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# BRIEF TECHNICAL NOTES ON VIBRATION MONITORING & CONTROL

An Informational Series

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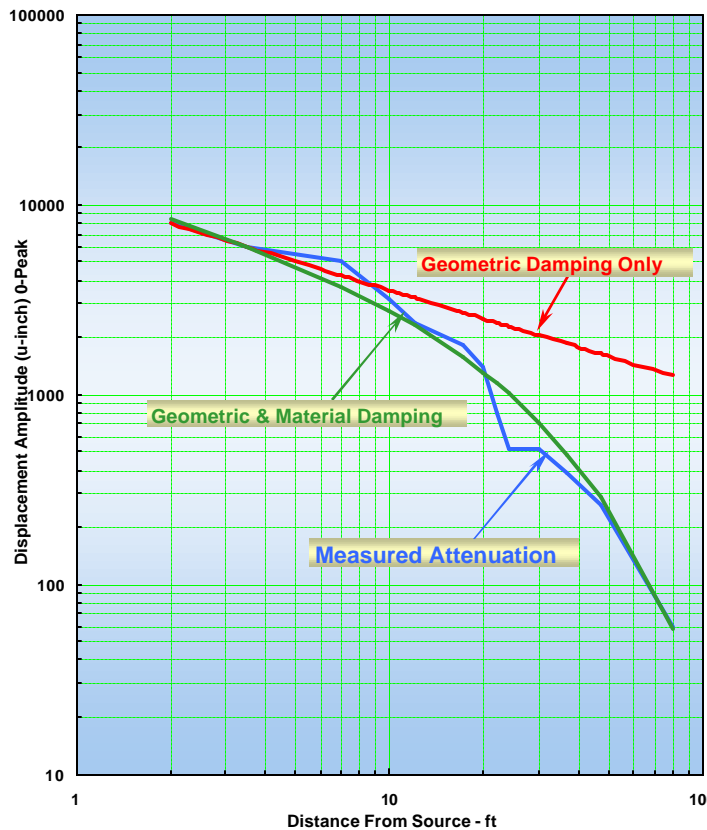
## CONSIDERATIONS FOR SITE LOCATION

Architects and engineers are finding that high-tech research and manufacturing processes have an increasing demand for low vibration levels in the building structure. Likewise, shock transmission resulting from any heavy manufacturing operation must be minimized. Site selection can play a vital role in achieving the vibration objectives.

Certain geologic and environmental conditions can be advantageous over others when locating the site for sensitive buildings. For example, buildings with foundations on or in sound, deep-seated bedrock will experience smaller vibration amplitudes than buildings with their foundations on weathered materials or soils if subjected to the very same excitation.

Seismologists have found that abandoned rock quarries provide excellent sites for quiet seismograph stations. The depth of the quarry screens micro-seismic noise and surface-transmitted vibration. Exposed rock on the quarry floor provides an excellent foundation for sensitive instruments. Mines and underground caverns have similar advantageous properties.

Geophysicists have suggested that isolation can be achieved by locating buildings in a protective, natural geologic feature such as a trough of stratified rock. Also, a deep valley or mountain range may act like a barrier to surface waves if situated between the source of vibration and the site to be isolated.



**Attenuation of Surface Wave with Distance  
from Source of Steady-state Vibration**

### DISTANCE FACTORS

Distance is very important to vibration control. Vibration transmitted through soil or rock is sometimes referred to as **surface-particle motion**.

The earth particles move as a wave front radiating out from the source of excitation similar to water ripples initiated by a point disturbance.

