Vibration Impact Analysis in Ponce de León Avenue of Phase IV

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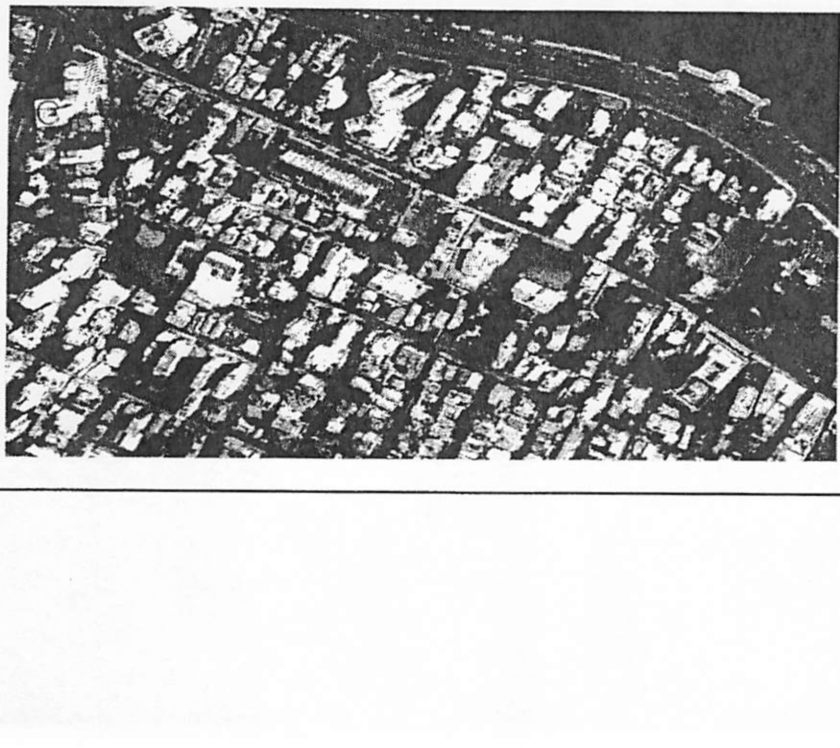
Objective

- **Investigate the vibration impact due to Tren Urbano in the Ponce de León Avenue corresponding to Phase IV.**



Basic Concepts

Definitions

Ground-borne vibration

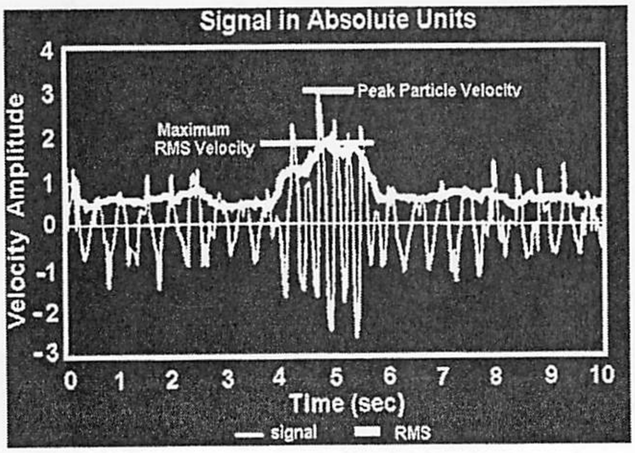
- **oscillatory motion transmitted through ground into buildings**
- **caused by trains, buses, construction activities, pile driving and operating heavy earth-moving equipment**
- **described in terms of:**
  - ***displacement* (inches)**
  - ***velocity* (inches per second)**
  - ***acceleration* (inches per second per second)**

Ground-borne noise

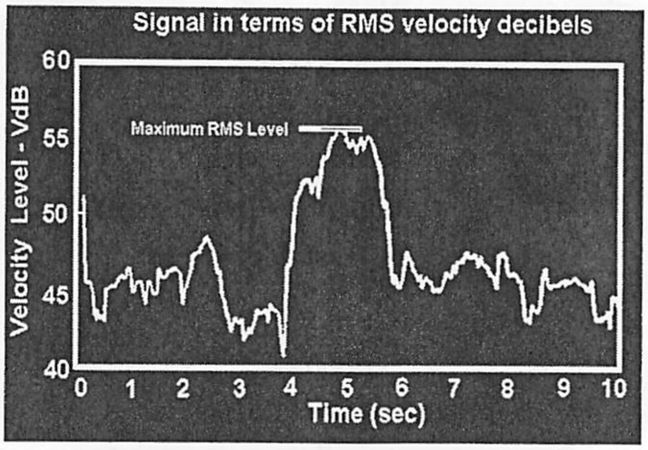
- **sound generated by shaking of walls, ceilings and floors**

