3D Site Response using NLSSI

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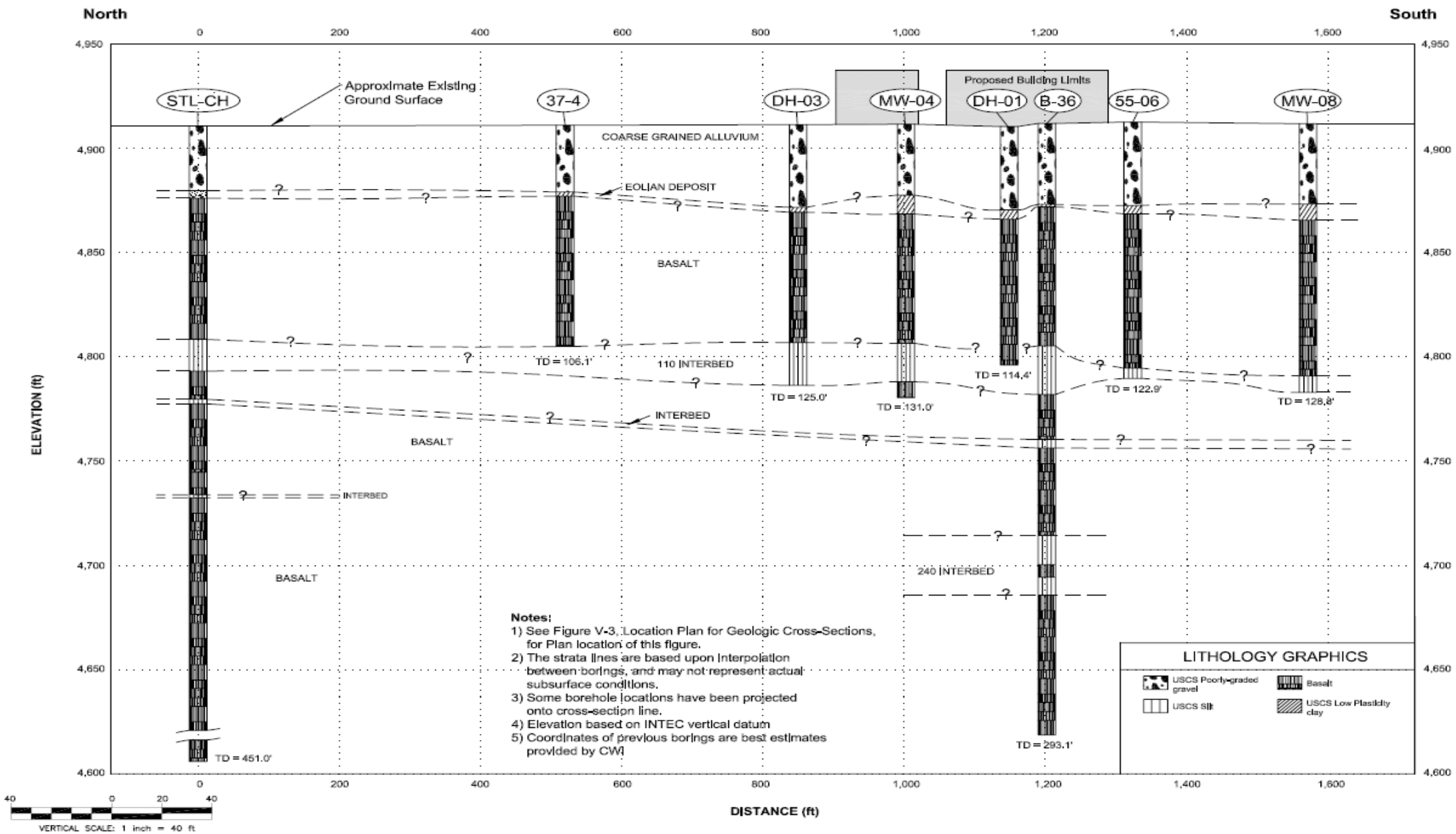
