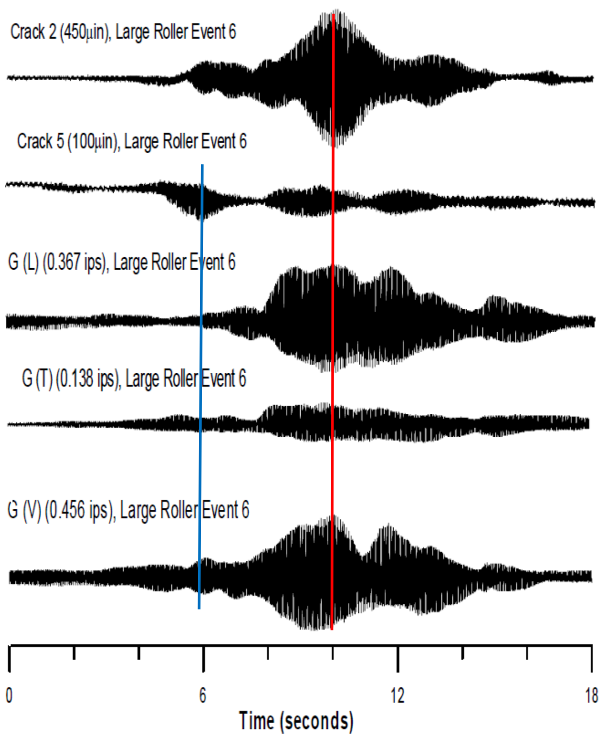
Newsletter #10

Vibrating Roller Excitation of Residential Structures Produces

Limited Numbers of Localized Peak Responses.

Field Measurements of structural and crack response to excitation of a large vibrating roller operating at 24 Hz show that response is localized and that the peak response lasts for a limited number of excitation pulses.



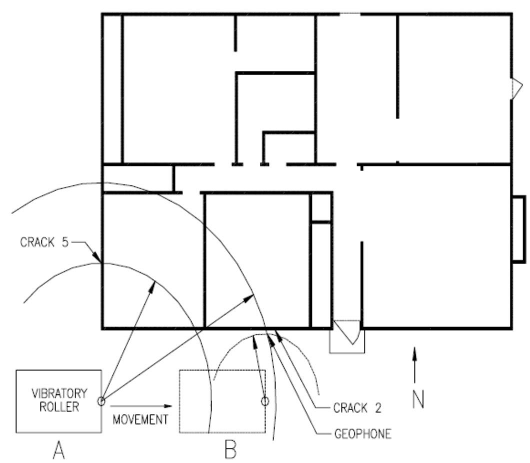


Figure 1 (left) compares time correlated time histories of two crack (2 & 5) responses (top) with the three components of particle velocity excitation at the center of the house near crack 2 during one pass of a vibratory roller.
Figure 2 (right) is a plan view of the house showing the locations of cracks 2 and 5 and the vibratory roller as it passed from left to right by the geophones located in the ground beneath crack 2.

A number of key factors can be observed from the time coordinated time histories of crack response and ground motion in this example: speed of the roller, small number of pulses with the peak particle velocity and peak crack response, and localized excitation. In addition, the vibratory crack response can be compared to the much larger climatologically induced crack response. Details of these measurements of the excitation and response produced by other construction equipment can be found in (Dowding and Snider, 2004) and Snyder's MS thesis (Snyder, 2003)

The event in Figure 1 was produced by a vibratory roller compacting roadway sub-grade material in preparation for a highway 2.5 m (8 ft) south of the house, which was to be demolished. The vibratory compaction was accomplished with an Ingersall-Rand (IR) Pro-Pack series SD115 soil compactor vibrating at 24 Hz. The unusually close passage produced a PPV of 0.46 ips (12 mm/s) in the vertical direction as shown in Figure 1.

The passing speed of the vibrating roller can be estimated in Figure 1 from the 4 second time difference between the maximum response of crack 5 (blue line) and the maximum ground motions at the geophones (red line).The geophones were located 7.6 m (25 ft) east of the west wall containing crack 5. Thus the passing speed was 7.6 m/4 sec =1.9 m/s (~6 ft/s).

The number of peak pulses produced by one pass can be calculated. As seen in Figure 1 the crack response and excitation motions have only several peak pulses. These time histories are presented in greater detail in Snider (2003) Thus at most there are 0.5 seconds worth, or (0.5* 24 =) 12 peak excitation pulses. These 12 pulses are far fewer than the 52,000 necessary to cause cosmetic cracking of plaster covered paper tape drywall joints described in RI 8896 described in Newsletter #9. In addition as will be described in a future newsletter, 24 Hz excitation of a 5 to 10 Hz structure produces less distortion and thus strain than did the repetitive 7 Hz excitation of the test house in RI 8896.

Differing times of maximum crack response in Figure 1 illustrate the local nature of excitation that occurs with compaction close enough to cause PPV's near 12.7 mm/s. In other words the entire house is not shaken harmonically (with peak response occurring simultaneously at all locations), which occurs with excitation from more distant, lower frequency, longer wave length sources. For example in this case, when the roller produced the maximum response of crack 5 (blue line), crack 2's response was only 25% of its maximum. At that time the roller was at the west edge of the house, some 7.6 m west of crack 2's location. Because crack 2 is further from the roller than crack 5 at this time, the PPV at crack 2 will be smaller than at crack 5.

Significance of vibrating roller crack responses to PPV's of 12 mm/s can be determined by comparison with those induced by climatological effects such as changes in temperature and humidity. As described in detail in Snider (2003), the maximum response of crack 2 to the vibrating roller was 11.4 µm (450 µin), while the average daily response was 81 µm (3200 µin). Thus every day on average crack 2 opened and closed some 7 times more than when vibrated by the roller producing a PPV of 12 mm/s. The maximum daily change was some 272 µm (10,700 µin) or 24 times that induced by the roller. Thus vibrating with a large roller within 2.5 m (8 ft) of a residential structure produces crack response far less than produced by climatological effects.

Importance of the vibrating roller excitation frequency on structural response in evaluation of continuous cyclic excitation will be discussed in the next newsletter.

References

Dowding, C.H. and Snider, M.L. (2004) "Response of Cracks to Construction Vibrations and Environmental Effects", Geotechnical Engineering for Transportation Projects, M.K. Yegian & E. Kavazanjian, Eds. Special Geotechnical Publication #126, ASCE, pgs 1767-1776. Available on http://www.civil.northwestern.edu/people/dowding/acm/publicationsRollers.html.

Snider, M.L. (2003) Crack Response to Weather Effects, Blasting, and Construction Vibrations, MS Thesis, Department of Civil and Environmental Engineering, Northwestern University. Available on http://www.civil.northwestern.edu/people/dowding/acm/publicationsRollers.html.