Basic Concepts

Amplitude Descriptors

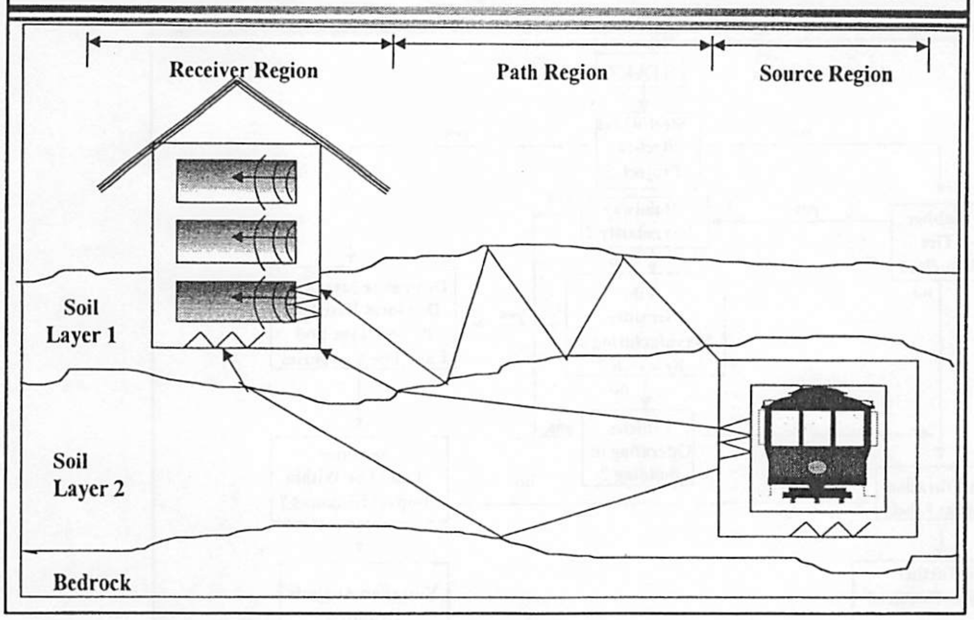


Basic Concepts
Amplitude Descriptors



$$L_V = 10\ \log_{10}\left(\frac{V^2_{rms}}{V_{ref}^{\,2}}\right)\ ;\ V_{ref} = 1\times10^{-6}\ \frac{in}{sec}$$

Basic Concepts
Propagation of ground-borne vibration into buildings



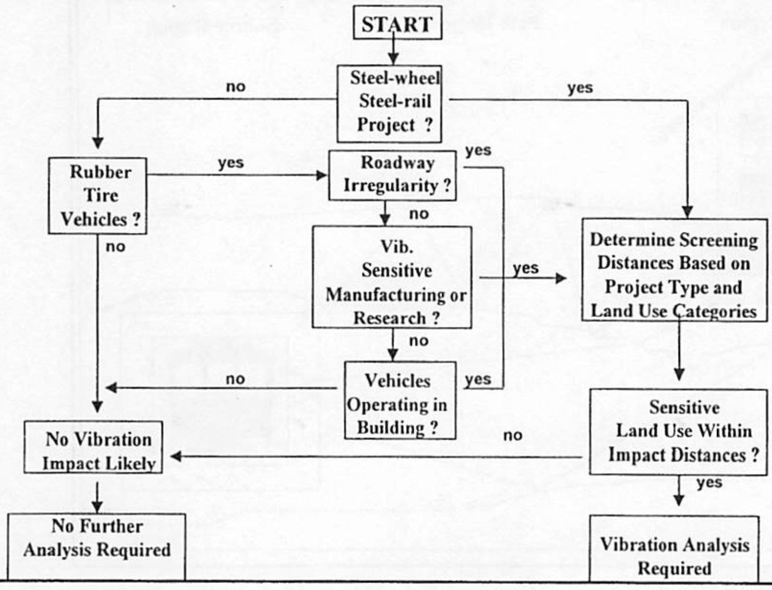
Factors that influence vibration levels

Source
- vehicle suspension
- wheel type and condition
- track / roadway surface
- track support system
- speed
- transit structure
    * at-grade
    * elevated
    * subway
- depth of vibration source