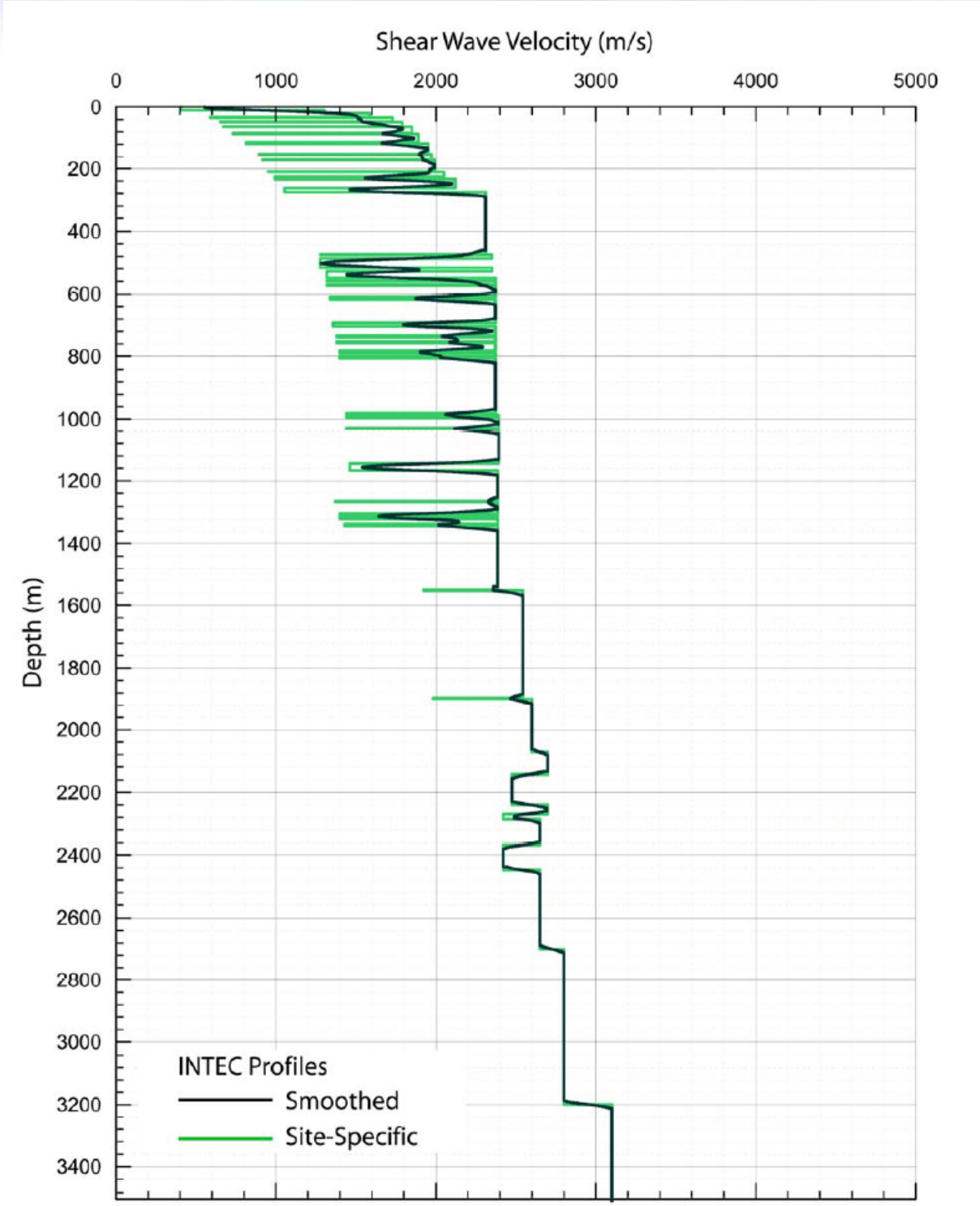
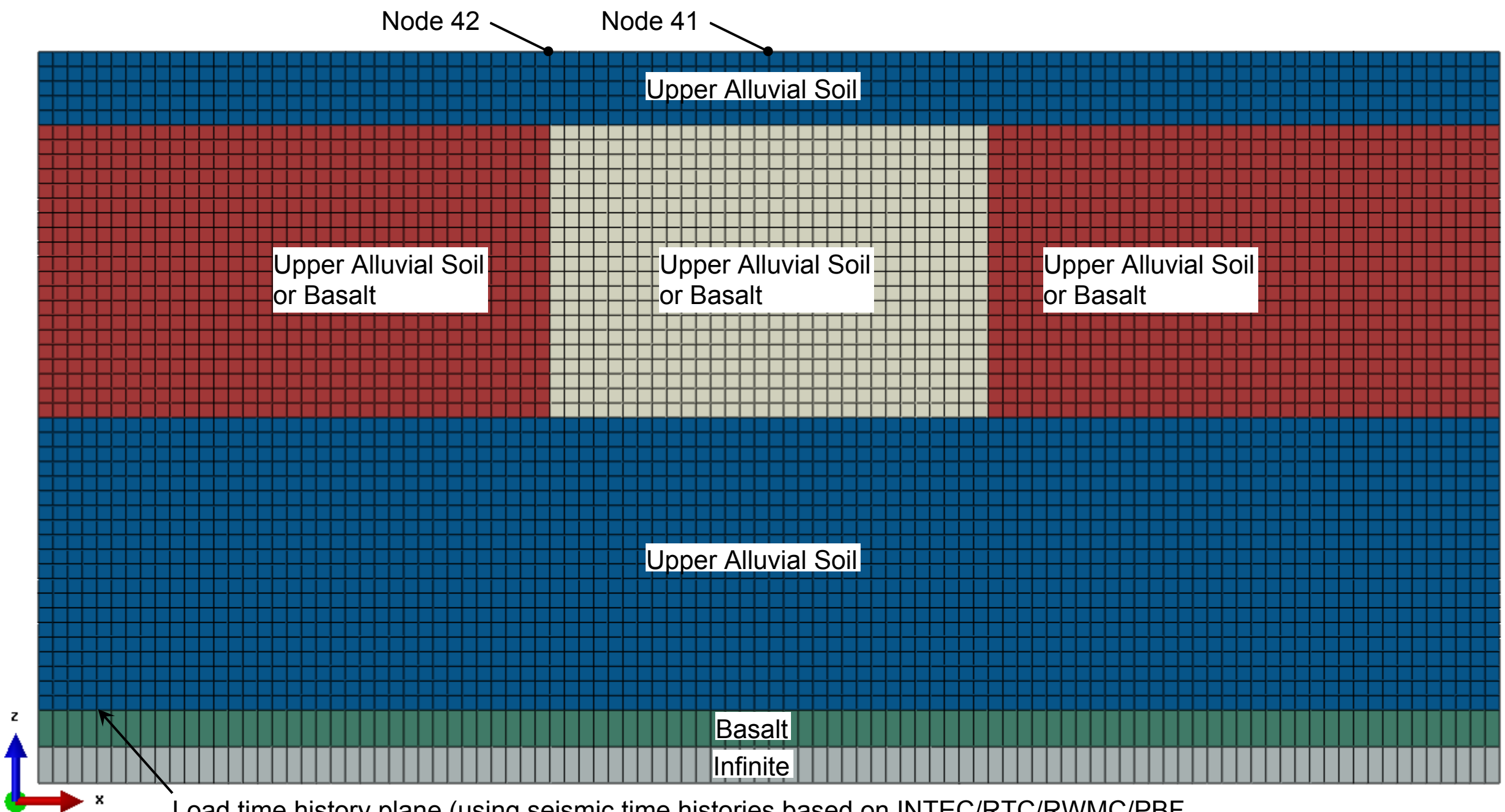
Is 3D Site Response Necessary?



