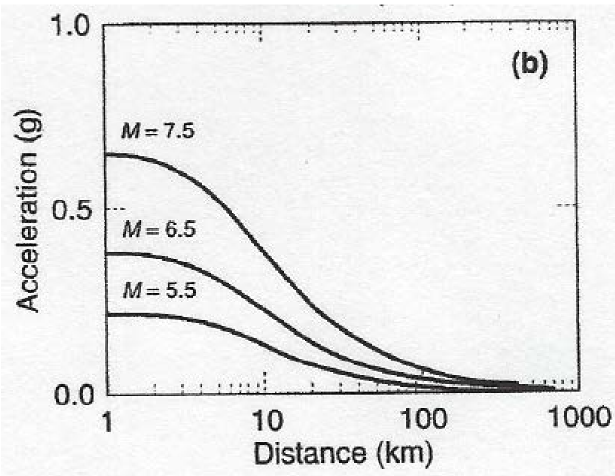
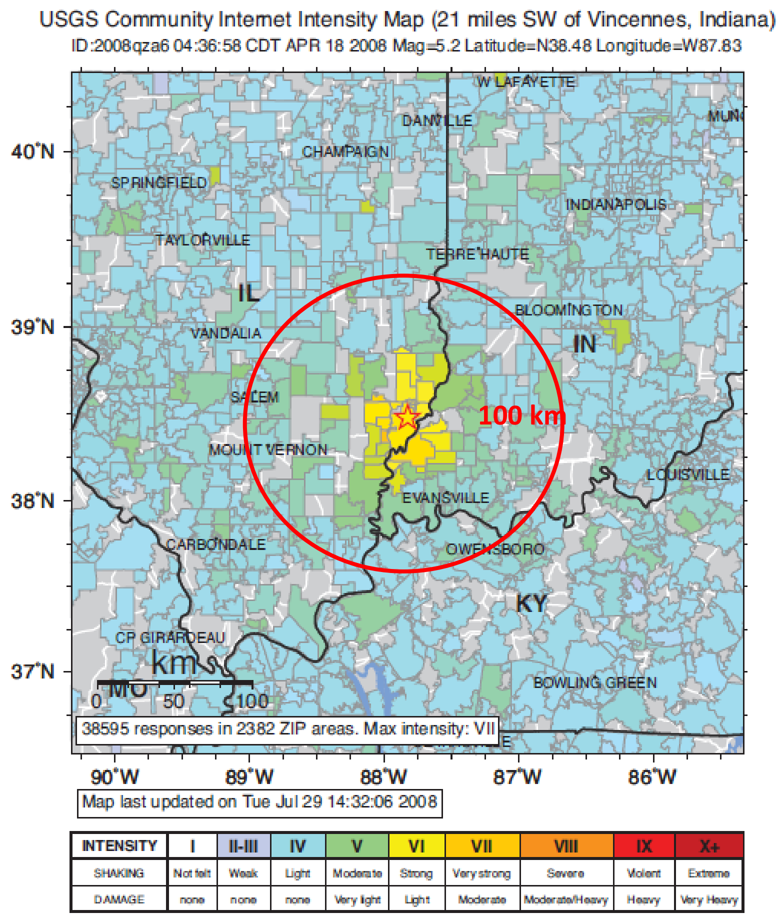
CONST-VIBRATIONS Newsletter # 32

Peak Ground Motions Produced by Earthquakes and Construction Depend upon Energy and Distance from the Source





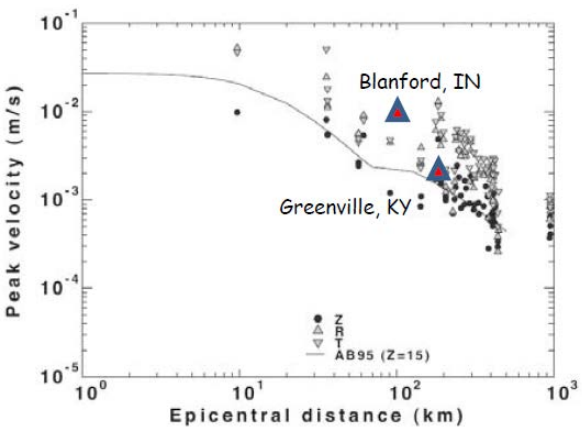


Figure 1 (top left) Attenuation of Peak Horizontal Acceleration of Earthquakes in the Western United States. Figure 2 (right) Modified Mercalli Intensity Map of 2008 Magnitude 5 Earthquake can be compared to Figure 3 (bottom left) Peak Particle Velocity Attenuation of the 2008 Earthquake Out to ~ 100 km. It Displays the Same Log-log Attenuation as Construction Vibrations in Newsletter #31. (Figures 2 & 3 after Herrmann et al 2008, and Figure 1 after Boore, 1993 from Kramer, 1996)

