VIBRATION TECHNICAL REPORT

Introduction

This section evaluates vibration impacts that would be generated by construction and operation of the Proposed Carson Triangle Project at 21212 Avalon Boulevard in the City of Carson. The analysis compares these impacts to applicable regulations and thresholds of significance. Vibration calculation worksheets are included in the Technical Appendix.

Fundamentals of Vibration

Characteristics of Vibration. Vibration is an oscillatory motion through a solid medium in which the motion's amplitude can be described in terms of displacement, velocity, and acceleration. Unlike noise, vibration is not a common environmental problem, as it is unusual for vibration from vehicle sources to be perceptible. Common sources of vibration include trains, construction activities, and certain industrial operations.

Vibration Definitions. This analysis discusses vibration in terms of Peak Particle Velocity (PPV). PPV is commonly used to describe and quantify vibration impacts to buildings and other structures. PPV levels represent the maximum instantaneous peak of a vibration signal and are usually measured in inches per second.[1] This analysis also discusses the vibration of events in decibel scale, known as Vibration Decibels (VdB), which is a unitless measure of vibration that is expressed on a logarithmic scale.

Effects of Vibration. High levels of vibration may cause physical personal injury or damage to buildings. However, groundborne vibration levels rarely affect human health. Instead, most people consider groundborne vibration to be an annoyance that can disrupt concentration or disturb sleep. Groundborne vibration can also interfere with certain types of highly sensitive equipment and machines, especially imaging devices used in medical laboratories.

Perceptible Vibration Changes. Unlike noise, groundborne vibration is not an environmental issue that most people experience every day. Background vibration levels in residential areas are usually well below the threshold of perception for humans, approximately 0.01 inches per second.[2] Perceptible indoor vibrations are most often caused by sources within buildings themselves, such as slamming doors or heavy footsteps. Common outdoor sources of groundborne vibration include construction equipment, trains, and traffic on rough or unpaved roads. Traffic vibration from smooth and well-maintained roads is typically not perceptible.

1 California Department of Transportation, Transportation and Construction Vibration Guidance Manual, April 2020; https://dot.ca.gov/-/media/dot-media/programs/environmental-analysis/documents/env/tcvgm-apr2020-a11y.pdf.

2 Ibid.

Regulatory Framework

Federal

Federal Transit Administration (FTA). In 2018, the FTA published the Transit Noise and Vibration Impact Assessment Manual to aid in the estimation and analysis of vibration impacts. Typically, potential building and structural damages are the foremost concern when evaluating the impacts of construction-related vibrations. Table 1 summarizes FTA's vibration guidelines for building and structural damage. While these are reference values for vibration levels at 25 feet of distance, this analysis uses logarithmic equations to determine whether building damage would occur regardless of actual distance between construction activity and nearby buildings.

Table 1
FTA Vibration Damage Potential Threshold Criteria

Structure and Condition	Threshold Criteria (in/sec PPV) at 25 Feet
I. Reinforced-concrete, steel or timber (no plaster)	0.5
II. Engineered concrete and masonry (no plaster)	0.3
III. Non-engineered timber and masonry buildings	0.2
IV. Buildings extremely susceptible to vibration damage	0.12
Source: Federal Transit Administration "Transit Noise and Vibration Impact Assessment Manual", September 2018.	

The FTA Assessment Manual also cites criteria for cases where more detailed analysis may be required. For buildings consisting of concrete wall and floor foundations, masonry or concrete walls, or stone masonry retaining walls, continuous vibrations of 0.3 inches per second PPV can be damaging. For buildings consisting of steel or reinforced concrete, such as factories, retaining walls, bridges, steel towers, open channels, underground chambers and tunnels with and without concrete alignment, continuous vibrations of 0.5 inches per second PPV can be damaging.

State

California's Civil Code Section 832 protects adjacent properties when excavation of a site occurs.

> *Each coterminous owner is entitled to the lateral and subjacent support which his land receives from the adjoining land, subject to the right of the owner of the adjoining land to make proper and usual excavations on the same for purposes of construction or improvement, under the following conditions:*
>
> *1. Any owner of land or his lessee intending to make or to permit an excavation shall give reasonable notice to the owner or owners of adjoining lands and of buildings or other structures, stating the depth to which such excavation is intended to be made, and when the excavating will begin.*
>
> *2. In making any excavation, ordinary care and skill shall be used, and reasonable precautions taken to sustain the adjoining land as such, without regard to any building or other structure which may be thereon, and there shall be no liability for*

damage done to any such building or other structure by reason of the excavation, except as otherwise provided or allowed by law.

