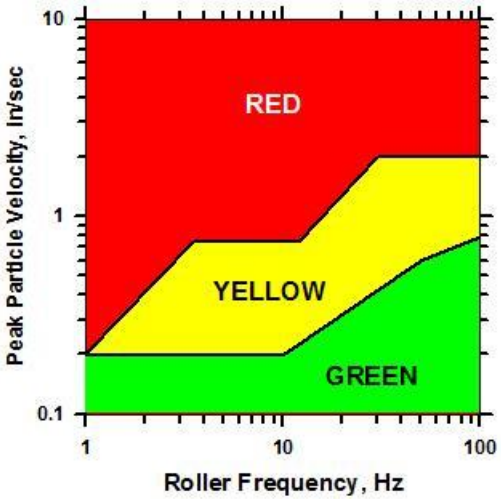


Identifying Vibration Sensitive Work Zones

About The Research

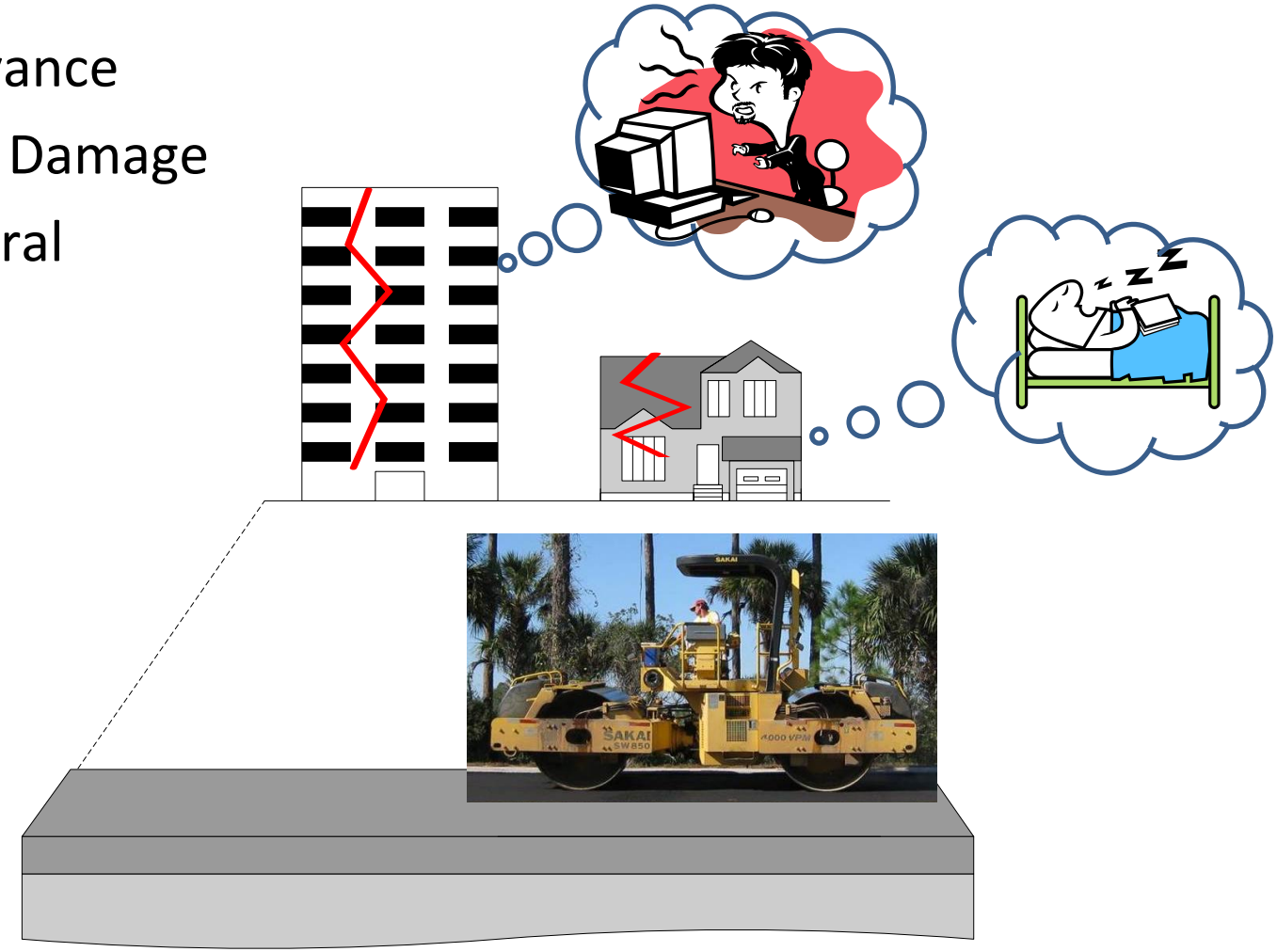
- FDOT Grant No. BDB-11
- Report Title
  - ✓ Use of Nondestructive Techniques to Estimate the Allowable Vibratory Compaction Level During Construction.
- Authors
  - ✓ N. Mike Jackson, Ph.D., P.E., University of North Florida
  - ✓ Michael Hammons, Ph.D., P.E., Applied Research Associates.
  - ✓ Robert Walker, Applied Research Associates.
  - ✓ Harold Von Quintus, P.E., Applied Research Associates.
- Research Report Available Online at
  - ✓ http://www.dot.state.fl.us/research-center/Completed_StateMaterials.htm

