Elastic constants of damaged zone estimated from in-situ stresses in the vicinity of fault core axis: Depth dependence

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The ratio of the rigidity to the Young's modulus of the damaged zone around a fault core axis is estimated from the stresses measured in or around the zone. The estimated ratio is smaller than about 1/10 of that of the host rock in shallow depths and from 1/4 to 1/3 in large depths of about 15 km even for the zone without sealed water. This implies the possibility that the shear strength of faults is small without pressurized water. The average velocities of the P- and the S-waves are obtained to be about 5.1 km/s and 2.2 km/s near 15 km in depth for the host rock whose P- and S-wave velocities are 6.32 km/s and 3.65 km/s. This P-wave velocity is close to that at the depths of about 15 km in the fault zone of the San Andreas Fault obtained by seismic profiling.

A fault plane is considered to consist of the asperity parts and the aperture parts filled with damaged rocks. The damaged zone means here the aperture parts filled with damaged rocks. When the asperities completely stick, the elastic property of the damaged zone is expected to control the shear strength of the fault.

For the Nojima fault, it has been clarified that the largest compressive stress acts in the direction nearly perpendicular to the fault plane and that the shear stress is decreased in the zone within the distance about 100 m from the fault core axis. Taking this zone close to the fault core axis as the damaged zone, the results of the stress measurement imply that the damaged zone is under the post-failure state by the compressive stress in the direction perpendicular to the fault plane. The elastic property of the zone can be estimated from the measured in-situ stresses by making use of the knowledge from the laboratory experiments on the fracturing process of rock specimens under tri-axial compression test.

Here, the rigidity and the Young's modulus are defined for a surface parallel to the fault plane. The ratio of the rigidity to the Young's modulus of the damaged zone may be taken as an index for the shear strength of fault. The ratio is estimated to be smaller than about 1/10 of that of the host rock in shallow depths of a few kilometers and from 1/4 to 1/3 in large depths of about 15 km, even if sealed water is absent in the zone. This means that the shear stress concentrated more than the normal stress at asperities probably decreases the shear strength of faults without pressurized water.

The average velocities of the P- and S-waves are obtained to be about 5.1 km/s and 2.2 km/s near 15 km in depth for the host rocks whose velocities of the P- and S-waves are 6.32 km/s and 3.65 km/s. The avearge velocity of P-waves is found to be close to that at the depths of about 15 km in the fault zone of the San Andreas Fault, which has been determined by the seismic refraction and reflection profiling.