

SUPPLEMENTAL MATERIALS

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Long-Term Response of Sand Subjected to Repetitive Simple Shear Loading: Shakedown, Ratcheting, and Terminal Void Ratio

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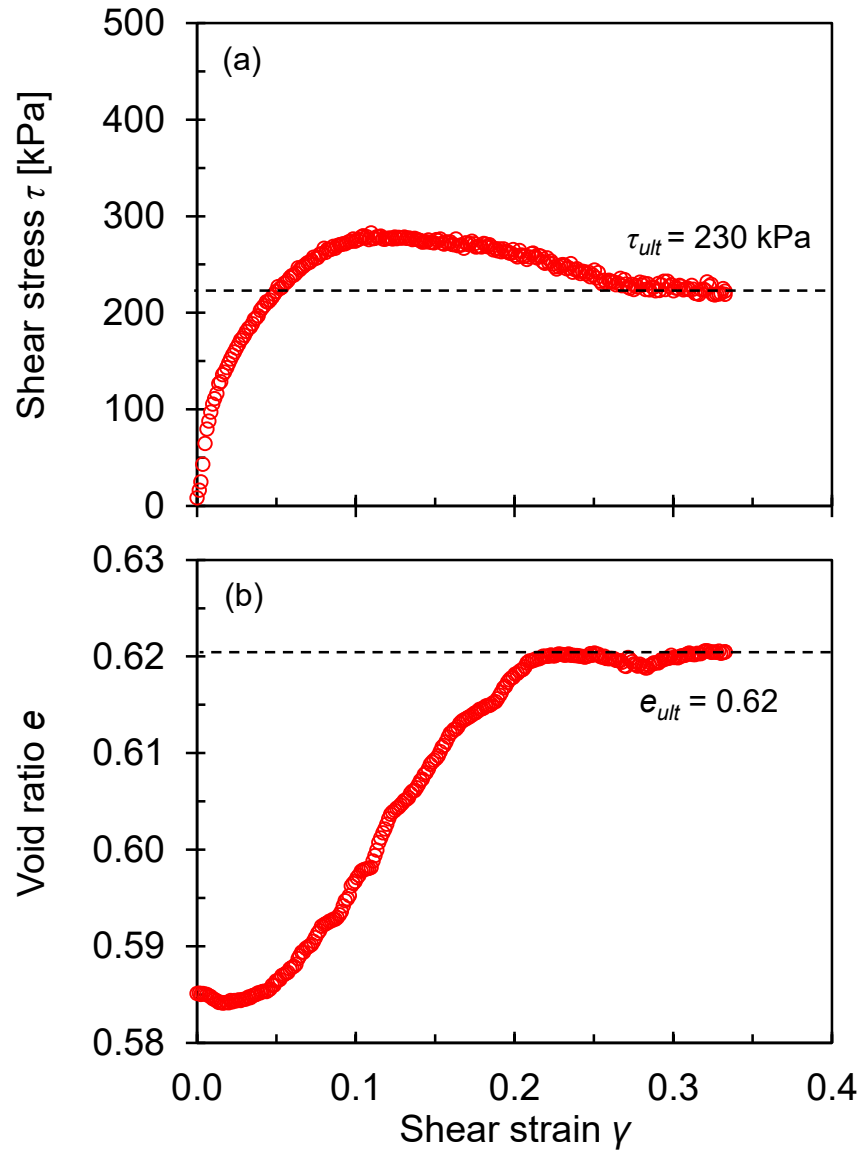


Figure S1. Monotonic load-deformation response of dense KAUST 20/30 sand at $\sigma_v = 500$ kPa. (a) Shear stress τ plotted against shear strain γ and (b) Void ratio e plotted against shear strain γ .

