A simple observation of friction history during stick-slips with a maximum slip rate of ~0.4 m/s and a maximum slip of ~0.6 m

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Stick-slips are easily reproduced by putting a spring-block system on a belt-conveyer with a constant rate. With a consumer video camera, we observed the movement of the spring-block system with the parameters so that the maximum slip rate is ~0.4 m/s and maximum slip displacement is ~0.6 m. We subtracted the movement that is predicted by the rate- and state- INDEPENDENT friction law. By fitting polynomials to the residual, deviating them twice and taking spring traction into account, we successfully deduced a friction history with an apparent Dc of ~5 cm during stick-slips.

Rate- and state- dependent constitutive law of friction plays an important role to account for the gamut of earthquake phenomena (e.g., Scholz, 1998; Dieterich, 1994). The constitutive law has been constructed based upon laboratory experiments, but dimensions of experimental specimens and a range of a slip rate or a slip displacement are limited. So, scaling relationship has not yet been established to sufficiently cover the range of a slip rate on the order of 1 m/s and a slip displacement on the order of 1 m, which are often observed during large earthquakes. Some attempts have been made to deduce a parameter of the constitutive law from near-field seismograms of large earthquakes (e.g., Ide and Takeo, 1997). However, we need more case studies of friction data for other range of a slip rate and a slip displacement. If possible, we have to find a method that potentially has flexibility to specify any magnitude of a slip rate and a slip displacement.

If a block with a spring with one fixed end is put on a belt-conveyer with a constant velocity v, we can easily observe stick-slips. Let the mass of the block be m, and spring constant k. If the rate- and state- INDEPENDENT friction law (a simple friction law) can be assumed, the movement of the block during the slip is identical to that of a part of a simple harmonic oscillator with a period of 2*pi*sqrt(m/k). The Maximum slip velocity referred to the belt-conveyer is sqrt[v*v+m*{ (fs-fd) * g }^2/k] - v, where fs and fd are static and dynamic coefficient of friction, and g gravity. The maximum slip displacement referred to the belt-conveyer is 2*(fs-fd)*m*g / k + v*ts, where ts is a duration time of the slip (e.g., Faculty of Science and Engineering, Ritsumeikan University 2000 Entrance Examination). By specifying various m and k, we can reproduce stick-slip phenomena with any range of slip rate and slip displacement.

The equation of motion is: 0 = m*a + k*x + F, where a is acceleration, F frictional force. If we observe a location and an acceleration of the block, a and x, we can deduce F. If the constitutive law of friction can be applied to the phenomena, the movement of the block must be slightly different from the movement predicted by the rate- and state- INDEPENDENT friction law that is described by the equations above. So, we put a block on a running pace maker in an athletic gym. A spring with one fixed end was connected to the block. A coefficient of the spring and a mass of the block are chosen so that we can reproduce stick-slip phenomena with a maximum slip rate of ~0.4 m/s and a maximum slip displacement of ~0.6 m. We recorded the movement of the block with a consumer video camera. We replayed the videotape and read a location of the block at every 1/30 s. We fit the theoretical movement assuming the rate- and state- INDEPENDENT friction law. We fit polynomials to the residual and derivates them twice to have an acceleration of the block. We carefully investigate the residual if there exist any fluctuation suggesting a rate- and state- DEPENDENT friction law. We successfully deduce an apparent Dc = 5 cm.

In our experiment, a time resolution is limited. However, this method has a flexibility to reproduce stick-slip phenomena with any range of slip. We hope this method potentially contribute to study scaling relationship of the constitutive law of friction.

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