

Appendix E – Construction Noise and Vibration Assessment

Memo

Date: June 30, 2021
To: Connor Tutino, David J. Powers & Associates, Inc.
From: Michael Thill, Adwait Ambaskar, Illingworth & Rodkin, Inc.
SUBJECT: 3300 El Camino Real, Palo Alto, California (IR Job # 21-055)

This memo has been prepared to describe the potential noise and vibration impacts attributable to the construction of a two-story office building at 3300 El Camino Real, Palo Alto, California. Figure 1 is an aerial image of the site vicinity with the project site plan overlay.

Project Location and Description

The project would involve construction of an approximately 52,872 square-foot (sf) two-story office building. The office building would include 50,355 sf of office space across both the first and second floors, as well as an approximately 2,517 sf traffic mitigating amenity space, likely to be a café or fitness area that serves to reduce off-site trips for employees. The second story would also include a rooftop terrace with landscaped areas, walkways, gathering areas, and canopies. An approximately 261 sf trash and transformer enclosure would also be constructed on-site, in the proposed surface parking lot. The floor area ratio (FAR) for the site would be 0.4, and the project would result in approximately 29 percent lot coverage. The building would reach a maximum height of 35 feet.

The project would include a surface parking lot and one level of underground parking. 86 parking spaces would be provided on the surface lot and 95 spaces would be provided in the underground garage, for a total of 181 parking spaces. Additionally, the project would provide 17 bicycle parking spaces. Fourteen (14) out of the 17 bicycle parking spaces would be long-term bicycle parking and the remaining three would be short-term bicycle parking spaces.

A pedestrian walkway connecting to the sidewalk along El Camino Real would be constructed to provide pedestrian access to the surface parking lot and office building. Additional pedestrian walkways would be provided along the southern and eastern sides of the office building. A fire access foot path would be constructed at the southeastern corner of the project site.

FIGURE 1 Project Site Plan and Vicinity



Source: Google Earth, June 2021.

Applicable Regulatory Criteria

City of Palo Alto Comprehensive Plan 2030. Chapter 4 of the 2030 Comprehensive Plan (Natural Environment) discusses noise. The following goals and policies apply to the construction of the proposed project:

Goal N-6: An environment that minimizes the adverse impacts of noise.

Policy N-6.3 Protect the overall community and especially sensitive noise receptors, including schools, hospitals, convalescent homes, senior and child care facilities and public conservation land from unacceptable noise levels from both existing and future noise sources, including construction noise.

Policy N-6.5 Protect residential and residentially-zoned properties from excessive and unnecessary noise from any sources on adjacent commercial or industrial properties.

Policy N-6.7 While a proposed project is in the development review process, the noise impact of the project on existing residential land uses, public open spaces and public conservation land should be evaluated in terms of the increase in existing noise levels for the potential for adverse community impact, regardless of existing

background noise levels. If an area is below the applicable maximum noise guideline, an increase in noise up to the maximum should not necessarily be allowed.

Policy N-6.11 Continue to prioritize construction noise limits around sensitive receptors, including through limiting construction hours and individual and cumulative noise from construction equipment.

City of Palo Alto Municipal Code. The noise ordinance of the City of Palo Alto limits noise levels caused by stationary noise sources and construction on adjacent residential properties. The applicable portions of the noise code are as follows:

9.10.020 Definitions.

- (a) "Local ambient" means the lowest sound level repeating itself during a six-minute period as measured with a precision sound level meter, using slow response and "A" weighting. The minimum sound level shall be determined with the noise source at issue silent, and in the same location as the measurement of the noise level of the source or sources at issue. However, for purposes of this chapter, in no case shall the local ambient be considered or determined to be less than: (1) Thirty (30) dBA for interior noise in Section 9.10.030(b); (2) Forty (40) dBA in all other sections. If a significant portion of the local ambient is produced by one or more individual identifiable sources which would otherwise be operating continuously during the six-minute measurement period and contributing significantly to the ambient sound level, determination of the local ambient shall be accomplished with these separate identifiable noise sources silent.

