CONST-VIBRATION listserv Newsletter #24

Whenever Blasting Occurs Closer Than Two Blast Hole Depths (within crater zone)

Explosive Gas Pressure Induced Rock Block Movement Becomes a Major Concern

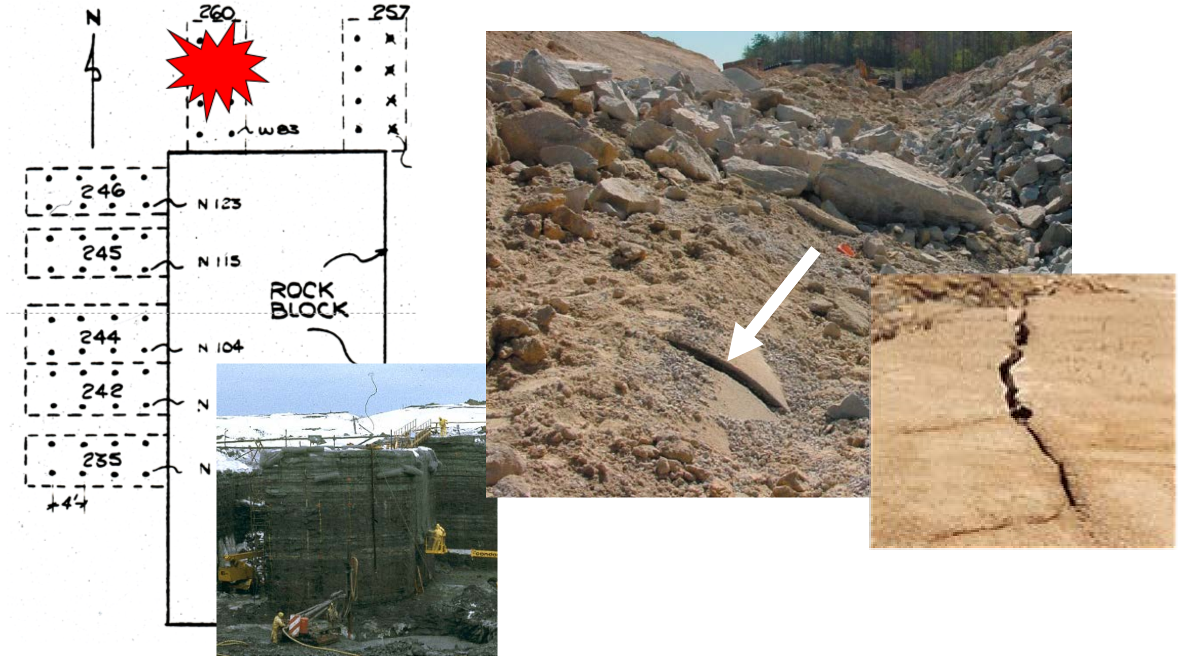
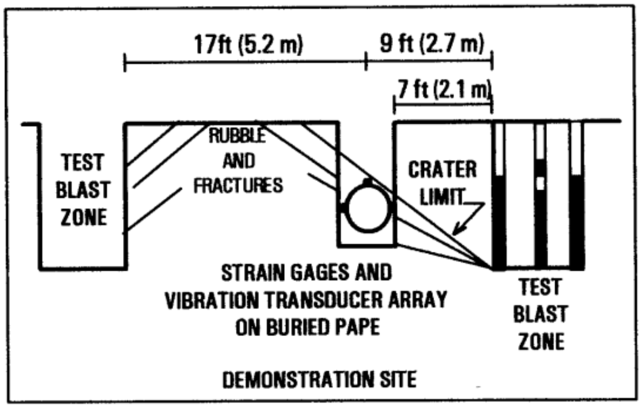


Figure 1 (left) Plan view and photograph of 3400 mTon horizontally bedded block displaced 50 mm by blast with a burden of 5 m (16ft) instead of 1.4 m (5 ft). Inset shows bedding (Dowding 1996, pg 339). Figure 2 (top right) Concrete pipe uplifted and displaced by blast in adjacent trench within the crater zone. Figure 3 (right) Back break crack from quarry shot producing permanent displacement.

The compliant pipeline strain formulation described in Newsletters 20-23 may not hold for blasting at very short distances within the crater zone. Some explosives produce large volumes of gas upon detonation, which do not escape as rapidly as the shock-induced strain energy as it radiates away from the blast zone. Thus, these gas pressures can accumulate, even though the wave energy is subdivided by detonating each hole separately at intervals of at least 8 milliseconds. This 8 msec rule of thumb is based upon pyrotechnic delays with large timing errors compared to micro-processor based electronic delays. These accumulating volumes of gas generate pressures of 10 s of MPa (100's of psi) and help propel the rock mass during the blast. These pressures are normally relieved by moving rock into an excavation such as a quarry. This relief is assured during blast design by restricting the horizontal burdens of rock between the explosives and free face of the excavation so that the rock can be easily broken and moved toward the free face opening. If this relief is not provided, this gas pressure energy may propagate along joints and open and shift unintended volumes of rock and even adjacent pipes as shown in Figures 1 through 3.

The shorter the distance between blasting and a buried pipeline, the more likely it is for there to be some localized displacement in the trench wall that causes a section of rock and/or soil to be displaced relative to the pipe, while not necessarily displacing or causing any damage to the pipeline. When carried to an extreme, a blast crater may cast away a section of trench rock and soil, leaving a pipeline exposed in the trench as shown in Figure 2. Upon occasion this condition has been deliberately induced by the test blast illustrated in Figure 4. Such a condition has been induced inadvertently on a



number of occasions when the exact location of a buried pipeline was not precisely known to the blasting contractor for the new work For an example of a blast-exposed, but undamaged ceramic conduit, see Oriard (2002, page 363).

Figure 4 Example geometry of test trench blast and crater zone inclined 30 to 35 degrees from the horizontal (Oriard,2002)

Even though material presented in Newsletters 20-23 demonstrate that pipelines can withstand high particle velocities it is important in high velocity situations to assure against the potential for cratering or permanent distortion of the remaining rock mass through delayed gas pressure jacking. Minimum stand-off distances should not be less than what would be prudent given the cratering angle and elevation of existing pipe and deepest adjacent blast hole. In addition, jointing and or weakness planes in the rock mass should be taken into account. The most critical situation would involve persistent joints or bedding planes that connect the existing pipeline trench and the "to-be-blasted" trench.

Controlled blast designs should be based upon considerations beyond scaled distance and peak particle velocity to protect against permanent displacements of the rock mass when pipes are located within or near the crater zone of the blast. Existing pipe should not be located within the potential crater zone including considerations of sub drilling. Explosive charges should be distributed as much as possible in space by employing a high drilling factor with small diameter bore holes, even if it requires a different drill to reduce the blast hole size. The initiation sequence should employ the smallest charge weight per hole as practical while maintaining the necessary powder factor. Finally, explosive types should be limited to those that produce the lowest volume of explosive gases per weight of explosive.

References

Dowding, C. H., 1996. Construction Vibrations, Prentice-Hall, 1996. Now available on eBay direct from author.

Oriard, L.L., 2002. Explosives Engineering, Construction Vibrations and Geotechnology, International Society of Explosives Engineers, Cleveland, OH, USA.