$$\begin{aligned}\frac{\mathrm{d}\phi_c}{\mathrm{d}t} = \Omega\left(\phi_c - \overline{\phi}\right) &= -E(\phi_c - \phi_e) + D(\phi_c - \phi_d) \\ &= -E_b(\phi_c - \overline{\phi}) + D_b(\phi_c - \phi_c) \\ &= -\frac{E_b}{\rho}\left(\phi_c - \overline{\phi}\right)\end{aligned}$$