What is done with data?



Finite Element Mesh

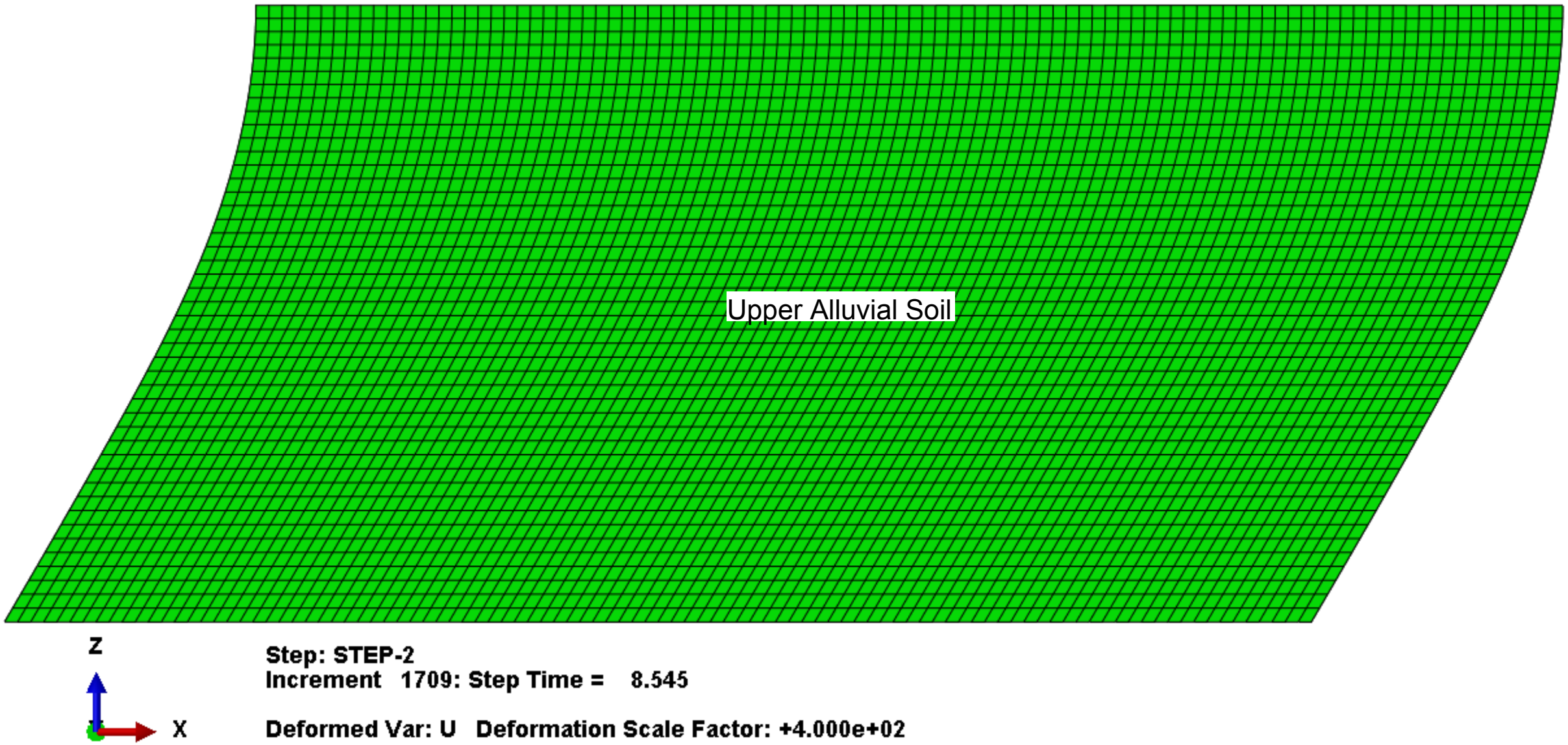


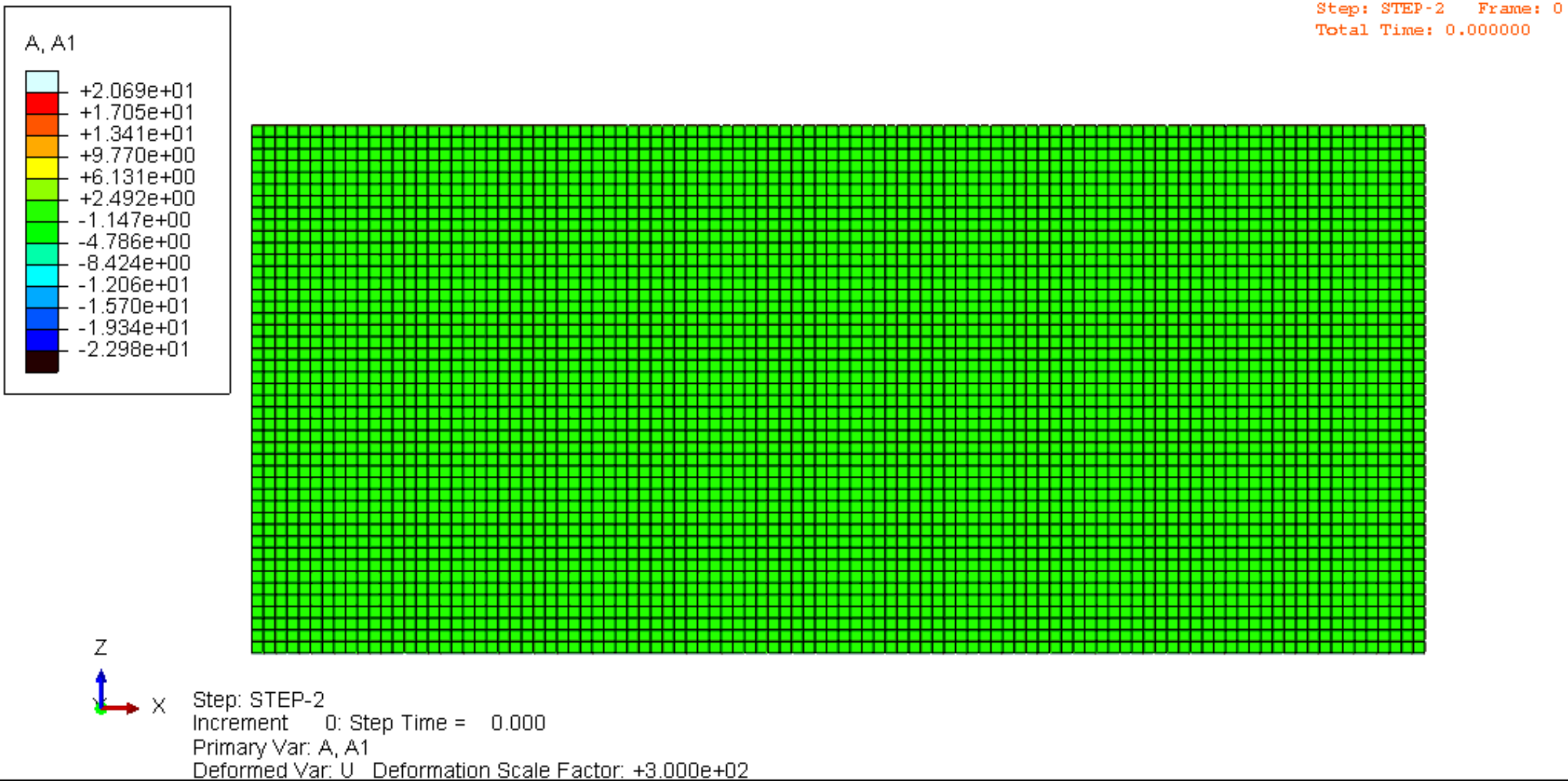
Load time history plane (using seismic time histories based on INTEC/RTC/RWMC/PBF PC 4 (10,000 yr) Rock DBE applied in the x- and z-directions)

