Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SSS017-18 会場:展示ホール7別室1 時間: 5月26日15:00-15:15

地震ハザード評価における特定震源の地震発生モデルに関する研究：BPTモデルの再考察

On the earthquake recurrence model: Revisit to the Brownian-passage time model

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In the case of characterized source models, the Brownian-passage time model was adopted to evaluate the seismic hazards for nuclear power plants by the Atomic Energy Society of Japan. In this study, starting from reviewing the uncertainty of interpretation of trench investigation, we revisit the Brownian-passage time model and show that parameterization of the BPT model should be reconsidered before we apply it to active fault models.

Since Matthews et al (2002) proposed a probability model on the basis of the drifted Brownian motion modeling to account for earthquake recurrences, the Brownian-Passage Time (BPT) distribution, has been preferred to other probability models due to its explicit physical explanation. Both the Earthquake Research Committee of the Headquarters of Earthquake Research Promotion (HERP) and the Atomic Energy Society of Japan recommended the BPT distribution to estimate the earthquake probability on those active faults with a known recurrence interval. However, estimation of the aperiodicity value is controversial. Against the common value of 0.24 proposed by HERP (2001), Kumamoto and Hamada (2005), and Ishizeki and Kumamoto (2007), and Hayashi and Maeda (2009) estimated a common value of 0.49, 0.42, and 0.44, respectively. Moreover, for all the estimations mentioned above, the aperiodicity estimated for each individual fault varied with a large range. Using trench results summarized by HERP, for example, Hayashi and Maeda (2009) estimated a value of 0.659 for the Atera Fault zone in contrast to a comparatively smaller value of 0.089 for the Nobi fault zone. Here we compare the HERP interpretation for the Atera fault zone with recently reported new trench investigation results, propose a different interpretation and obtain a quite different estimation for this fault zone considering the uncertainty in interpretation of the trench data. It suggests that the large variation of estimators is partly due to difficulties in interpretation of trench investigation, which is presently the only available method to determine the occurrence of prehistoric earthquakes for active faults.

Given that the tectonic loading L and the perturbation P for a certain area are the same for all fault zones, however, we can readily show that the drifted Brownian motion model itself predict a fault-dependent aperiodicity a. According to the Brownian motion, for a fault system characterized by the failure index F (could be the strength or the critical slip-deficit), the mean recurrence time T=F/L. Since a is defined as $a=P/(LF)^{1/2}$, we have $a=P/LT^{-1/2}$. Clearly, a decreases against T given constant L and P. On the other hand, recent studies on earthquake source ruptures favor the

asperity model. The BPT model is consistent with the asperity model if we interpret L as the rate of slip-deficit, and F as the maximum slip of the asperity. In this model, the more active seismicity is observed on a fault, the larger P one expects. For simplicity, let$P=bF=bLT$, we have $a=bT^{1/2}$, and hence expect that a increases with T. In reality, common L and P may be reasonable for in-land active faults due to comparatively low seismicity, whereas area-dependent P should be taken into account for earthquakes occurring on the subduction zone. It follows that, even the effects of uncertainty in trench interpretation have been taken into consideration, the assumption of a common aperiodicity for different faults might be inconsistent with the BPT model itself.

The above models are only two end-number models. Practically, relation between P and F might be complicated and probably vary from region to region. For a certain area, however, the tectonic loading could be inferred from geometrical observations, the perturbation be estimated from seismicity, and hence the aperiodicity value could be determined independently. The trench investigation should be the final judgment.

Keywords: BPT model, earthquake recurrence, seismic hazard evaluation