Background

- Asphalt Density
  - ✓ Critical for Pavement Performance
  - ✓ Quality Control Criteria for Hot Mix Asphalt
- Compaction of Asphalt
  - ✓ Static Rollers
  - ✓ Vibratory Rollers – Construction Vibration

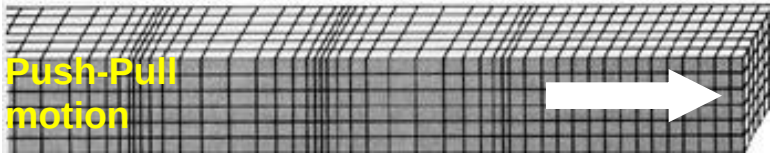
Construction Vibration

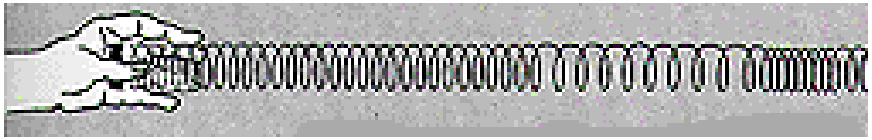
- Human Annoyance
- Infrastructure Damage
  - ✓ Architectural
  - ✓ Structural



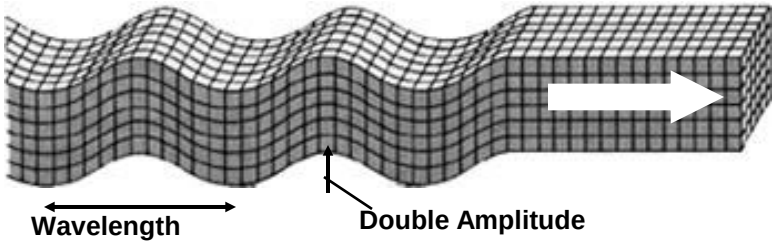
Types of Waves

P-Wave or Compression Wave (Seismic Body Wave)

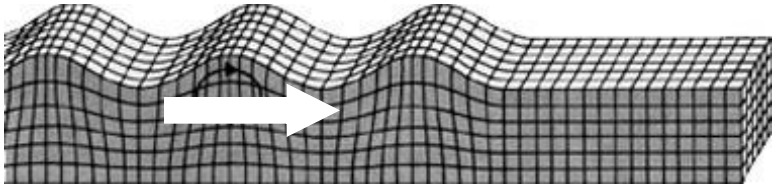




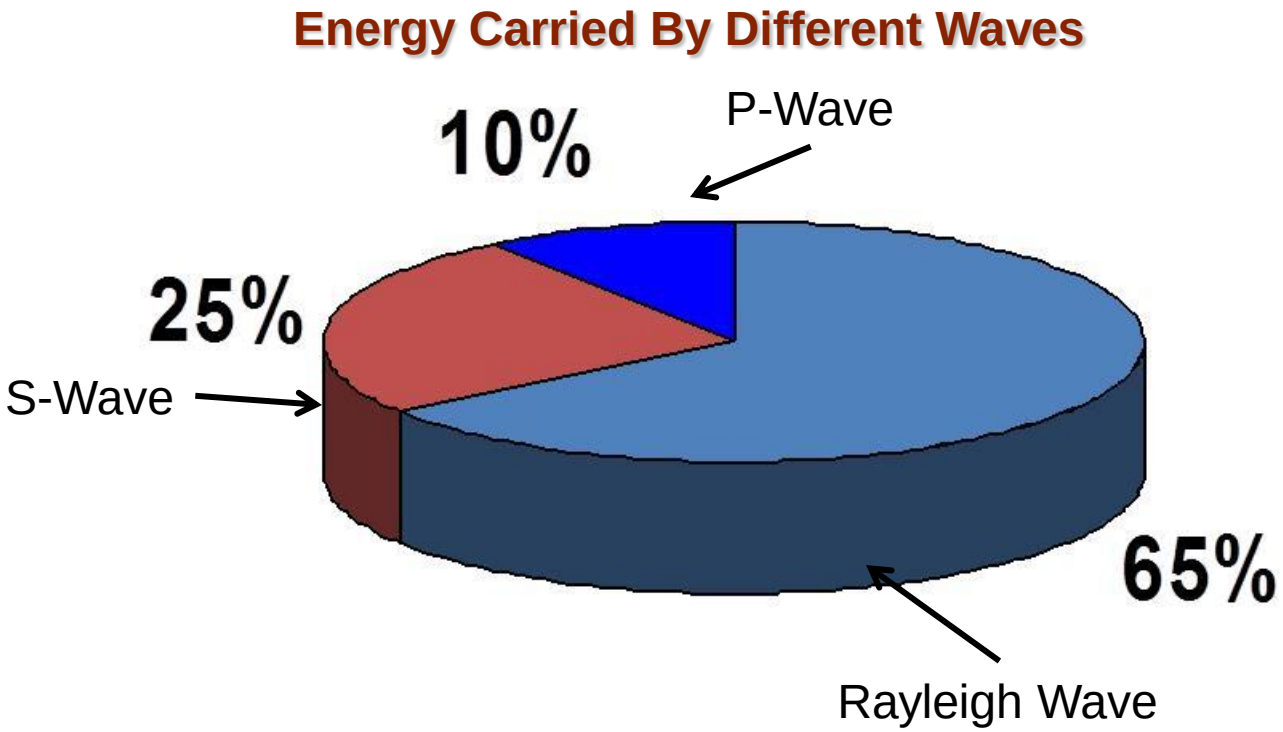
S-Wave or Shear Wave (Seismic Body Wave)



