Vibrations from Blasting

1 Introduction

QUAKE/W is designed and implemented primarily for analyzing the effects of earthquakes on earth structures. The same implementation can also be used to investigate the effect of a sudden impact on the structure, such as controlled blasting in an open pit mine, for example.

In a finite element stress-strain formulation, the activating forces can come as, (1) a body load, like an earthquake, (2) a specified nodal boundary force, or (3) specified nodal displacements. Velocities and accelerations cannot be applied as boundary conditions; at least not directly. Acceleration or velocity variations with time can, however, be integrated and applied as displacements with time at any particular location.

This example illustrates how this can be done. A velocity versus time record for an imaginary blast at the foot of a slope is converted into a displacement versus time function, and then applied as a boundary condition.

Figure 1 shows the configuration of the problem. The downward arrows at the foot of the slope indicate the location of the dynamic boundary condition.

Simple linear-elastic soil (rock) properties are used for this illustrative example.

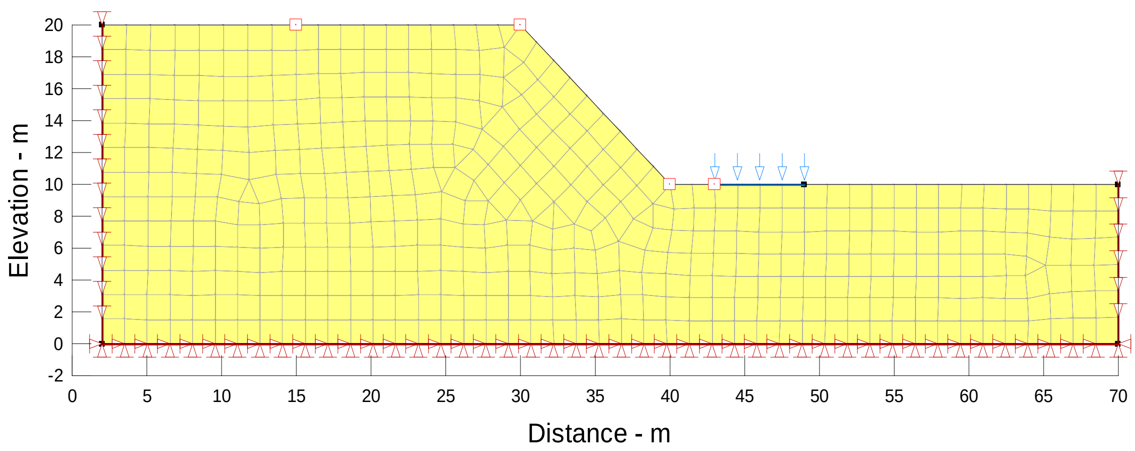

Figure 1 Problem configuration – arrows show location of blast

2 Initial insitu conditions

As with all QUAKE/W analyses, it is always necessary to first establish the insitu stress conditions. This can be done with the Initial Static analysis option. Fundamentally, this involves a simple gravity turn-on analysis; that is, the gravity is turned on after the model has been set up. The gravity effect is modeled by applying the self weight of each element as a boundary condition.

3 Blast analysis

The effect of the blast is specified by the velocity versus time function in Figure 2. QUAKE/W integrates the area under the velocity curve to obtain the displacement versus time function in Figure 3. As indicated by the displacement function, the blast causes a sudden uplift in the ground surface.

