

Education Examples for Constitutive Material Behavior

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8. February, 2017

- 1 Chapter Summary and Highlights**
- 2 Elastic Solid Constitutive Examples**

2.1 Linear Elastic Constitutive Examples

Pure Shear, Monotonic Loading

Material Parameters:

```
1 model name "test";
2
3 add material # 1 type linear_elastic_isotropic_3d
4   mass_density = 2E3 * kg/m^3
5   elastic_modulus = 2E7 * Pa
6   poisson_ratio= 0.25 ;
7
8 simulate constitutive testing strain control pure shear use material # 1
9   confinement_strain = 0.001
10  strain_increment_size = 0.0001
11  maximum_strain = 0.01
12  number_of_increment = 100;
13
14 bye;
```

Material Response:

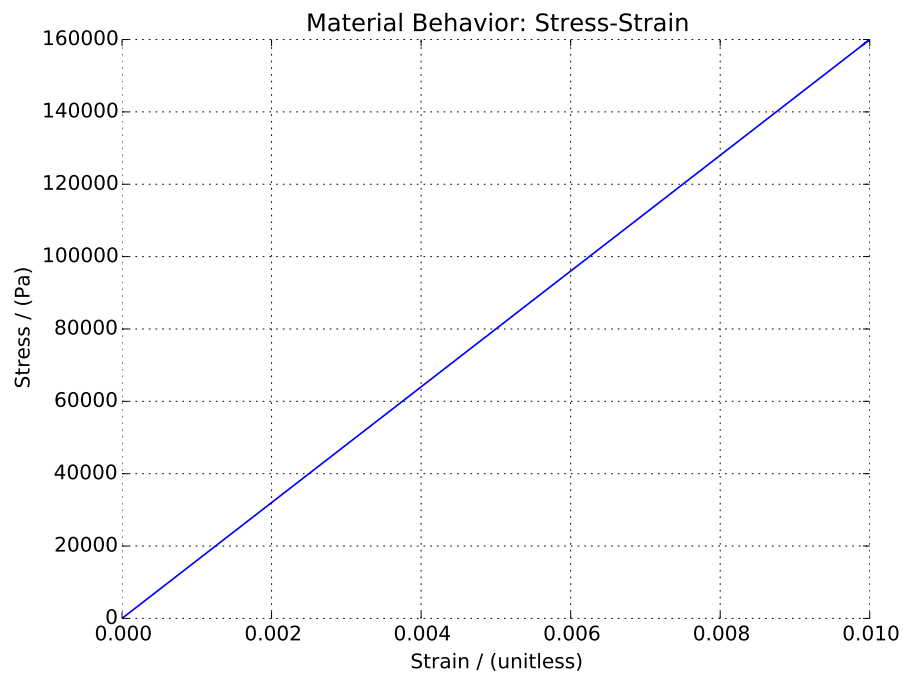


Figure 1: Linear Elastic Pure Shear Monotonic Loading

Pure Shear, Cyclic Loading

Material Parameters:

```

1 model name "test";
2
3 add material # 1 type linear_elastic_isotropic_3d
4   mass_density = 2E3 * kg/m^3
5   elastic_modulus = 2E7 * Pa
6   poisson_ratio= 0.25 ;
7
8 simulate constitutive testing strain control pure shear use material # 1
9   confinement_strain = 0.001
10  strain_increment_size = 0.0001
11  maximum_strain = 0.01
12  number_of_increment = 500;
13
14 bye;

```

Material Response:

