
Standard Practice for Evaluation of Transportation- Related Earthborne Vibrations

AASHTO Designation: R 8-96 (2023)¹

Technically Revised: 1996

Reviewed but Not Updated: 2023

Tech Subcommittee: 5c, Quality Assurance and Environmental



American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, DC 20004

Standard Practice for

Evaluation of Transportation-Related Earthborne Vibrations

AASHTO Designation: R 8-96 (2023)¹

AASHTO

Technically Revised: 1996

Reviewed but Not Updated: 2023

Tech Subcommittee: 5c, Quality Assurance and Environmental

1. SCOPE

- 1.1. This standard practice is to provide guidance for the assessment of potential or alleged structural damage due to earthborne vibrations related to transportation facility construction, maintenance, or operation.

2. INTRODUCTION

- 2.1. The construction, maintenance, and operation of transportation facilities generate vibrations, which are transmitted through the air and earth and are subsequently received or “sensed” by structures or inhabitants. Only earthborne vibrations are addressed in this standard practice (see Section X2.8, Appendix X2).
- 2.2. Currently accepted practice in monitoring earthborne vibrations considers two parameters—earth particle velocity and wave frequency—determined at the site of concern (Siskind et al., 1980; see Figure 1). Sensing instruments are usually set out on the ground adjacent to the subject structure. For determination of safe vibration control limits, special concerns may dictate placement of sensors directly on specific parts of a structure such as the foundation, a supporting column, or a wall.

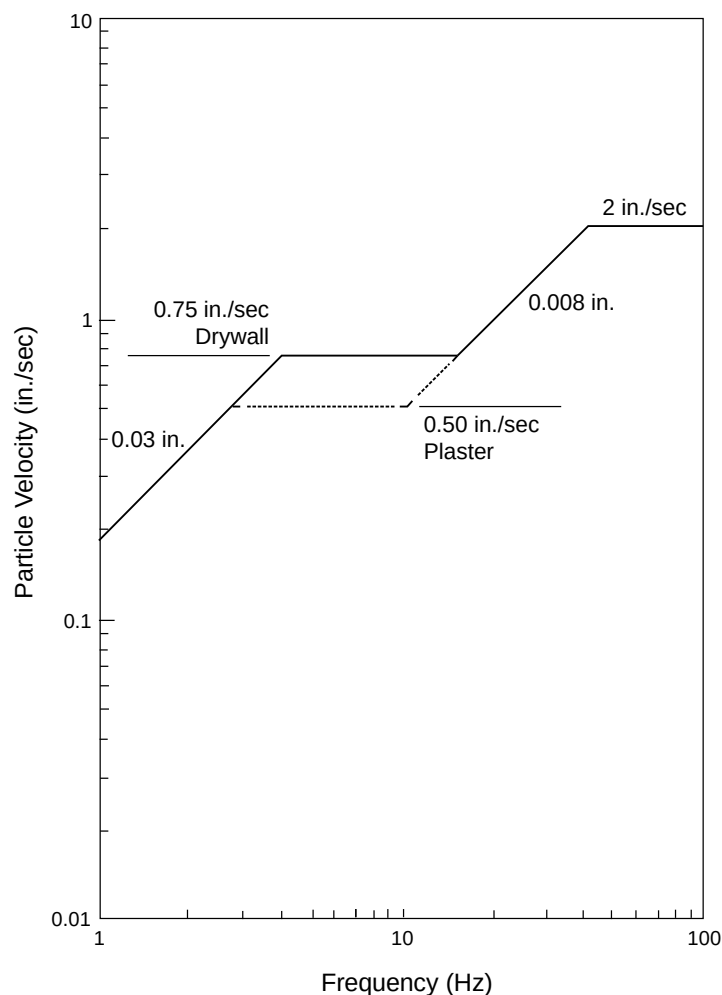


Figure 1—Safe Vibration Limit Recommendations for Residential Structures (USBM RI 8507)

- 2.3. Much of the data concerning structural damage have been determined from blasting activities. Blasting is a commonly used construction-related procedure that produces vibrations characterized by a wide frequency range and potentially high intensities but of very short duration. Transportation-related activities, such as vehicular or rail traffic, may be the source of repetitive, cyclical vibrations of much lower intensity than those caused by blasting. There may be concern in this regard because of potential for fatigue of structural components. Documentation of specific damage due to such transportation-related vibrations is scarce (Whiffin and Leonard, 1971; Ames et al., 1976).
- 2.4. People “sense” or respond to a much broader range of vibration frequencies and intensities than do structures. Intrusive vibration levels can annoy humans at much lower intensities than levels considered critical for structures (see Figure 2). Such sensitivity causes concern for structural damage potential even at the extremely low levels of vibration that are a recognized nuisance to people. Various threshold limits have been recommended in standards aimed at minimizing damage to various structures. Recommended safe vibration limits are based upon the appearance of “threshold cracks” or cosmetic cracking. Such cracks appear at lower vibration levels than do architectural or minor damage. The applicability of specific limitations is often the subject of litigation requiring expert witness opinion.