9.10.030 Residential property noise limits.

- (b) No person shall produce, suffer or allow to be produced by any machine, animal, or device, or any combination of same, on residential property, a noise level more than six (6) dB above the local ambient at any point outside the property plane.

9.10.040 Commercial and industrial property noise limits.

No person shall produce, suffer or allow to be produced by any machine or device, or any combination of same, on commercial or industrial property, a noise level more than eight (8) dB above the local ambient at any point outside of the property plane.

9.10.060 Special Provisions.

The special exceptions listed in this section shall apply, notwithstanding the provisions of Sections 9.10.030 through 9.10.050. Said exceptions shall apply only to the extent and during the hours specified in each of the following enumerated exceptions.

- (b) Construction. Except for construction on residential property, construction, alteration and repair activities which are authorized by valid city building permit shall be prohibited on Sundays and holidays and shall be prohibited except between the hours of eight a.m. and six

p.m. Monday through Friday, nine a.m. and six p.m. on Saturday provided that the construction, demolition or repair activities during those hours meet the following standards:

- (1) No individual piece of equipment shall produce a noise level exceeding one hundred ten (110) dBA at a distance of twenty-five (25) feet. If the device is housed within a structure on the property, the measurement shall be made outside the structure at a distance as close to twenty-five feet from the equipment as possible.
- (2) The noise level at any point outside of the property plane of the project shall not exceed one hundred ten (110) dBA.
- (3) The holder of a valid construction permit for a construction project in a non-residential zone shall post a sign at all entrances to the construction site upon commencement of construction, for the purpose of informing all contractors and subcontractors, their employees, agents, materialmen and all other persons at the construction site, of the basic requirements of this chapter.

Significance Thresholds

The following criteria were used to evaluate the significance of environmental noise resulting from the project:

- A significant noise impact would be identified if the project would generate a substantial temporary or permanent noise level increase over ambient noise levels at existing noise-sensitive receptors surrounding the project site and that would exceed applicable noise standards presented in the City of Palo Alto's Comprehensive Plan or Municipal Code at existing noise-sensitive receptors surrounding the project site.
 - During the allowable construction hours between 8:00 a.m. and 6:00 p.m. Monday through Friday and between 9:00 a.m. and 6:00 p.m. on Saturdays, no individual piece of equipment shall exceed 110 dBA at a distance of 25 feet or at a distance of 25 feet from the structure in which the equipment is enclosed. Further, 110 dBA shall not be exceeded at any point beyond the property plane of the construction site during allowable hours. For construction activities outside the allowable hours, noise levels shall not exceed local ambient levels at residential properties by 6 dBA or at commercial properties by 8 dBA.
- A significant impact would be identified if the construction of the project would generate excessive vibration levels at surrounding receptors. Groundborne vibration levels exceeding 0.3 in/sec PPV would have the potential to result in cosmetic damage to historic and some old buildings.

Construction Noise Impacts

Project construction is expected to start in September 2021 and to be completed by mid-December 2022. Construction phases would include demolition (2 weeks), grading/excavation (1.5 months), trenching/foundation (2 weeks), building exterior and interiors (9 months) and paving (3-4 months).

Section 9.10.060(b) of the City of Palo Alto Municipal Code states that construction activities are permitted between the hours of 8:00 a.m. and 6:00 p.m. Monday through Friday and between 9:00 a.m. and 6:00 p.m. on Saturdays provided that no individual piece of equipment produces a noise level exceeding 110 dBA at 25 feet or noise levels of 110 dBA are not exceeded anywhere outside the property plane. If the equipment is housed in a structure, the 110 dBA would be enforced at 25 feet from the structure. All construction activities are prohibited on Sundays and holidays.

Construction activities generate considerable amounts of noise, especially during earth-moving activities when heavy equipment is used. A list of typical maximum instantaneous noise levels measured at 50 feet are provided in Table 1. Maximum noise levels typically range from about 80 to 90 dBA L_{max} at 50 feet from the noise source. Typical hourly average construction-generated noise levels for office buildings are about 78 to 89 dBA L_{eq} measured at 50 feet from the center of the site during busy construction periods (e.g., earth moving equipment, impact tools, etc.), as shown in Table 2.