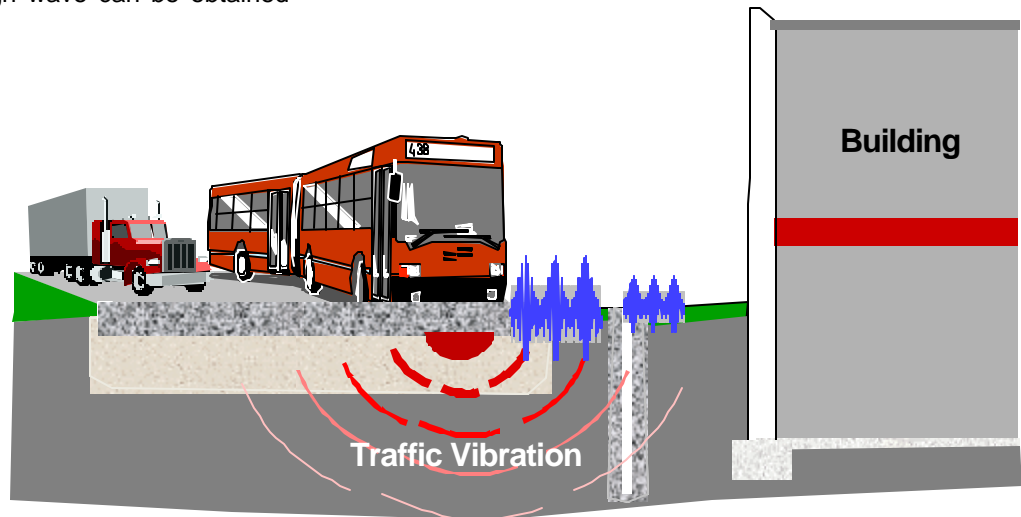
This wave called the Rayleigh Wave is of primary concern for foundations on or near the surface of the earth since this wave transmits most of the energy.

These waves encounter an increasingly larger circumferential surface area as they radiate outward; consequently, energy in each wave decreases with distance from the source of vibration. This decrease with distance is called **geometric damping** and is inversely proportional to the square of the distance away from the source.

Considering the geometric damping alone, it can be reasoned that a large degree of isolation can be achieved by locating buildings as far as possible from known vibrating sources. The same logic applies to locating vibrating mechanical and production equipment as far away as possible from sensitive areas within a building.

It can be shown that vibration attenuation in the field is greater than predicted by geometric damping alone. This happens because soil is not perfectly elastic and energy is lost by **material damping** as well as from geometric damping. Although material damping occurs in real soils, it is the geometric damping that contributes most to the attenuation of vibration.

An additional degree of isolation from the energy associated with the Rayleigh wave can be obtained by locating footings and foundations well below the surface. Since the Rayleigh waves are primarily associated with surface-particle motion, it is beneficial to locate the foundation as deep as practical and keep the sides of the foundation separated from surrounding soil by a soft material or trench-type barriers.



The ratio of the trench depth to the Rayleigh wavelength should be about 0.6 in order to accomplish this level of isolation. For the low disturbing frequencies of 10-30 Hz in the soil, this may become impractical because the trench would be on the order of 6-30 feet deep.

In the case of passive isolation, a trench is considered effective if the amplitude is reduced to 25 percent within a semicircular area behind the trench. Studies show that the trench depth must be on the order of 1.3 times the wavelength. Again, for the low disturbing frequencies of 10-30 Hz the trench would need to be between 12-70 feet deep.

In both active and passive isolation, the trench width is unimportant and should be based solely on construction requirements.

## TRENCH BARRIERS

Isolation of structures and foundations from ground transmitted vibrations by installation of wave barriers has been tried many times and met with varying degrees of success. With trench-type barriers there are two methodologies: 1) active isolation by isolating around the source and 2) passive isolation by screening around the protected area at some distance away from the source.

From studies of active isolation with trenches fully surrounding the source of vibration, a trench is generally considered effective if the amplitude is attenuated to 25 percent in an annular zone extending out ten times the wave length from the outer edge of the trench. Wavelength is a function of the soil properties and the frequency of excitation.

## ESI ENGINEERING, INC.

ESI Engineering, Inc. (ESI) offers consulting engineering services in vibration and noise.

- Establishing Vibration Criteria
- Monitoring Ambient Site Conditions
- Completing Vibration Analyses
- Determining Isolation Requirements

ESI offers vibration monitoring services for ground, building floors, and equipment. ESI has experience in vibration analysis and design of floors, buildings, foundations and equipment for many industries.

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