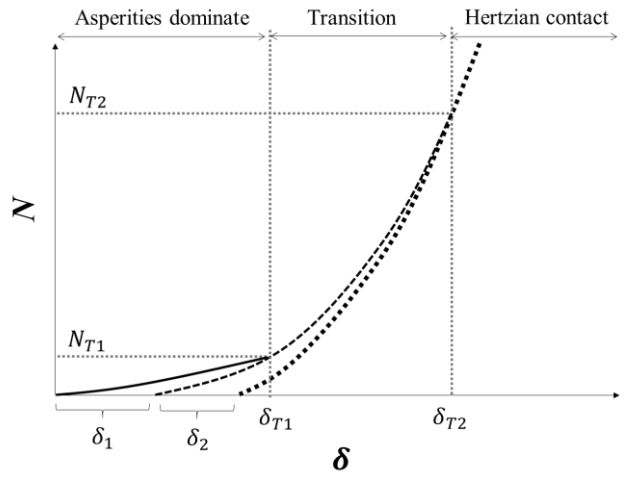


Fig. 1 Schematic illustration of proposed model for normal contact interaction.

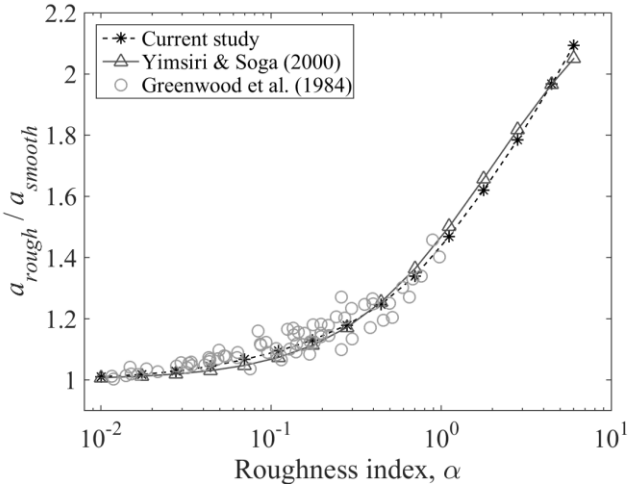


Fig. 2 Comparison of proposed model with published relationships: variation in rough / smooth contact radius ratio with roughness index.

