Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SSS30-20 Room:Main Hall Time:April 28 16:45-17:00

Structural mechanics model of plate-interface fracture at subduction zones

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There are unidentified and unveiled properties concerning the physical process of greater inter-plate earthquakes at subduction zones. We, here, present a stochastic fracture model of the plate-interface with dynamic discrete interaction blocks. The stochastic treatment in this study is mainly based on structural mechanics. Here, in the four-dimensional point of view, regarded as significant long-wavelength components of the mechanical inter-plate coupling, we assign several discrete lattice-like blocks being connected each other on a hypothesized plate boundary system. The representative mechanical interaction vector (or tensor) for each discrete block should be variable on the plate boundary system. The total number of the discrete blocks and their nesting pattern should also vary with time during the long-term subduction process with intermittent greater seismic events.

Hereafter, we treat the inter-plate coupling at discrete blocks, using parameters such as failure probability *(Psf)* and safe probability *(Pss)* of the total system of the plate boundary. Here, $Psf + Pss = 1$.

The system fracture for the case of parallel connecting blocks is defined as the breakdown of all parallel blocks. Whereas, for the case of a series connecting block system, the system fracture is defined as the failure of one of the series block, or more. The system failure probability of a simple mechanical system being coupled in parallel N blocks is given as a product of $p(i)$ from $i = 1$ to $i = N$. Here, $p(i)$ is the failure probability of the *i-th* block of the system. For the case of a mechanical system connected in series N blocks, the system safe probability becomes a product of $\{1-p(i)\}$ from $i = 1$ to $i = N$. For a mechanical system composed of both parallel and series blocks, the system failure probability and system safe probability can be estimated with the above definition. Then, we assume that the inter-plate shear coupling of the plate-interface progresses only at discrete blocks of brittle fracture.

We consider two different configuration models for a two-by-four matrix *(2x4)* system of discrete coupling blocks, consist of four columns in the trench-parallel direction and two rows of deep side and a shallow side in the dip direction, as follows.

Configuration model A is a series-connected system of both the shallower parallel-connected column blocks and the deeper parallel-connected ones.

Configuration model B is a parallel-connected system of the four columns of the shallower and deeper rows being directly series-connected in the dip direction.

By setting the failure probability, $p(i,j)$, of *(i,j)-th* block, we can estimate the system failure probability *(Psf)* and system safe probability *(Pss)* for the configuration models, A and B. For the configuration models A and B, the system safe probability, *Pss(A)* and *Pss(B)* can be obtained. In the case of p(i,j) less than 0.5 for all blocks, *Pss(A)* becomes larger than *Pss(B)*, indicating that the configuration model A is safer than the model B. When the representative pattern of the inter-plate coupling changes from the configuration model A to B, or vice versa, we should carefully estimate the system probabilities.

We also demonstrated the detailed hypothetical expression form of p(i,j) by considering the effect of preceding larger seismic ruptures at blocks and the subsequent healing process, etc.

Keywords: subduction zone, inter-plate coupling, structural mechanics, system failure probability, system safe probability