Finite Element Model Parameters

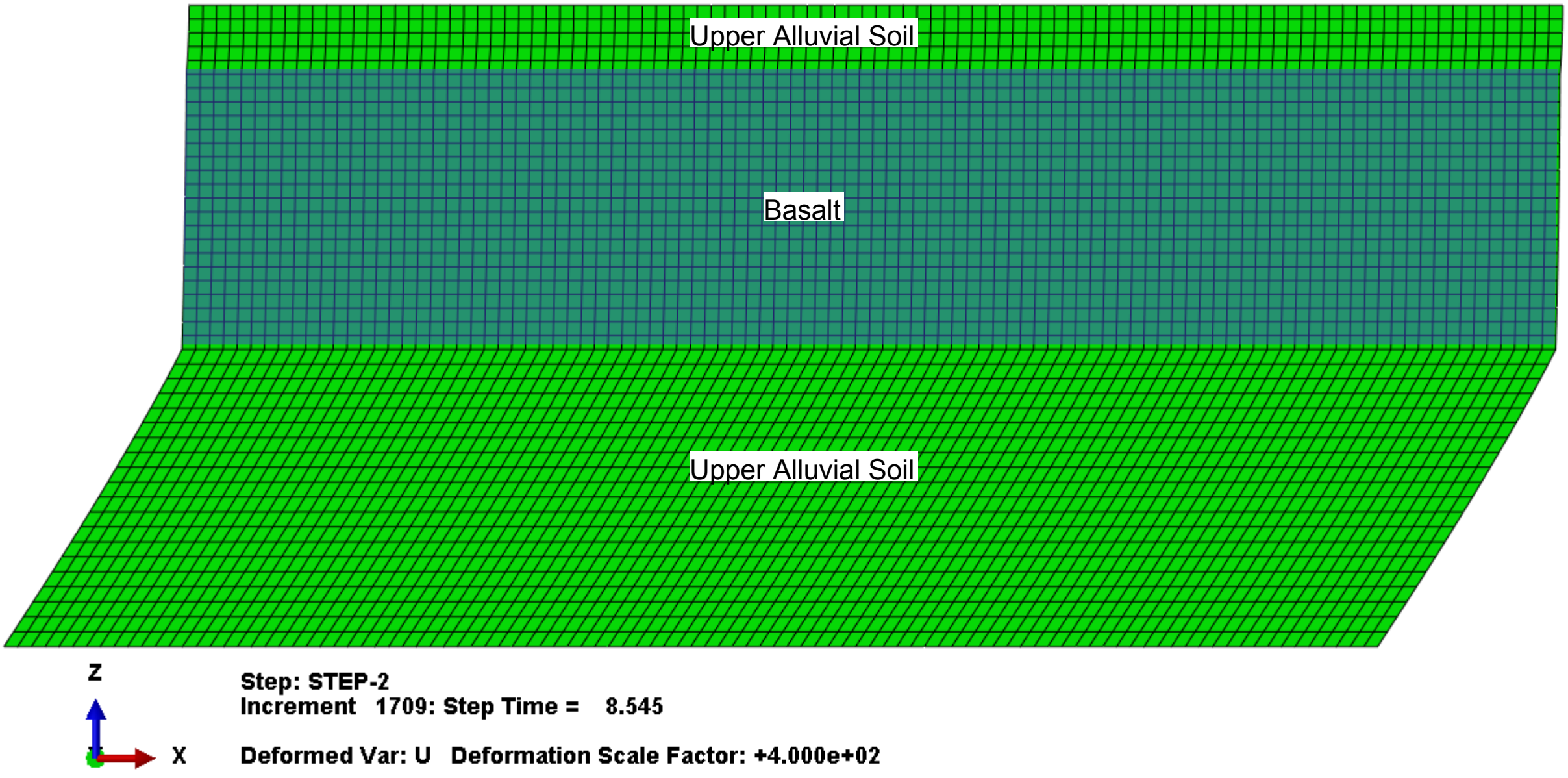
- The mesh includes 90 feet of soil or soil and basalt (with 4500 elements), a basalt layer that is 5 feet deep (with 100 elements), and an infinite element layer (with 100 elements)
- The mesh is 200 feet wide and includes a 40-foot high layer 10 feet below the surface that can be meshed as all basalt or as basalt in a 60-foot wide region
- The upper alluvial soil and basalt are modeled as linear-elastic with modulus of elasticity, Poisson's ratio, and density representative of INL soil properties
- The mesh uses 3-D brick elements but it is performed as a 2-D model by including y-directions restraints on the brick element nodes
- The basalt layer and infinite element layer (below the horizontal plane where the load time histories are applied) mimic a non-reflective, infinite basalt continuum
- Nodes at each given elevation on the positive and negative x-direction vertical edges are constrained to move together as though there is a uniform, infinite continuum in the positive and negative x-directions