Path
- soil type
- rock layers
- soil layering
- depth of water table
- frost depth

Receiver
- foundation type
- building construction
- acoustical absorption

Vibration Screening Procedure



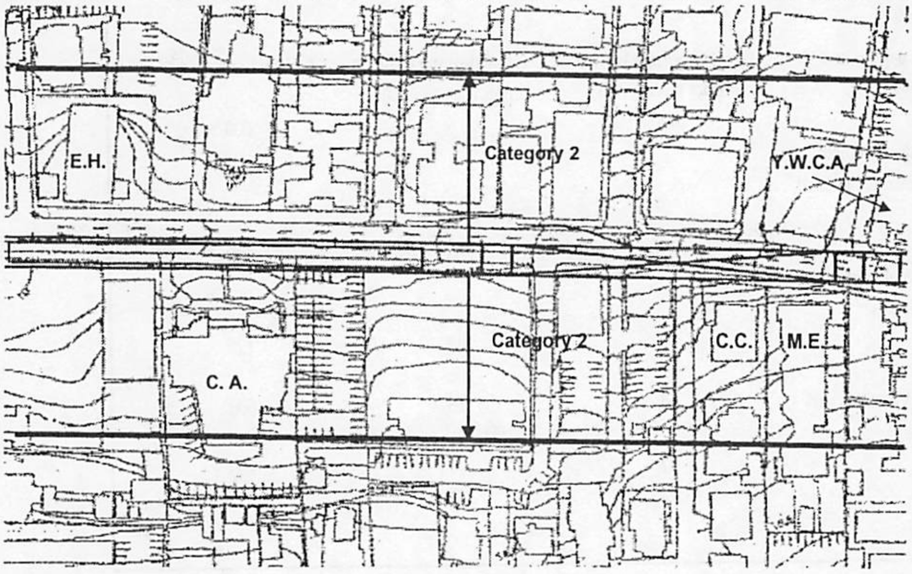
Vibration Impact Criteria

Land use category and special buildings	Ground-borne vibration impact levels (VdB)	Ground-borne noise impact levels (dB)	Critical Distance (ft)
Category 1 Buildings where low ambient vibration is essential for internal operations	65	–	600
Category 2 Residences and buildings where people normally sleep	72	35	200
Category 3 Institutions	75	40	120
Concert Halls, TV studios and recording studios	65	25	600
Auditoriums	72	30	200
Theathers	72	35	200

General Vibration Assessment

- **Select appropriate generalized ground surface vibration curve**
- **Apply source adjustment factors**
- **Apply path adjustment factors**
- **Apply receiver adjustment factors**

Case study: Ponce de León Avenue
Screening Procedure

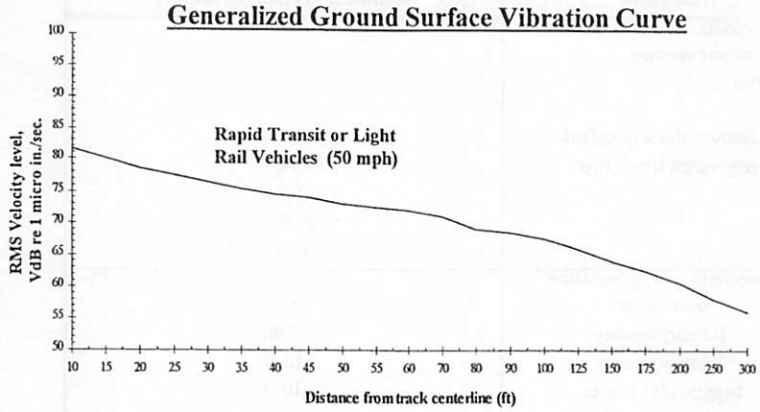


Case Study: Ponce de León Avenue
General Vibration Assessment

- Source
  - heavy rail
  - primary suspension:chevron springs
  - crossovers
  - welded rail
  - speed: 50 mph (13 mph at station)
  - bored subway tunnel
- Path :
  soil type: fine sand
- Receiver
  - categories 2 & 3
  - large masonry buildings