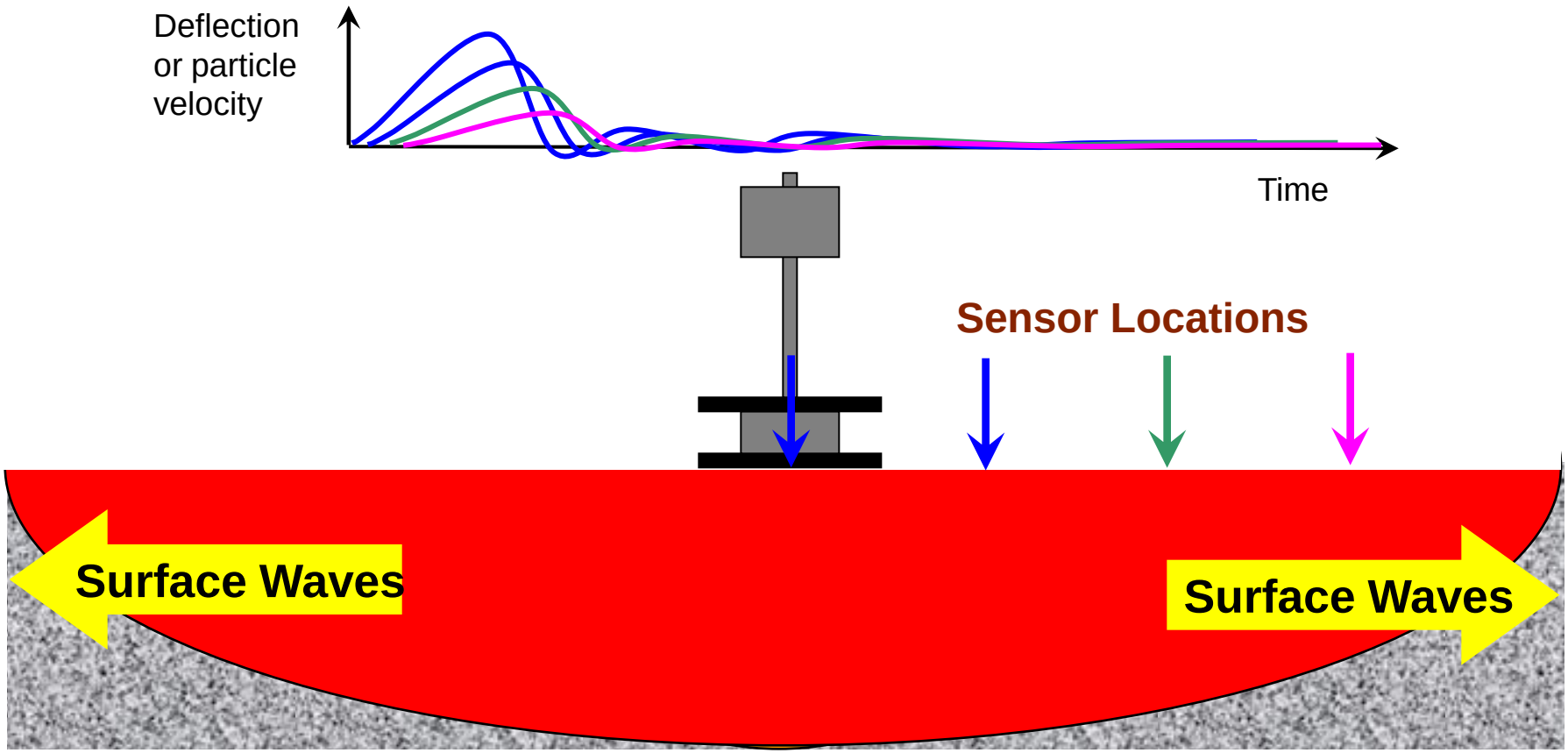
Rayleigh or Surface Wave (Seismic Surface Wave)



Construction Induced Vibrations



Falling Weight Deflectometer



FWD vs. Roller

- Falling Weight Deflectometer
  - Impact Load (Falling weight)
  - Peak load range: 1.5 to 27 kips
  - Typical peak load magnitude = 9 kips
- Vibratory Roller
  - Continuous vibration
  - Operating weight range: 3 to 30 kips
- Both induce ground vibration!