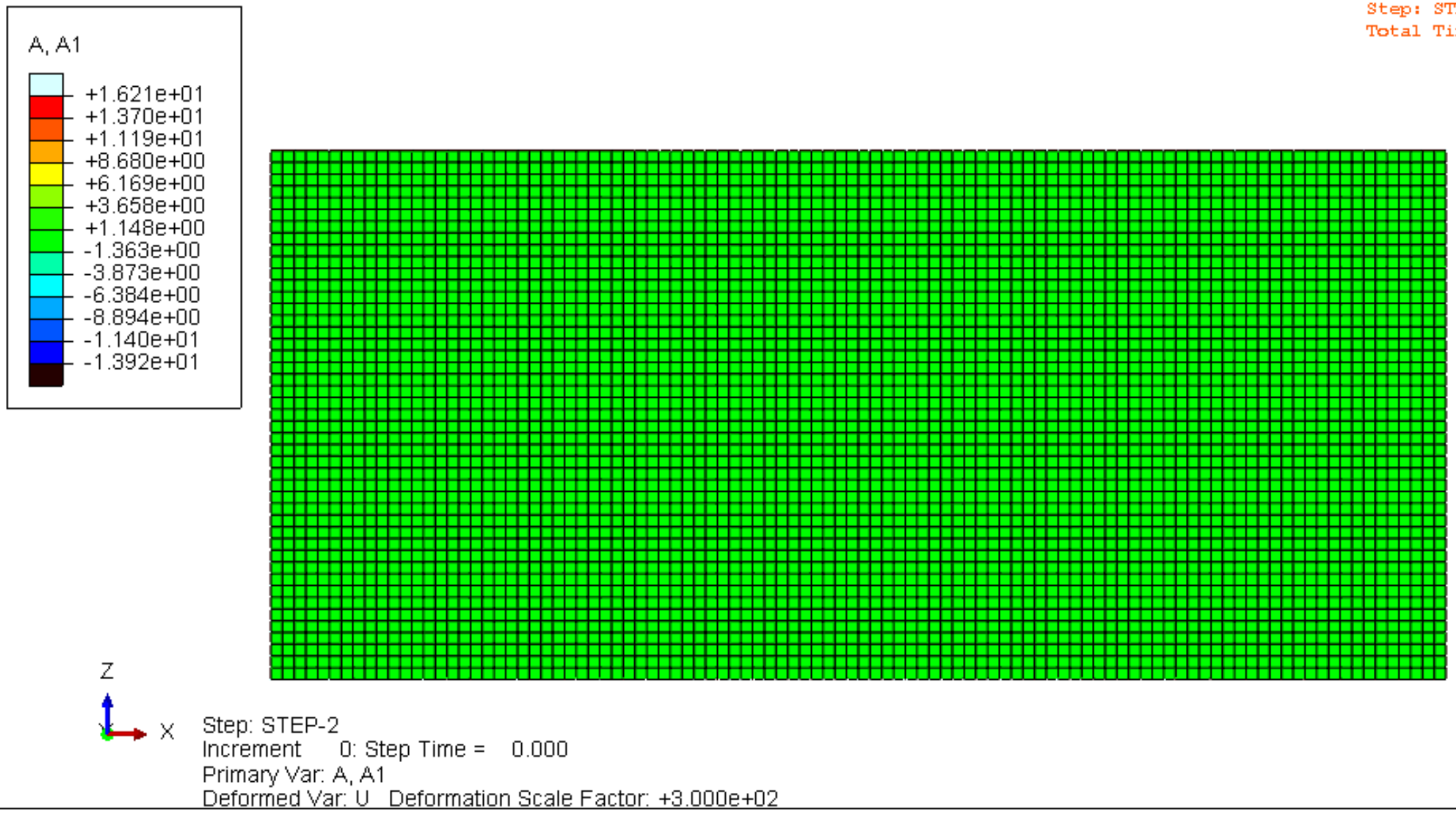
Model 1 (All Upper Alluvial Soil) Deformed Plot



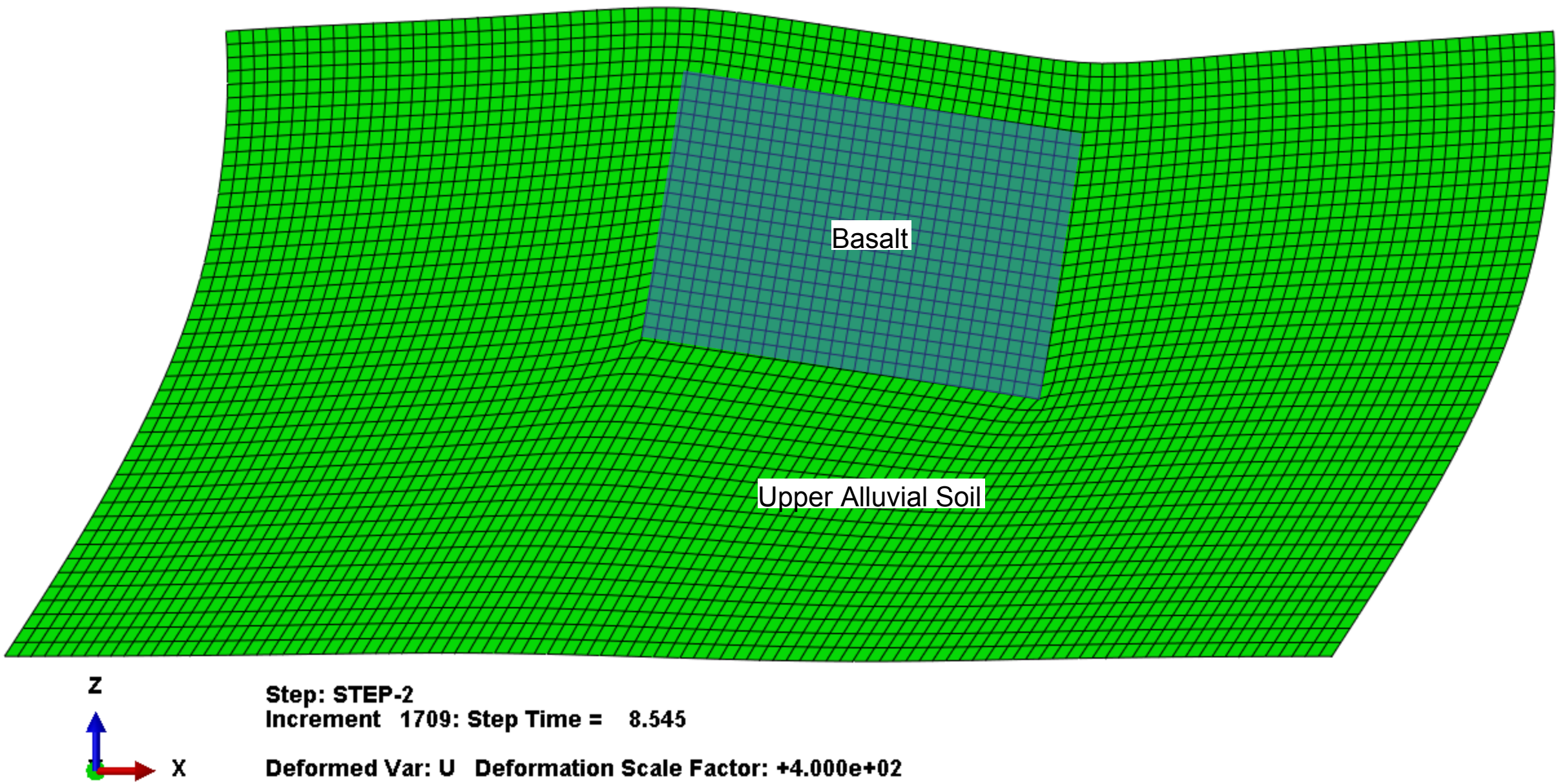

Step: STEP-2 Frame: 0
Total Time: 0.000000
A, A1
+2.069e+01
+1.705e+01
+1.341e+01
+9.770e+00
+6.131e+00
+2.492e+00
-1.147e+00
-4.786e+00
-8.424e+00
-1.206e+01
-1.570e+01
-1.934e+01
-2.298e+01
Z
X
Step: STEP-2
Increment 0: Step Time = 0.000
Primary Var: A, A1
Deformed Var: U Deformation Scale Factor: +3.000e+02

