Scaling Relationship for Crack and Asperity Models Estimated from Dynamic Rupture Simulation

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We present source-scaling relations derived from dynamic rupture simulations. A series of crack and asperity models for surface and sub-surface earthquakes is used in order to find the appropriate model that fit the existing empirical and theoretical scaling law models, as well as observed values of real earthquakes. Our simulations consist of pure-strike sub-surface earthquakes when L larger than W and surface earthquake when L larger or equal than W, where L and W are length and width of the fault, respectively. Wmax is assuming to be 20km that represents the brittle crust of the earth. The fault models are calculated up to L=20Wmax. The crack models are assumed to have constant stress drop over the fault and for the asperity models the stress drop is on the asperity area only and in the background area is zero. When compared our results with the empirical relations, the source scaling based on dynamic crack modeling suggests that the stress drop over the fault is:

-When L less or equal than 2Wmax, stress drop = 1.89MPa

-When L is between 2Wmax and 10Wmax, stress drop =1.89MPa to 7.5 MPa.

-When L larger than 10Wmax, stress drop = 7.5MPa

while for dynamic asperity model, where asperity area is around 22% of the total rupture area, the stress drop on the asperity area is:

-When L less or equal than 2Wmax, stress drop = 6.8MPa

-When L is between 2Wmax and 10Wmax, stress drop =6.8MPa to 24 MPa

- When L larger than 10Wmax, stress drop = 24MPa.

The dynamic faulting simulations successfully explain the three-linear source-scaling relationship between seismic moment and rupture area, observed in real earthquakes, through the mechanism of circular crack, L model and W model respectively for each linear scaling.

It is important to mention that the above stress drop values are dynamic stress drop. If assumed that overshoot exists that can be between 15% to 20%, then the static stress drop for ground motion prediction can be given as 1.15 to 1.20 times the dynamic stress drop.

Our results also suggest that the average displacement and maximum displacement seem to be saturated after L larger than15Wmax for crack models, however, for asperity models they are still not saturated even for L=20Wmax, but there is a tendency to soon be saturaded.

A relationship for conversion of a given crack model into an equivalent asperity model for ground motion prediction is proposed as a function of the aspect ratio (L/W).