

NCHRP 25-25/Task 72

Current Practices to Address Construction Vibration and Potential Effects to Historic Buildings Adjacent to Transportation Projects

Fact Sheet



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Construction Vibration:

- Heavy construction equipment, particularly equipment used for pile driving and other impact devices such as pavement breakers create substantial ground vibration.
- Vibration waves travel in the ground outward from the source with diminishing amplitude as distance increases.
- The velocity of the ground motion is measured in units of *inches/sec*.
- The maximum value of motion is referred to as the “peak particle velocity” (PPV).
- Vibration can be continuous (vibratory roller) or transient (blasting, pile driving).
- Depending on the amplitude, vibration can range anywhere from imperceptible to annoying and if strong enough can cause damage to buildings.

Typical values of PPV from Construction:

Equipment	PPV at 25 feet
Pile driver (impact)	0.644 to 1.518
Pile drive (sonic/vibratory)	0.170 to 0.734
Vibratory roller	0.210
Hoe ram	0.089
Large bulldozer	0.089
Caisson drilling	0.089
Loaded trucks	0.076
Jackhammer	0.035
Small bulldozer	0.003

Damage Classification Terminology:

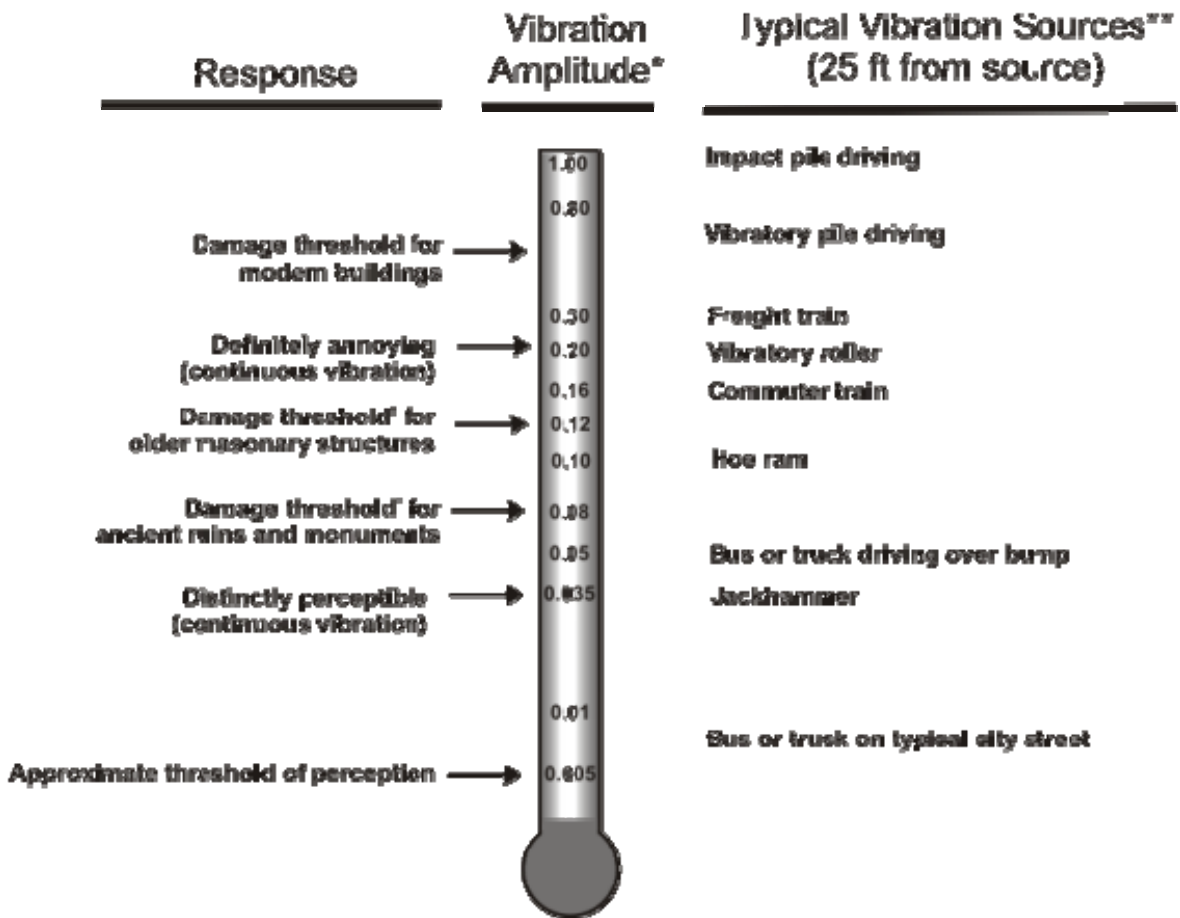
- Cosmetic - The formation of hairline cracks on drywall surfaces or the growth of existing cracks in plaster or drywall surfaces; the formation of hairline cracks in mortar joints of brick/concrete block construction.
- Minor - The formation of large cracks or loosening and falling of plaster or drywall surfaces, or cracks through bricks/concrete blocks.
- Major - Damage to structural elements of the building, cracks in support columns, loosening of joints, and splaying of masonry cracks.

Susceptibility of Historic Buildings to Vibration:

- Type of building construction – Older buildings are typically built from more brittle materials (brick masonry, terra cotta, and plaster) when compared to steel and even wood, which are more flexible.
- Age – Over time the effects of the aging process caused by weathering, temperature variation, freeze-thaw and long-term settlement of the structure weakens building elements decreasing their ability to absorb dynamic loads elastically without sustaining damage.
- Maintenance – A regular maintenance program that repairs age and weather related deterioration will improve a buildings resistance to exterior vibration.

Human Response to Vibration:

- Human perception of and response to vibration depends on many factors including:
 - the location of the person (indoors or outdoors),
 - the presence of distractions such as background noise and,
 - the level of activity of the person when vibration occurs.
- For continuous vibration from construction activities such as vibratory compaction or vibratory pile driving, an indoor PPV exceeding 0.035 inches/sec is generally considered to be distinctly perceptible, whereas a PPV of 0.2 inches/sec is definitely annoying.
- Because transient vibration has a short duration, it requires a higher level than continuous vibration to be perceived. For transient vibration caused by sources such as pile driving and blasting, an indoor PPV between 0.2 inches/sec is considered barely perceptible, whereas a PPV between 2.0 inches/sec would be strongly perceptible.



* Peak particle velocity (inches/sec)

** Actual vibration levels are dependent on many factors

† Approximate threshold for cosmetic damage

Vibration Criteria for Historic Buildings:

- There is a wide range of opinion on appropriate vibration limits for historic buildings.
- At one end of the range is a conservative PPV limit of 0.10 inches/sec except in the case of ancient ruins where 0.08 inches/sec is considered appropriate by some.
- At the other end of the range, some would consider 0.50 inches/sec to be appropriate or even 2.0 inches/sec.
- Conservative vibration limits can be set initially with some flexibility in modifying those limits based on detailed engineering investigation and analysis done on a case-by-case basis prior to award of the construction contract.

Vibration Monitoring:

- Monitoring of vibration during construction is one of the best means of protection for buildings.
- Modern seismographs are small, portable and battery operated.
- Threshold levels can be used to trigger visual or audio alarms to warn equipment operators and construction engineers when vibration limits are approached.