Identification of Vibration Sensitive Areas

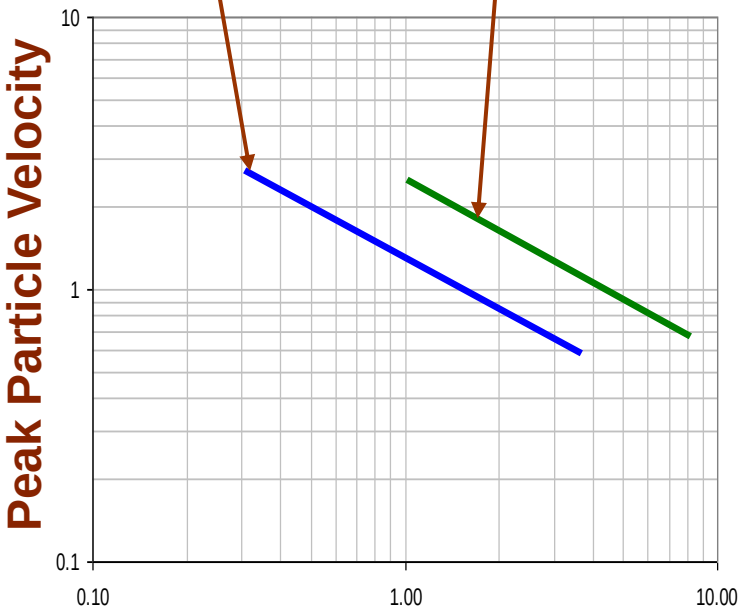
- A practical methodology for identifying vibration sensitive areas
  - Vibratory compaction not recommended
- Use FWD time histories to predict the ground oscillation from vibratory rollers

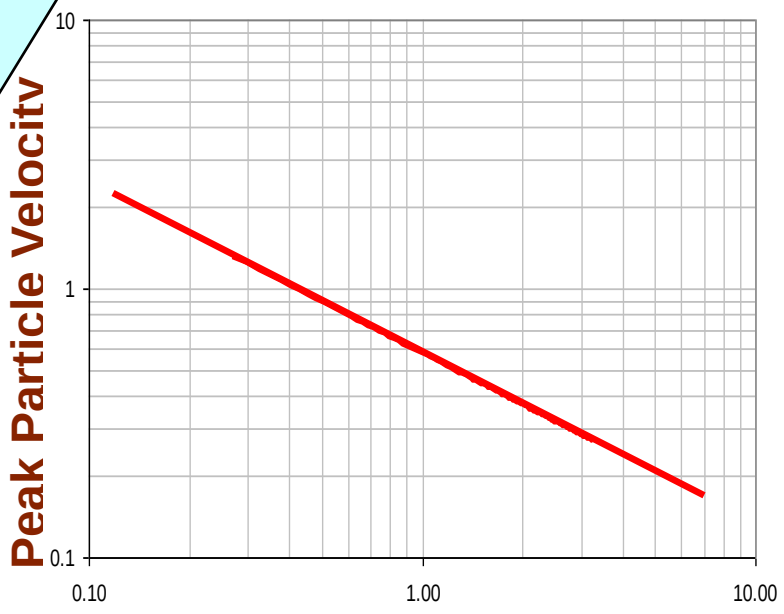
Vibration Descriptor

- Peak Particle Velocity (PPV)
  - ✓Correlates well with damage and complaints
  - ✓Particle movement is mostly in vertical direction
  - ✓Measured by Falling Weight Deflectometer