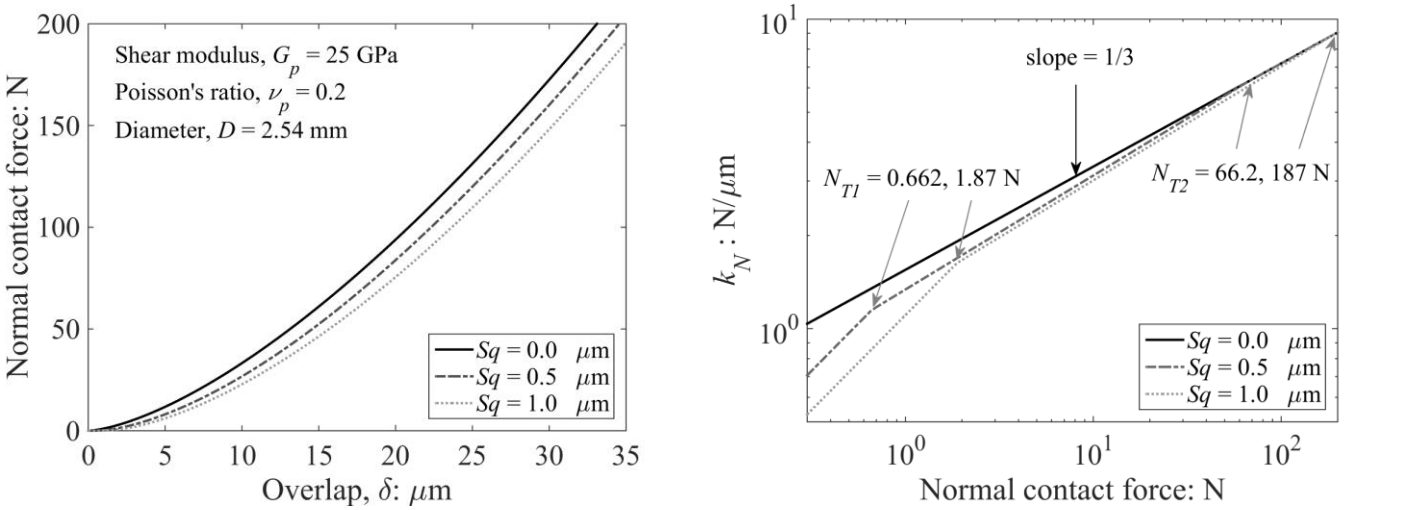


Fig. 3 Proposed model response for two particles in contact: (a) Normal contact force – Overlap, and (b) Normal contact stiffness - Normal contact force.

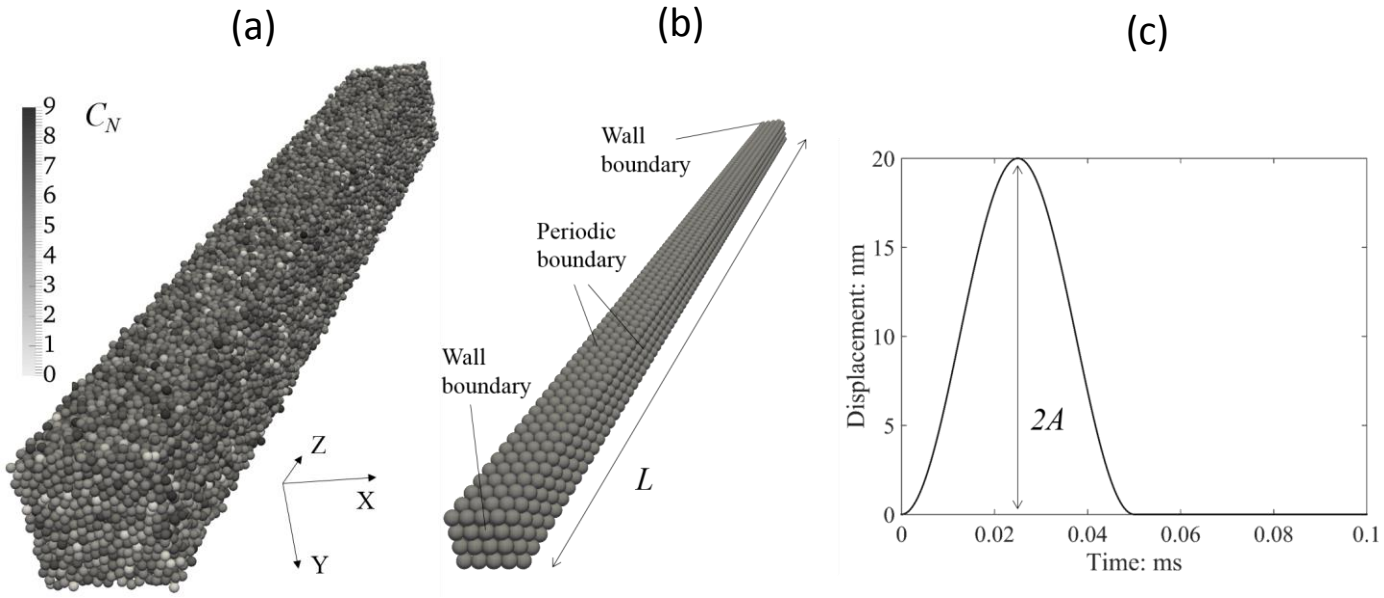


Fig. 4 (a) RLP sample and (b) FCC sample at σ' = 1 kPa with periodic boundaries in X and Y, and wall boundaries in Z. Particle shading indicates coordination number (C_N) in (a); (c) Time history of wall input motion in X direction.

