Blasting Vibration

Kentucky Division of Mining Reclamation and Enforcement

Explosives and Blasting Branch

Why does a company have to blast?

Earth moving equipment can not dig all of the natural bedrock in Kentucky. Explosives are used in construction, quarrying, and mining to fragment rock layers so that the mechanized equipment can move it.

Blasting operations range from trench blasting to install utility lines, breaking up limestone used for roads, to fragmenting overburden when mining coal. Small amounts of explosives are used in demolition of buildings and in some cases when installing utility poles.

Why does my house have to shake?

Although proper design controls the adverse effects from the use of explosives outside the blast area, people can feel the effects of blasting operations. It is understandable to be concerned about blasting when your home is shaking.

When explosives are detonated in rock two things happen, one a shock wave is produced, and secondly gas pressure is formed. The shock wave creates micro fractures around the blast hole; limited to a few diameters of the blast hole, generally speaking thirty feet or less. As the gas expands into these fractures the rock is broken, in fact, the gas pressure is what physically fragments the rock. Each blast is designed to consume the energy produced by the explosives in the breaking of the rock. However, a small amount of energy will radiate away from the blast site.

The ground movement that you can feel is from the shock wave, while the venting of the expanding gas and movement of the air caused by the displaced material will create a slight air over pressure. What you “feel” inside the house is a combination of both effects. Ground vibrations travel through the earth at several thousands of feet per-second, while the effects to the atmosphere move at approximately the speed of sound. How your house will respond depends on several factors that are related to the type of blasting operation, distance to your property, and the weather. For example blasting for a sewer line up the middle of your street in front of your house will create a high frequency shock wave and very little air over pressure, the vibrations pass very quickly. On the other hand, your house will respond noticeably longer from blasting on a surface coal mine, because greater volumes of material must be moved requiring larger blast designs than the trench. Often blasts are hundreds of feet away, and the ground movement begins to slow its rate of travel due to the distance. Even when farther away the ground vibration will reach your property before the air overpressure, consequently your home might respond for several seconds. The condition of the atmosphere may cause the air overpressure to produce different effects from similar blasts. On a clear day the pressure is dissipated vertically, but low clouds will cause the air wave to reflect and it may cause a structure to respond at a greater distance.

A low level change in air pressure can cause windows to rattle, an effect similar to a clap of thunder. When PPV is low, the structure may shake from the airblast instead of the ground vibrations.

If my house shakes, it must have damage!

A tremendous amount of research has been performed in order to determine the extent of damage that can be expected from blasting vibrations. The United States Bureau of Mines (USMB) performed the most thorough research concerning coalmine blasting effects on residential structures. These studies involved mounting instruments inside homes adjacent to a mine site and making observations during the blasting. Seismographs were used to measure ground movement and air overpressure from the blasting operations. A blasting seismograph measures the *Peak Particle Velocity (PPV)* of the ground vibrations in *inches per second* and records the rise in air over pressure above ambient conditions.

PPV is analogous to a speed limit. In other words, as the blasting vibration excites a particle it moves about its point at rest in three dimensions, not in a straight line. The seismograph geophone measures the rate of the movement in three separate planes, thereby determining the velocity of the vibration. Air overpressure measured in units of *Pounds Per Square Inch* above the pressure of the air before the blast; a common term for this effect is airblast. The seismograph converts PSI is to "C" weighted decibels (dB). Although represented in Db levels, what one would normally think of as a sound, blasts may not be heard because the frequency of the air blast is below the range of human hearing.

Other studies involved different types of blasts such as construction and quarry blasting operations. Mechanical shakers were installed in a test home to determine the actual effects of repeated vibrations. Results from this study indicated that damage did not occur from repeated vibrations. Additional studies continue to be performed on how homes respond to air overpressure and ground movement. USBM *RI 8507* was published several years ago; however the safe blasting levels recommended by the report have been validated by the continuing research.

How is blasting regulated?

The Bureau's reports combined with recommendations from other research studies provided the basis for the current regulations. Kentucky's laws and regulations require that blasting on construction and quarries be limited to ground movement of 2.00 PPV and air overpressure be limited to 133 Decibels.

If the blaster does not monitor the blast with a seismograph, the regulations require that the scale distance formula be used to calculate a maximum pound of explosives to be used based on the distance to the protected structure. The amount of explosives determined by the regulatory formula is very conservative and limits the PPV below 2.0 PPV. On all non coal blasts the maximum amount of explosives to be detonated within an eight millisecond (8ms) period is calculated by the distance (D) to structure divided by a factor of 50 and the resulting number squared.

Scaled distance formula - lbs. per 8ms = $(D/50)^2$

Blasting operations on coalmines have different ground movement limits:

Feet from Blast	PPV	Scale Distance Equation
0 to 300	1.25	$Wt = (D/50)^2$
301 to 5000	1.00	$Wt = (D/55)^2$
5001 and beyond	0.75	$Wt = (D/65)^2$

In addition on coalmines the compliance may documented with a combination of PPV and the frequency (Hz) of the ground movement.

If the blaster does not monitor the blast with a seismograph, a scale distance formula can also be employed to calculate a maximum pound of explosives detonated per eight milli seconds. The formula looks the same as for non coal operations except that different denominators are used for the corresponding distances and PPV limits (above). Again the amount of explosives determined by the regulatory formula is very conservative and keeps the vibration to below the regulatory limits.

Air overpressure from coal mine blasts is also limited to 133 dB at 6Hz.

Records are kept on explosives from its manufacture to end-use. Cross checking the records allows the regulatory authority to insure that all explosives are accounted for, making it difficult to falsify shot reports.

When the regulatory authority (RA) documents a violation, a citation or a notice of non compliance, or both is written to the blaster and or the company performing the work. Liability insurance is required for all blasting operation in the Commonwealth of Kentucky. Settlement of the monetary amount of damage claims is a civil matter. The RA cannot be involved in the monetary resolution of blasting damage claims.

What to do if you feel that a blasting operation is not operating in compliance.

The Explosive and Blasting Branch is responsible for inspecting blasting operations for compliance with state laws and regulations, and the investigations of blasting damage allegations. Call the Frankfort Office at 502- 564-2340 to request an investigation or report questionable behavior by the users of explosives.

The laws and regulations pertaining to blasting and technical reports on use of explosives can be found on these links.

http://www.dmre.ky.gov/eandb/

http://www.arblast.osmre.gov/

The information collected by the USBM documented the chance of damage to various building materials from blasting vibrations. The following table summarizes the results.

PPV	Observable Damages
0.00	None
0.03	Ground Vibrations are easily felt
0.50	Cracks in plaster may appear or existing cracks in plaster may extend
0.75	Existing cracks in drywall may extend
1.00	New cracks in drywall may appear
2.0	Above this level there is a possibility of structural damage
3.00	Cracking may begin in the mortar joints of masonry walls
4.50	Cracks in masonry may begin
10.00	Cracks in monolithic concrete form