In-Service Tests of the Effectiveness of Vibration Control Measures on the BART Rail Transit System

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Typical Section of Corridor
Test Sites, Existing Mitigation Measures

- Hayward Test Track (At-Grade Ballast & Tie)
Test Sites, Existing Mitigation Measures

- Hayward Test Track (At-Grade Ballast & Tie)
- Concord At-Grade Floating Slab
Test Sites, Existing Mitigation Measures

- Hayward Test Track (At-Grade Ballast & Tie)
- Concord At-Grade Floating Slab
- Balboa Park (“Egg” Fasteners)

- San Francisco Airport Extension
  - Direct fixation
  - Resiliently Supported Ties (LVT)
  - Continuous Pour Floating Slab
Test Procedures

- Line of impact locations along existing or future rail centerline
  - Accelerometers or geophones
  - Ground surface transducers (typically at distances of 0, 12.5, 25, 37.5, 50, 75 and 100 ft from near track centerline)
- Impact Device
Test Procedures
\[ L_V = FD_{Line} + TM_{Line} \]
Velocity Levels, At-Grade Track

![Graph showing velocity levels at different frequencies for Hayward Test Track and Concord Floating Slab with test track lengths of 28 ft, 57 ft, and 107 ft.](image)
Transfer Mobility, At-Grade Track

![Graph showing Line Source Transfer Mobility vs. 1/3 Octave Band Center Frequency for Hayward Test Track and Concord Floating Slab]
Insertion Loss, At-Grade Floating Slab

The graph illustrates the Insertion Loss in decibels (dB) for Ballast & Tie minus Floating Slab across different 1/3 Octave Band Center Frequencies in Hz.
Subway Average Vibration Levels

![Graph showing RMS vibration levels over frequency bands for different track types and distances.](image_url)
Ground Surface Vibration, Subway Floating Slab

![Graph showing RMS vibration velocity level in dB re 1 μm/sec versus 1/3 octave band center frequency in Hz. The graph compares two groups: Group 1 with 25 ft and 100 ft, and Group 2 with 25 ft and 100 ft.]
Relative Ground Surface Vibration

Vibration Difference, SFO Subway
(Floating Slab minus Direct Fixation)

Difference, dB

1/3 Octave Band Center Frequency, Hz
Relative Vibration, SFO Subway Direct Fixation and LVT Track
Balbao Open Cut, Illustration of Effects of Corrugation
NB = Egg Fasteners, SB = DF Fasteners

Vibration caused by 1.5 to 2 inch rail corrugation

RMS Vib. Velocity Level, VdB re 1μin/sec
1/3 Octave Band Center Frequency, Hz

- 9 ft, SB
- 9 ft, NB
- 58.5 ft, SB
- 58.5 ft, NB
Conclusions, Effectiveness of Vibration Mitigation Measures

• Floating slab track sections are functioning largely as designed
• LVT track is not providing additional vibration benefits
• Egg fasteners in the Balboa Park area may reduce vibration 5 to 8 dB at frequencies greater than 25 to 30 Hz
Conclusions, Vibration Mitigation for San Jose Extension

• Achieving vibration design standards in San Jose corridor will be difficult
• Ballast mats and floating slabs with resonance frequencies greater than 12 Hz could increase overall vibration levels
• Other approaches may be necessary…
Other Approaches

• Shredded Tire Underlay
• WIB (Wave impedance block)
• Straighter track
• to be determined