

Vibrations Caused by Construction Activity

Date:	May 16, 2007
To:	Planning and Growth Management Committee
From:	Chief Building Official and Executive Director, Toronto Building
Wards:	All
Reference Number:	P:\2007\Cluster B\BLD\CBO Office\PGM004

SUMMARY

This report responds to Council direction for the Chief Building Official and Executive Director, Toronto Building to provide recommendations for regulating vibrations in the City of Toronto which are the result of construction activity. The recommendations are based on a technical research study recently completed for Toronto Building.

This report recommends that Toronto Building report back to the Planning and Growth Committee with amendments to the City of Toronto Municipal Code Chapter 363, Building Construction and Demolition following a focussed consultation. The amendments would require permit applicants to conform to a set of vibration control criteria where there is the potential for construction borne vibrations. This approach is proactive and provides measures and protections not likely available through a complaints driven approach. The report further recommends that Toronto Building develop a public communication policy in a focused consultation with the building industry and residents' representatives.

RECOMMENDATIONS

The Chief Building Official and Executive Director, Toronto Building recommends that:

1. The Chief Building and Executive Director report to Planning and Growth Management Committee with the necessary amendments to Chapter 363 of the City of Toronto Municipal Code to require details and particulars from building permit applicants relating to the potential for construction vibrations, and where there is the potential for construction borne vibrations to require conformance with a set of vibration control criteria. These criteria will include but are not limited to precondition surveys, vibration monitoring and conformance with peak particle velocity measurements appropriate to the site.
2. Toronto Building conduct a focused consultation with the building industry and resident's representatives to establish a communications protocol in order to appropriately document all public complaints.

Financial Impact

The recommendations will have **no** financial impact beyond what has already been approved in the current year's budget

DECISION HISTORY

The Chief Building Official and Executive Director, Toronto Building reported to the Planning and Transportation Committee at its meeting of November 8, 2004, on the request, through Notice of Motion J(5) moved and adopted at the Council meeting of October 26, 27, 28, 2004, to investigate the impacts of vibrations from the Minto construction activities at 2195 Yonge Street and submit a report to the Planning and Transportation Committee.

Notice of Motion J(5) "2195 Yonge Street – Minto Construction Activity"
[http://www.toronto.ca/legdocs/2004/agendas/council/cc041026/nomj\(5\).pdf](http://www.toronto.ca/legdocs/2004/agendas/council/cc041026/nomj(5).pdf)

November 5, 2004 Report "2195 Yonge Street – Minto Construction Activity"
<http://www.toronto.ca/legdocs/2004/agendas/council/cc041130/plt9rpt/cl003.pdf>

Notice of Motion J(26) "By-law to Regulate Vibrations Caused by Construction Activity"
[http://www.toronto.ca/legdocs/2004/agendas/council/cc041130/nomj\(26\).pdf](http://www.toronto.ca/legdocs/2004/agendas/council/cc041130/nomj(26).pdf)

Toronto Building was directed to report back to the Planning and Transportation Committee with recommendations for regulating vibration from construction activity in the City of Toronto.

ISSUE BACKGROUND

The November 30, 2004 report to the Planning and Transportation Committee provided comments on the applicable regulations under the Building Code Act with respect to vibrations caused by construction and the building permit process enforced by Toronto Building. The report concluded that the Ontario Building Code (OBC) addresses the adverse impacts of construction borne vibrations on buildings through Sentence 4.2.5.2.(1). This sentence states that “every excavation shall be undertaken in such a manner as to prevent movement which would cause damage to adjacent property, existing structures, utilities, roads and sidewalks at all phases of construction. OBC Clause 2.3.7.5.(1)(c) further states that “deep foundation units shall be installed in such a manner as not to impair the integrity of neighbouring structures and services.” If there is evidence that the integrity of the surrounding structures and services are being compromised, the City would issue an order to comply under Section 12 of the Building Code Act, 1992.