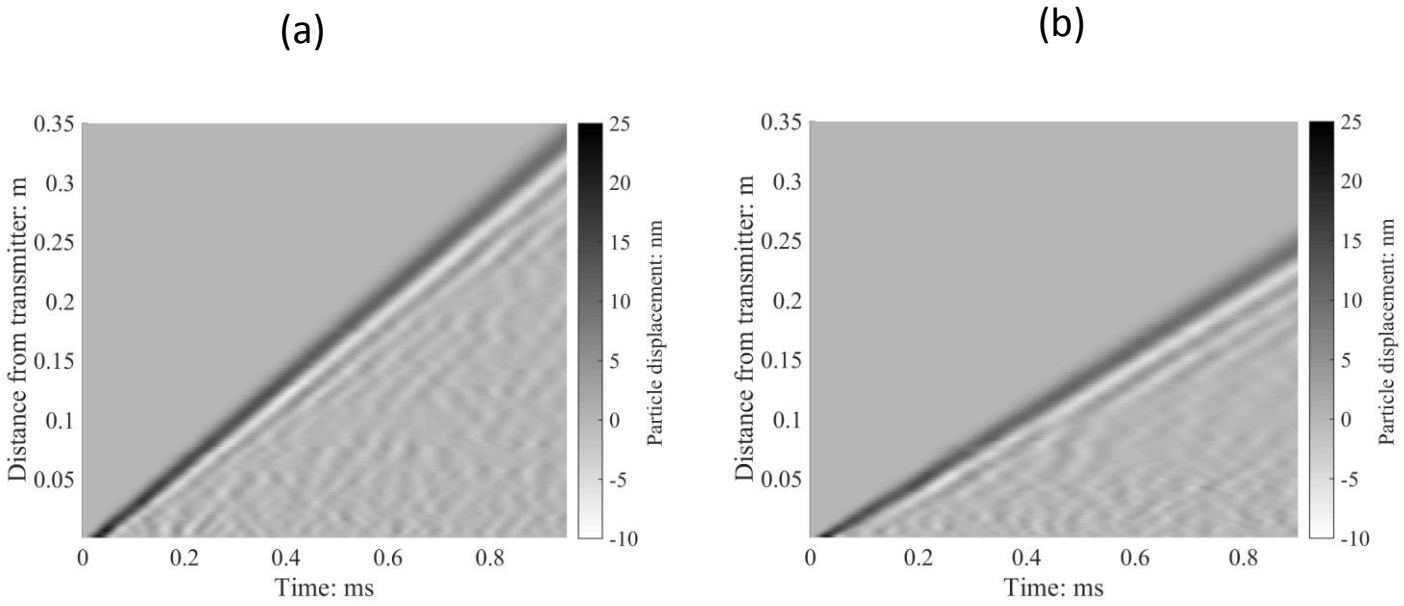


Fig. 5 Time history of particle displacements in excitation (X) direction at distances from transmitter wall (z) at σ' = 100 kPa (RDP sample) for (a) S_q = 0 μm (smooth), and (b) S_q = 1.0 μm.

