



Terms of Reference: Vibration Study



Study Description

A Vibration Study Report is the documentation of a technical study, which demonstrates the proximity and compatibility between vibration sources and locations that are vibration sensitive. The vibration sources considered in this Terms of Reference are the result of rail activity and construction or demolition activity. Rail activity is evaluated for human comfort while construction or demolition activity is evaluated for damage to buildings or disruption of sensitive equipment.

Purpose

The purpose of this Terms of Reference (“TOR”) is to establish clear expectations and requirements for the preparation of Vibration Studies submitted to the City of Waterloo. This document provides applicants and consultants with technical guidance for standardization of Vibration Study triggers and methodologies along with expectations for results presentation and mitigation. Compliance with these guidelines will help to expedite review times and mitigate the need for further revisions and submissions. Failure to satisfy the requirements set out in this TOR may result in an application being deemed incomplete. If an application is deemed incomplete it will be returned to the applicant to satisfy the necessary submission requirements.

Definitions

High Sensitivity Site – is a site that contains an MRI, CT scanner, hospital operating theatre, lab containing a scanning electron microscope (SEM) or nuclear magnetic resonator (NMR).

Peak Particle Velocity – is a measure of vibration commonly used for building damage that describes the velocity of particle movement by the maximum positive or negative amount. It has units of millimetres per second (mm/s).

RMS Velocity – is a measure of vibration commonly used for human response that describes the root mean square average of vibration level typically averaged over a 1 second period. It has units of mm/s RMS.

Rail Right of Way - is any part of the parcel of land on which a rail line is situated.

Sensitive Uses – is a location indoors that is sensitive to vibration, which is used as an alternative education centre, indoor amenity area, assisted living facility, child care centre, dwelling unit, group home, hospital, hotel, institution where a person sleeps or is present on a fulltime basis, long term care facility, medical clinic where a person sleeps or is present on a full-time basis, private school, public school, spiritual use, university/college residence, or residential use.

When is it Required?

A Vibration Study may be required for the following Planning Act applications:

- Official Plan Amendment
- Secondary and/or Community Plan
- District Plan
- Zoning Amendment
- Draft Plan of Subdivision
- Draft Plan of Condominium
- Consent
- Minor Variance
- Site Plan Control
- Other planning applications, as determined by the City.

The City may also request a Vibration Study Report concerning construction or demolition vibration as a pre-condition to a Building or Demolition Permit, or if concerns are raised during construction or demolition. The need for a Vibration Study as part of a complete application will be identified as part of the pre-application consultation review. In the instance where a planning application being advanced does not have a mandatory pre-application consultation process (e.g., Committee of Adjustment applications), the applicant is encouraged to contact the City's Planning Division to discuss the nature of the proposal and to determine if a Vibration Study is required.

Applicable Legislation

The authority to require or request information or material to evaluate and make a decision on proposed planning applications is provided by the Ontario *Planning Act*, the Provincial Policy Statement, and City of Waterloo Official Plan Section 12.2.14 ("Complete Applications").

This Terms of Reference document is to be applied in conjunction with all applicable regulations, by-laws, and guidelines, including the City of Waterloo's Urban Design Manual and Comprehensive Engineering and Landscape Manual.

Rail Vibration

A vibration study to address rail vibration is conducted when a development proposes sensitive uses within the zone of influence of rail activity.

Qualified Persons

The Vibration Study Report for rail vibration must be prepared by a consultant currently registered on the Region of *Waterloo's Prequalified Consultants for Noise Studies List* or be co-signed by a consultant who is registered on the List. Procedures concerning the *Prequalified Consultants for Noise Studies List* are provided in the *Regional Municipality of Waterloo Noise Policy Implementation Guideline*. The standard owner and consultant declarations also apply to rail vibration studies. The qualified professional that has signed the Report shall take professional responsibility for its contents and the accuracy of the information contained therein.

Zone of Influence

The zone of potential influence for rail vibration on proposed sensitive uses is 75 metres from the edge of the rail right of way.

Rail Vibration Criterion

Ground-borne vibration on and above the first floor of a sensitive use shall not exceed 0.14 mm/s RMS velocity.

Rail Measurement Requirements

If proposed sensitive uses are located within the zone of potential influence, levels of ground-borne vibration shall be evaluated by on-site measurement. Vibration measurements shall be conducted at the location closest to the rail right of way where sensitive uses are proposed. Equipment requirements and procedures for measurement can be found in Appendix C of the *Guidelines for New Development in Proximity to Railway Operations* from the Railway Association of Canada and Federation of Canadian Municipalities.

