Appendix H Vibration Damage Risk Assessment

FINAL
Vibration Damage Risk Assessment to the Oakville Grocery During Intersection Construction and Roadway Reconstruction for the SR-29 Intersections Improvement Project
04-NAP-29-22.72/24.59
EA 04-2W430
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INTRODUCTION

Under the proposed project, the intersections of Oakville / SR-29 and Rutherford / SR-29 modification will require construction of additional pavement and reconstruction of existing pavement. The construction limits will extend beyond the intersection area and will impact a stretch of the local street as well as SR-29 and SR-128. The closest structure that would be affected by the construction activities is the Oakville Grocery. This building is a wood frame and masonry structure. It is expected that the nearest construction activities to the Oakville Grocery structure is 10 feet.

Anticipated construction activities include:

1. Earthwork
    - Demolition / Clear and Grubbing
    - Excavation, Grading and Compaction
    - Drainage
    - Subgrade finishing
2. Pavement
    - Application of Binder and Slurry Seal
    - Asphalt Pavement placement and Compaction
    - Placement of Final Finishing Pavement
3. Roadway Pavement Delineation and Signage
    - Application of Paint Stripes on the Finished surface
    - Installation of Signage
        - Deep Foundation for Larger Signs and Traffic Control Related Equipment

CONSTRUCTION ACTIVITIES & CONSTRUCTION EQUIPMENT

Roadway Excavation

Roadway construction projects utilize heavy-duty machinery. The general activities include demolition and removal of the excavated material, grading, spreading of material, and compacting. It is expected that the following construction vehicles typical to roadway excavation work would be used:

- Dump trucks
- Bulldozers
- Excavators
- Trucks
- Graders
- Rollers

- Loaders
- Scrappers
- Pavement Saw cutter
- Trenching Equipment

Base Preparation and Pavement Placement

Prior to placement of Asphalt Concrete, base materials will be placed in layers over compacted subgrade. Base material will be gravel and hauled to the project site, spread, and then compacted in layers to meet the Caltrans requirements. Typically, prior to placement of the Asphalt Concrete, pavement binders/slurry seal will be applied over base material. Asphalt Concrete is then placed in thin layers and compacted. Both base material and Asphalt Concrete will be delivered to the project site by trucks. The conform areas along the existing pavement will require to be ground / cold [planed and removed. Anticipated work vehicles to be used during construction include:

- Trucks
- Spreader
- Pavement Screed
- Roller
- Cold Planers (Pavement grinding)

Concrete work – Curb, Gutter, Sidewalk, and Hardscape

The project includes construction of curb, gutter, sidewalk, and hardscape. The concrete will be delivered to the project site by concrete trucks. Project site will also include concrete washout areas for proper disposal of excess concrete. The work to construct concrete features will typically include:

- Minor Excavation / Demolition
- Forming
- Placement of Concrete
- And finishing

The typical work equipment include:

- Mini Excavators
- Compactors
- Concrete Trucks

Vibration Model

The FTA analytical/empirical construction vibration prediction model was used to estimate vibration level propagation from construction equipment to vibration-sensitive locations. The vibration model is based on a combination of previous works, including measured equipment vibration emission data from several reference sources and projects, including the FTA's Guidance Manual, and the Central Artery/Tunnel Project in Boston. The fundamental equation used in the model is based on propagation relationships of vibration through average soil conditions and distance, as follows:

$$PPV_{receiver} = PPV_{ref} \times (25/Dist_{receiver})n$$

where:

$PPV_{receiver}$ = predicted PPV at the receiver

PPV_{ref} = reference PPV of equipment at 25 feet

$Dist_{receiver}$ = distance from the receiver to the equipment in feet

n = 1.5 (the vibration attenuation rate through the soil)

Where PPV = peak particle velocity.

Short-term annoyance from vibration during construction is not a NEPA-significant impact. In most cases, the primary concern regarding construction vibration relates to potential damage effects to structures. To satisfy NEPA requirements, the potential for damage to structures associated with construction vibration has been assessed using FTA vibration damage criteria as shown in Table 1.

The suggested value for “n” in the FTA Guidance Manual is 1.5. The value for “n” can lie between 1.0 and 2.0, and a value of 1.5 is commonly used in general vibration prediction models for distances less than 100 feet. Equipment vibration emission levels used for the predictions are shown in Table 2. As additional guidance for the contractor, the distance beyond which the damage risk criteria would not be exceeded is presented in Table 3 for building category III, damage risk criteria of 0.2 in/sec (PPV) which is protective of the most fragile buildings such as the Oakville Grocery.

