Shaking Tie-Back Wall

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Introduction

This example demonstrates how QUAKE/W can be used to analyze the response to shaking of a sheet-pile wall tied-back with anchors. The prime purpose is to show how the forces in the structural components oscillate during an earthquake, and to show the procedures required to do this type of analysis.

The problem here is patterned after a similar SIGMA/W example. The same problem has been simplified for this example to reduce the details involved, for a more convenient discussion and presentation here.

Numerical Simulation

The configuration of the problem is shown in Figure 1. It is a 9 m high sheet-pile wall tied-back with two rows of anchors. The anchors have a bonded length and a free length. The bonded portion is modeled as a beam with an E-Modulus of 2 x 10^8 kPa, a cross-sectional area of 0.00126 m^2 and a Moment of Inertia of 0.00025 m^4. The free length is modeled with a bar with an E-Modulus of 2 x 10^8 kPa and a cross-sectional area of 0.00126 m^2. The sheet pile wall is modeled with a beam with a cross-sectional area of 0.002 m^2 and a Moment of Inertia of 0.0005 m^4.

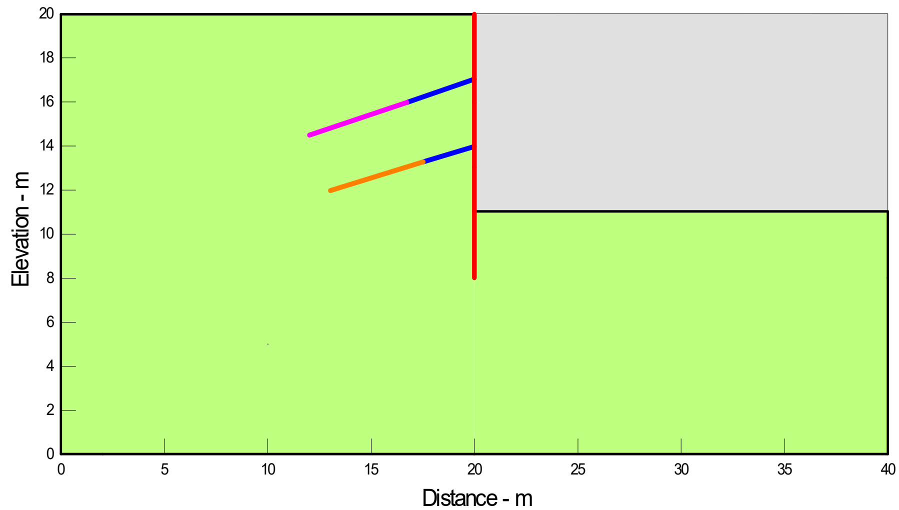

Figure 1. Tie-back wall configuration.

To set up the state of stress in the ground and in the structural components prior to the earthquake shaking, we must start with the stress in the ground and then simulate the construction of the wall.

The initial *in situ* stress is established with a simple gravity turn-on analysis using the Insitu option in SIGMA/W. The Effective E-Modulus is set to 5,000 kPa with a total unit weight of 20 kN/m^3 and a Poisson's ratio of 0.334. The Initial analysis simulates the stress of the ground prior to the excavation of the material and construction of the wall (Figure 2).

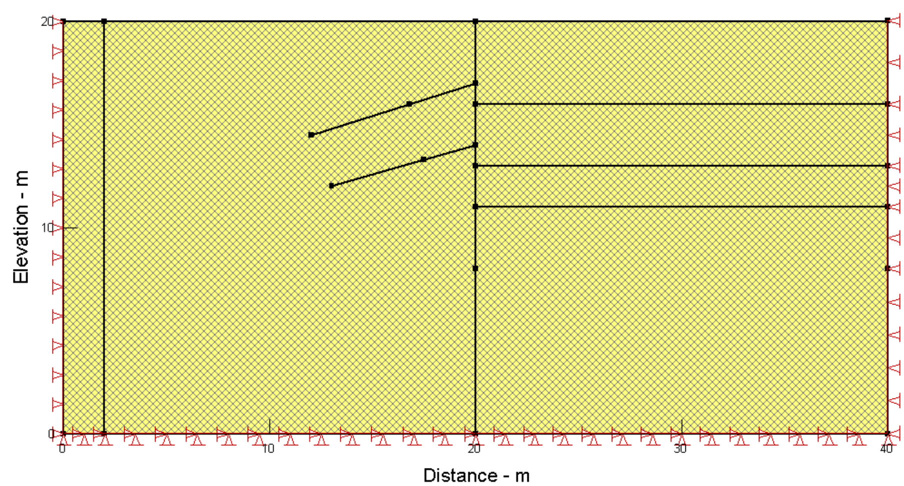

Figure 2. Initial stress problem configuration.