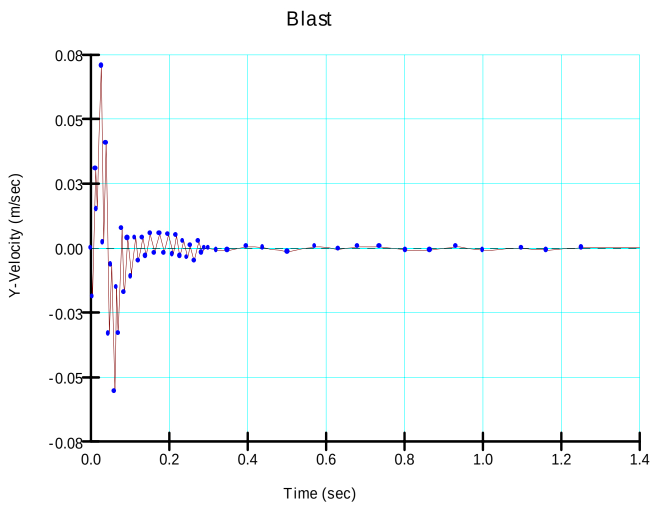

Figure 2 Velocity versus time function

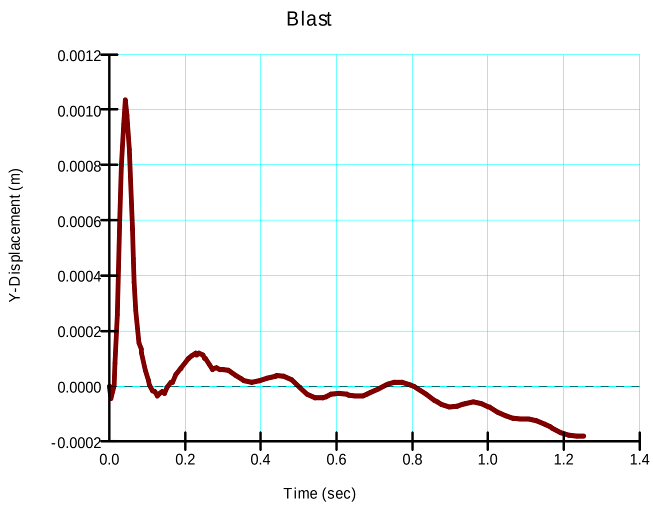

Figure 3 Displacement versus time function from the velocity function

To capture the sudden change in displacement and the resulting reverberations, it is necessary to use very small time integration steps. This example uses time steps equal to 0.001 (1/1000th) seconds.

There are many ways to view the impact of the blast. Only two graphs are shown here to illustrate what can be done. There is a History Point on the upland beyond the slope crest. The horizontal and vertical resulting velocities at this point are shown in Figure 4 and in Figure 5.