Prediction of Ground Motion

Normalize the distance by the square root energy scaling law





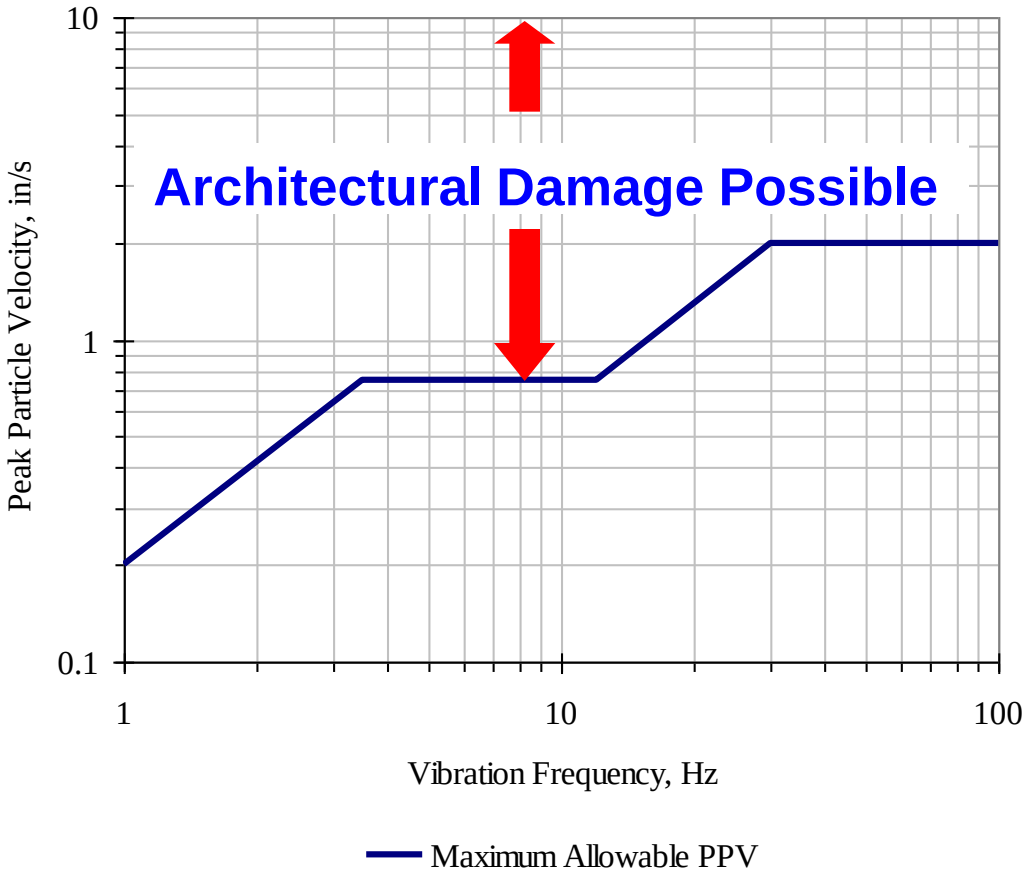
Ground Motion Predictor Curve

- Upper 95% Confidence Interval of curve fitted through FWD data

Vibration Criteria

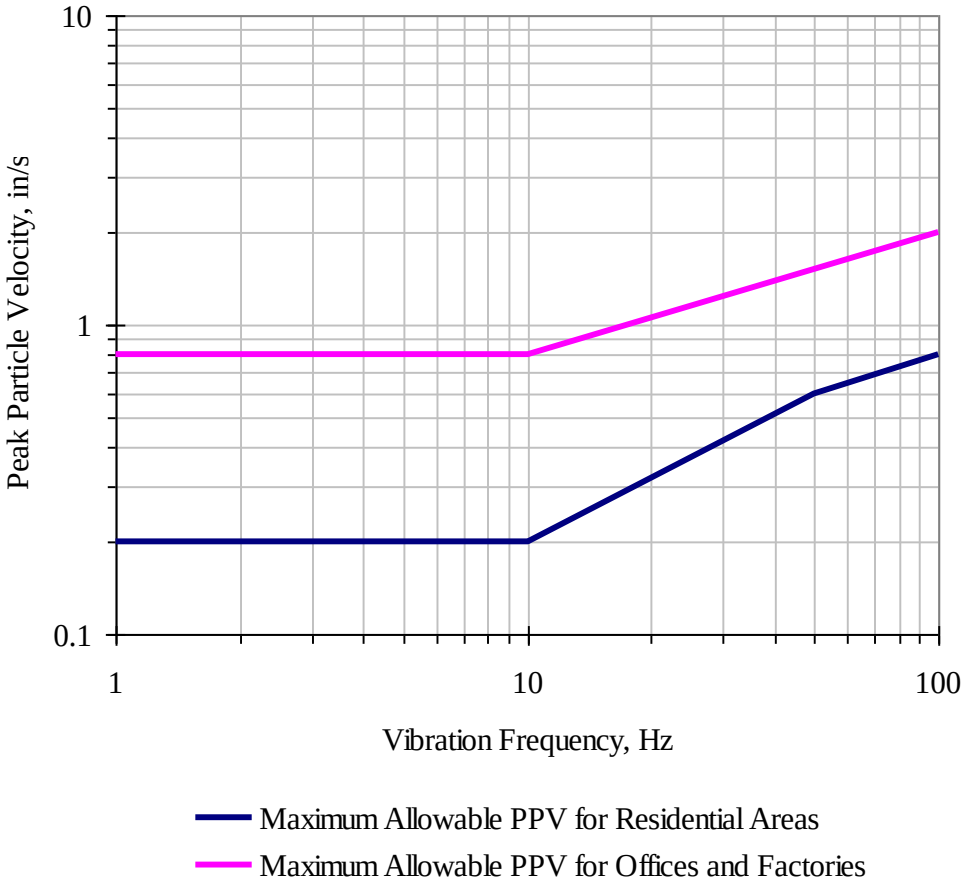
- Human perception
  - Subjective; depends upon individuals and circumstances
- Human annoyance
  - Subjective; uncomfortable for some individuals
- Architectural damage
  - Superficial damage such as hairline cracks in plaster
- Structural damage
  - Cracking in foundation, separation of masonry blocks, etc.

Office of Surface Mines – US Bureau of Mines



- Based on Architectural damage of low-rise residential structures
- Most often cited criteria
- Used by FDOT for pile driving

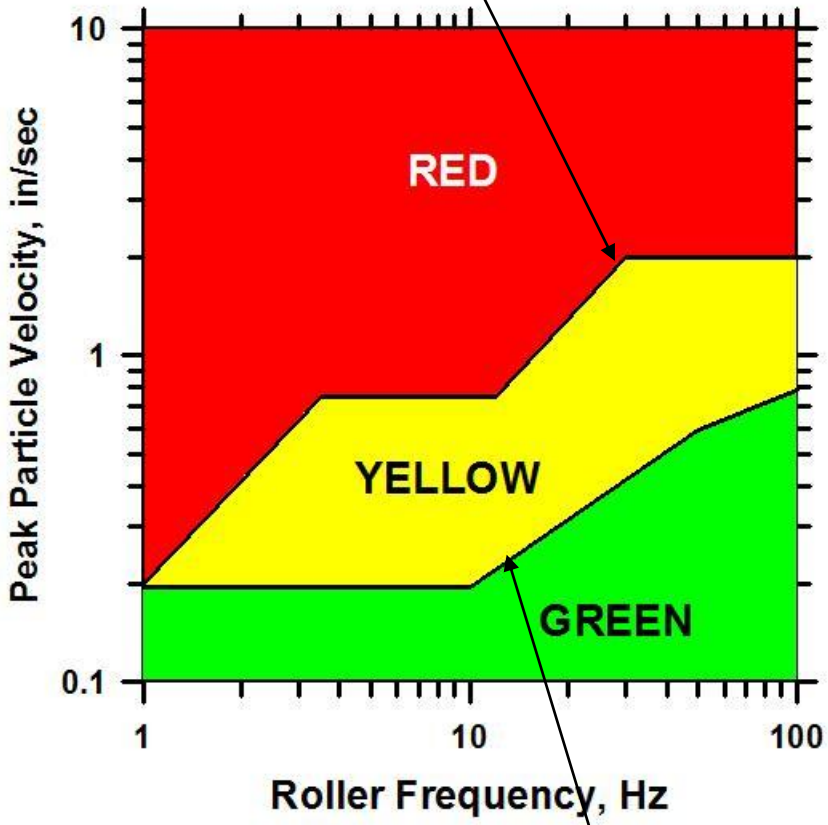
DIN 4150 (Germany)