Vibration Control Measures

Where vibration on or above the first floor of sensitive uses is predicted to exceed the rail vibration criterion, reduction measures are required. The design of mitigation measures shall be undertaken and signed by a Professional Engineer specializing in building vibration mitigation.

Reporting Requirements

The Vibration Study Report for rail vibration shall include:

- An introduction to the site, including a description of the proposed development.
- A dimensioned site plan indicating the location rail line, the edge of the rail right of way, and the proposed closest sensitive use.
- A dimensioned site plan showing the measurement location(s).
- Summary of the vibration measurement equipment, including its frequency range precision.
- Description of the trains measured (e.g., direction, freight/LRT/passenger, number of cars per train, and speed).
- Results for all of the measurements conducted.
- Assessment of compliance with the criterion and any exceedance.
- If required, details of the proposed mitigation. Where more than one possible option for mitigation exists, those should be listed, with a confirmation of the selected option.
- Conclusion, including a summary of how the vibration criteria will or will not be met.

Mitigation Signoff

The City may require financial security to address cases where mitigation measures are required. Release of this financial security will be connected with a letter signing off the satisfactory implementation of the mitigation from a Prequalified Consultant.

Construction and Demolition Vibration

A Vibration Study Report to address construction or demolition vibration is conducted when construction or demolition is proposed in proximity to an existing building or structure.

Qualified Persons

The Vibration Study Report for construction or demolition and the supporting assessment must be prepared by or co-signed by a supervising Professional Engineer with experience in ground and building vibration. The qualified professional that has signed the Report shall take professional responsibility for its contents and the accuracy of the information contained therein.

Zone of Influence

A report is required when the construction or demolition activity is within the distances shown in Table 1 or vibration is predicted to be equal to or greater than 5 mm/s PPV at any frequency. An exception to the values shown below can be presented should a Professional Engineer submit a report providing an alternative zone of influence with reasoning.

Table 1: Potential Zone of Influence Within Which a Vibration Study Report is Needed

Sources	Potential Building Damage	High Sensitivity Site
Trucks, Bulldozers, Jack Hammers, Vibratory Rollers, Drilled Caisons	Required within 10 m	Required within 150 m
Pavement Breakers	Required within 30 m	Required within 400 m
Vibratory Pile Drivers	Required within 50 m	Required within 600 m
Diesel Pile Drivers	Required within 60 m	Required within 1000 m

A Vibration Study Report for construction or demolition vibration will contain documentation identifying the buildings within the respective potential zones of influence identified in Table 1. Buildings designated under the Ontario Heritage Act (Heritage Buildings) shall be identified differently from other buildings. High Sensitivity Sites shall be identified differently from Heritage Buildings and from other buildings.



Construction Vibration Criteria

The Criteria provided in Table 2 is to be used for buildings, including Heritage Buildings, that are not High Sensitivity Sites. The criteria cannot be exceeded unless a Professional Engineer submits a report identifying alternative limits with reasoning.

Table 2. Vibration Criteria for Buildings that are not High Sensitivity Sites

Vibration Frequency	Peak Particle Velocity Criteria (mm/s)
Less than 4 Hz	8
4 to 10 Hz	15
More than 10 Hz	25

For High Sensitivity Sites, vibration impact on the specific type of high sensitivity equipment shall be evaluated using the corresponding *Vibration Criteria (VC) curves*, published by Amick et. al. in 2005.

Vibration Assessment

A zone of influence shall be calculated for the specific construction and demolition sources that will be used. In addition, this calculation shall account for any unique conditions of the site or surroundings that modify the specific zone of influence at the time that construction or demolition will occur. Site-specific measurements of vibration propagation in the local soil conditions may be included if the engineer deems it to be valuable. If the specific zone of influence identifies buildings or structures that may be subject to vibration above the applicable criteria, a Pre-Consultation with Neighbouring/Surrounding Properties and a Monitoring Program are required.

Pre-Consultation with Neighbouring/Surrounding Properties

Consultation with all property owners and occupants within the specific zone of influence shall occur prior to construction or demolition consultation. They shall be advised of the possibility of construction vibration and the contents of the Monitoring Program. The comments and questions from the property owners and occupants shall be recorded together with the responses provided.