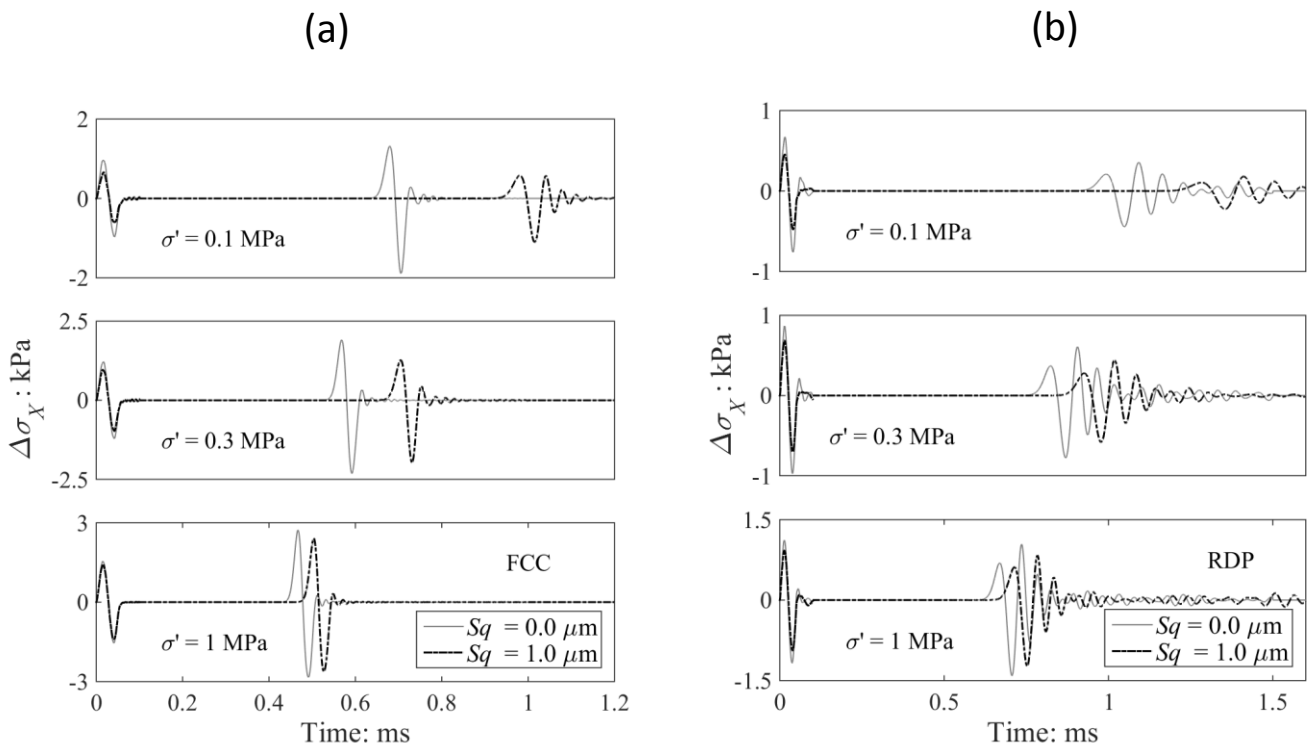


Fig. 6 Time history of increment in shear stress in excitation (X) direction on transmitter and receiver walls ($\Delta\sigma_X$) for S_q = 0.0 μm and 1.0 μm at σ' = 0.1 MPa, 0.3 MPa and 1 MPa for: (a) FCC, and (b) RDP.

