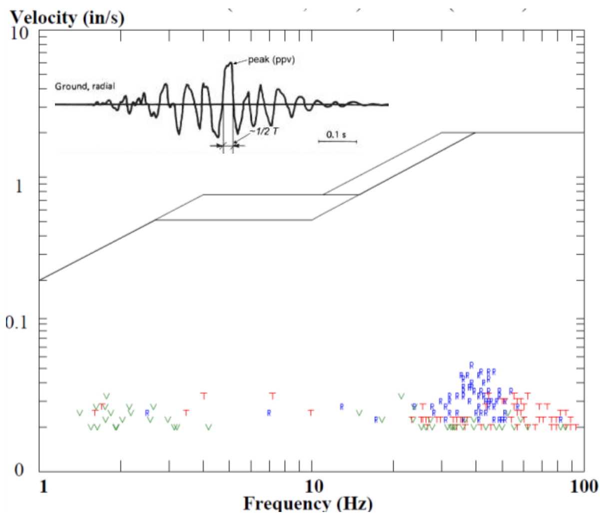
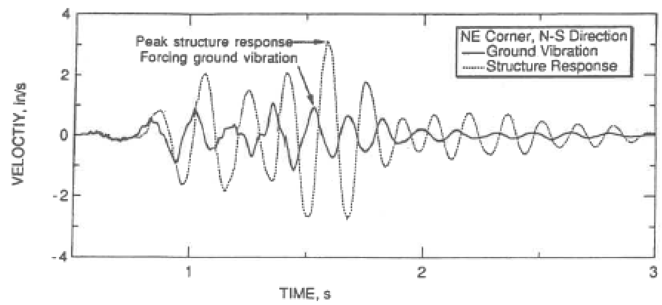
CONST-VIBRATIONS Listserve Newsletter #5

Nuances of choosing the pulse velocity and frequency to populate the Z curve and use of zero crossing to determine frequency





Left: comparison of Z curve with zero crossing "f"s and associated peak pulse velocities (colored symbols) of a typical ground motion time history. Left insert: example of zero crossing determination of "f" as 1/(2 x ½ T). Right: comparison of ground and response time histories and choice of pulse to populate the Z curve.

Vibration control with the above Z curve from RI 8507 involves two variables; peak particle velocity (PPV) and important or dominant frequency. These two variables are in of themselves simplifications of the transient wave train of blast induced ground motions. PPV is defined as the maximum ground particle velocity occurring on any one of the three orthogonal axes. Single axis motion along each of the three orthogonal directional components is obtained as a matter of course with computerized compliance seismographs.

There are three basic methods that could be employed in the determination of important or dominant frequency. They are: zero crossing – the easiest, fast Fourier frequency transform (FFT) analysis, and response spectrum analysis. Zero crossing analysis is the most widely employed because of its simplicity. FFT and response spectrum analyses are more complicated and their explanation would require more space than provided in a short newsletter.

Zero crossing frequency analysis is illustrated in the insert in the top left of the figure. Time between successive crossing of the zero velocity line is ½ the period, T, and "f" is then 1/(2x(½ of T)). This calculation is made for all zero crossings. Each zero crossing "f" is paired with its maximum pulse velocity (PV) and then compared to the Z curve as a point shown by the colored R,T,V symbols on the left hand figure. Pulse velocity (PV) is the amplitude of each of the pulses in the particle velocity wave train.

So, how was the appropriate amplitude and frequency determined for populating the Z curve? As explained on page 52 of RI 8507, where possible "The values of amplitude and frequency used corresponded to the part of the vibration record that produced the larger structure response, which was invariably the low frequency (7 to 30 Hz)". This approach is demonstrated in the right hand figure above, taken from Siskind's (1997) summary book. This example is straight forward for frequency as there is little difference in the zero crossing ½ periods.

Choosing the appropriate zero crossing velocity pulse, PV, for populating the Z curve with experimental data points requires choosing either a) the maximum, PPV, or b) that labeled by Siskind in the figure above as the forcing ground motion PV. In this above example the PV labeled "forcing" is some 16% smaller than the PPV that proceeds it. The forcing PV can never be larger than the PPV. Thus the Z curve is populated with some velocity assessments that are lower than if the PPV had been employed. Any new observation of cosmetic cracking to add to the existing Z curve would require measurement of structural response as well as excitation ground motion as illustrated in the above right figure.

For regulatory comparison with the Z curve, the question becomes, "are any PV-f pairs derived from each zero crossing pulse greater than the Z curve limit?" As can seen in the left-hand figure there are many ½ T zero crossing or "PV–f" points in each of the three orthogonal channels of ground motion wave trains. The blue "R"s in the left figure are for the radial component. These zero crossing comparisons with the Z curve are supplied by all commercial compliance seismographs. Since regulatory monitoring normally will not involve measurement of structural response, any of the "PV-f" points could have been the "forcing" pulse and thus they all need to be considered.