STRIKE SLIP SPLAY USING DYNAMIC RUPTURE MODELS

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Outline

- Issues in the dynamics of fault branches.
- Advantages and disadvantages of dynamic rupture modeling.
- Branch fault benchmark.
- Planned parameter study.
General Questions

- Can rupture propagate through all three limbs of a branch fault system?
- What are preferred rupture patterns, and which parameters control them?
- If the splay ruptures, does it behave as continuous rupture from the main fault, or is it a re-nucleation?
- How does the ground motion compare to that from rupture on a planar fault?
- How does the ground motion between the main fault and the splay compare to ground motion to the outside?
Releasing vs. Restraining Branch

- Branch point is dynamically clamped or unclamped, depending on slip direction.
- Is the clamping effect the same if rupture comes from the interior or exterior of the branch?
- In constant traction, flipping branch is equivalent to reversing slip direction.
Nucleation Point

- Affects dynamic stress changes, and therefore possible rupture geometries.
- Limits effects of directivity.
- Plan: one nucleation at end of each limb of the fault, one at branch point.
Branch Angle

- Branch angle influences whether or not rupture propagates on the splay, and, if so, how far.

Kame et al., 2003

Lozos et al., 2011
Effect of Regional Stress Field

- Uniform regional stress field resolves differently on branch than on main fault.
- Dynamically unfavorable branch may be favorable in the regional stress field, and vice versa.
- Switching branch side is not equivalent to switching slip direction.
Velocity Structure

- Has a controlling effect on ground motions.
- Can affect extent of rupture propagation.
- Will test homogeneous rock, northern California example, central coast example, and southern California example.
- 1D vs 3D?

Lozos, 2013
Advantages and Disadvantages

- Full physics of rupture.
  - Rupture behavior and extent not pre-determined.
  - Provides picture of source evolution.
- Allows complex initial conditions.

- Computationally intensive.
- Maximum achievable frequency content is lower than in kinematic models or than calculated by GMPEs.
  - Limited primarily by computational constraints.
TPV24-25 Summary.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Dimension</th>
<th>Rupture Type</th>
<th>Material Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPV24</td>
<td>3D</td>
<td>Right-lateral, releasing branch.</td>
<td>Linear elastic.</td>
</tr>
<tr>
<td>TPV25</td>
<td>3D</td>
<td>Left-lateral, restraining branch.</td>
<td>Linear elastic.</td>
</tr>
</tbody>
</table>

Requested resolutions: 100 m and 50 m.

Although these are linear elastic benchmarks, they are constructed like plastic benchmarks.
Junction Point Behavior

The boundary condition is that slip on the branch fault goes to zero at the junction point.

The picture shows a possible implementation for a finite-element code that uses split nodes. The junction point behaves as an ordinary split-node on the main fault. Other types of code may implement the junction point in different ways.
Results for Benchmarks TPV24 and TPV25 (rupture-front contour plots)

TPV24
Releasing Branch

TPV25
Restraining Branch

Harris, March 2013
Results for Benchmarks TPV24 and TPV25 (horizontal velocity vs. time)

TPV24
Releasing Branch

TPV25
Restraining Branch

Off-Fault Station Location
at the earth’s surface
between main fault & branch

3 hz low-pass Butterworth filter applied

Harris, March 2013
Model Setup

- Adapted from Dynamic Rupture Code Validation Workshop branch fault benchmark.

- 3D finite element code FaultMod (Barall, 2009).
Splay Fault Parameter Study

- Right and left branches.
- Right and left lateral slip.
- Four nucleation points per branch geometry.
- Four different velocity structures.
- Variable branch angle.
- Variable regional stress field orientation.
References