DS '11 KOBE
International Symposium on
Disaster Simulation & Structural Safety in the Next Generation (DS'11)
September 17-18, 2011, JAPAN

Modeling slow and fast ruptures at shallow subduction zones by considering friction at low-high slip velocities

SHIBAZAKI, Bunichiro

Keywords**:** *Subduction, Shallow very-low-frequency earthquakes, Accretion, Fast slip, Rate- and state-dependent friction law*

SUMMARY

Recent observations have revealed that very-low-frequency (VLF) earthquakes occur in the shallow subduction zones in the Nankai trough, Hyuganada, and off the coast of Tokachi, Japan (Ito and Obara, 2006; Asano et al., 2008). In the shallower subduction, in some cases, a very large seismic slip occurs leading to mega-thrust earthquakes such as the 2011 off the Pacific coast of Tohoku Earthquake (M9). In this study, we discuss the mechanisms of the various types of slip processes acting in the shallower subduction zone.

Tsutsumi et al. (2011) examined the frictional properties of clay-rich fault materials collected from a major splay fault within the Nankai accretionary complex under water-saturated conditions. Their experimental results reveal that both velocity-weakening and velocity-strengthening fault materials exist for intermediate slip velocities. Their results suggest that both velocity-weakening and velocity-strengthening regions are comingled in the shallow subduction zones. We performed two-dimensional (2D) quasi-dynamic modeling of the sequential occurrences of VLF earthquakes using a rate- and state-dependent friction law. On the basis of the experimental results of Tsutsumi et al. (2011), we considered several unstable patches comprising an area of a few km in the stable zone in order to simulate VLF earthquakes. Further, we set the effective normal stress to be on the order of 1.0 MPa. When the intervals between patches are considered to have a certain range, the VLF earthquakes occur sequentially. After large earthquakes occur, the activity of VLF earthquakes is extremely high due to afterslips but the recurrence intervals between the sequences of VLF earthquakes gradually increase with time.

Tsutsumi et al. (2011) also found that strong velocity weakening occur with an evolution at a large critical displacement when the slip velocity is high. On the basis of these frictional properties, we have investigated the generation process of the 2011 off the Pacific coast of Tohoku Earthquake (M9). We propose a rate- and state-dependent friction law with two-state variables that exhibits velocity weakening or velocity strengthening with a small critical displacement from low to intermediate slip velocities and strong velocity weakening with a large critical displacement at high slip velocities. This friction law is employed for 2D quasi-dynamic modeling of earthquake cycles. We consider three asperities where velocity weakening occurs at low to intermediate slip velocities, considering the off-Miyagi region. Ruptures of the asperities occur at intervals of 30–50 years. On the other hand, large events occur at intervals of several hundred years. In the case of such an event, ruptures occur in regions where velocity strengthening occurs at low to intermediate velocities since the slip velocity becomes sufficiently high that velocity weakening occurs.