- Based on human annoyance
- Recognizes two settings:
  - Offices and factories
  - Residencial areas

Criteria Adopted by FDOT

US OSM Criteria

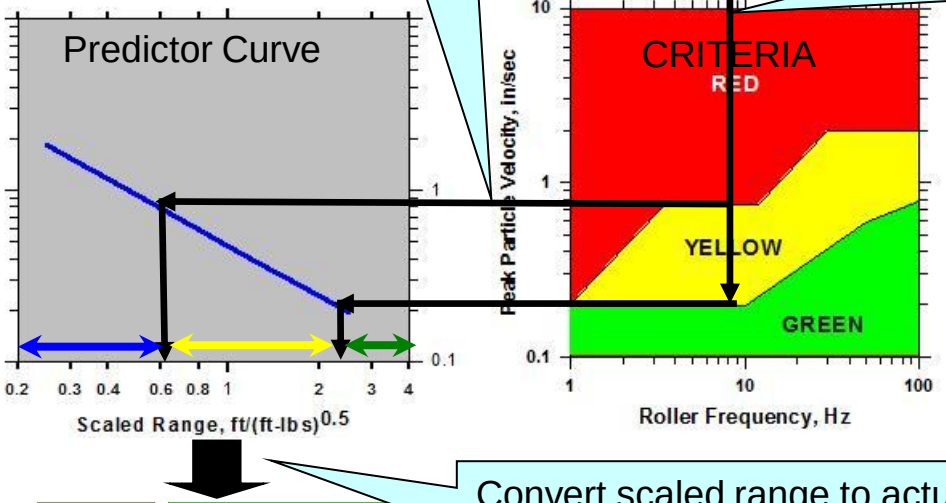


German DIN 4150 Criteria

- Red – Architectural damage possible
- Yellow – People may be annoyed, but architectural damage unlikely
- Green - People may perceive vibration, but annoyance is unlikely

Analysis Procedures

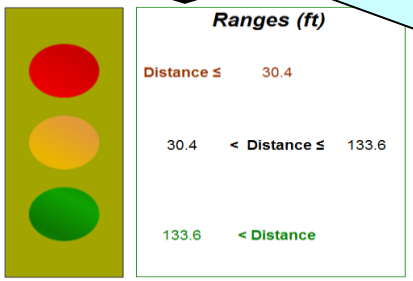
Use FWD to characterize site



Obtain PPV threshold

Operating Frequency of vibratory roller

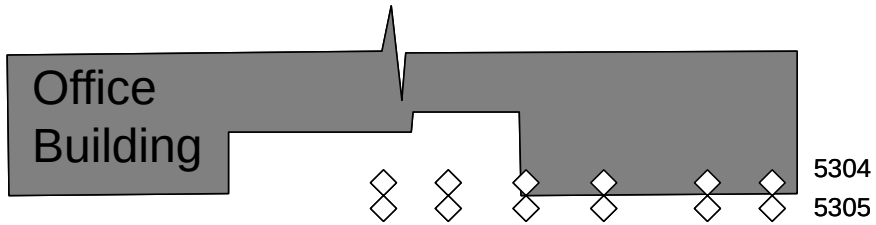
Convert scaled range to actual distance using the energy of the vibratory roller

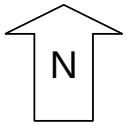


Field Verification

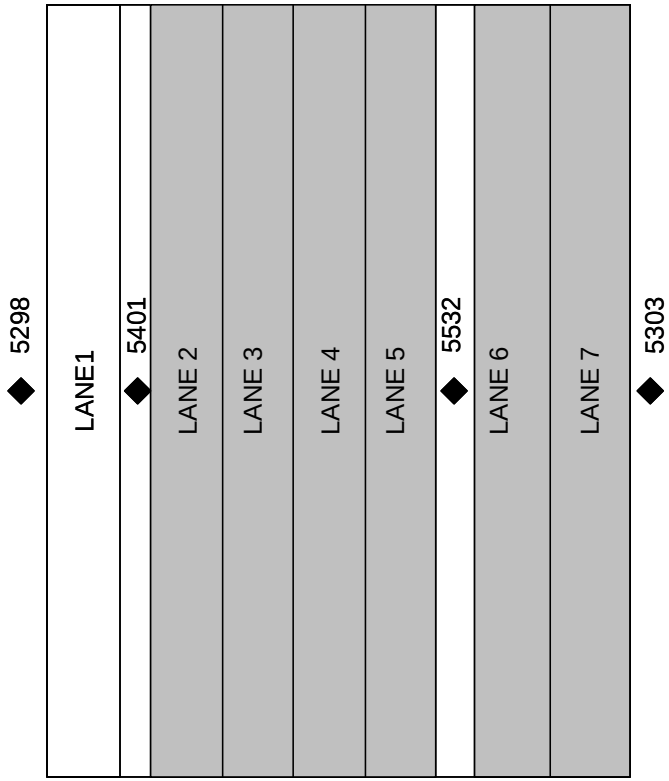
- Re-Paving Accelerated Pavement Test Tracks at the State Materials Office of the Florida Department of Transportation