TABLE 1 Construction Equipment 50-foot Noise Emission Limits

Equipment Category	L_{max} Level (dBA)^{1,2}	Impact/Continuous
Arc Welder	73	Continuous
Auger Drill Rig	85	Continuous
Backhoe	80	Continuous
Bar Bender	80	Continuous
Boring Jack Power Unit	80	Continuous
Chain Saw	85	Continuous
Compressor ³	70	Continuous
Compressor (other)	80	Continuous
Concrete Mixer	85	Continuous
Concrete Pump	82	Continuous
Concrete Saw	90	Continuous
Concrete Vibrator	80	Continuous
Crane	85	Continuous
Dozer	85	Continuous
Excavator	85	Continuous
Front End Loader	80	Continuous
Generator	82	Continuous
Generator (25 KVA or less)	70	Continuous
Gradall	85	Continuous
Grader	85	Continuous
Grinder Saw	85	Continuous
Horizontal Boring Hydro Jack	80	Continuous
Hydra Break Ram	90	Impact
Impact Pile Driver	105	Impact
In situ Soil Sampling Rig	84	Continuous
Jackhammer	85	Impact
Mounted Impact Hammer (hoe ram)	90	Impact
Paver	85	Continuous

Equipment Category	L _{max} Level (dBA) ^{1,2}	Impact/Continuous
Pneumatic Tools	85	Continuous
Pumps	77	Continuous
Rock Drill	85	Continuous
Scraper	85	Continuous
Slurry Trenching Machine	82	Continuous
Soil Mix Drill Rig	80	Continuous
Street Sweeper	80	Continuous
Tractor	84	Continuous
Truck (dump, delivery)	84	Continuous
Vacuum Excavator Truck (vac-truck)	85	Continuous
Vibratory Compactor	80	Continuous
Vibratory Pile Driver	95	Continuous
All other equipment with engines larger than 5 HP	85	Continuous

Notes:

- ¹ Measured at 50 feet from the construction equipment, with a “slow” (1 sec.) time constant.
- ² Noise limits apply to total noise emitted from equipment and associated components operating at full power while engaged in its intended operation.
- ³ Portable Air Compressor rated at 75 cfm or greater and that operates at greater than 50 psi.

Source: Mitigation of Nighttime Construction Noise, Vibrations and Other Nuisances, National Cooperative Highway Research Program, 1999.

TABLE 2 Typical Ranges of Construction Noise Levels at 50 Feet, L_{eq} (dBA)

	Domestic Housing		Office Building, Hotel, Hospital, School, Public Works		Industrial Parking Garage, Religious Amusement & Recreations, Store, Service Station		Public Works Roads & Highways, Sewers, and Trenches	
	I	II	I	II	I	II	I	II
Ground Clearing	83	83	84	84	84	83	84	84
Excavation	88	75	89	79	89	71	88	78
Foundations	81	81	78	78	77	77	88	88
Erection	81	65	87	75	84	72	79	78
Finishing	88	72	89	75	89	74	84	84

I - All pertinent equipment present at site.

II - Minimum required equipment present at site.

Source: U.S.E.P.A., Legal Compilation on Noise, Vol. 1, p. 2-104, 1973.

Based on a review of the applicant supplied construction equipment list, construction noise levels are calculated to range from 78 to 85 dBA L_{max} and from 77 to 85 dBA L_{eq} at 50 feet, using FHWA’s Roadway Construction Noise Model (results in Table 3). These project-specific construction noise levels generally agree with the range of typical maximum and average noise levels presented above.

Construction-generated noise levels drop off at a rate of about 6 dBA per doubling of the distance between the source and receptor. Shielding by buildings or terrain can provide an additional 5 to 10 dBA noise reduction at distant receptors.