3. If at any time it appears that the excavation is to be of a greater depth than are the walls or foundations of any adjoining building or other structure, and is to be so close as to endanger the building or other structure in any way, then the owner of the building or other structure must be allowed at least 30 days, if he so desires, in which to take measures to protect the same from any damage, or in which to extend the foundations thereof, and he must be given for the same purposes reasonable license to enter on the land on which the excavation is to be or is being made.

4. If the excavation is intended to be or is deeper than the standard depth of foundations, which depth is defined to be a depth of nine feet below the adjacent curb level, at the point where the joint property line intersects the curb and if on the land of the coterminous owner there is any building or other structure the wall or foundation of which goes to standard depth or deeper then the owner of the land on which the excavation is being made shall, if given the necessary license to enter on the adjoining land, protect the said adjoining land and any such building or other structure thereon without cost to the owner thereof, from any damage by reason of the excavation, and shall be liable to the owner of such property for any such damage, excepting only for minor settlement cracks in buildings or other structures.

California Building Code (CBC) Section 3307 provides additional protection of adjoining property from damage during construction, remodeling, and demolition work. Protection must be provided for footings, foundations, party walls, chimneys, skylights, and roofs.

Caltrans has identified building damage significance guidance that provides thresholds for different categories of structures, including historic buildings that may not be considered extremely fragile (Table 2).

Table 2
Caltrans Vibration Damage Potential Threshold Criteria

Structure and Condition	Significance Thresholds (in/sec PPV)	
	Transient Sources	Continuous/ Frequent/ Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5
Source: California Department of Transportation, 2013. Transient noise is that whose average properties do not remain constant over time and are considered extremely short in duration (e.g., single gunshot)		

City of Carson. The Carson Municipal Code (CMC) governs construction-related vibration issues and public notification. CMC Section 9147.2 states that no use can create a disturbance to the surrounding area through vibration, noise, or other radiations. Section 12.08.560 limits the vibration from the operation of any device that creates vibration which is above the vibration perception threshold of any individual at or beyond the property boundary of the source if on private property, or at 150 feet (46 meters) from the source if on a public space or public right-of-way is prohibited. The perception threshold shall be a motion velocity of 0.01 in/sec over the range of 1 to 100 Hertz.

Methodology

Construction Vibration. Ground-borne vibration impacts during construction activities were evaluated for both on-site and off-site construction activities by identifying potential vibration sources (e.g., construction equipment), estimating the vibration levels at off-site structures, and comparing the proposed impacts against applicable vibration significance thresholds.

Operational Vibration. As with many non-industrial projects, the Proposed Project does not include land uses that would generate high levels of ground-borne vibration. Instead, any vibration related to operation of the Proposed Project would involve vehicle activity traveling to and from the Project Site. However, vibration from vehicle activities using rubber-tired wheels is unlikely to be perceptible by people. Rubber-tired vehicles traveling at a distance of 50 feet typically generate groundborne vibration of approximately 63.5 VdB.[3] The typical threshold of perception for groundborne vibration is approximately 65 VdB.[4] As such, operational impacts on ground-borne vibration are not analyzed further.

Threshold of Significance

Groundborne Vibration Thresholds. There are no adopted City standards or other applicable regulations that would govern the Project's vibration impacts. In assessing impacts related to noise and vibration in this section, the City uses Appendix G as the thresholds of significance. The FTA's criteria in its 2018 Transit Noise and Vibration Impact Assessment manual will be used where applicable and relevant to assist in analyzing the Appendix G thresholds. In addition, Caltrans' thresholds for historic buildings will be used when structures are not Category IV structures considered extremely susceptible to vibration damage.

Existing Conditions

Existing Ambient Vibration Levels

The Project Site is developed with five buildings that house commercial uses, including a used car facility and new car dealership. These commercial activities involve use of rubber-tiered vehicles and do not involve major equipment that can cause groundborne vibration.

[3] Federal Transportation Administration, Transit Noise and Vibration Impact Assessment Manual; Generalized Ground Surface Vibration Equations (Table 6-10); September 2018.

[4] Ibid.

