TPV8

Part I. SOME DEFINITIONS:

Displacement = motion relative to its initial position. Since all of the calculations start with this position at zero, Displacement = Absolute motion.

Velocity = Absolute motion with respect to time.

Slip = Relative motion across the fault plane (e.g., for split nodes).

Slip-Rate = Relative motion across the fault plane (e.g., for split nodes), with respect to time.

Rupture Front = Location of the leading edge of the rupture. Here we define this region as where (and when) slip-rate first changes from zero to greater than 1 mm/s.

Part II. MODEL DESCRIPTION - THE PROBLEM, VERSION 8 (Feb.14, 2008)

Please note that this is **THE 3D** model that we are investigating for TPV8. Although variations are of course interesting, our goal is to follow the description precisely. If the code you're using will not run with Version 8's parameters, please contact Ruth ASAP.
Please feel free to point out to me as soon as possible, if I have omitted some critical details that you and others may need to run the simulations, or if there are any mistakes in the descriptions/requests.

Note: All units are in MKS.

1) Material properties are homogeneous throughout the medium and set to:
   vp = **5716**. m/s
   vs = **3300**. m/s
   density = **2700**. kg/m3

2) The fault within the three-dimensional medium is a vertical right-lateral strike-slip planar fault that resides in a halfspace. The fault reaches the Earth's surface.

3) The rupture is allowed within a rectangular area that is 30000 m long x 15000 m deep.

4) The bottom boundary of the allowed 30000m x 15000m rupture area is defined by a strength barrier*.

5) The right and left ends of the allowed 30000 m x 15000 m rupture area are defined by a strength barrier*.

6) The nucleation patch (a square) is centered in the along-strike direction of the 30000m x 15000m rupture area, at 15000m along-strike. This nucleation patch is not in the middle of the fault plane along-dip, but instead is deeper on the fault so that its center-point is located on the fault plane at **12000m** down-dip distance, which for this vertical fault case, is also at **12000m** depth.

7) Nucleation occurs because the initial shear stress in a 3000 m x 3000 m square (side-length of 3000m) nucleation patch is set to be higher than the initial static yield strength in that patch. Failure occurs everywhere on the fault plane, including in the nucleation patch, following a linear slip-weakening fracture criterion.

8) Within the entire 30000m x 15000 m fault plane, including in the 3000m x 3000m nucleation patch, a slip-weakening fracture criterion is followed,
and

Cohesion = 1×10^6 Pa
Static coefficient of friction = **0.760**
Dynamic coefficient of friction = **0.448**
Slip-weakening critical distance = **0.50** m

9) Outside the 30000m x 15000m fault plane, slip-weakening is followed but the strength is high

Cohesion = 1×10^6 Pa
Static coefficient of friction = **10000.**
Dynamic coefficient of friction = **0.448**
Slip-weakening critical distance = **0.50** m

10) **Within the entire fault plane, including in the nucleation patch, the initial (t=0) normal and horizontal shear stresses increase linearly with depth.**

The initial normal stress is a linear function of depth such that in the entire faulting area,

Initial normal stress (at t = 0) = 7378 Pa/m x meters-downdip-depth
e.g., at 10 km depth, initial normal stress =
= 7378 x 10000 Pa = 73.78 $\times 10^6$ Pa

The initial shear stress also increases linearly with depth, but its value depends on whether one is within or outside of the nucleation patch:

Outside the nucleation patch,

Initial horizontal shear stress (t=0) = 0.55 x initial normal stress

e.g., at 10 km depth, initial horizontal shear stress =
= 0.55 x 73.78 $\times 10^6$ Pa = 40.579 1×10^6 Pa

Inside (and on) the 3000 m x 3000 m nucleation patch,

the initial horizontal shear stress is higher than the static yield strength that includes cohesion, so that the

Initial horizontal shear stress (t=0) =
= cohesion + (1.005 x 0.760 x initial normal stress)

e.g., at 12 km depth, in the 3000m x 3000m nucleation patch,
initial horizontal shear stress =
= 1×10^6 Pa + (1.005 x 0.760 x 7378 x 12000) Pa
= 1×10^6 Pa + 67.62 $\times 10^6$ Pa = 68.62 $\times 10^6$ Pa

Everywhere on the fault plane, the dip-direction initial shear stress (at t=0) = 0

11) Inside the 30000m x 15000m faulting area,
but Outside the 3000m x 3000m nucleation patch at t=0 seconds:

Linear slip-weakening is followed,
The initial normal stress is a linear function of depth,
The initial horizontal shear stress is a linear function of depth