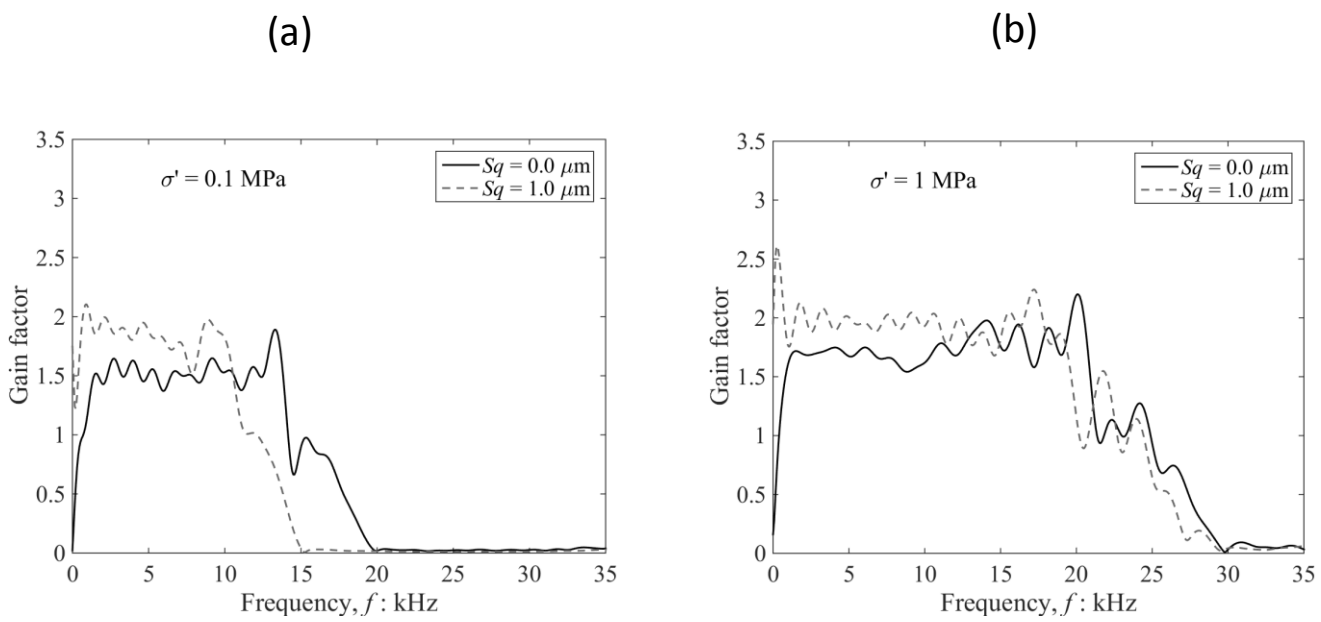


Fig. 7 Gain factor of incremental shear stress on transmitter and receiver walls for S_q=0 and S_q=1.0 μm at: (a) σ' = 0.1 MPa, and (b) σ' = 1 MPa.

