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Frictional property of earthquake rupture surfaces in soft basement rock

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Frictional properties of earthquake rupture surfaces were examined in laboratory experiments to obtain a fundamental data for probing causes of variability of surface slips on an identical active fault accompanied by repeated large earthquakes.

A surface slip of a few tens cm on an active fault was associated with the 2008 Mw 6.9 Iwate-Miyagi inland earthquake, while paleoseismic trench studies on the identical fault reveal past earthquakes with a substantially larger slip of about 2 m (Maruyama et al., 2010). The 2004 Mw 6.6 Mid-Niigata earthquake also showed such variability of surface slips: a small surface slip of about 20 cm on an active fault was associated with the 2004 earthquake, while a trench survey reveals a large slip of about 2 m with a past earthquake on the identical fault. Such a variability of surface slips on active faults poses a major issue in assessing earthquake hazard based on active fault evaluations, because the variability leads an underestimation of a repetition of past earthquakes.

Rock samples of lapilli tuff involving earthquake faults and intact rock samples from its hanging wall and footwall were hewed out from a trench wall exposed for the paleoearthquake study in the source region of the 2008 Iwate-Miyagi inland earthquake. A density, a porosity, P- and S-wave velocities of the these samples are about 1.6 g/cm^3, 50 %, 1.7 km/s, and 0.3 km/s, respectively. Box shear and triaxial compression methods were adopted to measure frictional coefficients (FC) and cohesive stresses (CS) of the earthquake faults and compressional strengths of the intact rock samples. Normal stresses and confining pressures for both the tests are given at 0.1-0.6 MPa and 0.1-0.4 MPa, respectively. Additionally, reciprocating slips were repeatedly applied to the earthquake fault sample in the box shear test in order to emulate a large slip up to 1 m of an actual earthquake.

Experimental results are summarized as follows:

1) FC and CS of the sample from earthquake faults are 0.27-0.38, and 14-64kPa, respectively. The frictional coefficients are much less than the standard FC 0.85 of hard rocks under low normal stresses (Byerlee, 1978).

2) FC and CS of the samples from both the hanging wall and footwall rocks are about 0.2 and 200 kPa, respectively. The cohesive stresses of these rocks are, thus, much larger than those of the earthquake fault.

3) Repeated sliding test for emulating a large slip suggests that frictional strength is not largely depend on the slip amount.

4) Compressional strengths of the hanging wall and footwall rocks are almost the same: Internal frictional coefficients (IFC) of both the rocks are about 0.8. A large difference of IFC and FC from the above result 2) is likely caused by a difference of fracturing mechanisms involved in the two different test methods.

Keywords: surface earthquake fault, variability of surface slip, frictional property, box shear test