COMMENTS

In response to Council direction, Toronto Building retained a consultant to carry out research on ground borne vibrations produced through construction activity in Toronto. Municipal Licensing and Standards were part of the staff working group in view of their responsibility for enforcing the City’s noise by-law. Technical Services staff reviewed the consultant’s reports and recommendations, given that City construction may be required to comply with any proposed construction vibration by-law. The following is a summary of the consultant’s research:

Measuring Vibrations

The parameters used to develop vibration thresholds or limits across North America are frequency and peak particle velocity (PPV). Any by-law developed for the City of Toronto should use these parameters as the basis. Research related to construction induced impacts on buildings have focused on blasting related studies, as normal construction activity typically does not produce vibrations at levels that are high enough to affect buildings. Standards for vibrations associated with blasting activity are more common than regulations for construction borne vibrations.

Impact of Vibrations on People

Traffic and human occupancy of buildings can produce vibrations in buildings similar to construction induced vibrations. The consultants noted that property owners are more likely to complain about construction vibrations. Human sensitivity and reaction to vibrations from construction machinery and other sources is highly subjective and varies from person to person. Studies have shown that human tolerances are controlled by many factors making a strict definition to what represents a nuisance difficult.

Impact of Vibrations on Buildings

The predominant concerns related to the impacts of vibrations on buildings are related to cosmetic cracking. The construction techniques on the interior walls of older buildings used wood support covered in thick plaster. Modern construction uses drywall with paint or wallpaper. The likelihood for cosmetic cracking in older buildings is greater than modern buildings.

Masonry or concrete are strong materials. Structures from these materials will only crack at very high strains that are produced by a peak particle velocity consistent with a blast or earthquake

Historic Buildings

The risk or uncertainty of damage to historic buildings from vibrations is higher than ordinary buildings. There should be greater assurance or a higher factor of safety against the impact of vibrations on these buildings. Allowable vibration levels for these types of structures should be set out only after consideration of the structure. Some European jurisdictions (i.e., Switzerland and Germany) establish vibration limits for historic structures at 10 to 20% of the limits applicable to new construction.

Methods of Construction

Equipment or construction methods that operate at high frequency or for short periods of time will have less effect on neighbouring buildings and human responses than lower frequency equipment operating continuously. The best approach to reduce ground vibrations is to decrease the dynamic load from construction equipment. In the industry today there are no special pile driving hammers that are widely used that can specifically limit vibration while still advancing the pile adequately. However, it is becoming more common for other techniques such as cast-in-place piles to be used as an alternative to conventional pile driving. With this technique a newer technology drill (Bauer Drill) reduces vibrations. The consultants suggested that limiting or imposing certain types of equipment may have a major impact to both private and public works projects and should be carefully considered.

Case Studies

The consultant reviewed five construction projects recently completed across the City in order to identify some of the vibration related issues at the design, approval and construction stages. The report identified that the nature of complaints from the public was related to human perception and the fear that vibrations may have an adverse affect on buildings nearby.

The case studies showed that the nature of the issues varied. Complaints were more specific in the North York and Toronto and East York districts due to larger projects

involving heavy construction. In these cases, vibrations were monitored by independent testing firms at the request of City staff or the building designers.

The consultant also identified that in the absence of specific construction vibration regulations, Toronto Building staff have used different approaches to managing the issue. In some cases, vibration was not identified as a potential issue at the permit application stage. Inspectors have responded to complaints from the public. In other cases the issue has been considered on a project by project base prior to the permit issuance, based on criteria relating to the nature of construction and the proximity to adjacent buildings. In these cases, staff have requested monitoring and precondition surveys. Plan review staff have been identifying vibration control requirements for the developer and contractor to follow during construction.