The next step is to establish the stress conditions that would be present in the ground and structural members after excavation and construction just before the earthquake. This can be done by "wishing in place" the structural members and then removing the excavation soil. In this example, this is all done in one step. This could be done in many stages to more accurately simulate the construction sequence, as in the SIGMA/W tie-back wall example, but for this illustrative example, it is sufficient to do it in one step.

Next we can use the SIGMA/W computed static stresses as the initial (Parent) conditions for the QUAKE/W dynamic analysis. The earthquake record used for this case is shown in Figure 3.

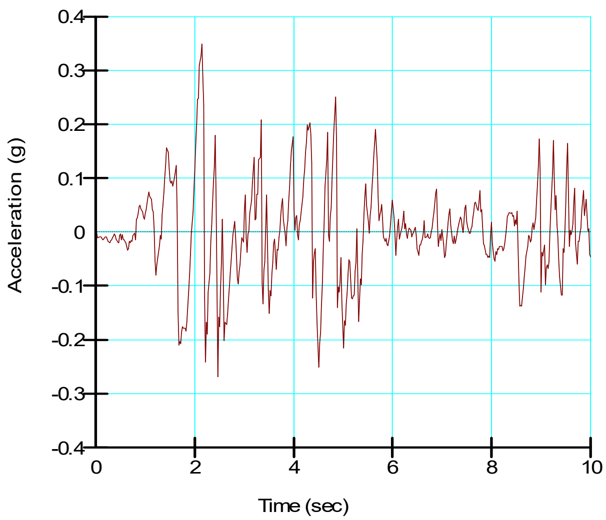

Figure 4. Earthquake time history record.

Only linear-elastic soil properties are used to reduce the complexity of this illustrative example. Linear-elastic properties are adequate to demonstrate the QUAKE/W features and capabilities. The Damping Ratio is 0.1 with a G_{max} of 100,000 kPa.

Results and Discussion

The results of the Insitu analysis can be explored with the Graph command in CONTOUR by creating plots along a vertical profile.

At the end of the second SIGMA/W analysis, the static forces and stress are known. The moment distribution in the sheet-pile wall is, for example, as in Figure 4.

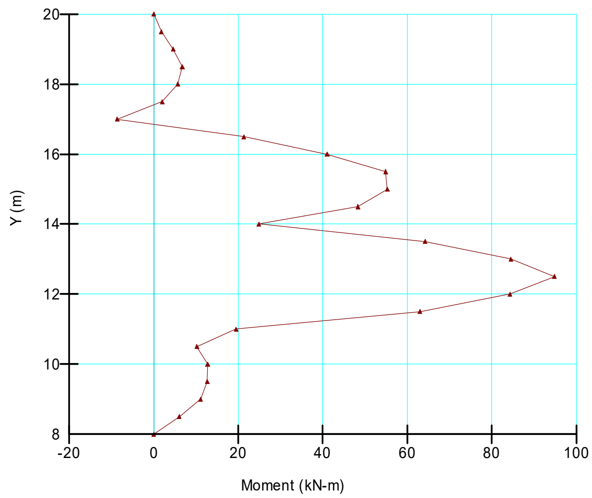

Figure 4. Moment distribution in the sheet-pile wall before the earthquake.

Figure 5 shows the computed oscillations in the moments in the sheet-pile wall during the QUAKE/W analysis. The results suggest that the wall is bending in the form of a wave.

