FIRMATEK SEISMIC

A Summary of U.S. Bureau of Mines Research: *Effects of Blast Vibrations on Residential Structures*

Prior to its closure due to budget cuts, the United States Bureau of Mines (USBM) was the primary government agency involved in blasting research. The USBM's blasting research began sometime around the early 1930s. Over the years they have produced a number of publications dealing with the effects of blasting vibration on structures.

In 1980 the USBM published RI 8507, "Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting." This report contained a comprehensive study of how residential structures react to blast generated vibrations. Prior to RI 8507, vibration-limiting criteria were based on a single peak particle velocity value. From their research, the USBM recommended limiting criteria based on a combination of particle velocity amplitude and vibration frequency.

The USBM determined that for low frequency vibrations, limits of 0.50 inch per second and 0.75 inch per second apply with respect to plaster and modern drywall, respectively. These limits provide for a probability of better than 95 percent that the most superficial cosmetic cracking will not occur. The limits increase gradually to 2.00 inches per second as frequencies approach 40 hertz. Concrete block, masonry and concrete are much less susceptible to damage by short-term vibration effects. In general, an applicable limit for concrete block and masonry is in excess of 3.00 inches per second. Solid concrete can withstand vibration levels in excess of 10.00 inches per second.

Another relevant USBM study was RI 8896, "Effects of Repeated Blasting on a Wood-Frame House." In this study, the USBM built a residential structure in the path of an advancing surface coal mine. A summary of some of the pertinent results follows:

- The residence was 1144 square feet. It had a concrete block basement, brick veneer exterior, brick fireplace and it was heated and cooled.
- The residence was subjected to 587 production blasts with ground vibration amplitudes ranging from 0.10 to 6.94 inches per second.
- Cosmetic hairline cracks occurred during construction and when no blasts were detonated.
- The formation of cosmetic cracks increased from 0.3 to 1.0 cracks per week when ground motions exceeded 1.00 in/sec.
- Human activity and changes in temperature and humidity caused strains in walls equivalent to ground motions of up to 1.20 to 3.00 inches per second.
- After two years, the structure was mechanically shaken to determine fatigue effects. The first crack appeared after 56,000 cycles. This is the equivalent of 28 years of blast-generated ground motions of 0.50 inch per second twice a day.

Typical Stresses on Residential Structures

Activity	Corresponding Blast Vibration Level (inches per second)
27° F Temperature Change	4.15
14 MPH Wind	1.20
Nail Pounding	0.88
Door Slam	0.50
Jumping	0.28
Shoe Drop	0.10
Walking	0.03

This study showed conclusively that environmental effects and human activity such as door slams create strains in a residence well in excess of those corresponding to typical low-level blast vibrations. The study also proved that repeated low-level blast effects do not cause material fatigue.

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A Summary of U.S. Bureau of Mines Research:
Effect of Blasting Air Overpressure on Residential Structures

When explosives are used to break rock in a mine or construction project, the blast produces both ground vibration and air overpressure (noise). In most cases the atmosphere selectively absorbs the higher frequencies from a blast, leaving relatively low energy (5 hertz) sound waves to effect structures. If a structure has a natural vibration frequency around 5 hertz, it will respond to the air overpressure by producing higher frequency secondary noise on internal walls. It is this response from the middle of flat walls in a structure which causes much of the secondary rattling noise and other observed effects such as movement of pictures, clocks, etc.

Most concern about structural damage comes from people who feel the effects while inside their homes. They are actually responding to the structural motion that produces rattling and motion and not to the actual noise and ground vibration from the blast, which are often imperceptible when outside the structure.

The stress on a structure from a 131.7 dB overpressure produced by a blast is roughly equivalent to the stress produced by a 25 mph wind. The wind isn't as noticeable as the air overpressure due to its slow rate of pressure change and the correspondingly minor or nonexistent rattling, in contrast to the relatively rapid pressure changes produced by air overpressure waves. The BOCA (residential building) code has a general requirement for vertical residential walls to be able to withstand a pressure of 10 pounds per square foot. Some areas have higher standards (such as Florida with its seasonal hurricanes). The 10 pounds per square foot pressure standard is equivalent to a gusty wind of 62.5mph. Thus residential structures are designed to withstand air overpressures well in excess of those produced by normal blasting operations.

Air overpressure produced by blasting is expressed in pressure units called decibels (dB). This overpressure can be measured accurately with specialized instruments called seismometers. The following table gives the decibel levels produced by some typical situations:

0 dB	Threshold of hearing
20 dB	Whisper
40 dB	Hospital Room
65 dB	Ordinary Conversation
95 dB	Riveter
115 dB	Threshold of Complaints
134 dB	Bureau of Mines recommended "Safe Level" for Blasting
140 dB	Historically Proven Safe Level
151 dB	Occasional Window Breakage
171 dB	General Window Breakage
180 dB	Possible Structure Damage

The United States Bureau of Mines was the federal government organization responsible for research into the effects of blasting operations on residential and commercial structures. Extensive research by the Bureau of Mines over many years and in many different blasting situations showed that as long as the air overpressure produced by a blast did not exceed 140 dB, damage to structures was highly unlikely. As a result of these findings, the Bureau of Mines established a recommended "safe" level of 134 dB, well below the proven damage threshold, for commercial blasting operations.

Present day mining and construction firms typically perform their blasting operations in such a manner as to ensure that this "safe" level is not exceeded, thus protecting nearby structures