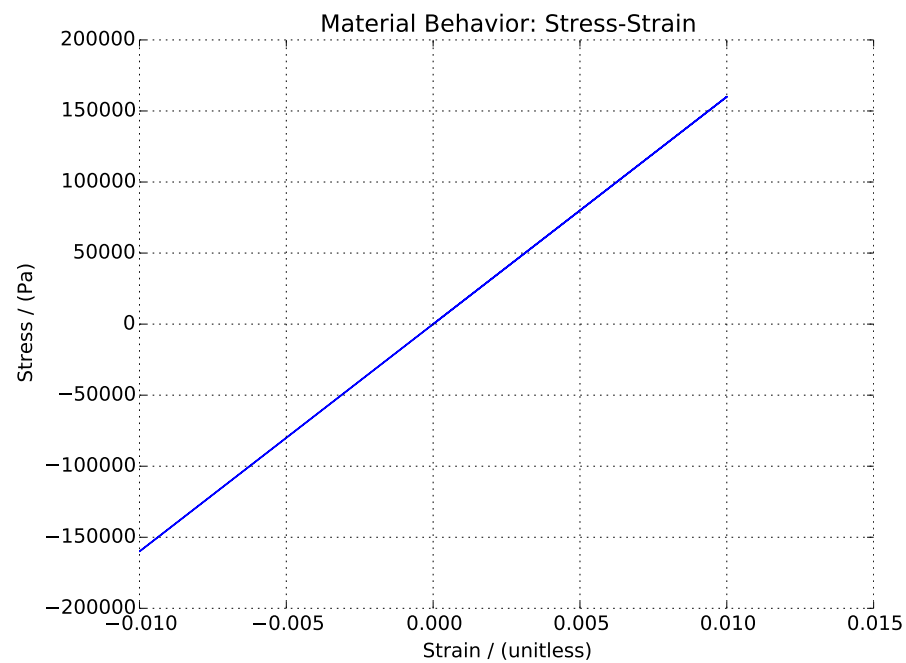


Figure 2: Linear Elastic Pure Shear Cyclic Loading

Uniaxial Strain, Monotonic Loading

Material Parameters:

```

1  model name "test";
2
3  add material # 1 type linear_elastic_isotropic_3d
4      mass_density = 2E3 * kg/m^3
5      elastic_modulus = 2E7 * Pa
6      poisson_ratio= 0.0 ;
7
8  simulate constitutive testing strain control uniaxial loading use material # 1
9      confinement_strain = 0.001
10     strain_increment_size = 0.0001
11     maximum_strain = 0.01
12     number_of_increment = 100;
13
14  bye;

```

Material Response:

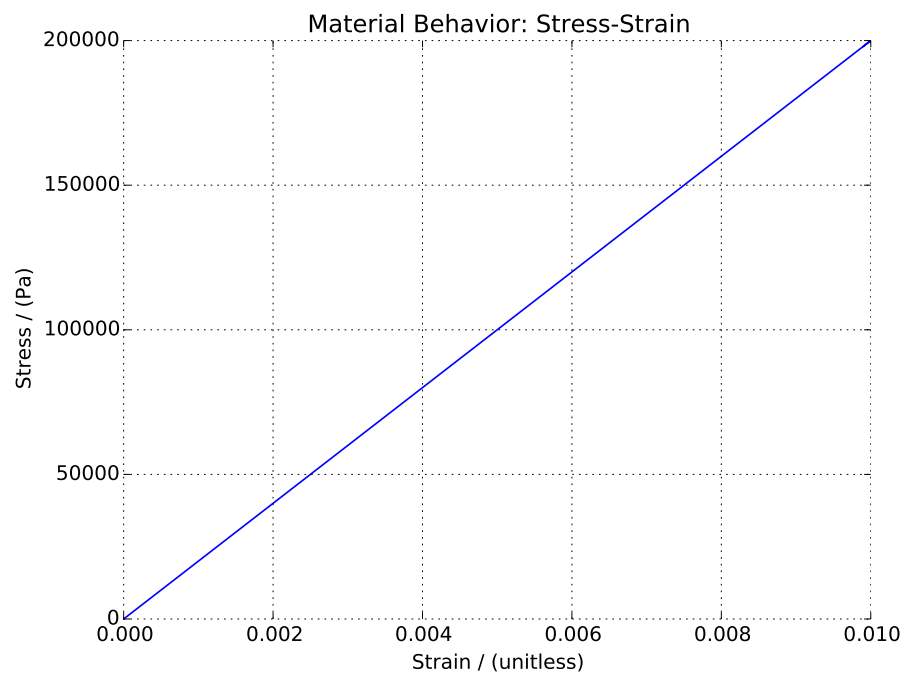


Figure 3: Linear Elastic Pure Shear Cyclic Loading

Uniaxial Strain, Cyclic Loading

Material Parameters:

```

1  model name "test";
2
3  add material # 1 type linear_elastic_isotropic_3d
4      mass_density = 2E3 * kg/m^3
5      elastic_modulus = 2E7 * Pa
6      poisson_ratio= 0.25 ;
7
8  simulate constitutive testing strain control pure shear use material # 1
9      confinement_strain = 0.001
10     strain_increment_size = 0.0001
11     maximum_strain = 0.01
12     number_of_increment = 500;
13
14  bye;

```

Material Response:

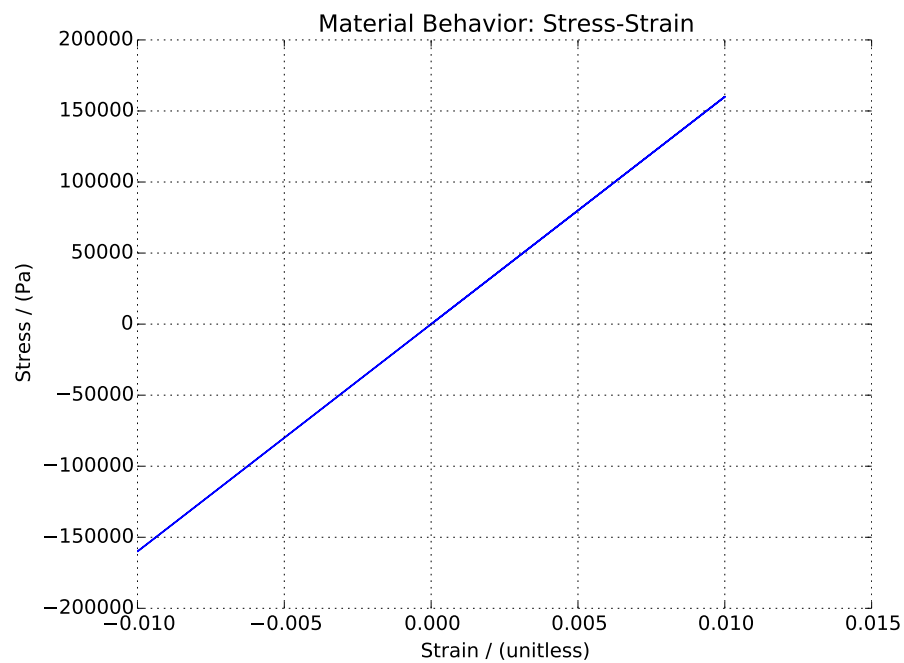


Figure 4: Linear Elastic Pure Shear Cyclic Loading

2.2 Nonlinear Elastic Constitutive Examples

Pure Shear, Monotonic Loading

Pure Shear, Cyclic Loading

Uniaxial Strain, Monotonic Loading

Uniaxial Strain, Cyclic Loading

3 Elastic Plastic Solid Constitutive Examples

3.1 Elastic Perfectly Plastic Constitutive Examples

Pure Shear

Material Parameters:

```

1  model name "test";
2  add material # 1 type VonMises
3    mass_density = 2E3*kg/m^3
4    elastic_modulus = 2E7 * Pa
5    poisson_ratio=0.25
6    von_mises_radius = 1E5*Pa
7    kinematic_hardening_rate = 0.0 *Pa
8    isotropic_hardening_rate = 0.0*Pa ;
9  define NDMaterial constitutive integration algorithm Backward_Euler
10    yield_function_relative_tolerance = 1E-2
11    stress_relative_tolerance = 1E-3
12    maximum_iterations = 30;
13  simulate constitutive testing strain control uniaxial loading use material # 1
14    confinement_strain = 0.001
15    strain_increment_size = 0.0001
16    maximum_strain = 0.01
17    number_of_increment = 500;
18  bye;

```

Material Response:

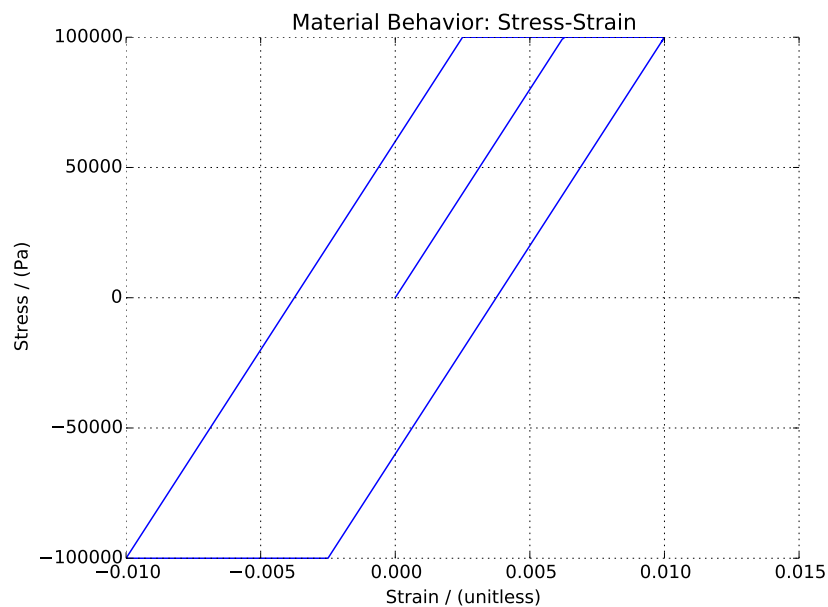


Figure 5: Linear Elastic Pure Shear Cyclic Loading

Uniaxial Strain

Material Parameters:

```

1 model name "test";
2 add material # 1 type VonMises
3   mass_density = 2E3*kg/m^3
4   elastic_modulus = 2E7 * Pa
5   poisson_ratio=0.25
6   von_mises_radius = 1E5*Pa
7   kinematic_hardening_rate = 0.0 *Pa
8   isotropic_hardening_rate = 0.0*Pa ;
9 define NDMaterial constitutive integration algorithm Backward_Euler
10  yield_function_relative_tolerance = 1E-2
11  stress_relative_tolerance = 1E-3
12  maximum_iterations = 30;
13 simulate constitutive testing strain control uniaxial loading use material # 1
14  confinement_strain = 0.001
15  strain_increment_size = 0.0001
16  maximum_strain = 0.01
17  number_of_increment = 500;
18 bye;