Monitoring Program

Where the specific zone of influence identifies buildings or structures that may be subject to vibration above the applicable criteria, a Monitoring Program shall be prepared. The following minimum contents are required:

- Background vibration measurements within the zone of influence;
- A pre-condition inspection of the subject buildings and structures must be completed in enough detail to enable pre-construction or demolition and post-construction or demolition comparisons. The inspection will identify cracks in walls, floors and exterior surfaces of the first two above-grade stories. If access is not gained for inspection, then the efforts to gain access shall be documented, including dates, times and the methods used within the report.
- A monitoring program to measure vibration levels before and during construction or demolition activity is required to include:
 - Quantity and locations of vibration monitors.
 - Vibration monitor specifications, including the vibration frequency and peak particle velocity ranges to be recorded.
 - Sampling times and durations. At least one monitor operating continuously during construction or demolition activity. Monitoring prior to construction or demolition is also required.
 - Mitigation measures required to be implemented so that construction or demolition activities do not exceed the criteria.
 - Procedures to notify of and address vibration events in excess of the criteria; and
 - Results reporting, including how often results are reported.
- Monitoring shall be conducted according to the monitoring program.

It should be noted that construction or demolition activities that do or will exceed the criteria is not permitted to commence or continue to occur.

Reporting Requirements

The Vibration Study Report for construction or demolition vibration is expected to include information as described in previous sections. The information can be summarized as follows:

- An introduction including description of the subject site, the proposed construction or demolition activities and a site plan.



- A summary of the guidelines and criteria that apply.
- Sources of construction or demolition vibration and their precise locations.
- A map showing the specific zone of influence for construction or demolition sources that will be considered.
- The survey identifying buildings within the specific zone of influence. Buildings designated under the Ontario Heritage Act and High Sensitivity Sites are to be identified and differentiated within the report.
- Soil conditions for the construction or demolition site and adjacent lands should be detailed. This should include conditions such as weather that will influence vibration levels at the time of construction or demolition and location of the water table.
- Identification of mitigation measures, including substitution of the vibration sources or construction or demolition techniques with another, which may be used to reduce the vibration levels.
- Summary of the pre-consultation with neighbouring/surrounding properties.
- The monitoring program.
- Conclusion, including a summary of how meeting the vibration criteria will or will not be achieved.

Monitoring Report Requirements

Monitoring results shall be reported in a separate document to the Chief Building Official or an inspector who has been designated to receive them. The Monitoring Report shall include:

- The range of dates and times to which the report applies;
- A record of the monitored vibration levels; and
- Highlight the date, time and level of any vibration events in excess of the criteria.

Additional Information

Note 1:

If City staff consider the submitted Vibration Study to be incomplete, unsatisfactory, inconsistent, insufficient, authored by an unqualified individual, or if it fails to satisfy the requirements set out in this TOR in any other manner, the associated development application may be deemed incomplete and returned to the applicant.

Note 2:

Deeming an application complete does not guarantee that the contents of the study are acceptable to City staff and/or that the application will be approved.

Note 3:

If a request for a Vibration Study is not made at an earlier stage in the development process, this does not preclude the City from requesting a Vibration Study at a later stage. Once an application has been deemed “complete”, the City may require additional information, reports, and/or studies following a more detailed review to assess the implications of an application for approval.

Note 4:

The City of Waterloo is committed to complying with the Accessibility for Ontarians with Disabilities Act (AODA). In our everyday work with businesses institutions, and community partners we anticipate the same commitment to AODA compliance. Therefore, the Vibration Study must be AODA compliant and must meet the current provincial standard for compliance.

Note 5:

The City reserves the right to request an updated study, or an addendum thereto, should staff determine that changes in the development proposal or changes to legislation warrant further/modified planning analysis.

Note 6:

City staff reserve the right to require a peer review of submitted materials by an appropriate agency or qualified professional, the cost of which will be borne by the applicant.

Note 7:

Documents and all related information submitted to the City as part of a complete development application are considered public documents once submitted.

Note 8:

The Vibration Study shall be submitted in conjunction with the applicable development application(s), unless otherwise agreed to by the City.

Note 9:

This Terms of Reference document is intended to be used for guideline purposes only, and will be used to provide technical direction throughout the planning and development process. Completion of a report in alignment with the requirements of this Terms of Reference will not guarantee approval of the development application in question.

Note 10:

This TOR is relevant at the time of publishing and will be updated as necessary to reflect current policy, best practices, and accepted standards. It is the applicant's responsibility to ensure the report is prepared in accordance with the most recent version of the TOR issued by the City.

References

The Railway Association of Canada and Federation of Canadian Municipalities, May 2013, *Guidelines for New Development in Proximity to Railway Operations*.

Amick, Hal and Michael Gendreau et al., 2005, *Evolving Criteria for Research Facilities*, Proceedings of SPIO Conference 5933.

This Terms of Reference was prepared by a qualified external consulting firm. For clarification for any information contained within this document, please contact the City of Waterloo staff assigned to the pre-consultation process.