TABLE 3 Total Calculated L_{max} and L_{eq} Noise Levels from RCNM

Phase	Equipment	Quantity	Total Calculated (dBA)	
			L_{max}	L_{eq}
Demolition	Excavators	2	81	80
Grading/Excavation	Excavators	2	85	85
	Graders	1		
	Tractors/Loaders/Backhoes	1		
Trenching/Foundation	Tractors/Loaders/Backhoes	1	84	80
Building - Exterior	Cranes	1	84	81
	Forklifts	1		
	Tractors/Loaders/Backhoes	1		
Building - Interior	Air Compressors	1	78	77
	Aerial Lift	4		
Paving	Pavers	1	80	80
	Paving Equipment	1		
	Rollers	2		

The existing land uses surrounding the project site consist of commercial land uses. Theoretically, the maximum noise levels could reach 100 to 110 dBA at the property plane if equipment is used within about 5 feet. Typically, however, a receptor would not be located at the property line of the adjacent property when construction occurs in close proximity. Therefore, construction noise levels are calculated from the center of the construction area in order to credibly represent typical noise levels experienced at adjacent receptor locations. The nearest commercial property is about 300 feet from the center of the proposed project site (30 feet away from the closest edge of the project property line), which would result in noise levels that typically range from 65 to 70 dBA L_{max} and 61 to 66 dBA L_{eq} . The nearest existing residences are located approximately 400 feet to the southeast. At this distance, maximum noise levels generated by project construction would typically range from about 58 to 67 dBA L_{max} , and hourly average noise levels would typically range from about 50 to 63 dBA L_{eq} .

As stated above, the 110 dBA threshold for individual pieces of equipment would not typically be exceeded during the allowable construction hours. Although the impact is considered less-than-significant, the incorporation of the following construction best management practices should be

considered as part of the conditions of approval, given the proximity of the site to nearby commercial land uses.

Construction Best Management Practices

- Construction will be limited to the hours of 7:00 a.m. to 6:00 p.m. Monday through Friday and between 9:00 a.m. and 6:00 p.m. on Saturdays for any on-site or off-site work within 300 feet of any residential unit.
- The contractor shall use “new technology” power construction equipment with state-of-the-art noise shielding and muffling devices. All internal combustion engines used on the project site shall be equipped with adequate mufflers and shall be in good mechanical condition to minimize noise created by faulty or poorly maintained engines or other components.
- Construct temporary noise barriers, where feasible, to screen adjoining land uses. Temporary noise barrier fences would provide a 5 dBA noise reduction if the noise barrier interrupts the line-of-sight between the noise source and receptor and if the barrier is constructed in a manner that eliminates any cracks or gaps. The unnecessary idling of internal combustion engines shall be prohibited.
- Staging areas and stationary noise-generating equipment shall be located as far as possible from noise-sensitive receptors, such as residential uses (a minimum of 200 feet).
- Ensure that generators, compressors, and pumps are housed in acoustical enclosures.
- Locate cranes as far from adjoining noise-sensitive receptors as possible.
- During final grading, substitute graders for bulldozers, where feasible. Wheeled heavy equipment are quieter than track equipment and should be used where feasible.
- Substitute nail guns for manual hammering, where feasible.
- Substitute electrically powered tools for noisier pneumatic tools, where feasible.
- The surrounding neighborhood shall be notified early and frequently of the construction activities.
- A “noise disturbance coordinator” shall be designated to respond to any local complaints about construction noise. The disturbance coordinator would determine the cause of the noise complaints (e.g., beginning work too early, bad muffler, etc.) and institute reasonable measures warranted to correct the problem. A telephone number for the disturbance coordinator would be conspicuously posted at the construction site.

Mitigation Measures: No further mitigation required.

Construction Vibration Impacts

Proposed construction phases would include demolition, grading/excavation, trenching/foundation, paving, and new building framing and finishing. Perceptible vibration may occur when heavy equipment or impact tools are used. However, the proposed project would not require pile driving, which can cause excessive vibration.

