Source parameter relationship of asperity model

Tetsu Masuda[1], Kazuhito Hikima[2]

[1] Oyo Corporation, [2] Oyo Corporation,Technical Center

www.oyo.co.jp

In order to understand the difference between the asperity model and crack model, we have investigated the source parameter relationship of asperity model. Asperities are distributed on the fault ares, the rest of the fault area being the background area, where non-zero stress drop are considered. Slip on asperities is propportional to asperity radius and stress drop, and the coefficient is larger than in the case of crack model. Slip on the background area is described as proportional to the average asperity stres drop. By using the reciprocal theorem to the crack model and asperity model, and by putting the total moment of asperity model equal to that of crack model, we have got the relationship between the slip coefficient for asperities and the backgroud. We have set the trial function for the asperity slip coefficient as,

ga*ea=(ea**2+n*eb**2)**1/3,

where ga is the asperity slip coefficient in concern, ea**2 the total asperity area over fault area, eb**2 the background area over fault area, and n the ratio og background stress drop to average asperity stress drop.

When ea**2=0.3 and n=0.1, asperity slip is 30% larger than the crack slip, while ea**2=0.2 and n=0.1, it is 40% larger. When ea**2=0.3 and n=0.1, or when ea**2=0.2 and n=0.2, the asperity slip is twice as large as the average slip of entire fault, which is found for large earthquakes.

As the asperity slip is derived to be larger than the crack slip, the slip velocity on asperity is almost the same with the slip velocity of the crack with the same stress drop. Thus the slip duration time of asperity is shown to be longer than the slip duration of crack with the same stress drop and the radius. The corner frequency of seismic radiation is determined by the slip duration and the source size. The long duration of slip in case of asperity model results in smaller corner frequency than in the case of crack model.

Hence we can uniquely specify all the necessary parameters for strong motion prediction based on the slip coefficient of asperity model.

アスペリティモデルにおける震源パラメタの関係

増田徹，引間和人
（応用地質株式会社，技術本部）

(A) クラックモデル

S　：断層全体の面積($S=\pi r^2$)
M_0　：地震モーメント
C_D　：変位の係数

$M_0=\mu S D_c$, (1)
$D_c=C_D(\Delta\sigma_c/\mu)r$. (2)

(B) アスペリティ

S_{am}　：m 番目のアスペリティの面積($S_{am}=\pi r_{am}^2$)
D_{am}　：アスペリティでの平均変位
M_{0am}　：アスペリティでの地震モーメント
$\Delta\sigma_{am}$　：アスペリティでの応力降下量
g_{am}　：アスペリティ変位の係数

$\varepsilon_{am}^2=S_{am}/S$, (3)
$\varepsilon_a^2=\Sigma\varepsilon_{am}^2$, (4)
$\Delta\sigma_a=\Sigma\Delta\sigma_{am}\varepsilon_{am}^2/\varepsilon_a^2$, (5).
$D_{am}=g_{am}C_D(\Delta\sigma_{am}/\mu)r_{am}$
$\quad=g_{am}\varepsilon_{am}C_D(\Delta\sigma_{am}/\mu)r$, (6)
$M_{0am}=\mu S D_{am}\varepsilon_{am}^2$
$\quad=\pi g_{am}\varepsilon_{am}^3 C_D\Delta\sigma_{am}r^2$, (7)
$g_{am}\geq 1$. (8)
$g_a=\Sigma(g_{am}\varepsilon_{am}^3\Delta\sigma_{am})/(\varepsilon_a^3\Delta\sigma_a)$, (9)

(C) 背景領域

S_b　：背景領域の面積($S_b=\pi r_b^2$)
$\Delta\sigma_b$　：背景領域での応力降下量
D_b　：背景領域での平均変位
M_{0b}　：背景領域での地震モーメント
g_b　：背景領域変位の係数

$\varepsilon_b^2=S_b/S$, (10)
$\nu=\Delta\sigma_b/\Delta\sigma_a\leq 1$, (11)
$D_b=g_b C_D(\Delta\sigma_b/\mu)r_b$
$\quad=g_b\varepsilon_b C_D(\Delta\sigma_b/\mu)r$, (12)
$M_{0b}=\mu S D_b\varepsilon_b^2$
$\quad=\pi g_b\varepsilon_b^3 C_D\Delta\sigma_b r^2$, (13)
$g_b\geq 0$. (14)

(D) 相互関係

$M_0=\Sigma M_{0am}+M_{0b}$. (15)
$\Delta\sigma_c=\Sigma g_{am}\varepsilon_{am}^3\Delta\sigma_{am}+g_b\varepsilon_b^3\Delta\sigma_b$, (16)
$\Delta\sigma_c=\Sigma\varepsilon_{am}^2\Delta\sigma_{am}+\varepsilon_b^2\Delta\sigma_b$
$\quad=\Delta\sigma_a(\varepsilon_a^2+\nu\varepsilon_b^2)$, (17)
$\Sigma g_{am}\varepsilon_{am}^3\Delta\sigma_{am}+g_b\varepsilon_b^3\Delta\sigma_a$
$\quad=(\varepsilon_a^2+\nu\varepsilon_b^2)\Delta\sigma_a$, (18)
$g_b=(\varepsilon_a^2+\nu\varepsilon_b^2-g_a\varepsilon_a^3)/\varepsilon_b^3$, (19)

(E) $\nu\to 1$ のとき

$g_{am}\to 1/\varepsilon_{am}$, (20)
$g_b\to 1/\varepsilon_b$. (21)

(F) $\nu<0$，$D_b\to 0$

$g_{am}\to 1$, (22)
$g_b\to 0$. (23)
$\nu_c\geq(\varepsilon_a^3-\varepsilon_a^2)/\varepsilon_b^2$, (24)

(G) $g_{am}=(\varepsilon_a^2+\nu\varepsilon_b^2)^{1/3}/\varepsilon_{am}$. (25)

$g_a=(\varepsilon_a^2+\nu\varepsilon_b^2)^{1/3}/\varepsilon_a$. (26)