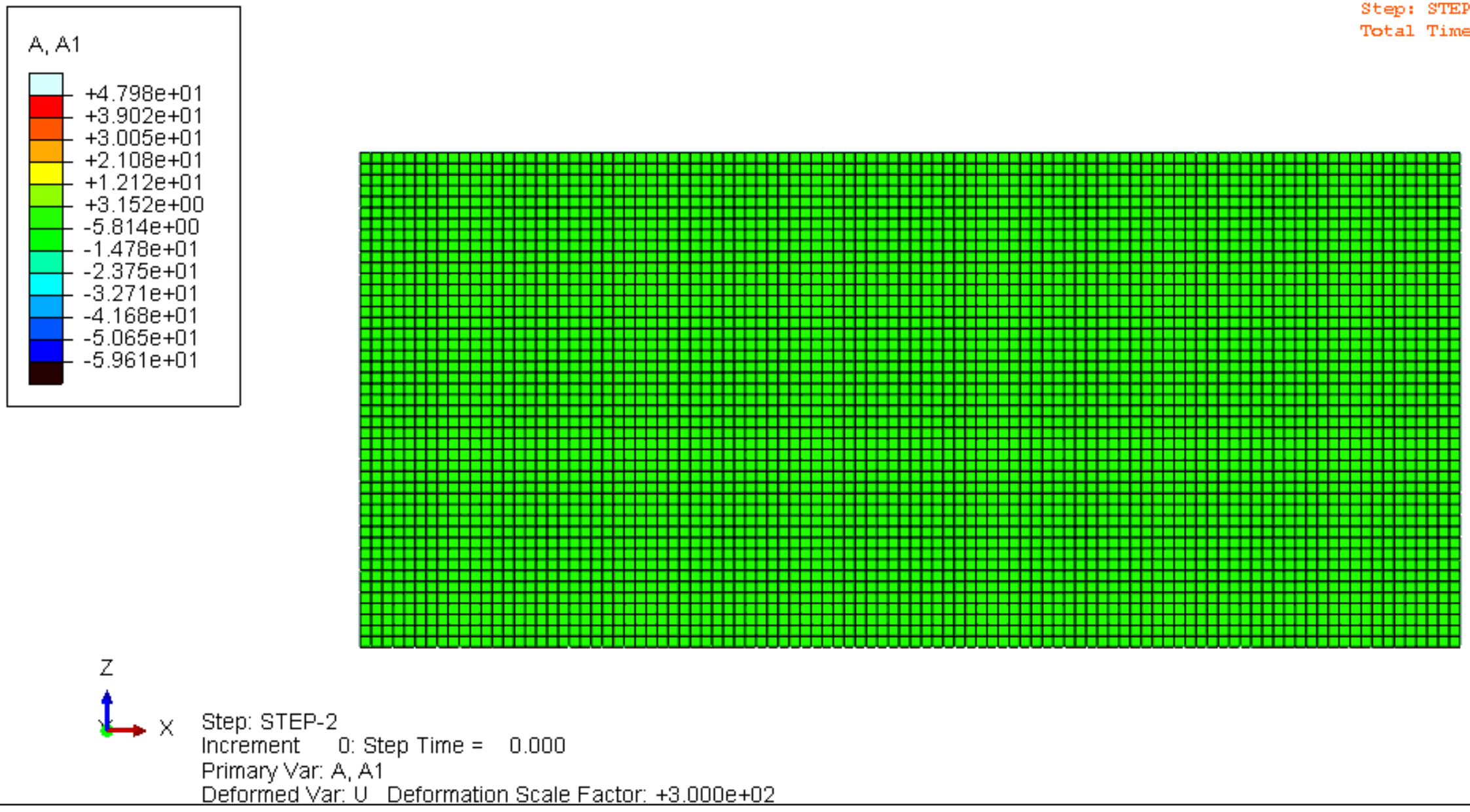
Model 2 (Basal Layer) Deformed Plot



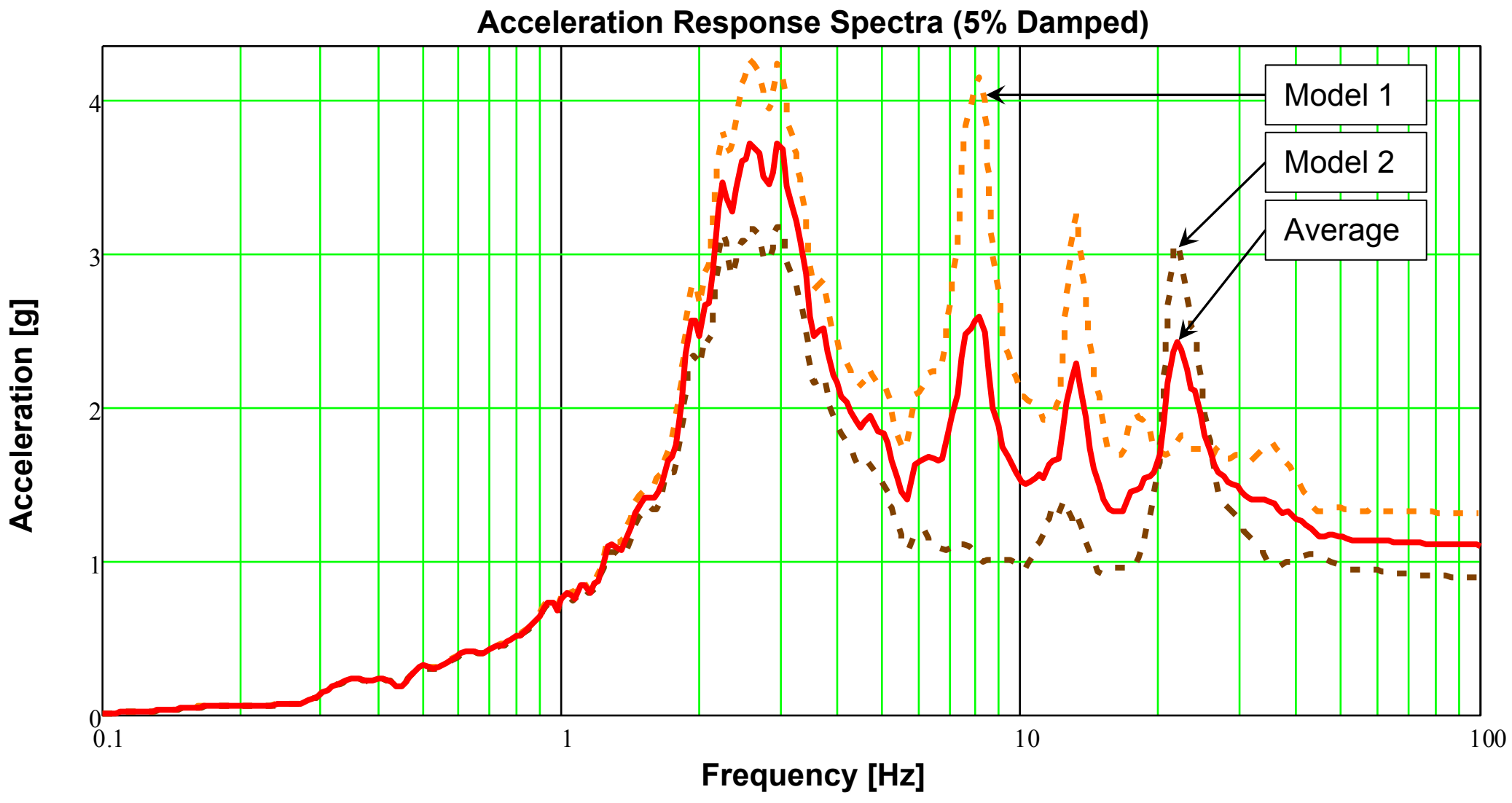

Step: STEP-2 Frame: 0
Total Time: 0.000000
A, A1
+1.621e+01
+1.370e+01
+1.119e+01
+8.680e+00
+6.169e+00
+3.658e+00
+1.148e+00
-1.363e+00
-3.873e+00
-6.384e+00
-8.894e+00
-1.140e+01
-1.392e+01
Z
X
Step: STEP-2
Increment 0: Step Time = 0.000
Primary Var: A, A1
Deformed Var: U Deformation Scale Factor: +3.000e+02

Model 3 (Basalt Local) Deformed Plot



