

Benchmark 2 - OLD

Benchmark 2

Various tests on the implementation of gravity in viscoelastic finite element models. All analyses are 2D plane strain and assume uniaxial strain boundary conditions.

Benchmark 2a: Relaxation of deviatoric stresses following application of body forces in a viscoelastic block. Lateral and vertical density homogeneity is assumed ($\rho = \rho_1$).

Benchmark 2b: Relaxation of deviatoric stresses following application of body forces in a viscoelastic block. Lateral variations in density are included with a region of lower density located in the upper, +x-direction quadrant of the model (see Figure 1; low density material in $x > 12$ km, $z > -8$ km). The block has uniform viscosity.

Benchmark 2c: Relaxation of deviatoric stresses following application and removal of a surface load in a block containing an elastic layer overlying a viscoelastic layer (see Figure 1). Lateral and vertical density homogeneity assumed ($\rho = \rho_1$).

GOALS

- All benchmarks: Test the implementation of gravity and confirm an approach toward an isostatic response.
- All benchmarks: Test the effects of different meshes, e.g., optimizing the mesh based on expected strain energy distributions, the effect of free form meshes, etc.
- Benchmark 2c: Test the viscoelastic gravitational response to surface loads during both loading and unloading.

DETAILED DESCRIPTION

- Model size: 24 km by 24 km ($0 \text{ km} \leq x \leq 24 \text{ km}$; $-24 \text{ km} \leq z \leq 0 \text{ km}$)
- Top layer: $-12 \text{ km} \leq z \leq 0 \text{ km}$; Bottom layer: $-24 \text{ km} \leq z \leq -12 \text{ km}$
- (Note: Top and bottom layers only necessary in benchmarks 2b and 2c)
- Elastic material properties: Poisson solid, $G = 30 \text{ GPa}$
- Maxwell viscoelastic material properties: Top layer (if elastic): $\eta = 10^{25} \text{ Pa-s}$
- Rest of model: $\eta = 10^{18} \text{ Pa-s}$
- Power-law material properties: $\eta_{\text{ref}} = 10^{18} \text{ Pa-s}$ and $\eta_{\text{ref}} = 10^8 \text{ Pa}$. (Note: This value is chosen because the maximum initial elastic stress is of order 10^9 Pa , only a fraction of that is deviatoric, and the deviatoric stress decreases with time.)
- Density and Gravity: $\rho_1 = 3000 \text{ kg/m}^3$; $\rho_2 = 2700 \text{ kg/m}^3$; $g = 10 \text{ m/s}^2$
- Boundary conditions: Bottom pinned
- Sides pinned in x and y; free in z
- Top free (except 2c)
- Coarse mesh node spacing: $dx = dz = 2 \text{ km}$

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- Surface loading (Benchmark 2c only): Sinusoidal surface load defined by TBD.

REQUESTED OUTPUT AND RESULTS

Mesh Variations: As memory, time, and patience allow, run models at 1/2, 1/4, and 1/8, etc. the original coarse mesh spacing, investigate variable mesh spacing, and/or employ a variety of element types.

For All Benchmark Variations:

- Stresses along a path through (0,0,-24) and (24,24,0) at $t = 0, 1, 5,$ and 10 years.
- Displacements along a path through (0,0,-24) and (24,24,0) at $t = 0, 1, 5,$ and 10 years.
- CPU time, wallclock time, memory usage info, compiler info, and platform info

TRUTH

Analytical solutions for each benchmark will be posted at geoweb.mit.edu/fe

ADDITIONAL NOTES

None.