Newsletter #40

High Particle Velocities at Ultra High Frequencies Do Not Produce High Strains

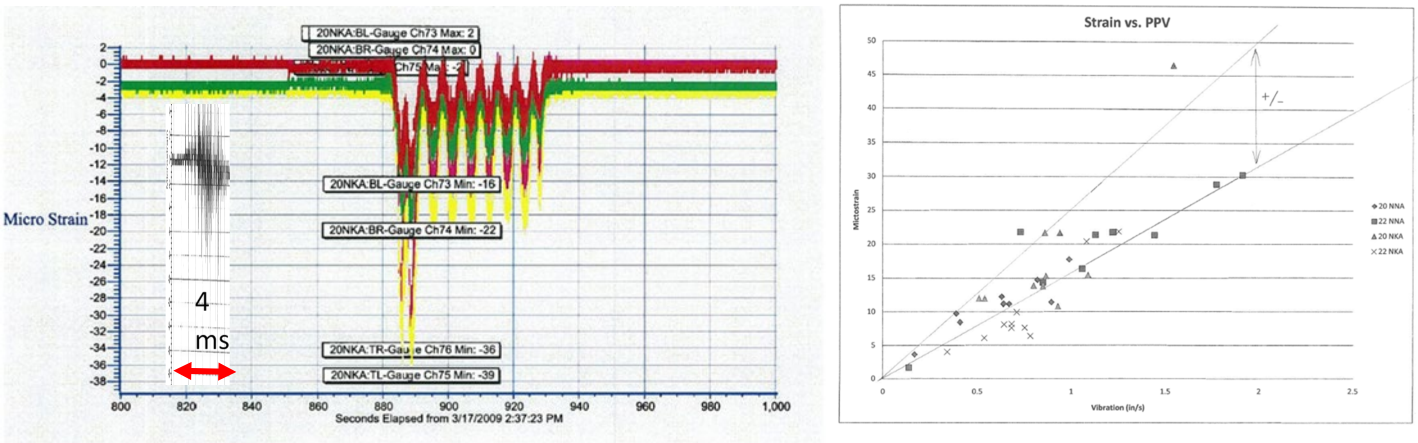

Figure 1: (right) Strains at the bottom of the columns supporting the train shed and Park Ave buildings above Grand Central Station train yard (described in Newsletter # 39) are proportional to the peak particle velocities (PPV) and small compared to the strains produced by trains passing overhead (left)

This Newsletter compares column strains and peak particle velocities produced by close in, small charge per delay blasts beneath Grand Central Station's trainshed. It is the second in a series of four Newsletters (#'s 39-42) that describe the importance of this unique data set. Project geometry and raw data are introduced in Newsletter #39. Attenuation of strains within the trainshed and comparison of measured and calculated strains are presented in Newsletters 41 ands 42.

Strains and PPVs at the bottom of the four corner columns 20xxx and 22xxx are graphically compared in the tight side of Figure 1. Location of 21 NNA wrt shaft #5 is shown in the upper left inset of Figure 1 in Newsletter #39. Maximum strains are roughly proportional to the PPVs with only one exception. The relationship between the strain and particle velocity time histories is best understood with a specific example set of time histories, which are discussed Newsletter #42. Each of the columns was instrumented with a triaxial transducer and two strain gauges at both the base and top of the column

Strains produced by trains passing by on the upper level of the trainshed provide the context for evaluating the acceptability of 50 µ-strains produced by blasting. A typical train-induced strain time history is shown in Figure 1 (left). Passage of the engine produces a strain pulse of some 36 µ strain and the following cars some 20 µ strain. The inset within the train time history is a blast pulse producing 14 µ strain. Blast induced strains are comparatively shorter and higher in dominant frequency; lasting only some 2 to 4 seconds compared to the 50 seconds of train vibration. Dominant frequency of the passing train is some 0.2 Hz, whereas the dominant frequency of the blast induced strain pulses are some 100 to 200 Hz as will be shown below and in Newsletter #42.

Excitation Frequency

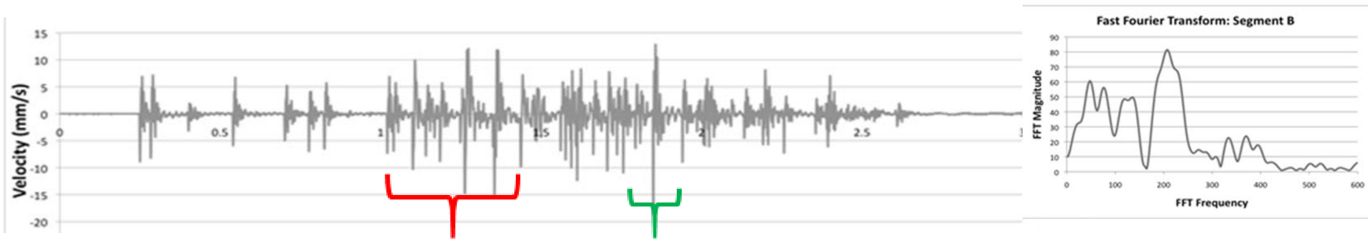

Figure 2: – Fourier transform analysis of a velocity time history of a multiple pulse, 2 second excitation event displays its ultra-high frequency. Segment A (red) is that of the multiple pulses and segment B (green) is that of the single pulse containing the peak particle velocity. To the right of the time history is the FFT analysis of the single pulse (green segment)

A Fast Fourier Transform (FFT) analysis was performed on two segments of the transverse velocity time history in Figure 2. This time history is the transverse component of the excitation at column 20NKA whose vertical response is described in Newsletter #42. It also had a high PPV and a high dominant frequency because of the small distance between the shot and column. This analysis was undertaken to provide a broad basis for describing excitation frequencies. Two regions of the time history are highlighted at the left in figure 2; segment A (red {) and segment B (green {). The red segment contains a series of pulses, two of which are have the highest PPV, and the green segment contains only one high amplitude pulse.

The FFT analysis of segment B is displayed on the right in Figure 2. The dominant frequency of the single pulse B is 200 Hz. Thus the single pulse, B, is dominated by the higher, 200 Hz, frequency. Velocity recording systems sampled at a rate of 1028 samples per second and the transducers were attached to the column. Other recordings of ground motions in rock with higher sampling rates have shown that excitation pulses are higher in frequency and PPV.

As discussed in Dowding et al (2016 & 2018), these ultra-high frequency (> 200 Hz) pulses contain little energy and do not excite the structures coherently. This observation of low excitation energy is confirmed above by measured column strains that show PPV's on the order of 50 mm/s (2 ips) produce strains no greater than those imposed by the passage of trains.