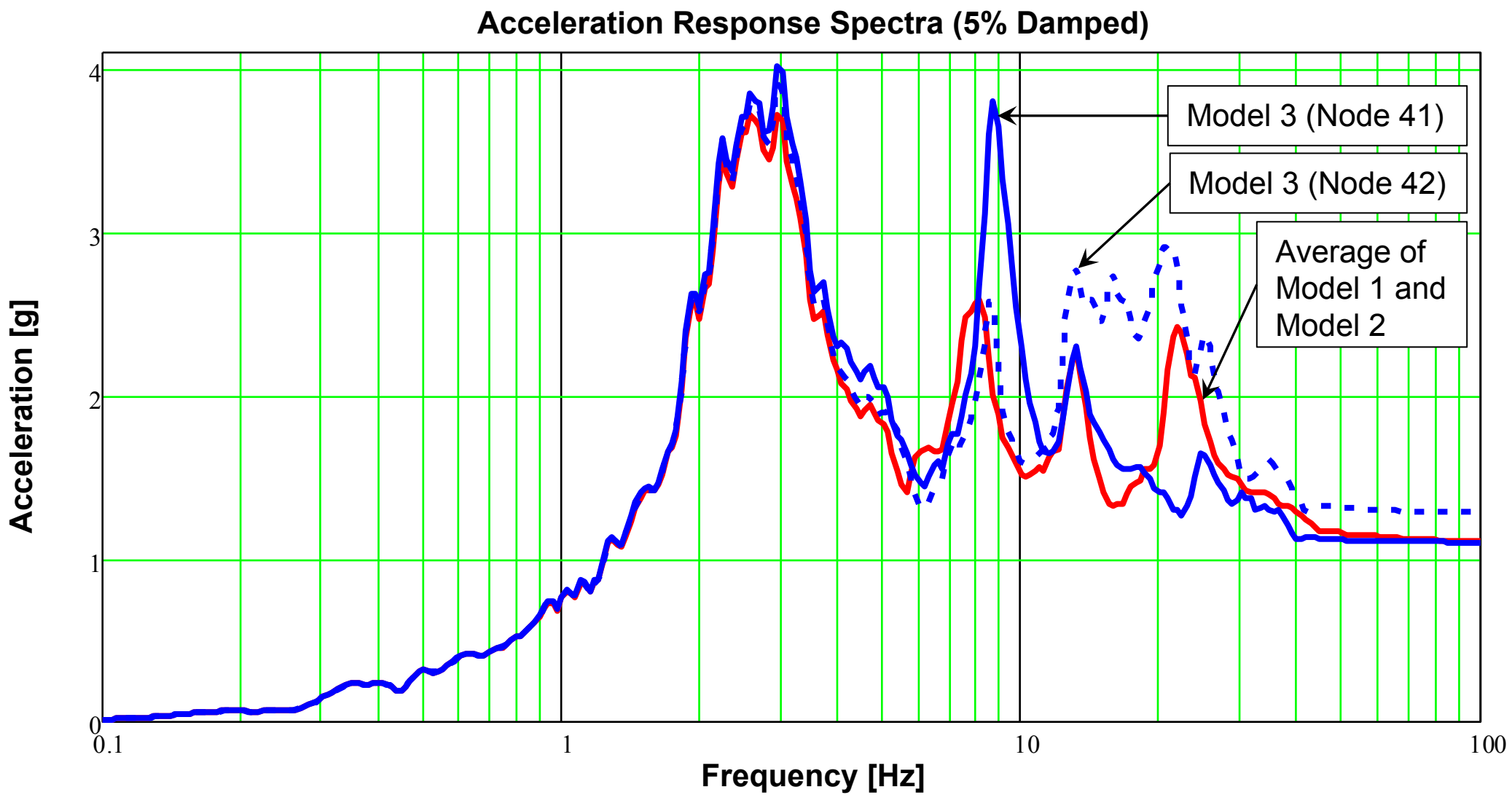

Step: STEP-2 Frame: 0
Total Time: 0.000000
A, A1
+4.798e+01
+3.902e+01
+3.005e+01
+2.108e+01
+1.212e+01
+3.152e+00
-5.814e+00
-1.478e+01
-2.375e+01
-3.271e+01
-4.168e+01
-5.065e+01
-5.961e+01
Z
X
Step: STEP-2
Increment 0: Step Time = 0.000
Primary Var: A, A1
Deformed Var: U Deformation Scale Factor: +3.000e+02

Model 1 and 2 Acceleration Response Spectra



Note: Model 1 and Model 2 produce the same results for Node 41 and Node 42.

