ISSUE NO. **38**

RWDI
CONSULTING ENGINEERS
& SCIENTISTS

TECHNOTES

Advancement in Imaging Equipment and Vibration Isolation Requirements

Vibration-sensitive devices must meet design specifications provided by manufacturers to ensure their proper functioning. One of these specifications relates to the maximum allowable vibration levels of the flooring system upon which the equipment is placed. These vibrations are generally attributed to nearby pedestrian traffic (i.e., footfall), roadway traffic, and mechanical equipment operation. Vibration criteria recently published by manufacturers have become much more specific, and often significantly more stringent, which require additional vibration isolation and structural re-enforcement of the flooring systems. These criteria are now often provided in narrow-frequency bands (based on FFT analysis methods, in lieu of the 1/3 octave band) which vary across all frequencies.

Figure 1 illustrates the measured response of a floor supporting a scanning electron microscope (based on a 1/3 octave band analysis), which meets the VC-D (1/3 octave band) criterion. The same response was re-processed in narrow frequency bands (using FFT methods) and is presented in **Figure 2**. The response now exceeds the manufacturer's criterion between 1 and 2 Hz. The new methodology applied by manufacturers has not only yielded more stringent criteria (compared to previous methods), but has created a need for professionals to develop and apply tools that output vibration responses based on FFT analysis methods.

The most commonly used analysis method to predict footfall vibration levels in North America is based on the American Institute of Steel Construction (**AISC Design Guide 11**). This method relies on oversimplifying assumptions (e.g., structure has a uniform layout of bays; vibration source/location of predicted vibrations coincide in the center of the bay; the floor's response can be represented by only the natural frequency, etc.). In our experience, this method yields inconsistent findings that can result in floors that do not meet the required vibration criteria, or in over-specification of materials and added costs.

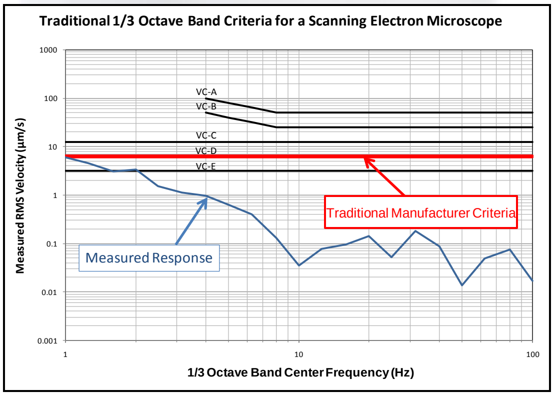

Figure 1: Measured response of a floor beneath a scanning electron microscope (based on a 1/3 octave band analysis)

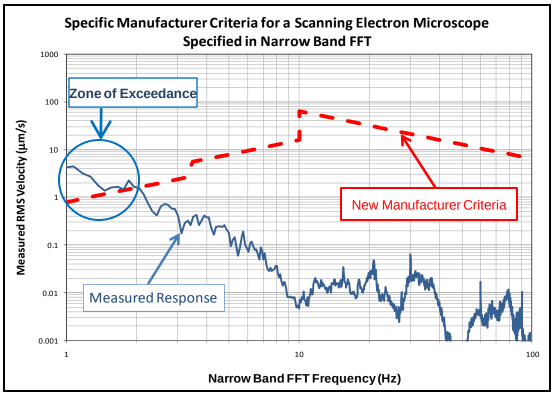

Figure 2: Measured response of a floor beneath a scanning electron microscope (based on FFT methods)

Another method available to predict footfall vibrations is published by the **Steel Construction Institute** (SCI), which involves the development of a three-dimensional finite-element model of the entire flooring system (i.e., all bays) to predict the floor's response to footfall. This method yields accurate predictions of the vibration response (verified using field measurements) over a wide range of frequencies. Vibration levels can also be represented in either 1/3 octave bands (to compare to traditional criteria) or in FFT frequency bands (to compare to the newer criteria). While both methodologies may have been successfully utilized in the past, recent changes by manufacturers have exacerbated the discrepancies between the AISC and SCI. **Figure 3** illustrates the response of a flooring system using AISC and SCI methods, as well as those obtained from field measurements of the same system.