The City of Palo Alto does not specify a construction vibration limit. For structural damage, the California Department of Transportation recommends a vibration limit of 0.5 in/sec PPV for buildings structurally sound and designed to modern engineering standards, 0.3 in/sec PPV for buildings that are found to be structurally sound but where structural damage is a major concern, and a conservative limit of 0.25 in/sec PPV for historic and some old buildings. A review of the City of Palo Alto Master List of Structures on the Historic Inventory indicates that the nearest structure of historical significance is at 686 Matadero Avenue, approximately 900 feet from the project site. Therefore, the 0.3 in/sec PPV vibration limit would be applicable to properties in the immediate vicinity of the project site.

Vibration levels would vary depending on soil conditions, construction methods, and equipment used. Jackhammers typically generate vibration levels of 0.035 in/sec PPV and drilling typically generates vibration levels of 0.09 in/sec PPV at a distance of 25 feet. Vibration levels are highest close to the source, and then attenuate with increasing distance at the rate $(D_{ref}/D)^{1.1}$, where D is the distance from the source in feet, and D_{ref} is the reference distance of 25 feet. Table 4 presents typical vibration levels that could be expected from construction equipment at 25 feet and summarizes the expected vibration levels at buildings bordering the site (30 feet), across the street from the site (80 feet), and at the nearest historic buildings to the site (900 feet). Vibration levels at distances greater than 25 feet from the project site would not exceed the 0.3 in/sec PPV threshold for buildings of normal conventional construction or the 0.25 in/sec PPV threshold for historic buildings.

The US Bureau of Mines has analyzed the effects of blast-induced vibration on buildings in USBM RI 8507,¹ and these findings have been applied to vibrations emanating from construction equipment on buildings.² Figure 2 presents the damage probability, as reported in USBM RI 8507 and reproduced by Dowding, assuming a maximum vibration level of 0.3 in/sec PPV. As per Table 4, buildings of normal conventional construction located 25 to 80 feet from the project site would not be exposed to vibration levels exceeding the 0.3 in/sec PPV. Based on the data summarized in Figure 2, there would be no observations of “threshold damage,” “minor damage,” or “major damage” at buildings of normal conventional construction when vibration levels were 0.3 in/sec PPV or less.

Project-generated vibration levels would fall below the 0.3 in/sec PPV threshold at all surrounding conventional buildings. Neither cosmetic, minor, or major damage would occur beyond 25 feet. At these locations and in other surrounding areas where vibration would not be expected to cause structural damage, vibration levels may still be perceptible. However, as with any type of construction, this would

¹ Siskind, D.E., M.S. Stagg, J.W. Kopp, and C.H. Dowding, Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting, RI 8507, Bureau of Mines Report of Investigations, U.S. Department of the Interior Bureau of Mines, Washington, D.C., 1980.

² Dowding, C.H., Construction Vibrations, Prentice Hall, Upper Saddle River, 1996.

be anticipated and would not be considered significant, given the intermittent and short duration of the phases that have the highest potential of producing vibration. By use of administrative controls, such as notifying neighbors of scheduled construction activities and scheduling construction activities with the highest potential to produce perceptible vibration during hours with the least potential to affect nearby residences and businesses, perceptible vibration can be kept to a minimum.