The primary source of groundborne vibration near the Project Site is vehicle travel. For example, Avalon Boulevard carried 29,718 average daily vehicles at Carson Street in 2018.[5] The San Diego Freeway that flanks the eastern portion of the Project Site carried about 220,000 annual average daily trips at Avalon Boulevard in 2021.[6] The blend of passenger vehicles, trucks, delivery trucks, transit buses, and other light-, medium-, and heavy-duty vehicles generate minimal levels of vibration. As noted by federal guidance, "[i]t is unusual for vibration from sources such as buses and trucks to be perceptible…"[7] As such, vehicle movement generates imperceptible ground vibration, with the occasional exception of heavy-duty vehicles that travel over speed bumps, potholes, and other street irregularities.

There are several buildings near the Project Site that could be exposed to groundborne vibration during construction and operation of the proposed development that include:

- Residences, Garston Avenue; 75 feet south of the Project Site. These one- and two-story timber and stucco structures would be considered Category III structures (Non-engineered timber and masonry) under FTA guidelines. There are other adjacent buildings along 213th Street that are set back the same distance from the Project Site that would experience similar levels of groundborne vibration and generally are of similar construction.

- Bel-Aire Park mobile homes, 21425 Avalon Boulevard; 430 feet southwest of the Project Site. These one-story structures would be considered Category III structures (Non-engineered timber and masonry) under FTA guidelines.

- Residences, 213th Street; 720 feet west of the Project Site. These one- and two-story timber and stucco structures would be considered Category III structures (Non-engineered timber and masonry) under FTA guidelines.

Analysis of Project Impacts

a. Generation of excessive groundborne vibration or groundborne noise levels?

Less Than Significant Impact.

Construction

Building Damage Vibration Impact – On-Site Sources

Construction equipment can produce groundborne vibration based on equipment and methods employed. While this spreads through the ground and diminishes in strength with distance, buildings on nearby soil can be affected. This ranges from no perceptible effects at the lowest levels, low

[5] City of Carson Traffic Count Map, 2018; https://ci.carson.ca.us/content/files/pdfs/BusinessDev/demographics/Traffic_Count_Map.pdf .

[6] California Department of Transportation, Traffic Census Program 2021 data; https://dot.ca.gov/programs/traffic-operations/census.

[7] Federal Transit Administration, Transit Noise and Vibration Impact Assessment Manual, September 2018.

rumbling sounds and perceptible vibration at moderate levels, and slight damage at the highest levels. Table 3 summarizes vibratory levels for common construction equipment.

Table 3
Vibration Source Levels for Construction Equipment

Equipment	Approximate PPV at 25 feet (in/sec)
Pile Driver (impact)	0.644
Pile Drive (sonic)	0.170
Clam shovel drop (slurry wall)	0.202
Hydromill (slurry wall)	0.008
Vibratory Roller	0.210
Hoe Ram	0.089
Large Bulldozer	0.089
Caisson Drilling	0.089
Loaded Truck	0.076
Jackhammer	0.035
Small Bulldozer	0.003
Source: Federal Transit Administration, Transit Noise and Vibration Impact Assessment Manual, 2018.	

Groundborne vibration would be generated by a number of construction activities at the Project site. As a result of equipment that could include on-site bulldozer operations or the vibrational equivalent, vibration velocities of up to 0.017 inches per second PPV are projected to occur at the nearest structures. These impact is below the 0.20 in/sec PPV thresholds of significance for Category III structures. Other potential construction activities would produce less vibration and have lesser potential impacts on nearby sensitive receptors. As a result, construction-related structural vibration impacts would be considered less than significant.

Table 4
Building Damage Vibration Levels – On-Site Sources

Off-Site Receptor Location	Distance to Project Site (feet)	Vibration Velocity Levels at Off-Site Sensitive Receptors from Construction Equipment (in/sec PPV)					Significance Criterion (PPV)	Potentially Significant Impact?
		Large Bulldozer	Caisson Drilling	Loaded Trucks	Jack-hammer	Small Bulldozer		
FTA Reference Vibration Level (25 Feet)	N/A	0.089	0.089	0.076	0.035	0.003	--	--
Residences, Garston Ave.	75	0.017	0.017	0.015	0.007	0.001	0.20[a]	No
Bel-Aire Park Mobile Homes	430	0.001	0.001	0.001	0.000	0.000	0.20[a]	No
Residences - 213th St.	720	0.001	0.001	0.000	0.000	0.000	0.20[a]	No
[a] FTA criterion for Category III (non-engineered timber and masonry buildings) Source: DKA Planning, 2024.								