```

Material Response:

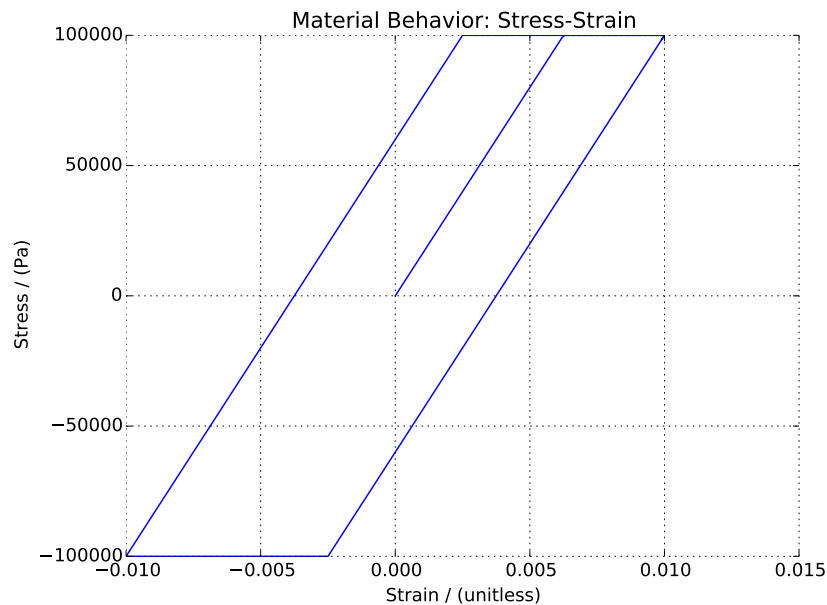


Figure 6: Linear Elastic Pure Shear Cyclic Loading

3.2 Elastic Plastic, Isotropic Hardening, Constitutive Examples

Pure Shear, Monotonic Loading

Pure Shear, Cyclic Loading

Uniaxial Strain, Monotonic Loading

Uniaxial Strain, Cyclic Loading

4 Elastic Single Solid Finite Element Examples

4.1 Linear Elastic, Solid Examples

Pure Shear, Monotonic Loading

Pure Shear, Cyclic Loading

Uniaxial Strain, Monotonic Loading

Uniaxial Strain, Cyclic Loading

4.2 Nonlinear Elastic Pure Shear Solid Examples

Pure Shear, Monotonic Loading

Pure Shear, Cyclic Loading

Uniaxial Strain, Monotonic Loading

Uniaxial Strain, Cyclic Loading

5 Elastic-Plastic Single Solid Finite Element Examples

5.1 Elastic Perfectly Plastic, Monotonic Loading, Pure Shear Solid Examples

5.1.1 von Mises Yield Function, von Mises Plastic Potential Function

5.1.2 von Mises Yield Function, Drucker Prager Plastic Potential Function

5.1.3 Drucker Prager Yield Function, von Mises Plastic Potential Function

5.1.4 Drucker Prager Yield Function, Drucker Prager Plastic Potential Function

5.2 Elastic Perfectly Plastic, Monotonic Loading, Triaxial Solid Examples

5.2.1 von Mises Yield Function, von Mises Plastic Potential Function

5.2.2 von Mises Yield Function, Drucker Prager Plastic Potential Function

5.2.3 Drucker Prager Yield Function, von Mises Plastic Potential Function

5.2.4 Drucker Prager Yield Function, Drucker Prager Plastic Potential Function

5.3 Elastic Plastic, Isotropic Hardening, Pure Shear Solid Examples

Monotonic Loading

Cyclic Loading

5.4 Elastic Plastic, Isotropic Hardening, Triaxial Solid Examples

Monotonic Loading

Cyclic Loading

5.5 Elastic Plastic, Cam Clay Model, Various Stress Paths

Monotonic Loading

Cyclic Loading

5.6 Elastic Plastic, Kinematic Hardening, Pure Shear Solid Examples

Monotonic Loading

Cyclic Loading

5.7 Elastic Plastic, Kinematic Hardening, Triaxial Solid Examples

Monotonic Loading

Cyclic Loading

5.8 Elastic Plastic, SaniSand Models, Pure Shear and Triaxial Solid Examples

6 Stiffness Reduction and Damping Curves Modeling

6.1 Pisano Material Model

6.2 Drucker Prager with Armstrong Frederick Nonlinear Kinematic Hardening Material Model