Let us first consider the fully aged initial state. In this state, $\Sigma_S = \Sigma_S^0$ and (in)stability does not depend on the rate of deformation but only on the relative efficiency of hardening and softening processes in the fully aged state. For the parameters given above, we can see that the initial state of the material is within the unstable domain, hence initial deformation is in our simulations always characterized by strain localization.

We now consider a homogeneous deformation process without spatial dependency and fixed imposed strain rate. In this case, a stationary solution of Eq. 6 is $\Sigma_S \approx \Sigma_S^0/(1 + \dot{e}\tau/\varepsilon_S)$, i.e., strength is reduced due to the on-going destruction of bonds in the snow microstructure. This leads to an upper critical strain rate above which the specimen behaves after initial softening like a cohesionless aggregate which compacts homogeneously. From the parameters above, the critical strain rate can be estimated to be of the order of 1 s^{-1}, which is well above the strain rate regime accessible in our experiments.

5 Correction for friction forces

The lateral stresses measured at the end of our experiments are small, which justified the assumption of a uniaxial stress state as consistent with the parameters $\alpha = 0.5$ and $\nu \approx 0$. Nevertheless, the lateral forces cause friction forces which oppose the movement of the anvil and thus influence the measured force data. To clarify the nature of these forces we observe that, during passage of the first compaction band, there is an asymmetry of the recorded force signal depending on whether the band moves downwards or upwards. During motion of a compaction front from top to bottom of the sample, the total force rises as more snow becomes compacted and moves with the anvil. By contrast, the force remains steady when snow is being compacted but not moving with the anvil (motion of a compaction front from bottom to top). Comparing both cases allows us, together with the lateral force data, to estimate the coefficient of friction at the wall.

With $\delta = 1/2 - \alpha$ the lateral plastic expansion of the snow is given by $\varepsilon_{yy}^{\mathrm{pl}} = \varepsilon_{zz}^{\mathrm{pl}} = (2/3)\delta e$ where e is the axial compressive strain evaluated for $\alpha = 1/2$. Because of the confinement due to the side walls, this expansion is offset by a compressive stress $\sigma_{yy} = \sigma_{zz} = (2/3)\delta e(x)E(x)$ which causes a total lateral force

$$\frac{2\delta}{3} wL\langle e(x)E(x)\rangle \tag{9}$$

If frictional motion occurs at the side walls, i.e., if the displacement rate $\dot{u}_x$ is negative, this in turn causes a total friction force

$$\frac{4\delta\mu}{3} wL\langle \Theta(-\dot{u}_x)e(x)E(x)\rangle \tag{10}$$

where μ is the coefficient of friction at the side wall-snow interface and Θ is Heaviside's function. This force superimposes on the force required for axial compression of the snow sample and needs to be taken into account when comparing experimental and simulated force distance curves. In particular, during passage of the first band our constitutive model predicts a constant stress, hence, any slope of the measured force distance curve can be attributed to friction. From the measured slope and the lateral forces, we can deduce an estimate for the coefficient of friction at the side walls, which is found to be in the range $0.4 < \mu < 0.6$. This is in rough agreement with a direct friction measurement