Vibration Monitoring Plan





Units 5401 and 5532 were set to record full time histories

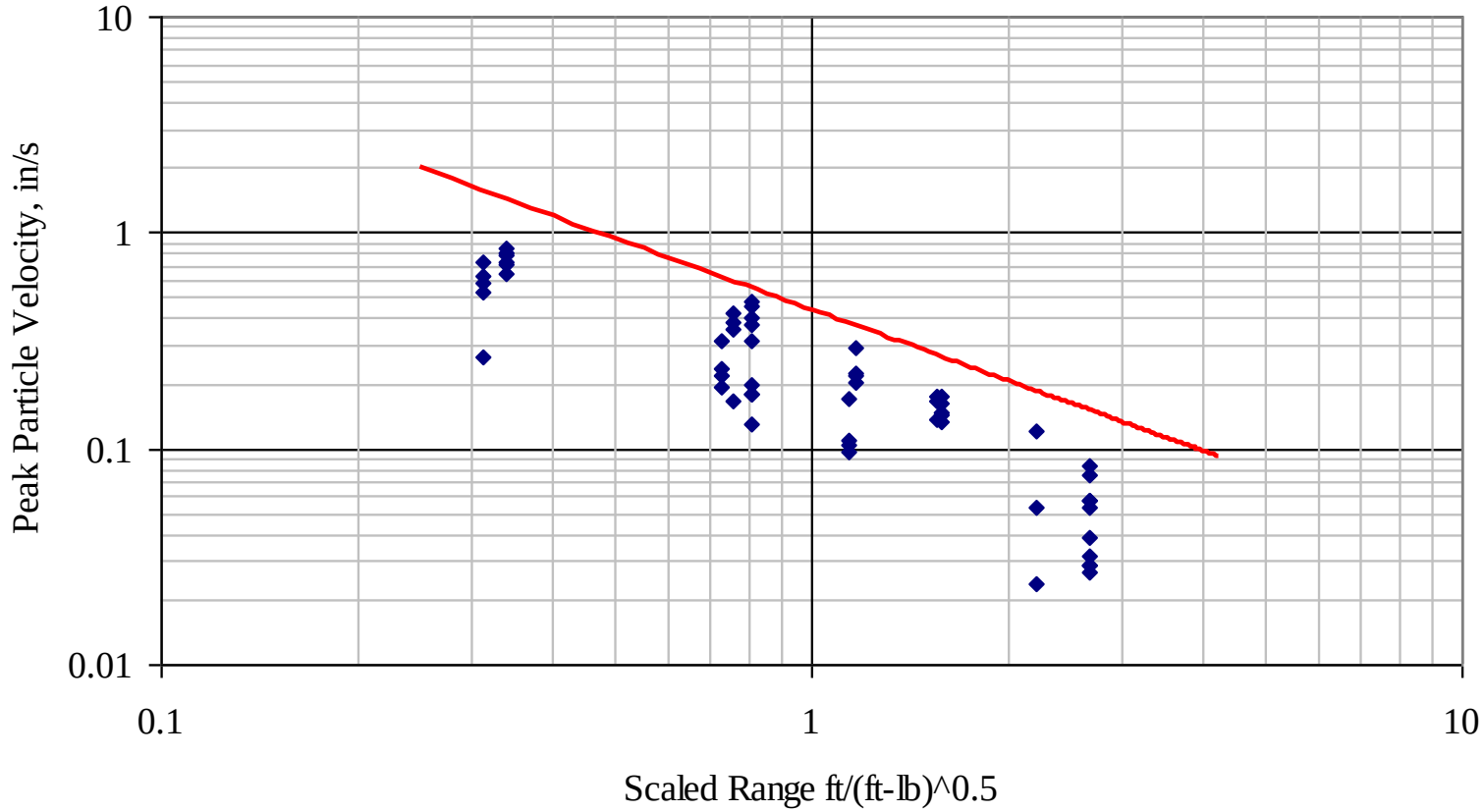


LEGEND

5304	Unit Number
◆	Fixed Unit
◇	Moving Unit (Relocated as paving operations moved from lane to lane)

Caterpillar CB-634C

Scaled Vibration From Compactor

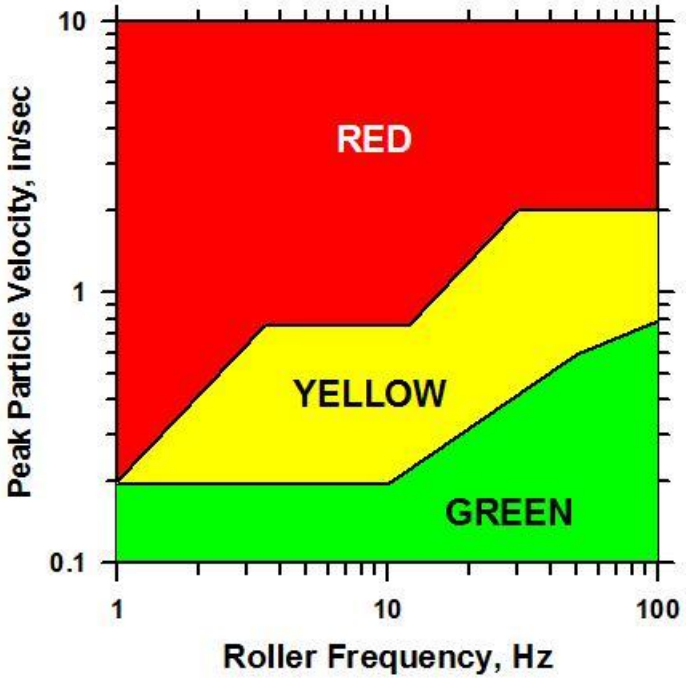


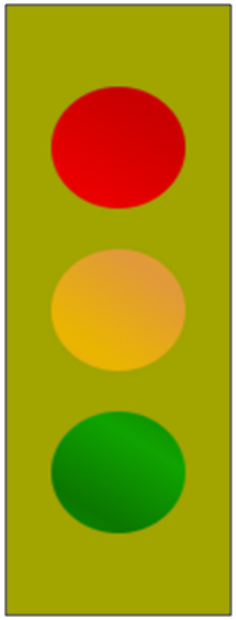
FDOT Example

- Public Complaint
  - Increased Vibration after Patch Installation
  - Human Annoyance
  - Plaster Wall Damage

FWD Survey Results