Regulating Construction Vibrations in Toronto

The research conducted for Toronto Building on construction related vibration in the City of Toronto concluded that the establishment of precise or universal criteria that define vibration thresholds is difficult. Doing so would depend on a myriad of factors related to the nature of vibrations, including the source, geologic characteristics, and sensitivity of people near the source, among others. There are site specific characteristics that are likely to be unknown prior to consideration of individual sites. As a result specific criteria for construction vibrations would be an estimate of many factors.

For typical structures in Canada and the United States, a safe level of blasting is 50mm/sec, measured next to a foundation wall. This level is certainly high and would need to be reduced to minimize damage to buildings and address issues of human disturbance. However, if the City were to impose a single level of vibration limitation to be enforced on all projects in the City, the limit would need to be set at a sufficiently low level to meet all potential conditions. This would likely be unworkable for private and public construction and significantly increase construction costs.

The technical research report recommended that the City's vibration levels should be flexible to address the varying issues to be considered with construction vibrations. A flexible system would take into account the variables such as proximity to and types of adjacent properties/buildings, methods of construction and selection of vibration limits to protect buildings and sensitive equipment. This approach would be more flexible than an attempt to establish fixed limits through a by-law under the general provisions of the City of Toronto Act.

The Building Code Act, 1992 allows the City to require plans, drawings and specifications, documents and other information to accompany building permit applications. Some requirements are already set out in Municipal Code Chapter 363, (Building Construction and Demolition). Amendments to Municipal Code Chapter 363 would allow for variable limits to be established based on the specific circumstances of the site. The Municipal Code provisions would also include the capacity to review plans in advance of construction.

This approach would not only involve establishing criteria for each site based on a number of factors but would also allow for monitoring of vibration levels. The City could adjust vibration limits based on findings during a preconstruction survey, or during the course of construction. The vibrations limits established on a site by site basis would be based on good engineering practice and require ongoing monitoring by professionals during construction. Monitoring would ensure that vibration levels do not exceed established limits. Enforcement of a by-law under the City of Toronto Act would not provide for these measures and protections and could likely only be enforced on a complaint driven basis.

Based on the results of the technical research, the consultant recommended that frequency based limits for peak particle velocity be well defined by a protocol and that the vibration limits at the point of the nearest neighbouring building be 25 mm/sec regardless of frequency. The following frequency based limits for peak particle velocity were recommended to Toronto Building by the consultant.

Table 1.0 Recommended Frequency Based Limits

Frequency (Hz)	Vibration Peak Particle Velocity (mm/sec)
<4	8
4-10	15
>10	25

Establishing a single level (e.g., PPV of 8 mm/sec) to account for all potential conditions may in fact preclude staff from requiring lower vibration levels depending on site circumstances. For example, the peak particle velocity limit near certain historic buildings in Toronto may need to be less than the values in Table 1.0 and should be determined on a case by case basis.

In order to implement a flexible approach to regulating construction related vibrations it is recommended that the Chief Building Official and Executive Director, Toronto Building report to the Planning and Growth Committee by November 2007 with proposed amendments to Toronto Municipal Code Chapter 363, Building, Construction and Demolition requiring details and particulars from building permit applicants relating to the potential for construction vibrations. Where there is the potential for construction borne vibrations the by-law amendments would require conformance with a protocol and a set of vibration control criteria.

This protocol could include requirements that the developer/contractor:

- Retain an engineer specializing in vibration monitoring. The engineer could determine the zone surrounding the construction site at which vibrations would reach 1.5 to 2.0mm/sec and undertake a pre-construction survey documenting the

existing condition of structures with the zone of influence. The communications protocol would be a component of the preconstruction survey.

- Establish a vibration monitoring program prior to starting construction activity including number of seismographs, location, frequency of monitoring and transmittal of results protocol.
- Conduct test measurements to develop site specific vibration attenuation curves to identify the significant vibration causing construction activities associated with the project.

It is further recommended that Toronto Building conduct a focused consultation with the building industry and residents' representatives to review this approach and design a complaints protocol in order to appropriately document all complaints from the public.

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SIGNATURE

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