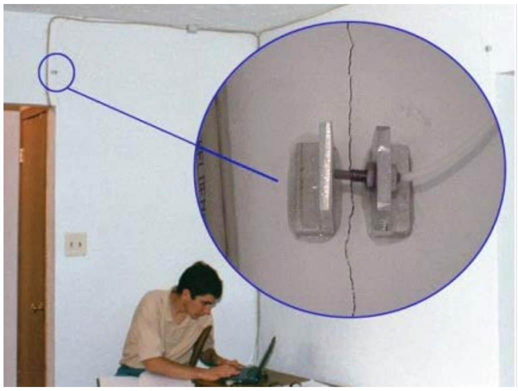
CONST-VIBRATION Newsletter # 16

Long-term or climatologically-induced crack response overwhelms vibratory response both at ordinary and high vibration levels as well



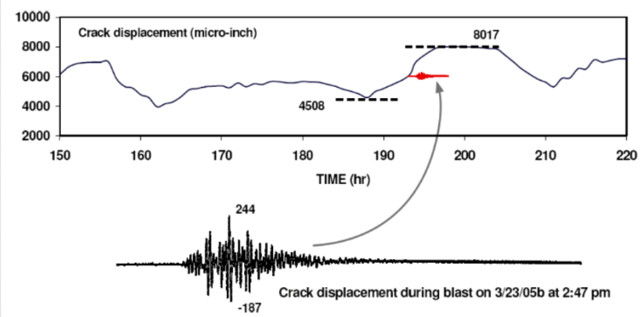


Figure 1 (left): Micro-meter displacement sensor that measures both long-term, climatological and vibratory crack response is shown placed across a crack in the inset.

Figure 2 (right): Vibratory response (red) is almost too small for graphical comparison with daily climatological response (black). Even in this case where ground motions were as high as 11.9 mm/s (0.45 ips), vibratory crack response was still only 1⁄6 that of the daily temperature response.

Placement of micro-meter displacement sensors across a crack as shown in Figure 1 allows comparison of long term (climatological induced) changes in crack width (responses) with those produced by vibratory sources such as blasting and vibrating rollers. Climatologically-induced responses are captured by recording crack response every hour over the course of days and months. Vibratory response is captured by recording crack response to ground motion at 1000 samples per second.

Climatological or weather effects occur slowly and without noise, and therefore are undetectable by neighbors of construction. However, vibrations, especially those induced by blasting, are accompanied by noise and construction activity that can be disconcerting and noticeable. Comparison of climatological and vibratory crack response demonstrates the significance of "silent crackers" such as extreme changes in humidity and temperature, drought, etc. Just because these long term, climatological effects are not heard or felt does not mean that they are not active and large.

Measurements summarized in the book Micro-meter Crack Response to Weather and Vibrations (Dowding 2008) show that climatological crack response, which occurs daily as well as with the passage of weather fronts and seasons, overwhelms vibratory crack response at ordinary and larger excitation peak particle velocities (PPV's). The web site that supports the crack book (ACM, 2020) presents responses of over 62 cracks in 30 structures. The largest number of cases involve coal and aggregate mining; three cases involve reciprocating construction machinery and another vibroseis truck excitation.

Crack responses were recorded in 12 states in the USA, which represent a wide range of climates: from Nevada's desert west to Minnesota's cold north to Florida's tropical southeast. Cases from Australia, and the United Kingdom are included as well. The majority of the structures were of one story; 11 or 37% were two or more stories. While the majority were constructed with a wooden frame, five were constructed with a cementicious block or stone exterior frame, which is of special importance for countries with a housing stock built predominantly with concrete block. For a special article on three concrete block structures see Dowding (2007). Periods of surveillance varied considerably; from several days to over a year.

Behavior of cracks in many materials has been measured. Of the interior cracks or joints some 30 or more were in gypsum dry wall, 8 were in plaster and lath, 2 were in brick or block, 1 was in wood and 1 was at a wood-brick joint. Of the exterior cracks, 9 were in stucco, 4 were in cement block, and 1 in adobe. Cracks were fitted with either Kaman eddy current or Macrosensor LVDT micro-meter displacement sensors.

Ratios of vibratory response to climatological response at typical vibration levels are small. For example, for PPV's between 4 and 5 mm/s, the average ratio of vibratory crack response to long-term or climatological response is 0.03 during an observation period of 3 to 4 months. In other words at PPV's espoused by the German DIN standards to be a control limit for vibratory excitation of residential structures, crack responses to these vibrations are only 1/30 of those produced by the weather.

Even for cases where the ground motions are much higher than 4 mm/s, the ratio of vibratory to climatological response is still small. Consider the cases where excitation PPV's were greater than 11 mm/s (0.43 ips). Of these 14 cracks, 4 were exposed to ground motions of 25 mm/s, 1 to 20 mm/s, another to 18 mm/s, 2 to 12, and 6 to ~11 mm/s. The average ratio of vibratory to long-term response for this group was 0.146. Thus even at PPV's that exceed 11 mm/s (0.43 ips) climatological response is still 7 times greater than vibratory response.

Long periods of observation reveal the truly small magnitude of the ratio of vibratory to climatological crack response caused by extreme events. Consider only the 22 cracks that were monitored for more than 10 weeks or 2½ months in the 2008 compilation. Four, 4, were exposed to ground motions of 25 mm/s, 1 to 20 mm/s, and 4 to 11+ mm/s. Thus of the 22 cracks, 9, were exposed to ground motions greater than 11 mm/s (0.43 ips). For these 22 cracks monitored for 2½ months or longer the average ratio of the vibratory to climatologically induced crack response is some 0.067. For those with PPV's greater than 11 mm/s, the ratio is virtually the same, 0.093. So despite excitation far greater than that thought to be annoying and even crack inducing, climatologically induced crack response during observation periods of 2 to 3 months and longer are 10 times greater than vibration induced response.

This comparison of large, long-term or climatolgically-induced crack response to vibratory response demonstrates why current vibration control limits are conservative for preventing even hair sized, cosmetic cracks.

References

ACM (2020) http://www.civil.northwestern.edu/people/dowding/acm/microbook/index.html.

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