

memorandum

DATE: November 9, 2020
TO: Rochester Hills Planning Commission
FROM: Jill Bahm & Eric Fazzini, Giffels Webster
SUBJECT: Zoning Issue Discussion – Nuisance Vibration

Introduction

Planning staff has asked us to assist in reviewing and improving the Zoning Ordinance standards for nuisances caused by ground vibration. This has previously come up related to a complaint between two businesses where one claimed it was being negatively affected by the vibration coming from an adjacent business. In 2018, a report was produced for city staff by SME Geodynamic Consulting Services related to the complaint and the report found that the current Zoning Ordinance standards did not sufficiently address this issue.

Background

Staff previously approached the Planning Commission with a proposal for an amendment to reference “vibration discernible to the human sense of feeling;” however, the Planning Commission preferred a, specific measurement for reference. Staff previously researched other communities and found that some communities provide the following measures for reference:

- Novi and Auburn Hills: 0.003 inches per second (ips)
- Sterling Heights: 0.1 gravities

Staff would like to explore amending the ordinance to refer to a specific measurement of 0.003 ips and would like to discuss with the Planning Commission if this is an appropriate standard as the SME report did not address this approach in detail. **The purpose of this discussion will be to address:**

- **What a reasonable vibration standard would be for Rochester Hills**
- **How exactly vibration should be measured as far as instruments or perception**
- **Other issues related to vibration and zoning**

2018 SME Vibration Ordinance & Test Report Review

The existing Zoning Ordinance standard (provided below) was considered as part of SME’s review of an additional report that was created by one of the businesses related to the complaint described above. SME provided a review of the Zoning Ordinance standard, the additional report by the business (from their consultant, TEC), and a comparison of the findings in the additional report to the Zoning Ordinance standard.

1. Zoning Ordinance - Section 138-10.310 Performance Standards

The following performance standards are established in order to preserve the environmental health, safety and welfare of the City. No activity, operation or use of land, building or equipment shall be

used or occupied in any manner so as to create any dangerous, injurious, noxious or otherwise objectionable element or condition that adversely affects the surrounding area. Any use permitted by this ordinance shall be operated in conformance with all applicable performance standards set forth in this Section 138-10.310. The following standards are deemed the minimum requirements to be maintained.

D.2. Vibration.

No use shall generate any ground transmitted vibration in excess of the limits set forth below. Vibration shall be measured at the nearest adjacent lot line. The vibration maximums set forth below are stated in terms of particle velocity, which may be measured with suitable instrumentation or computed on the basis of displacement and frequency. When computed, the following standards shall apply:

Particle Velocity in Inches Per Second	
Frequency in Cycles per Second	Displacement in Inches
0 to 9.99	0.0010
10 to 19.99	0.0008
20 to 29.99	0.0006
30 to 39.99	0.0004
40 and over	0.0002

- a. If requested by the enforcement official the petitioner shall provide evidence of compliance with the above noted vibration calculations.
- b. Vibrations resulting from temporary construction activity shall be exempt from the requirements of this section.

2. SME Review of Zoning Ordinance & Vibration Criteria

SME reviewed the referenced Rochester Hills vibration ordinance and noted some issues with the language regarding the use of vibration and displacement in the ordinance. They found that the ordinance is unreasonably restrictive based on their “experience with vibration measurements of various activities, and published vibration criterion.”

In terms of regulating vibration based on human perception, the SME review included “generally accepted ranges of subjective human response based on peak particle velocities from Richart, Hall and Woods (1970).” This is shown below.

Subjective Human Response	Peak Particle Velocity (inches per second)
<i>Not Noticeable</i> to Persons	< 0.01
<i>Barely Noticeable</i> to Persons	0.01 to 0.035
<i>Easily Noticeable</i> to Persons	0.035 to 0.1
<i>Troublesome</i> to Persons	greater than 0.1

The SME report included additional study by Jones & Stokes (2004) that indicates that at a continuous vibration level of 0.1 ips PPV represents “Amplitude at which continuous vibrations begin to annoy people.” In the subject case, the maximum vibration levels measured by TEC range between the “barely noticeable to persons,” to “easily noticeable to persons” range.

The SME report concluded by stating that “Overall, the vibration criterion for different types of equipment are well below the vibration a human can feel or perceive and can often be exceeded by typical ambient site conditions such as pedestrian or vehicle traffic. In some cases, special vibration dampening materials or large mass isolation foundations are installed/constructed to dampen external vibration sources experienced by these sensitive equipment types.”

Giffels Webster - Items for Consideration

As noted in SME’s report, the Zoning Ordinance vibration maximums provided at the top of page two do not appear to align with industry practices for vibration measurement. The Zoning Ordinance provides “displacement in inches” amounts as the basis for vibration requirements. However, the TEC report used in the complaint provides measurements during each monitoring period using the following categories:

- Average Peak Particle Velocity
- Maximum Peak Particle Velocity
- Maximum Frequency in Hertz

Our research shows many communities include specific vibration standards in their ordinances. However, many of those communities use “blasting” levels – standards that respond to specific short-term incidents. It is clear from the complaint that ongoing vibration as a result of industrial activities can also be problematic. As the intent of the Zoning Ordinance is to measure vibration using peak particle velocity measured in inches per second (ips), the table in this section should be amended to use ips units, rather than only “displacement in inches.” The following are zoning standards that we found from Hudson, Colorado, that may better align with how vibration could be measured for land use purposes. We find this example to be very inclusive, particularly as it addresses different land uses that may be adjacent to industrial activities. Further, it addresses “steady-state” vibration, which means that the velocity of particles is a **continuous** periodic quantity. “Pact vibration” refers to individual and random impacts that generate vibration. The sample ordinance below includes this information at the end.

Zoning Ordinance Standards (Hudson, CO)

- a. Ground transmitted vibration is measured with a complement of instruments capable of recording vibration displacement and frequency, particle velocity, or acceleration simultaneously in three mutually perpendicular directions. The instruments used to measure vibration in industrial zone districts shall conform to the applicable ANSI standard for such equipment used to measure community vibrations.
- b. **Maximum permitted vibration levels.** The table below designates the maximum peak particle velocities that apply on or beyond adjacent lot lines within all industrial zones and on or beyond appropriate use boundaries. Vibration shall not exceed the maximum permitted particle velocities in the table below. When a vibration source can be identified and its effects are on more than one land use category, the limits of the most restrictive use shall apply at the boundaries between different land use categories. Readings may be made at points of maximum vibration intensity.

Maximum Permitted Vibration Levels		
Zoning (boundary use)	Steady State Vibration (continuous)	Pact Vibration (discrete)
Residential	0.02	0.04
Commercial	0.05	0.10
Light Industrial	0.10	0.20
Industrial	0.15	0.30

- c. The maximum particle velocity shall be the maximum vector sum of three mutually perpendicular components recorded simultaneously. Particle velocity shall be measured in inches multiplied by the frequency in cycles per second. For purposes of these standards, steady-state vibrations are vibrations which are continuous; or vibrations in discrete impulses more frequent than 60 per minute, shall be considered impact vibrations. Between the hours of 9:00 p.m. and 7:00 a.m. all the permissible vibration levels indicated in the previous table for residential district boundaries shall be reduced to one-half the indicated levels.

We recommend the information in this memo be reviewed for city staff by SME, or another geotechnical consultant that we can provide, in order to ensure these would be appropriate standards for Rochester Hills as we are not familiar with the details and exact methods of measuring vibration that are available using various devices.