Appendix E

A priori estimation of equivalent slip – weakening parameters

In Chapter 2 we have derived a set of approximated relations to express the equivalent slip – weakening distance (equation 2.13), the equivalent kinetic friction level t_f^{eq} (equation 2.16) and the equivalent upper yield stress t_u^{eq} (equation 2.17) as a function of the rate – and state – constitutive parameters. However, these equations also depend on slip velocity and state variable values associated to particular stages of the breakdown process, which are unknown *a priori* (v_0, v_u and F_u). The only possible solution to overcome this limitation and to associate rate – and state – friction laws and slip – weakening parameters is to find useful equations relating these unknown slip velocity and state variable values to the final slip velocity value v_2. These empirical relations depend on the adopted constitutive law and the parameters a, b and L, as well as on v_{init}. We have verified that, for our set of constitutive parameters and initial conditions, the following empirical approximated relations hold: $v_0 \cong 2v_2$, $v_u \cong 3v_2/4$, $F_u \cong (F_{init} + F_2)/3$ (where $F_{init} = L/v_{init}$ and $F_2 = L/v_2$). The velocity v_2 is derived by the shear impedance relation (see, for instace, Scholz, 1990):

$$\frac{v_2}{2\,v_S} = \frac{Dt_s}{m} \tag{E.1}$$

where Dt_d is the dynamic stress drop, defined as the difference existing between the initial and the final (kinetic) shear stress values (Brune, 1970). This equation expresses the asymptotic level at which the slip velocity drops when the crack tip has propagated a sufficient distance beyond the actual point, so that the influence of crack tip energy concentration is absent. We remark here that in equation (2.16) the friction at the end of phase IV is at the steady state and it is equal to $t^{ss}(v_2)$. Therefore we have:

$$Dt_s = (b-a)\,s_n^{eff}\,ln\left(\frac{v_2}{v_{init}}\right) \tag{E.2}$$

The final velocity v_2 is therefore determined by solving the following transcendental equation:

$$m\,v_2 = 2\,v_S(b-a)\,s_n^{eff}\,ln\left(\frac{2\,v_2}{v_{init}}\right) \tag{E.3}$$

from which we can simply obtain a rough estimate of the v_2 value. Once this slip velocity value is known, we can measure d_0^{eq}, t_f^{eq} and t_u^{eq} through equations (2.13), (2.16) and (2.17) after expressing all the other unknown values in terms of v_2 by using the approximated relations proposed here. This is a practical approach to have an *a priori* estimate of the equivalent slip – weakening parameters.

We emphasize however that the equivalent relations here derived depends on the adopted constitutive parameters and they are valid only for a slowness (ageing) evolution law.