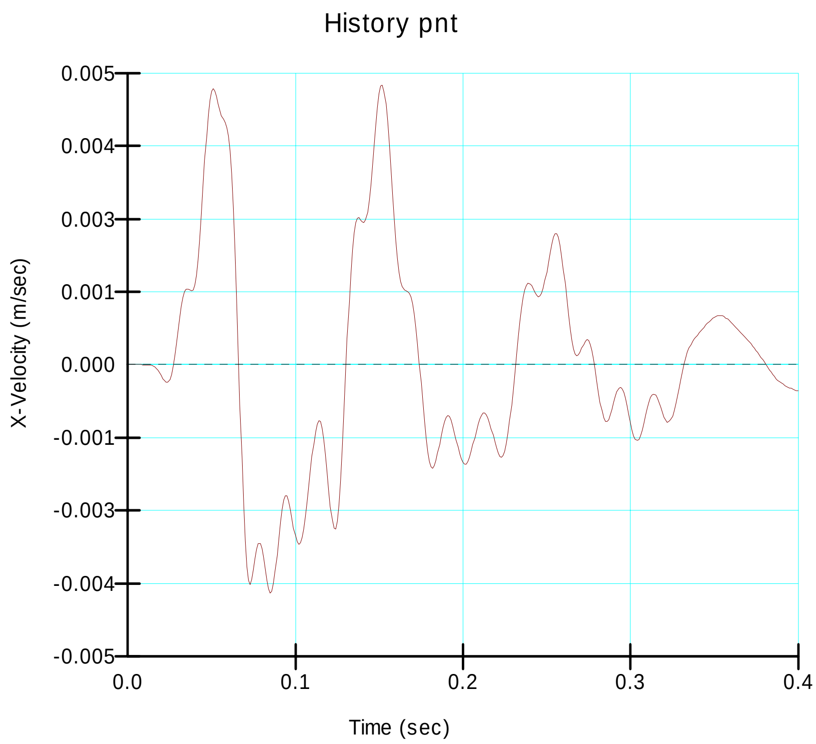

Figure 4 X-velocities on the upland

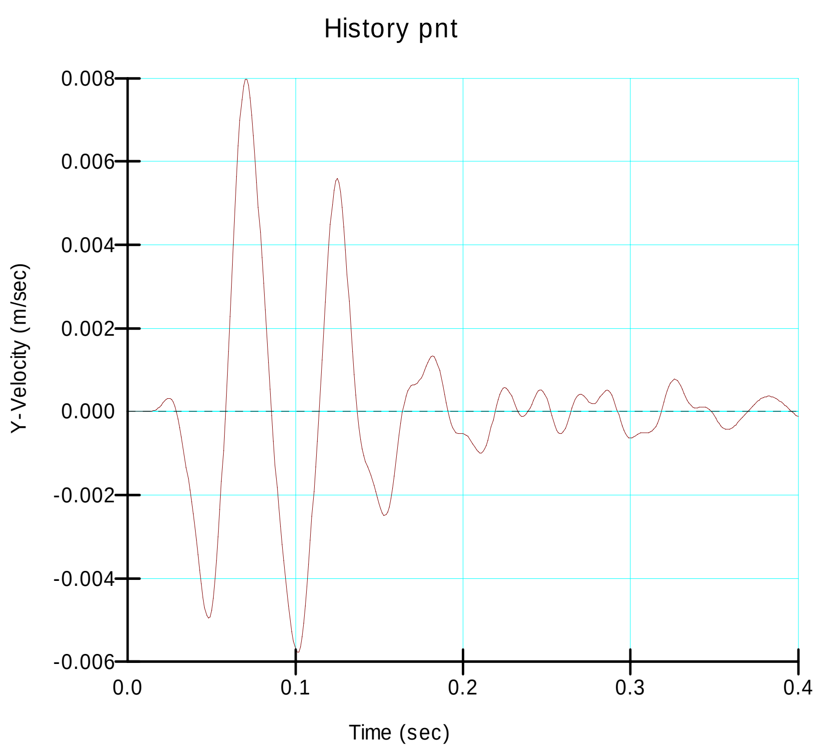

Figure 5 Y-velocities on the upland

4 Effect on stability

The Newmark deformation analysis type in SLOPE/W can be used to look at the effect that the blast has on the slope stability. The results from such an analysis are shown in Figure 6. The sudden uplift at the foot of the slope causes the safety factor to increase suddenly, and then oscillate more or less about the static factor of safety. There are, however, some indications that the factor of safety does fall below the initial static value momentarily.

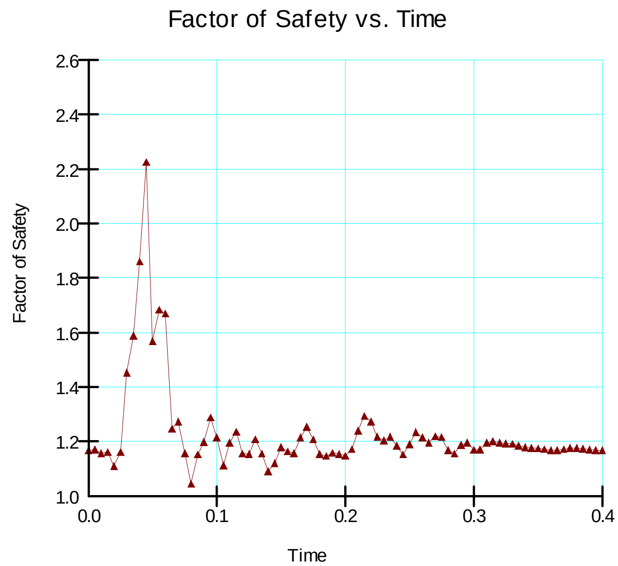

Figure 6 Factors of safety with time due to the blast

The factor of safety at no time drops below 1.0, and so the Newmark analysis infers there will be no permanent deformation.

5 Source of input data

The input for an analysis like this could possibly be obtained from a monitoring seismograph at a site, which can record velocities and or accelerations in multiple directions.

6 Concluding remarks

The data used in this example is not all that realistic, but it is sufficient to demonstrate what can be done with QUAKE/W in conjunction with SLOPE/W to investigate the effects of a sudden impact on an earth structure.