Nodes 41 and 42 Acceleration Response Spectra



Note: Model 1 and Model 2 produce the same results for Node 41 and Node 42.

Conclusions

- There is a need to quantify if SHAKE like analysis can quantify heterogeneous soil sites
- Finite element analysis sensitivity studies can be performed to determine the uncertainty associated with making 1D assumptions
- Time domain analysis can be used to generate 2D and 3D results
- Validation of site response codes is needed.

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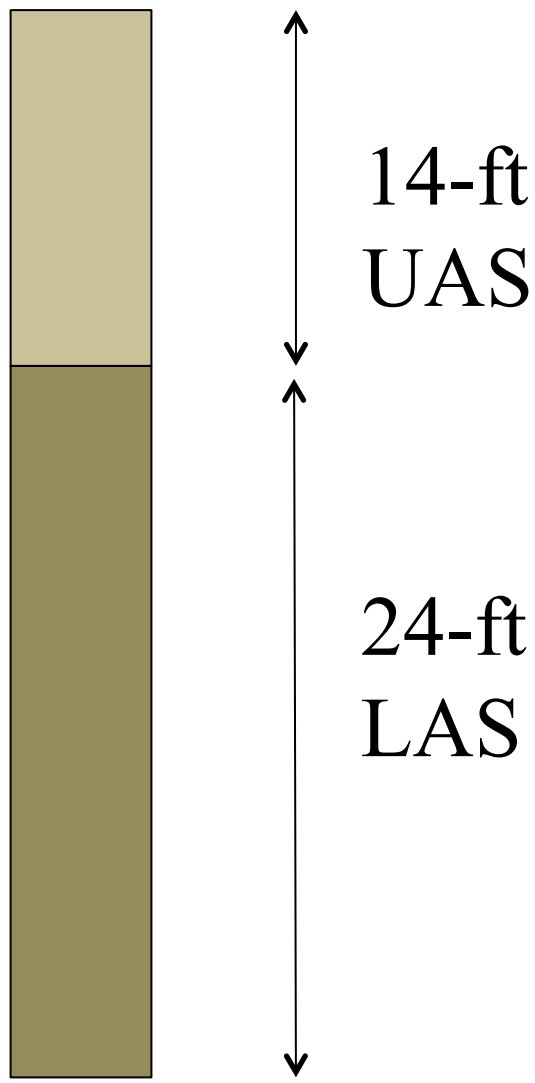
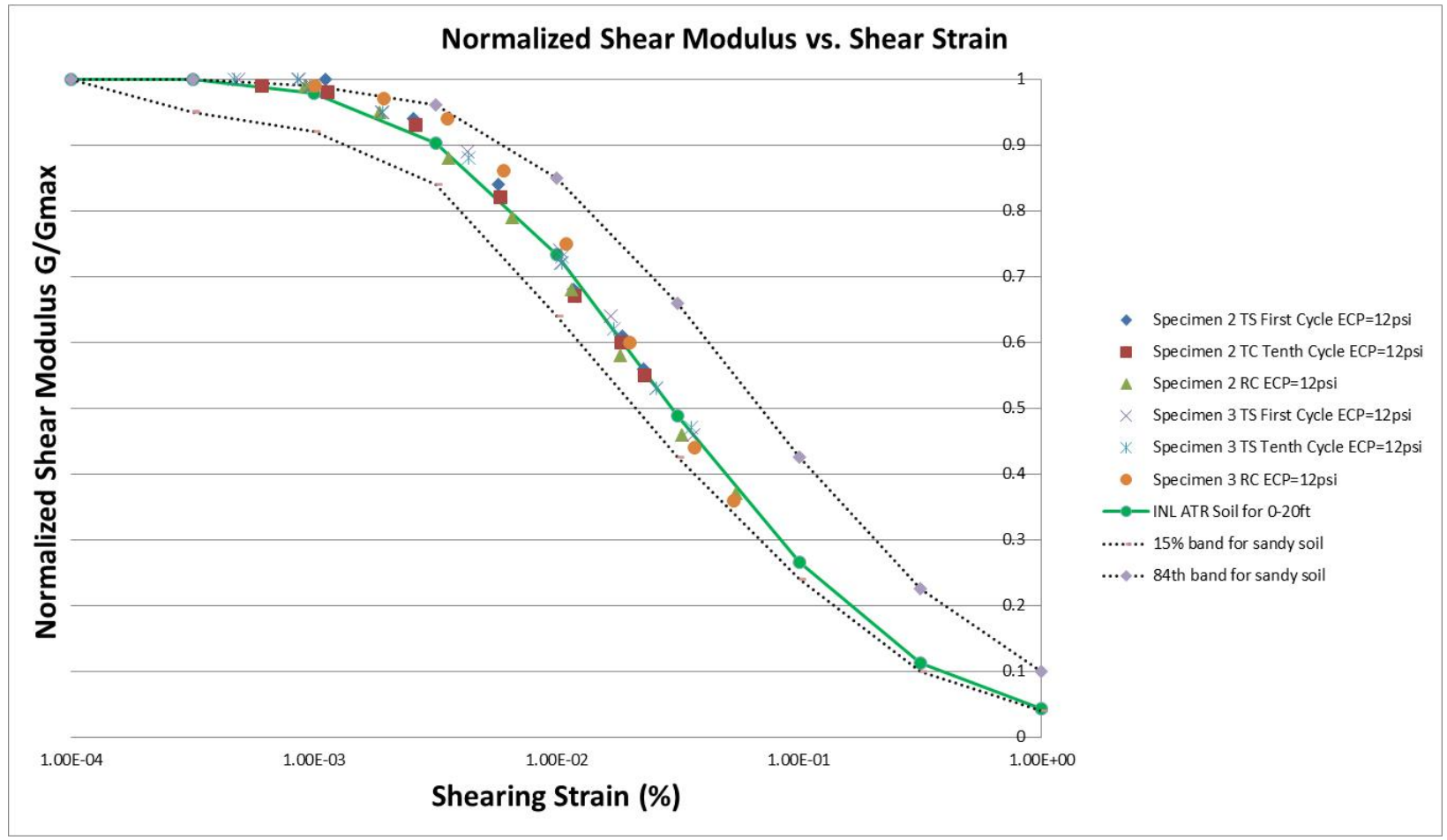
NLSSI Plan…Site 1





UAS: Upper Alluvial Soil
LAS: Lower Alluvial Soil