This newsletter expands the discussion of intensity of the ground motion (the effect or degree of response of humans or structures), which depends upon the energy of the source (Richter Magnitude, RM, for earthquakes) and the distance between the source the receiver. Details of a midcontinent Richter Magnitude (RM) 5 earthquake are employed to illustrate the use of intensity to describe earthquakes. Only peak particle velocity should be employed with construction activity induced ground motions.

The most helpful introduction to earthquake intensity and avoiding its use for construction and blasting induced ground motions was written by Oriard (2002). It is paraphrased as follows. “Earthquake intensity scales are intended to describe different levels of effects associated with earthquake induced ground shaking. They were developed long before there was a magnitude scale, and evolved over a long period of time. The best known is the Modified Mercalli Intensity scale (MMI). It was largely developed from anecdotal reports of homeowners. The observations of the signs of hairline cracking in masonry and plaster could be biased or overstated as often happens in reports of blasting. At greater intensities the observations could be considered more reliable.”

One version of MMI intensity descriptors, I, II, III,….X+, is defined and color coded below Figure 2. MMI declines with distance as shown by the zip code based, colored intensity “heat map” of the 2008 RM 5 earthquake in Figure 2.

Intensity descriptors include one row for human responses from the USGS Community Internet Survey and one row for correlated and sometimes observed structural effects. These descriptors are the reports of humans, not measured ground motions. The red circle defines a 100 km radius around the epicenter, where the epicentral intensity was mostly MMI VI with one or two zip codes of VII. There are some three different intensities damage for (V-VII) for the same earthquake. The “damage” intensity level declines with distance with the smallest effect, V, being more distant than VII, the largest, at the epicenter. Remember Oriard’s observation that the low levels of “reported” damage are likely to be less accurate than the higher.

Consider the basic difference between energy and peak ground motions. For earthquakes intensity is sometimes substituted for ground motions as in the example from the internet survey above. Comparison of the ground motions from earthquakes (Figure 1 above) with those from construction (Figure 1 in Newsletter #31) show the same principles. At the same distance from the source, the most energetic (with equivalent parameters) will produce the greatest ground motions. A Richter “energy” Magnitude (RM) 7.5 earthquake produces greater ground motions at 30 km than does a RM 5.5. Similarly, the more energetic 380 k ft-lb drop weight (M2) produces greater ground motions at 10m (30 ft) than does a 7 k ft-lb drop weight (NC1) in Figure 1 in Newsletter #31.

Peak ground motions decline with distance for both earthquake and constriction induced events. The amplitude of the ground motions declines in the familiar linear fashion when plotted in log x – log y form. This similarity can be seen by comparing attenuation of construction induced ground motions (Figure 1 in Newsletter # 31) with that for the magnitude 5 earthquake in Figure 3 above. For earthquakes, distance is the “horizontal” surface distance from the epicenter, which is the location on the ground surface directly above the earthquake’s origin. As seen in Figure 3, within 10 km of epicenter earthquake ground motions do not decline. Among the many reasons are the multiple vertical pathways from and imprecision of the rupture’s hypocenter 10’s of km below the surface. The large stars in Figure 3 represent data collected from blast vibration seismographs at coal mines as described by Dowding and Meissner (2011).

References

Dowding, C.H., Meissner, J. (2011) “Interpretation of Microseismic Effects from Response to Large Coal Mine Blasts “ 8th International Conference on Earthquake Resistant Engineering Structures, Wessex Institute of Technology, Southampton, UK, September, 2011

Herrmann, R.B,, Wither, M, Benz, H. (2008) The April 18, 2008 Illinois Earthquake, An ANSS Monitoring Success. Seismological Research Letters. V 79. No. 6. Nov/Dec.

Kramer, S. (1996) Geotechnical Earthquake Engineering, Prentice Hall, Upper Saddle River, NJ, 653 pgs.