Building Damage Vibration Impact – Off-Site Sources

Construction of the Project would generate trips from large trucks including haul trucks, concrete mixing trucks, concrete pumping trucks, and vendor delivery trucks. Regarding building damage, based on FTA data, the vibration generated by a typical heavy-duty truck would be approximately 63 VdB (0.006 PPV) at a distance of 50 feet from the truck.[8] According to the FTA "[i]t is unusual for vibration from sources such as buses and trucks to be perceptible, even in locations close to major roads." Nonetheless, there are buildings along the Project's anticipated haul route on Avalon Boulevard that are situated away from the right-of-way and would be exposed to groundborne vibration levels of approximately 0.006 PPV. This estimated vibration generated by construction trucks traveling along the anticipated haul route(s) would be well below the most stringent building damage criteria of 0.12 PPV for buildings extremely susceptible to vibration. The Project's potential to damage roadside buildings and structures as the result of groundborne vibration generated by its truck trips would therefore be considered less than significant.

Operation

During operation of the mixed-use residential and commercial development, there would be no significant stationary sources of groundborne vibration, such as heavy equipment or industrial operations. Operational groundborne vibration in the Project Site's vicinity would be generated by its related vehicle travel on local roadways. However as previously discussed, road vehicles rarely create vibration levels perceptible to humans unless road surfaces are poorly maintained and have potholes or bumps. As a result, the Project's long-term vibration impacts would be less than significant.

8 Federal Transit Administration, "Transit Noise and Vibration Impact Assessment," May 2006, Figure 7-3.

TECHNICAL APPENDIX

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21212 Avalon Boulevard Project

Construction Vibration

Receptor: Residences - Garston Avenue
Equipment: Large Bulldozer, Auger Drill Rig

Source PPV (in/sec)	0.089
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	75
Vibration Level (in/sec)	**0.017**

Receptor: Residences - Garston Avenue
Equipment: Loaded Trucks

Source PPV (in/sec)	0.076
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	75
Vibration Level (in/sec)	**0.015**

Receptor: Bel-Aire Park Mobile Homes
Equipment: Large Bulldozer, Auger Drill Rig

Source PPV (in/sec)	0.089
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	430
Vibration Level (in/sec)	**0.001**

Receptor: Bel-Aire Park Mobile Homes
Equipment: Loaded Trucks

Source PPV (in/sec)	0.076
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	430
Vibration Level (in/sec)	**0.001**

Receptor: Residences, 213th Street
Equipment: Large Bulldozer, Auger Drill Rig

Source PPV (in/sec)	0.089
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	720
Vibration Level (in/sec)	**0.001**

Receptor: Residences, 213th Street
Equipment: Loaded Trucks

Source PPV (in/sec)	0.076
Reference Distance (ft)	25
Ground Factor (N)	1
Distance (ft)	720
Vibration Level (in/sec)	**0.003**

21212 Avalon Boulevard Project

Receptor: Residences - Garston Avenue
Equipment: Small Dozer-Type Equipment

Source PPV (in/sec)	0.003
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	75
Vibration Level (in/sec)	**0.001**

Receptor: Residences - Garston Avenue
Equipment: Jackhammer

Source PPV (in/sec)	0.035
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	75
Vibration Level (in/sec)	**0.007**

Receptor: Bel-Aire Park Mobile Homes
Equipment: Small Dozer-Type Equipment

Source PPV (in/sec)	0.003
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	430
Vibration Level (in/sec)	**0.000**

Receptor: Bel-Aire Park Mobile Homes
Equipment: Jackhammer

Source PPV (in/sec)	0.035
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	430
Vibration Level (in/sec)	**0.000**

Receptor: Residences, 213th Street
Equipment: Small Dozer-Type Equipment

Source PPV (in/sec)	0.003
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	720
Vibration Level (in/sec)	**0.000**

Receptor: Residences, 213th Street
Equipment: Jackhammer

Source PPV (in/sec)	0.035
Reference Distance (ft)	25
Ground Factor (N)	1.5
Distance (ft)	720
Vibration Level (in/sec)	**0.000**

Sources

California Department of Transportation (Caltrans), *Transportation and Construction Vibration Guidance Manual*,
Federal Transit Administration (FTA), *Transit Noise and Vibration Impact Assessment*, September 2018