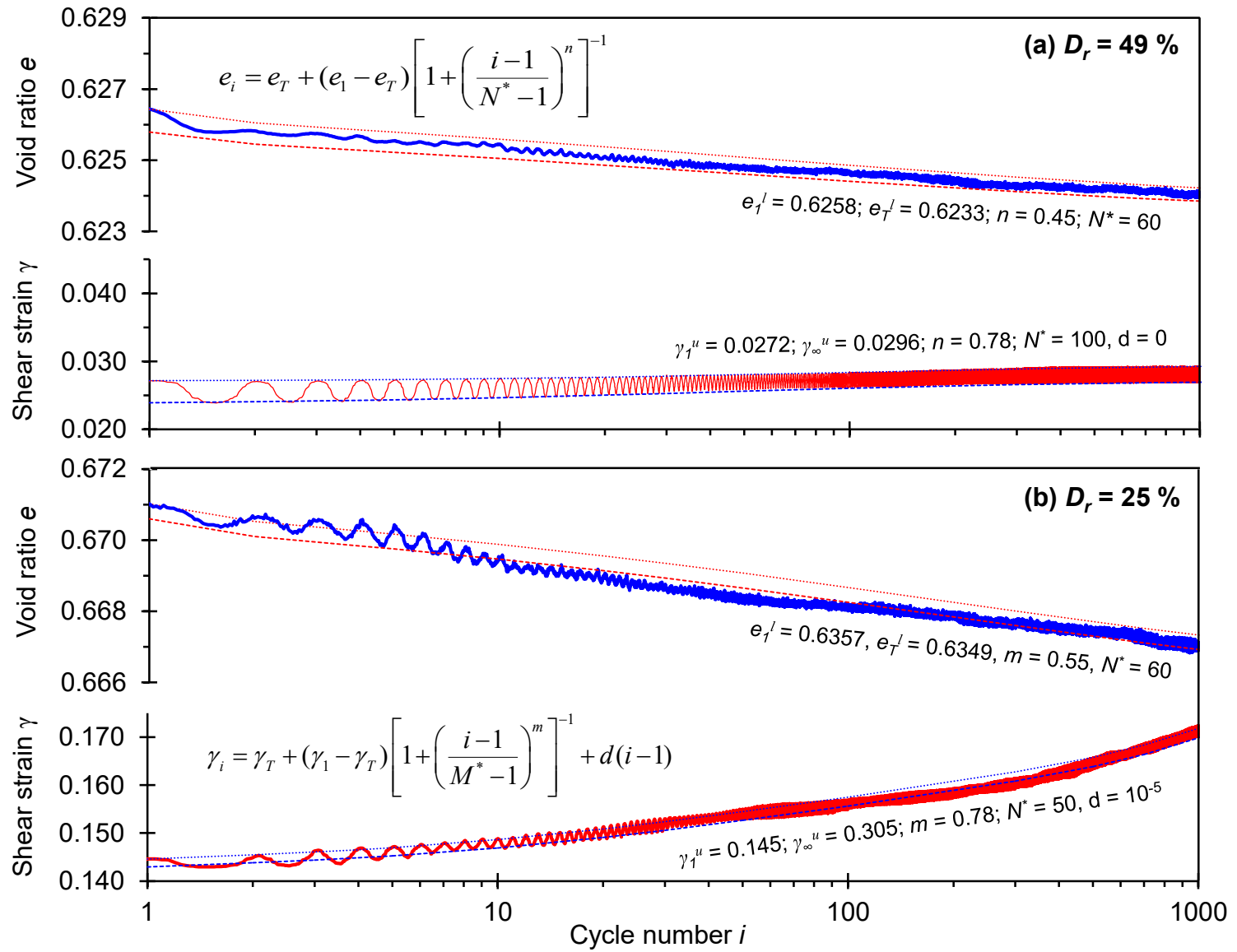


Figure S2. Void ratio e and shear strain γ evolution during repetitive shear loading. The dotted line indicates the fitted upper and lower accumulation trends. (a) Medium dense sand: $D_r = 49\%$, $\tau_o = 50$ kPa, $\Delta\tau = 50$ kPa (#2 in Table 1); (b) Loose sand: $D_r = 25\%$, $\tau_o = 150$ kPa, $\Delta\tau = 50$ kPa (#4 in Table 1). The accumulation model captures the asymptotic terminal void ratio e_T and shear strain γ_T .

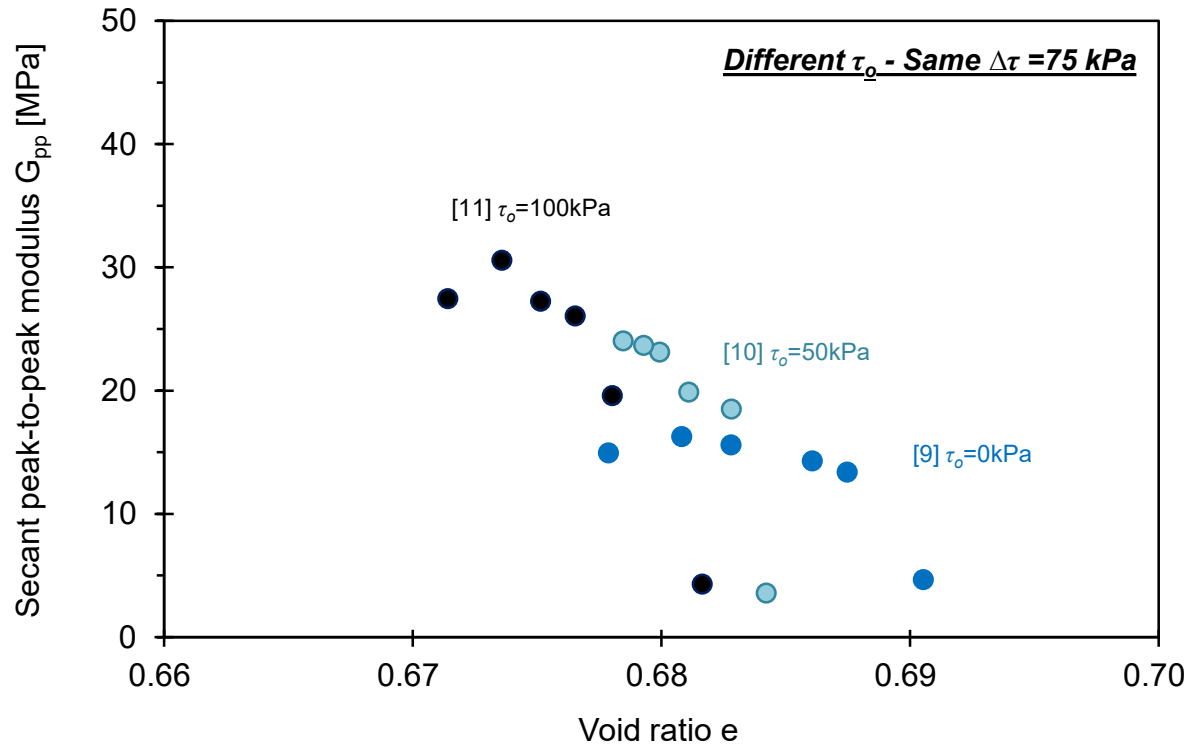


Figure S3. Evolution of secant peak-to-peak shear modulus G_{pp} versus void ratio during repetitive simple shear loading. Initial shear stress $\tau_o = 0, 50$ and 100 kPa, same $\Delta\tau = 75$ kPa. In square brackets [#]: test number in Table 1. Peak-to-peak strain $\gamma_{pp} \sim 10^{-3}$ to 10^{-2} .