.

Table 1 Crossrail 2 – Ground-borne Noise Criteria

Uses	Ground-borne noise levels in occupied spaces during train passes
Residential	35 dB LA _{max,F}
Commercial*	40 dB LA _{max,F}

*Note: the CR2 report does not contain a criterion for generic retail uses, therefore the Offices criterion has adopted.

1.2 Assessment parameters

Parameter	Adopted value
Tunnel excavated diameter, D	7.8 m
Tunnel radius, r0	3.9 m
Tunnel centreline depth, z	25.0 m
Horizontal distance to nearest Block E1 edge	27.0 m
Maximum screw pile length	12.0 m
Compressive wave speed for London Clay, cs	1611 m/s
Loss factor for London Clay, η	0.10
Train speed	100 km/h
Room sound pressure correction	27 dB

Table 2 – Ground-borne Noise Assessment Parameters

The Crossrail 2 guidance relates room sound pressure level to rms vibration velocity using:

$$L_p = L_v - 27 \text{ dB}$$

1.3 Distance to closest ground floor location

The nearest Block E1 edge is approximately 27.0 m horizontally from the tunnel centreline.

$$R_{gf} = \sqrt{(27.0^2 + 25.0^2)}$$

$$R_{gf} = 36.80 \text{ m}$$

$$r_{gf} = R_{gf} - r_0$$

$$r_{gf} = 36.80 - 3.90$$

$$r_{gf} = 32.90 \text{ m}$$

The corresponding tunnel circumference position is approximately 47.2° from crown. For the relevant side of the tunnel, this corresponds to approximately 312.8°, and the nearest available Crossrail 2 prediction position is taken as 315°.



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1.4 Distance to nearest screw pile

The maximum screw pile length is 12.0 m.

$$z_p = 25.0 - 12.0 = 13.0 \text{ m}$$

$$R_p = \sqrt{(27.0^2 + 13.0^2)}$$

$$R_p = 29.97 \text{ m}$$

$$r_p = R_p - r_0$$

$$r_p = 29.97 - 3.90$$

$$r_p = 26.07 \text{ m}$$

The corresponding tunnel circumference position is approximately 64.3° from crown. For the relevant side of the tunnel, this corresponds to approximately 295.7°, and the nearest available Crossrail 2 prediction position is taken as 297°.

This pile-tip assessment is treated as the worst-case, consistent with the Crossrail 2 guidance, which states that for piled foundations the shortest distance to any part of the nearest pile may be used to obtain a worst-case estimate.

1.5 Ground vibration attenuation

The soil vibration level at the receiving location is calculated using the Crossrail 2 Appendix B distance function:

$$L_r = L_t - 4.34(\omega \eta r / c_s) - 10 \log_{10}[(r_0 + r) / r_0]$$

- L_t = tunnel wall radial vibration velocity, dB re 1 nm/s
- L_r = soil radial vibration velocity at the receiver, dB re 1 nm/s
- $\omega = 2\pi f$
- η = soil loss factor = 0.10
- r = distance from tunnel wall to receiver
- c_s = compression wave speed = 1611 m/s
- r_0 = tunnel radius = 3.9 m

Reference: Crossrail 2 Information for Developers, Appendix B, Section 5.2.

1.6 Ground floor assessment – best case

For the nearest occupied ground floor location:

$$r = 32.90 \text{ m}$$

$$\text{Tunnel circumference position} = 315^\circ$$



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The 100 km/h tunnel wall vibration levels are taken from Crossrail 2 Appendix B, Table 2.

Worked example at 80 Hz:

$$L_t = 87.8 \text{ dB}$$

$$\omega = 2\pi \times 80 = 502.7 \text{ rad/s}$$

$$\Delta L_{\text{ground}} = -4.34 \times (502.7 \times 0.10 \times 32.90 / 1611) = -4.46 \text{ dB}$$

$$\Delta L_{\text{distance}} = -10 \log_{10}[(3.90 + 32.90) / 3.90] = -9.75 \text{ dB}$$

$$L_r = 87.8 - 4.46 - 9.75 = 73.59 \text{ dB}$$

$$L_p = L_r - 27 = 46.59 \text{ dB}$$

$$L_{A,80} = 46.59 - 22.5 = 24.09 \text{ dB(A)}$$

Frequency (Hz)	Tunnel wall L_t (dB)	Ground loss (dB)	Distance correction (dB)	A-weighted level (dB)
20	78.7	-1.1	-9.7	-9.7
25	93.3	-1.4	-9.7	10.5
31.5	88.0	-1.8	-9.7	10.1
40	86.2	-2.2	-9.7	12.6
50	82.8	-2.8	-9.7	13.1
63	84.1	-3.5	-9.7	17.6
80	87.8	-4.5	-9.7	24.1
100	82.8	-5.6	-9.7	21.4
125	85.7	-7.0	-9.7	25.9
160	86.7	-8.9	-9.7	27.6

Table 3 – Ground Floor Ground-borne Noise Calculation

Overall A-weighted level:

$$L_{A,\text{total}} = 10 \log_{10} \Sigma(10^{(L_{A,i} / 10)})$$

$$L_{A,\text{total}} = 31.7 \text{ dB } L_{A\text{max},F}$$

31.7 dB < 35 dB residential criterion – PASS

1.7 Nearest pile assessment – worst case

For the nearest screw pile tip:

$$r = 26.07 \text{ m}$$

$$\text{Tunnel circumference position} = 297^\circ$$

The same Crossrail 2 Appendix B procedure is repeated using the 100 km/h vibration levels at 297°.



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Frequency (Hz)	Tunnel wall Lt (dB)	Ground loss (dB)	Distance correction (dB)	A-weighted level (dB)
20	81.8	-0.9	-8.9	-5.4
25	97.4	-1.1	-8.9	15.7
31.5	91.8	-1.4	-8.9	15.2
40	90.4	-1.8	-8.9	18.2
50	87.2	-2.2	-8.9	18.9
63	87.6	-2.8	-8.9	22.8
80	91.0	-3.5	-8.9	29.1
100	84.1	-4.4	-8.9	24.7
125	86.7	-5.5	-8.9	29.2
160	86.8	-7.1	-8.9	30.5

Table 4 – Nearest Pile Ground-borne Noise Calculation

LA,total = 35.4 dB LAmax,F

Residential criterion: 35.4 dB > 35 dB – marginally above

Commercial criterion: 35.4 dB < 40 dB – PASS

1.8 Assessment summary

Assessment location	Predicted level	Residential criterion	Commercial criterion
Ground floor – best case	31.7 dB LAmax,F	35 dB – PASS	40 dB – PASS
Nearest pile – worst case	35.4 dB LAmax,F	35 dB – marginally above	40 dB – PASS

Table 5 – Crossrail 2 – Ground-borne Noise Predictions

1.9 Conclusion

The preliminary ground-borne noise assessment has been undertaken in accordance with Appendix B of the Crossrail 2 Information for Developers.

The predicted ground-borne noise level at the nearest pile is 35.4 dB LAmax,F, which marginally exceeds the residential criterion of 35 dB LAmax,F by 0.4 dB. This is considered acceptable given that the assessment represents a conservative worst-case scenario and assumes that the pile transmits ground-borne noise without allowing for attenuation through the pile and surrounding ground.

The predicted noise level at the occupied ground floor is 31.7 dB LAmax,F and therefore complies with the residential criterion. Overall, the predicted ground-borne noise levels are considered **acceptable**.