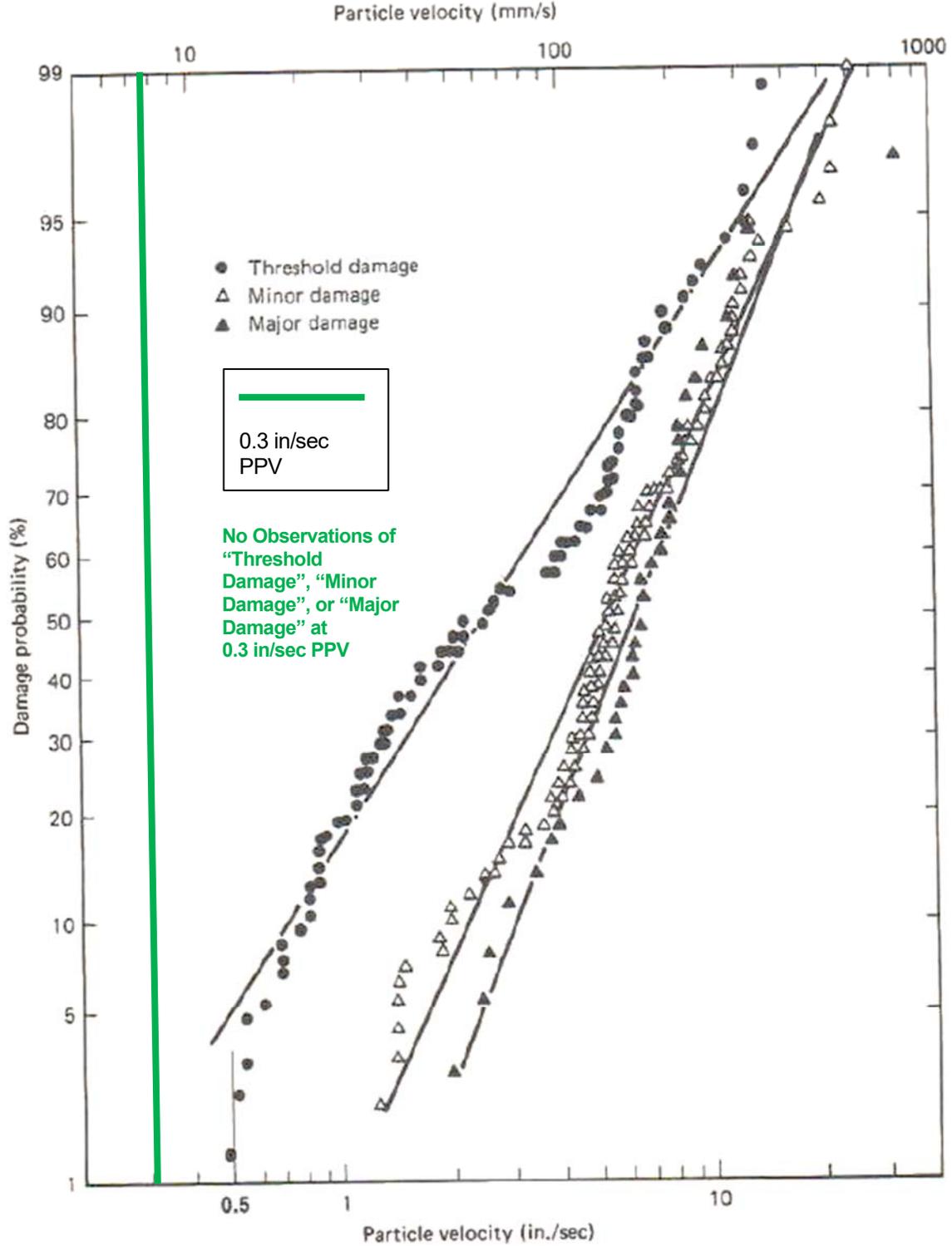
Mitigation Measures: No further mitigation required.

TABLE 4 Construction Vibration Levels at Nearby Buildings

Equipment	PPV (in/sec)			
	Source Level at 25 ft	Vibration Level at 30 ft	Vibration Level at 80 ft	Vibration Level at 900 ft
Clam shovel drop	0.202	0.165	0.056	0.004
Hydromill (slurry wall)	in soil	0.008	0.007	0.002
	in rock	0.017	0.014	0.005
Vibratory Roller	0.210	0.172	0.058	0.004
Hoe Ram	0.089	0.073	0.025	0.002
Large bulldozer	0.089	0.073	0.025	0.002
Caisson drilling	0.089	0.073	0.025	0.002
Loaded trucks	0.076	0.062	0.021	0.001
Jackhammer	0.035	0.029	0.010	0.001
Small bulldozer	0.003	0.002	0.001	0.000

Source: Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, Office of Planning and Environment, U.S. Department of Transportation, FTA Report No. 0123, September 2018, as modified by Illingworth & Rodkin, Inc., June 2021.

FIGURE 2 Probability of Cracking and Fatigue from Repetitive Loading



Source: Dowding, C.H., Construction Vibrations, Prentice Hall, Upper Saddle River, 1996 as modified by Illingworth & Rodkin, Inc., June 2021.