- 18 kip Single Axle Modeled
- Building is Approx. 90 ft. from Pavement Edge
- In Green Zone!!



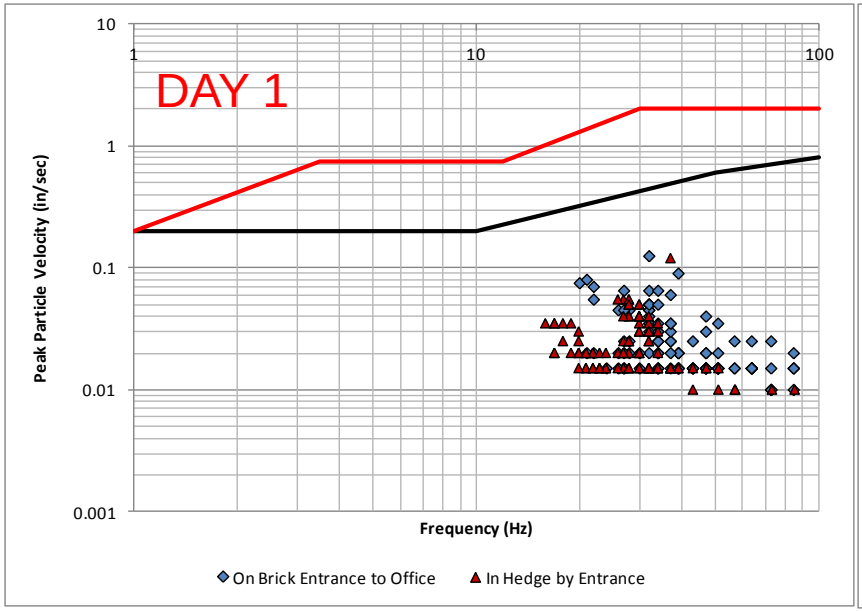


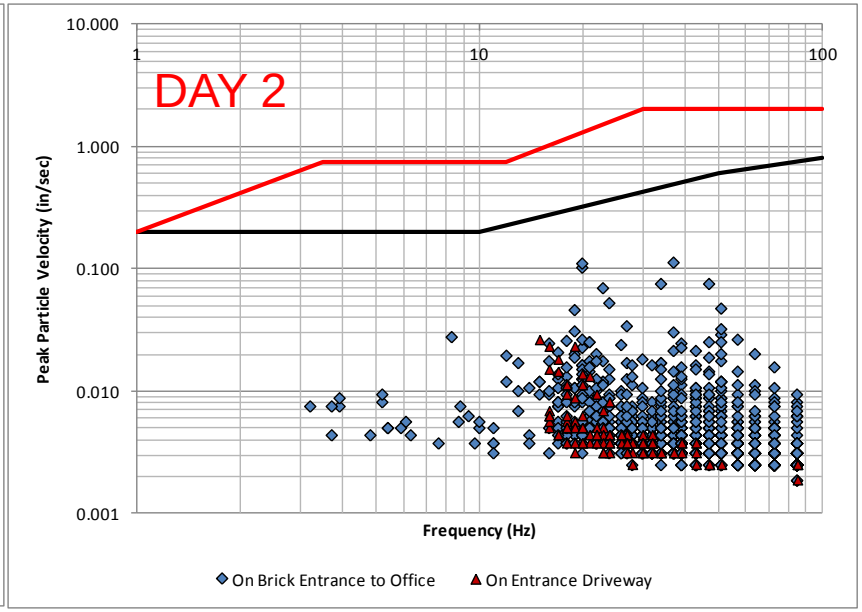
Ranges (ft)

Distance ≤	3.1			
3.1	<	Distance ≤	24.5	
24.5	<	Distance		

Vibration Monitor Results

- Vibration Monitored
  - 2 Monitors Set to Report PPV and Frequency
  - 2 different Days
- All PPVs in Green zone





Conclusion - FDOT Example

- Building is in the Green Zone
- Architectural Damage Unlikely

Implementation of Algorithm