Cohesion = 1x10^{6} Pa
Static coefficient of friction = 0.760
Dynamic coefficient of friction = 0.448
Slip-weakening critical distance = 0.50 m
Initial normal stress (t=0) = 7378 Pa x downdip depth (in meters)
Initial horizontal shear stress (t=0) = 0.55 x 7378 Pa x downdip depth (m)
Initial vertical (dip-direction) shear stress (t=0) = 0 Pa
Initial static yield strength (t=0) =
= 1x10^{6}Pa + (0.760 x 7378 Pa x downdip depth (m))
Initial dynamic friction stress (t = 0) =
= 1x10^{6}Pa + (0.448 x 7378 Pa x downdip depth (m))
Initial stress drop (t=0) =
= - 1x10^{6}Pa + (0.102 x 7378 Pa x downdip depth (m))

12) Inside and on the border of the 3000m x 3000m nucleation patch, at t=0 seconds:

Linear slip-weakening is followed,
The initial normal stress is the same linear function of depth,
The initial horizontal shear stress is a <u>different</u> linear function of depth, such that the initial shear stress is set to be higher than the static yield strength,

Cohesion = 1x10^{6} Pa
Static coefficient of friction = 0.760
Dynamic coefficient of friction = 0.448
Slip-weakening critical distance = 0.50 m
Initial normal stress (t=0) = 7378 Pa x downdip depth (in meters)
Initial horizontal shear stress (t=0) =
= 1x10^{6}Pa + (1.005 x 0.760 x 7378 Pa x downdip depth (m))
Initial vertical (dip-direction) shear stress (t=0) = 0 Pa
Initial static yield strength (t=0) =
= **1x10^{6}Pa + (0.760 x 7378 Pa x downdip depth (m))**
Initial dynamic friction stress (t=0) =
= **1x10^{6}Pa + (0.448 x 7378 Pa x downdip depth (m))**
Initial stress drop (t=0) = 0.3158 x 7378 Pa x downdip depth (m)

*13) On the fault plane, but outside of the 30000 m x 15000 m faulting area, there is a strength barrier.
This is accomplished by including cohesion and setting the static coefficient of friction to the high value of 10000. so that the rupture is not able to propagate on the fault plane beyond 30000 m x 15000 m:

Cohesion = $1x10^6$ Pa
Static coefficient of friction = **10000.**
Dynamic coefficient of friction = **0.448**
Slip-weakening critical distance = **0.50 m**
Initial normal stress (t=0) = 7378 Pa x downdip depth (in meters)
Initial horizontal shear stress (t=0) = 0.55 x initial normal stress (t=0)
Initial vertical (dip-direction) shear stress (t=0) = 0 Pa
Initial static yield strength (t = 0) =
= **$1x10^6$ Pa + (10000 x 7378 Pa x downdip depth (m))**
Initial dynamic friction stress (t = 0) =
= **$1x10^6$ Pa + (0.448 x 7378 Pa x downdip depth (m))**
Initial stress drop (t=0) =
= - $1x10^6$Pa + (0.102 x 7378 Pa x downdip depth (m))

End of TPV8 Description

Helpful tip:

Diagrams of the TPV8 benchmark are available on the website in the following files:

- "Diagram showing locations of on-fault stations, for TPV8 and TPV9"
- "Diagram showing locations of off-fault stations, for TPV8 and TPV9"

Part III. RESULTS TO PROVIDE

Note 1.

The requested output files are:

1) A rupture- time contour plot

2) *Time-series files in ASCII format*

Please provide the results in raw form (no filtering). Don't worry about oscillations.

Note 2.

The requested stations are located both on and off the fault plane.

Note 3.

Computations should be run using the following element-size/node-spacing
(please provide a complete output-file set for each of these):

100m

If the code you are using cannot run with 100m spacing, due to memory/processor constraints, please run using 150m instead and please note that you used 150m in the files and accompanying information that you send me.

Part III. RESULTS TO PROVIDE, CONTINUED:

1) A 2D contour plot of the rupture front, as defined by the locations where (and when) fault slip-rate first changes from zero to greater than 1 mm/s, contoured at 0.5 second intervals. This plot information should be in ASCII format
(**see website directions**
"Required file formats, and instructions for uploading files, for TPV8 and TPV9"
for specific formatting information)

2) ASCII Time Series Files
(**see website directions**
"Required file formats, and instructions for uploading files, for TPV8 and TPV9"
for specific formatting information)

Please provide the time series results
for the times **0.0 to 15.0 seconds after nucleation**.

There are stations located on the fault. These are shown in the website file "Diagram showing locations of on-fault stations, for TPV8 and TPV9"

There are stations located off the fault. These are shown in the website file "Diagram showing locations of off-fault stations, for TPV8 and TPV9"

Part IV. FILE FORMATS AND FILE NAMING CONVENTION

see website directions
"Required file formats, and instructions for uploading files, for TPV8 and TPV9"

Part V. SIGN-CONVENTIONS

see website file
"Diagram showing coordinate system and sign conventions, for TPV8 and TPV9"