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Fan-head shear rupture mechanism as a source of off-fault tensile cracking

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This presentation discusses the role of a recently identified fan-head shear rupture mechanism [1] in the creation of off-fault tensile cracks observed in earthquake laboratory experiments conducted on brittle photoelastic specimens [2,3]. According to the fan-mechanism the shear rupture propagation is associated with consecutive creation of small slabs in the fracture tip which, due to rotation caused by shear displacement of the fracture interfaces, form a fan-structure representing the fracture head. The fan-head combines such unique features as: extremely low shear resistance (below the frictional strength) and self-sustaining tensile stress intensification along one side of the interface. The variation of tensile stress within the fan-head zone is like this: it increases with distance from the fracture tip up to a maximum value and then decreases. For the initial formation of the fan-head high local stresses corresponding to the fracture strength should be applied in a small area, however after completions of the fan-head it can propagate dynamically through the material at low shear stresses (even below the frictional strength).
The fan-mechanism allows explaining all unique features associated with the off-fault cracking process observed in photoelastic experiments [2,3]. In these experiments spontaneous shear ruptures were nucleated in a bonded, precut, inclined and pre-stressed interface by producing a local pressure pulse in a small area. Isochromatic fringe patterns around a shear rupture propagating along bonded interface indicate the following features of the off-fault tensile crack development: tensile cracks nucleate and grow periodically along one side of the interface at a roughly constant angle (about 80 degrees) relative to the shear rupture interface; the tensile crack nucleation takes place some distance behind the rupture tip; with distance from the point of nucleation tensile cracks grow up to a certain length within the rupture head zone; behind this zone static microcracks are left in the wake of the propagating rupture.
Unfortunately, the modern technology used in these experiments is not able to identify the shear rupture mechanism itself operated within the narrow rupture interface. However, a special analysis of side effects accompanying the shear rupture propagation (including the off-fault tensile cracking) allows supposing that the failure process was governed by the fan-mechanism.

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