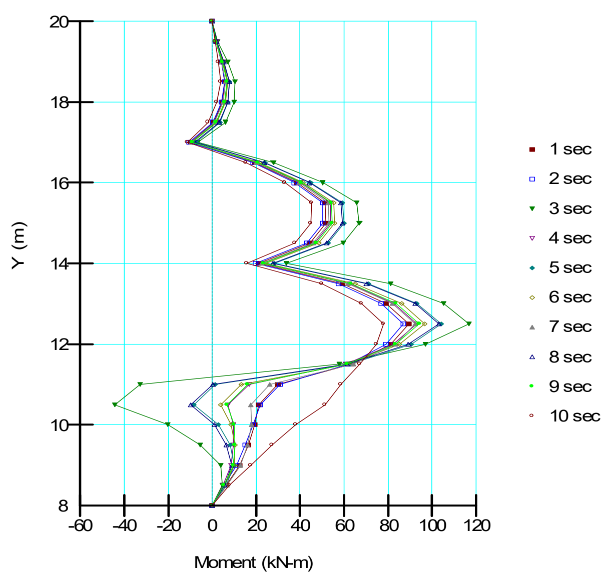

Figure 5. Moment oscillations in the sheet-pile wall during the earthquake.

Figure 6 shows the variation of the axial force in the grouted length of the anchor during the shaking at five different times. The forces are, of course, the highest (most negative indicating tension) where the bonded length is connected to the free length portion of the anchor (x = 16.75).

Figure 7 shows the corresponding axial force in the free (unbonded) length of the upper anchor. Note that at time zero, the axial force is equal to the static force from the SIGMA/W analysis.

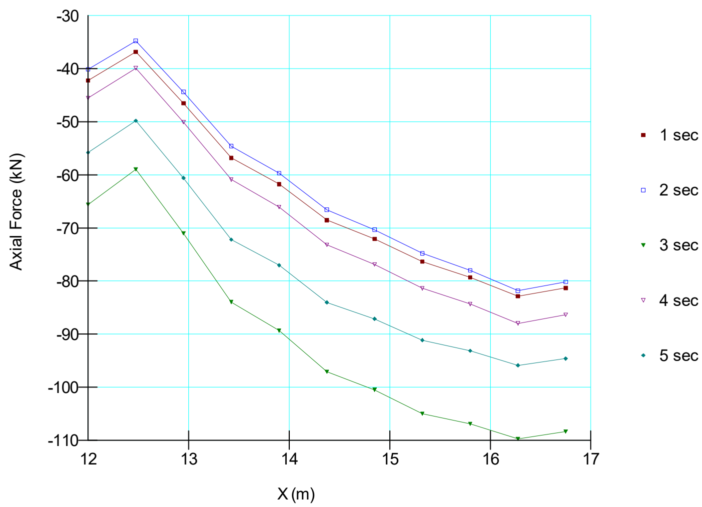

Figure 6. Axial forces in the grouted (bonded) anchor length during the earthquake.

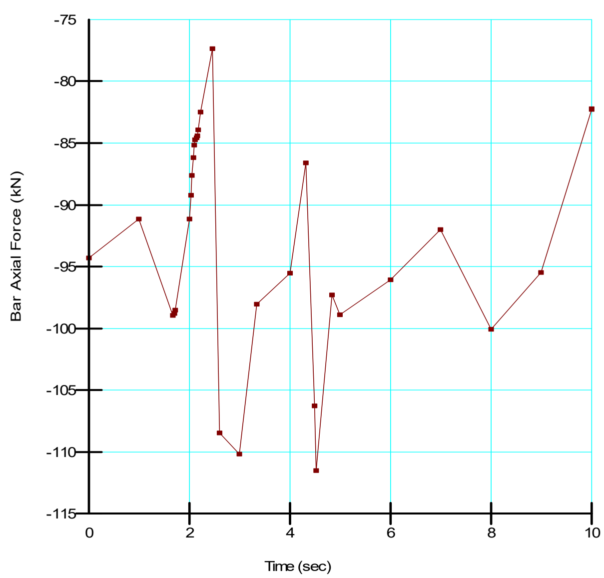

Figure 7. Axial force in the free length of the upper anchor.

Summary and Conclusions

This example illustrates how the results from a SIGMA/W soil-structure interaction analysis can be used in QUAKE/W to subject the structure to the effects of an earthquake. The trends in the structural moments and axial force appear to be correct. Unfortunately, there is no way to verify the magnitudes of the forces. Another example named, *Structural Beams*, demonstrates that the formulations for the beam and bar elements in QUAKE/W are correct.