Table 1. Construction Vibration Damage Risk Criteria

Building Category		PPV (inches / second)
I.	Reinforced-concrete, steel, or timber (no plaster)	0.5
II.	Engineered concrete and masonry (no plaster)	0.3
III.	Historic buildings that have average sensitivity to vibration damage and non-engineered timber and masonry buildings	0.2
IV.	Buildings extremely susceptible to vibration damage	0.12

Source: FTA, 2018
Note: PPV = peak particle velocity

Table 2. Equipment Vibration Emission Levels

Equipment	Vibration Level at 25 feet (in/sec PPV)
Large Bulldozer	0.089
Caisson Drilling	0.089
Jack Hammer	0.35
Loaded Truck	0.076
Vibratory Roller	0.210

Source: FTA, 2018

Table 3. Construction Vibration Levels at Distance to 0.20 in/sec PPV Impact Threshold

Equipment	Vibration Level at 25 feet	Distance to FTA Building Impact Category III of 0.20 in/sec PPV (feet)
Backhoe	0.028	7
Bulldozer	0.089	15
Concrete Mixer	0.076	13
Concrete Pump	0.076	13
Excavator	0.175	23
Front End Loader	0.0866	15
Grader	0.0867	15
Jackhammer	0.350	35
Paver	0.076	13
Vibratory Roller	0.21	26

Note: Damage risk criteria of 0.20 in/sec PPV for well-constructed historic buildings.

The limit of 0.12 in/sec for fragile historic structures is among the most restrictive limits used for vibration damage risk to buildings. A damage risk criterion of 0.2 in/sec (PPV) would be protective of most fragile buildings, such as the Oakville Grocery structure.

Construction activities within 10 feet of the Oakville Grocery structure would exceed the damage risk criteria of 0.20 PPV during the use of most of the equipment in Table 3, including the following: bulldozers, excavators, front end loaders, jack hammers, pavers, and vibratory rollers. The use of this equipment would need to be restricted to distances of more than 20 feet from the Oakville Grocery building.

To minimize potential impacts, the following Caltrans Standard Specifications would be implemented:

14-8.06 Photo and Video Documentation

A pre-construction photo survey/video survey of the Oakville Grocery structure would be completed to document exterior and interior conditions of the structure. In the event of

potential concerns regarding vibration induced damage to the structure by the property owner during construction, this photo documentation will serve as a point of comparison.
14-8.04 Crack Monitoring

Prior to construction the Contractor shall also prepare a Geotechnical Instrumentation and Monitoring Plan to protect the Oakville Grocery structure from excessive vibration. The purpose of the Plan is to:

- Document the pre-construction baseline data of building and slab cracks and ground movements with for comparison with construction and post-construction data;
- Furnish, install, and maintain crack monitoring gages.
- Provide reliable information for the Project Engineer to assess construction-induced adverse impacts imparted on Oakville Grocery structure;
- Permit timely implementation of appropriate remedial measures, when and as required, to mitigate construction-induced adverse impacts imparted to the Oakville Grocery structure;
- Accommodate timely warnings of conditions that may require modifications (i.e., changes) to the Contractor's construction "means and methods" or implementation of remedial or precautionary measures, during performance of the Work, to mitigate construction-induced adverse impacts; and

Document the extent and the magnitude of construction-induced adverse impacts.
14-8.03 Vibration Monitoring

Before construction begins the Contractor shall prepare a Vibration Control Plan (VCP) prior to construction starting. Vibration levels are calculated at the closest face of the Oakville Grocery building to the roadway and compared with the damage risk criteria 0.20 in/sec PPV. If the damage risk criteria are exceeded, vibration control measures will be identified and implemented as required.

The Contractor shall also prepare a Vibration Monitoring Plan specifying construction activities, monitoring locations, equipment, procedures, schedule of measurements and reporting methods to be used. Submit vibration monitoring data collected during the previous week to Residence Engineer on a weekly basis. Contractor's Acoustical Engineer shall review all data prior to submitting to Residence Engineer. Weekly reports shall indicate whether the vibration monitoring data exceeds the damage risk criteria of 0.20 in/sec PPV allowable limits. If exceeded the activity causing the exceedance and shall be immediately halted. Work on that activity shall be suspended until such time as an alternative construction method can be used and additional Abatement Measures can be implemented as specified in the Vibration Control Plans.

If the damage risk criteria are exceeded, the Contractor shall use all reasonable efforts to implement vibration reduction methods such as those listed below to minimize construction-induced vibration levels.

1. Use of alternative construction methods that produce less vibration.
2. Limiting the number and duration of equipment working on site.
3. Filling potholes and/or grinding paved roadway surfaces smooth in order to minimize truck passby-induced vibrations.

4. Scheduling of construction events and limiting usage times to minimize disruption from vibrations, especially near the Oakville Grocery building.