RWDI's unique method begins with the development of a three-dimensional structural finite-element model of the floor. Once the model has been used to accurately characterize its dynamic properties, floor motions from occupant traffic are predicted based on methodologies published by the SCI and Concrete Centre (CCIP). These methods consider critical walking speeds and a full range of walking paths, unlike conventional single-bay models (such as AISC). Vibration amplitudes can subsequently be mapped on floor plans to visually demonstrate areas of compliance with the applicable vibration design criteria. Use of this method allows for greater accuracy in the prediction of vibration responses of the flooring system; graphical representation of the vibration responses to optimize the equipment or room layout based on the lower vibration response within the space. An example of a typical output is presented in **Figure 4**.

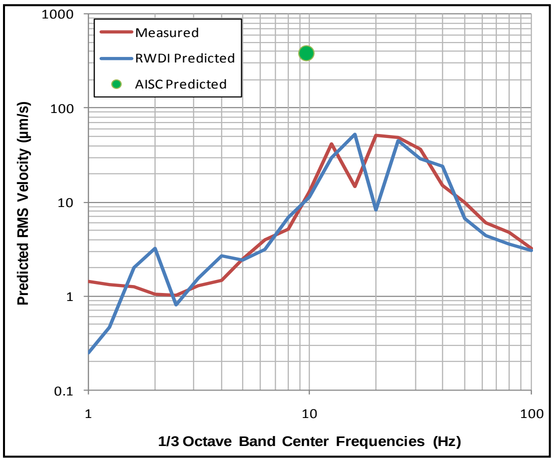

Figure 3: Response of a flooring system using AISC and SCI methods

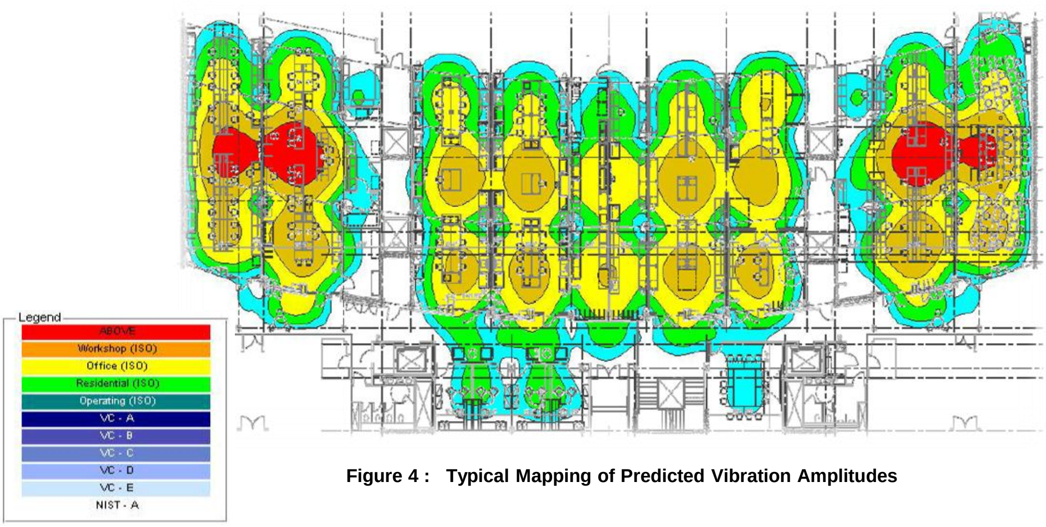

Figure 4 : Typical Mapping of Predicted Vibration Amplitudes

While this new method allows for greater accuracy in the prediction of vibration responses, it is now an essential part of the design of structural flooring systems for imaging equipment.

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