Newsletter #7

Probability of blast induced cracking below 12.7 mm/s (0.5 ips) is zero

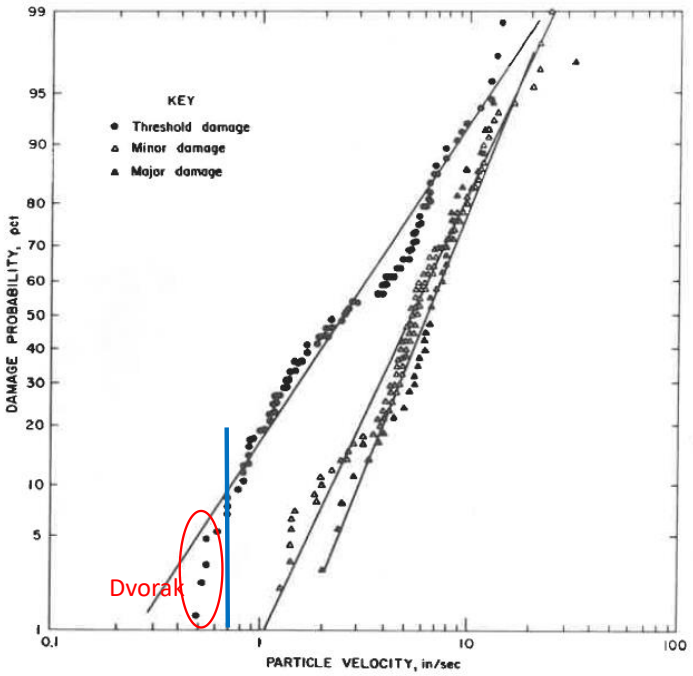
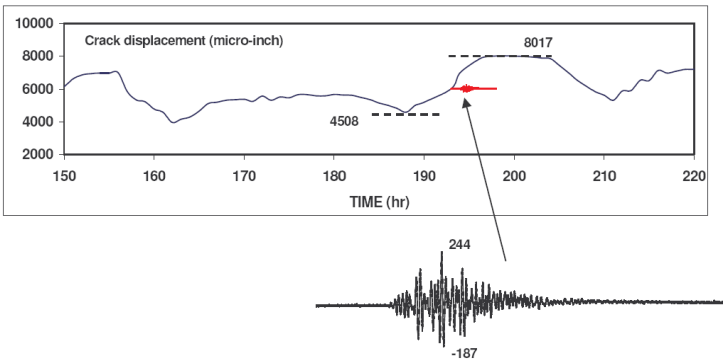


Figure 59.—Probability damage analysis summary, set 7.

TABLE 6. - Comparison of strain levels induced by daily environmental changes, household activities, and blasting

Loading phenomena	Site[1]	Induced strain, μin/in	Corresponding blast vibration level,[2] in/s
Daily environmental changes.	K_1	149	1.2
	K_2	385	3.0
Household activities:			
Walking.....	S_2	9.1	.03
Heel drop.....	S_2	20.0	.03
Jumping.....	S_2	37.3	.28
Door slam.....	S_1	48.8	.50
Pounding a nail....	S_{12}	88.7	.88

[1]From figure 13.
[2]Based on envelope line of strain versus ground vibration plot.



Lower limits to the "Z" curve bound can be further understood by probabilistic study of the cases of scientifically observed cracking that involve immediate pre-and post-inspection to screen out naturally induced cosmetic cracks. Results of this probabilistic study are summarized in Figure 59 from USBM RI 8507. As shown on this probability graph there is a lower limit of peak particle velocity (PPV) of 12 mm/s (0.5 in/sec) below which no cosmetic or threshold cracking (extension of hairline cracks) has been observed from blasting. Data in this low PPV region (encircled in red) were reported by Dvorak in 1962 and involve older plaster and lath walls, not modern gypsum drywall. This zero probability -- to a reasonable degree of engineering certainty---conclusion is the same reached by Siskind in his summary book (Siskind, 2000). As shown by the blue vertical line, the USBM researchers were not able to detect threshold cracking at PPV's below 20 mm/s (0.79 ips) in modern gypsum drywall structures (Siskind et al, 1980)

The lower limit to observation of cosmetic cracking is a result of long-term, climatological crack response. Climatological response overwhelms the vibratory response not only at ordinary but also at high vibration levels as shown by Table 6 from RI 8507. For these two cracks in the table, just the daily temperature response produces crack response equal to that caused by peak particle velocities of 30 to 76 mm/s, some 50 to 375% greater than that associated with cracking in distorted gypsum, drywalled structures. Longitudinal studies of more than 20 structures has shown that over the course of a year climatological crack response is far greater than that produced by daily changes (Dowding, 2008).

This natural phenomenon – distortion of structures by climatological factors -- establishes the base level below which vibratory effects do not exceed naturally occurring effects. This base level of excitation vibration (as measured on the ground in the United States) provides a vibratory control limit below which there is zero probability of the appearance of cosmetic cracking (and distortion of the walls in which they might appear). Furthermore since typical and larger PPV's do not change patterns of long-term, natural, climatologically induced crack response there is no vibration-induced proximate cause of change at the Z curve based control limits. There is no proximate cause even for distorted homes since the Z curve based control limits were defined by crack response of older, distorted homes with weak wall covering.

The figure on the lower right compares the vibratory crack response (red) to a 11 mm/s (0.45 ips) blasting vibration with the daily climatologically induced response (black) (AMA, 2005). Despite the near control limit PPV, the crack response is only some $1/7^{th}$ to $1/10^{th}$ that induced by the daily change in temperature and humidity.

REFERENCES

AMA (2005), "Structure Response Study," Report prepared for the City of Henderson, NV by Aimone-Martin Associates. In CH Dowding's files and soon to be available in at http://www.iti.northwestern.edu/acm/publications.html as soon as the server is repaired in Dec of 2019.

Dowding, C.H. (2008), Micrometer Crack Response to Vibration and Weather, International Society of Explosive Engineers, Cleveland, OH, 422 pgs

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Siskind, D. E., Stagg, M. S., Kopp, J. W. and Dowding, C. H.(1980), "Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting," U.S. Bureau of Mines Report of Investigations, RI 8507, available from the Office of Surface Mining: https://www.osmre.gov/resources/blasting/arblast.shtm.