Case Study: Ponce de León Avenue

General Vibration Assessment



Adjustment factors to generalized vibration curve

Source Factor	Adjustment to Propagation Curve
Speed	+20 $\log_{10}$ (speed / speed$_{ref}$) dB
Vehicle with stiff primary suspension	+8 dB
Resilient wheels	0 dB
Worn wheels or wheels with flats	+10 dB
Worn or corrugated Track	+10 dB
Crossovers and other special trackwork	+10 dB
Jointed rail track	+5 dB
Floating slab track bed	-15 dB
Ballast mats	-10 dB
High resilience fasteners	-5 dB
Resiliently supported ties	-10 dB
Type of transit structure	
At-grade	0 dB
Open cut	0 dB
Elevated structure	-10 dB
Bored subwaytunnel	0 dB
Cut & cover subway	-3 dB
Subway station	-5 dB
Rock-based subway	-15 dB

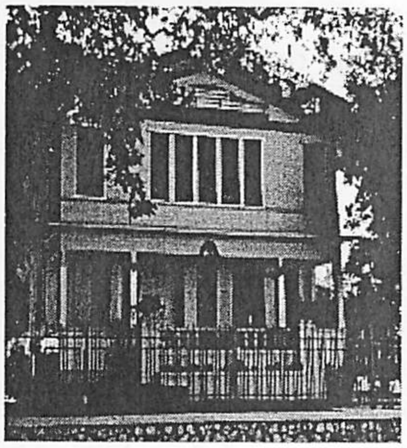
Adjustment factors to generalized vibration curve

Path Factor	Adjustment to Propagation Curve
Geologic conditions that promote efficient vibration propagation shallow bedrock or stiff soil propagation in rock layer :	 +10 dB +2 dB @ 50 ft +4dB @ 100 ft +6 dB @ 150 ft +9 dB @ 200 ft
Coupling to building foundation wood frame 1-2 story masonry 2-4 story masonry large masonry on piles large masonry on spread footings foundation in rock	 -5 dB -7 dB -10 dB -10 db -13 dB 0 dB

Adjustment factors to generalized vibration curve

Receiver Factor	Adjustment to Propagation Curve
Floor-to-floor attenuation 1-5 floors above grade 5-10 floors above grade	 -2 dB/floor -1 dB/floor
Amplification due to floor, wall and ceiling resonances	+6 dB
Radiated Sound Peak frequency of ground vibration: Low frequency (< 30 Hz) Typical (30-60 Hz) High frequency (> 60 HZ)	 -50 dB -35 dB -20 dB

General Vibration Assessment Example:
Centro Cultural Ramón Aboy Miranda



- Lv = 72 VdB at 60.8 ft for 50 mph
- Speed adjustment : +20 $\log_{10}$ (speed / speedref) = +20 $\log_{10}$ (50 / 50) = 0 dB
- Source adjustment : crossovers (+10 dB)
  bored subway (0 dB)
- Path adjustment : 2 story mansory (-7 dB)
- Receiver adjustment : amplification (+6 dB)
- Radiated sound adjustment = -50 dB
- Adjusted Lv = 72 +10 + 0 - 7 + 6 = 81 VdB
- Ln = 81 - 50 = 31dB

For category 3, vibration impact level = 75 VdB

Vibration Impact : Yes

Case Study: Ponce de León Avenue
Results

Building	Station No. / Cat.	Vertical Distance (m)	Horizontal Distance (m)	Diagonal Distance (m)	Diagonal Distance (ft)
Excelsior Hotel	304+25 / 2	14.8	13.0	19.7	64.6
Colegio deAbogados	303+79 / 3	14.2	21.0	25.4	83.1
Lourdes Chapel	307+26 / 3	12.6	10.0	16.1	52.8
Centro Cultural Ramón Aboy Miranda	302+22 / 3	15.6	10.0	18.5	60.8
Y.W.C.A.	301+52 / 3	17.5	9.0	19.7	64.5
Miramar Embassy	301+84 / 2	16.6	9.0	18.9	61.9

Building	Curve Value (VdB)	Adjusted Value (VdB)	Ground-borne Noise (dB)	Impact
Excelsior Hotel	71	43.3	0	No
Colegio deAbogados	69	51.3	1.3	No
Lourdes Chapel	73	72	22	No
Centro Cultural Ramón Aboy Miranda	72	81	31	Yes
Y.W.C.A.	72	81	31	Yes
Miramar Embassy	72	73	23	Yes

Case Study: Ponce de León Avenue
Conclusions

- **There is not impact in the buildings near the station due to:**
  - **- low speed**
  - **- thicker wall of the station**
- **The impact will be higher in the buildings near the crossover.**