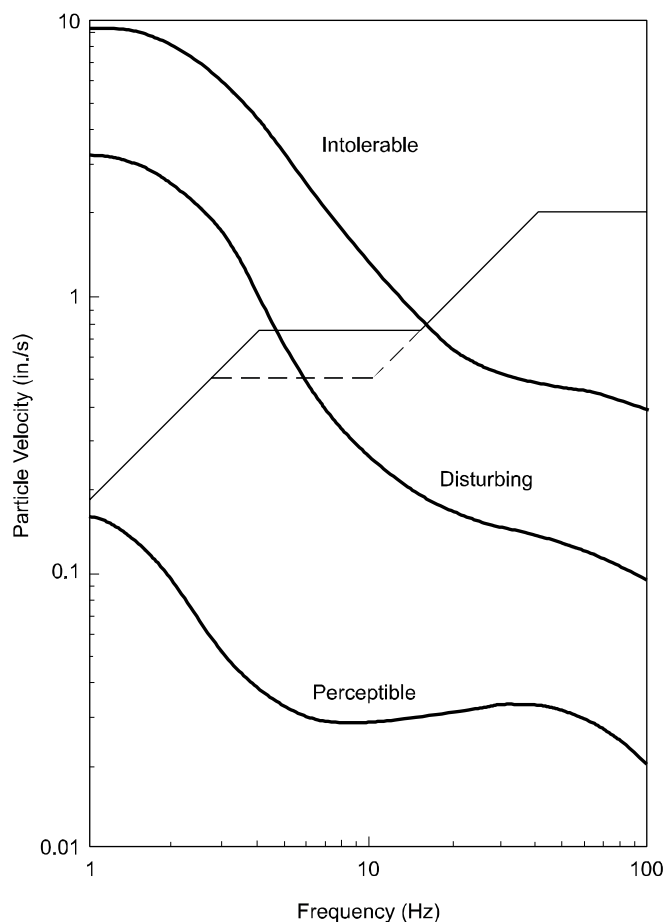


Figure 2—Safe Vibration Limit (USBM RI 8507) and Human Perception (Rathbone)

- 2.5. Concerns of anticipated or perceived damage can be related to structures or their contents. Practically all buildings contain fine cracks or imperfections that are not noticed until concern is stimulated by perception of abnormal vibrations. Evaluation of the potential effects of transportation-related earthborne vibrations requires documentation of the background or pre-existing condition of the structure or component of concern. Such an evaluation should also include a determination of the intrusive vibration characteristics (amplitudes and frequencies) at the point of interest. Dowding (1992) reviews the various methods for determining ground vibration frequencies. Analysis of the results may necessitate modification at the vibration source or mitigation of effects at the location of concern.

3. PROCEDURE

- 3.1. A survey of the site should be made by personnel capable of locating, evaluating, and documenting significant or apparent evidence of distress. Such surveys preferably should be made before the onset of any objectionable vibration-producing activity. The scope of the inspection should be appropriate for both the subject of concern and the intensity of the vibrations. Photographic or video documentation of the inspection is recommended. Any procedures requiring intrusion on property should be specifically permitted by the property owner, preferably in writing. Specialists in vibration monitoring are often contracted for survey services.

- 3.2. All vibrations arriving at the monitoring location within the selected sensitivity range of the seismograph are recorded. For comparison purposes, it is often useful to obtain recordings of the normal or background vibrations at the site when the specific objectionable source is not present. The sensitivity range of the instrument should be selected so that recording is initiated below the intensity of the objectionable vibrations and extends above the highest expected intensity. It may be necessary to estimate or predetermine the expected intensity level to be sensed in order to select the appropriate instrument range setting to be used during monitoring. It is necessary to determine the time when the vibration source is active. Specific activities of the vibration source, such as driving of piles, as opposed to extraction, vibratory compaction, or pavement-breaking activities, should be indexed in time for proper correlation with the arrivals on the vibration records. Because the determination of frequency is important, instruments that provide a time-history or waveform of each velocity component for a vibration event are preferred.
- 3.3. A field calibration procedure should be conducted before the start of monitoring and recording. The incoming ground vibrations should be measured on the ground at foundation level, as close to the structure as possible, to be consistent with studies providing safe vibration limits (Siskind and Stagg, 1985). The transducer is positioned with the longitudinal axis (indicated by an arrow) toward the vibration source or parallel to the structure. Transducers must be adequately coupled with the ground or the structural component being monitored (see Section X1.5, Appendix X1). Instrument manufacturers provide appropriate instructions and recommendations for special installations. Some published threshold criteria are based on specific monitoring procedures. Consistent procedures in the placement and location of transducers during monitoring are recommended for comparison of results.
- 3.4. Records of the incoming vibrations are typically displayed in a waveform plot or strip chart plot. The peak particle velocities in longitudinal, transverse, and vertical planes are shown along with the respective dominant or principal frequencies. The highest recorded particle velocity among the three planes is indexed to its time of occurrence within the recorded interval. This velocity is reported as the peak particle velocity for a particular event.
- 3.5. The recorded peak particle velocity is compared with criteria appropriate for the subject of concern. Many currently used digital instruments produce a record that displays the particle velocities and associated zero-crossing frequencies, or arrivals plotted against a base of the U.S. Bureau of Mines (USBM) RI 8507 curve, which is a commonly accepted criterion for threshold cracking concerns in the United States (see Figure X2.1). Other criteria may be applicable in special circumstances (see Appendix X2).
- 3.6. In the event of a complaint, a site visit should be made as soon as possible to assess the situation and to compile necessary documentation. A report document should include all relevant data, such as the basis for the investigation, time and date of the survey, persons involved, and a description of the property. It should also include a description of the instrumentation; a description and log of the monitoring procedure; the monitoring results; and the conclusions reached based on comparison with applicable criteria, standards, or expert recommendation.
- 3.7. *The following information should be obtained when complaints of intrusive vibrations are received:*
- 3.7.1. Time and date of the complaint;
- 3.7.2. Name, address, and phone number of the complainant;
- 3.7.3. The alleged damage or complaint, or both;
- 3.7.4. The time and date on which the damage occurred;