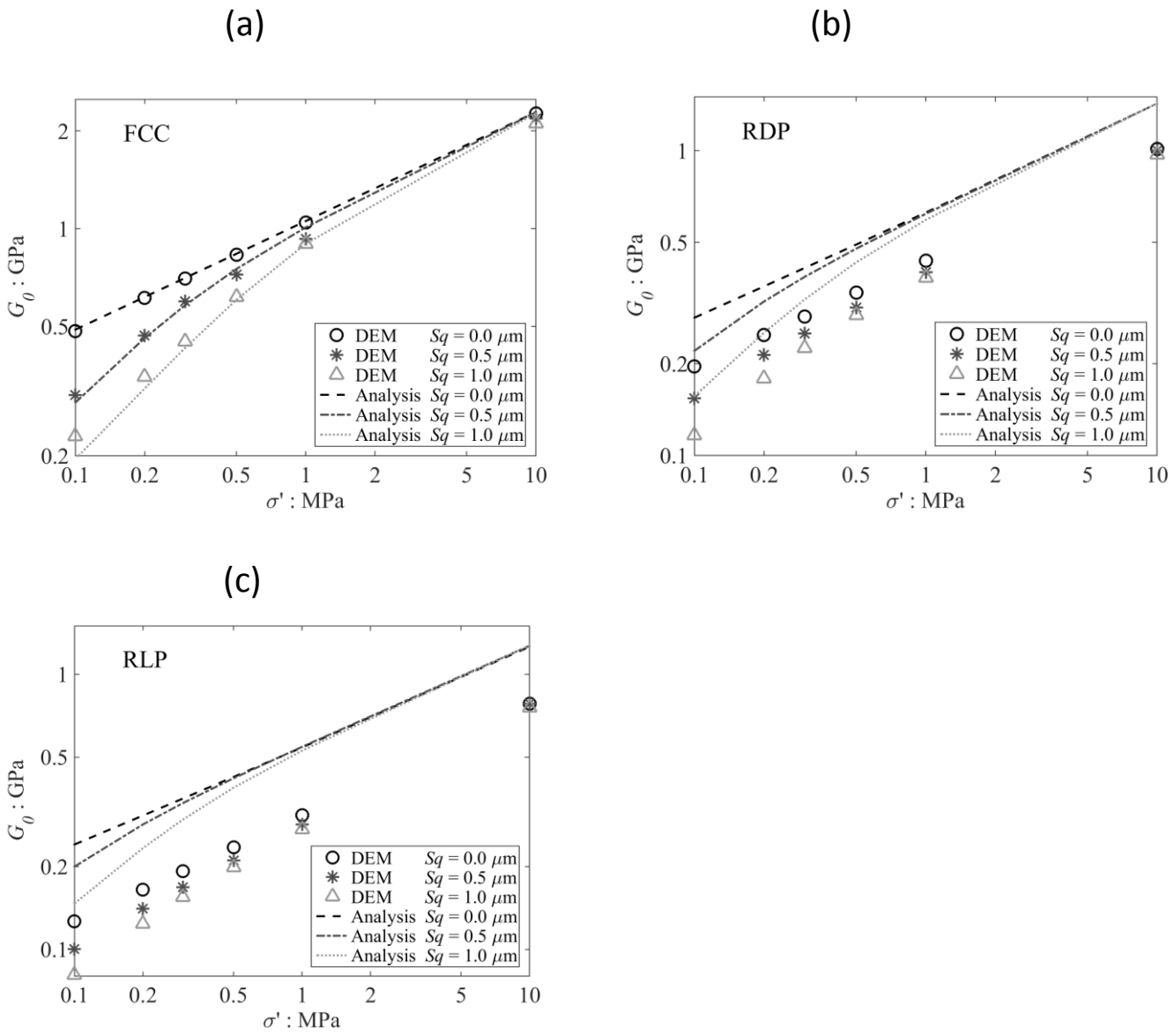


Fig. 8 Influence of surface roughness on small-strain shear modulus obtained by analytical approach and DEM results – relationship between G_0 and σ': (a) FCC, (b) RDP, and (c) RLP.

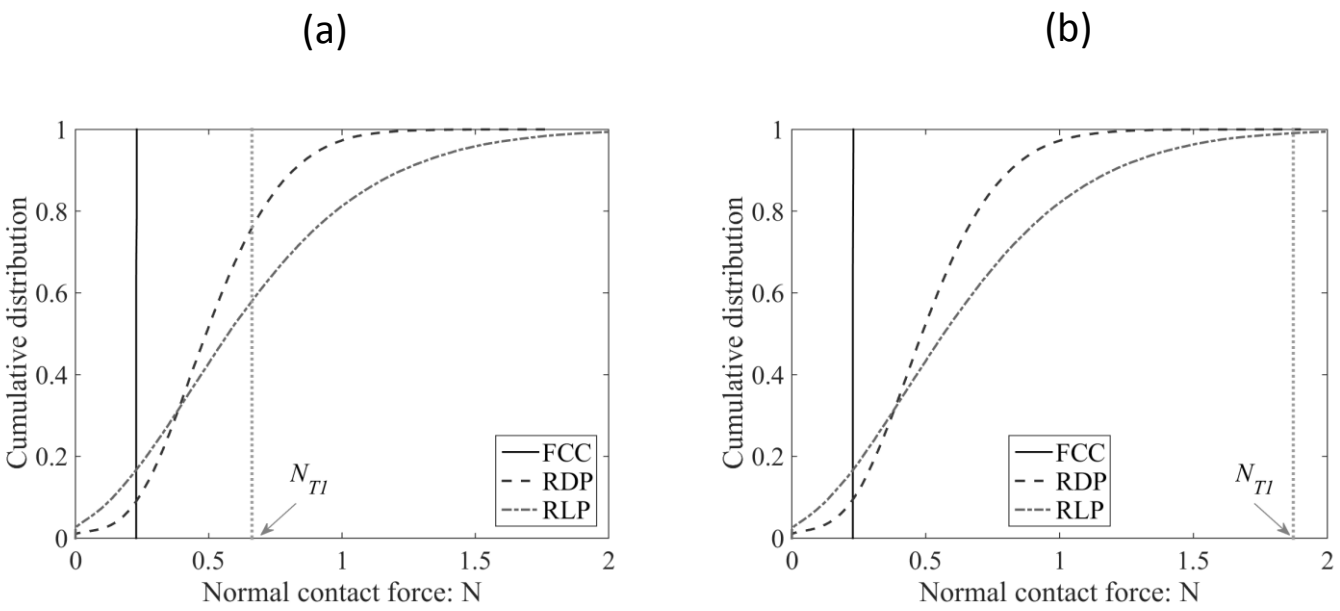


Fig. 9 Cumulative distributions of normal contact forces for different packings at p' = 100 kPa: (a) S_q = 0.5 μm, and (b) S_q = 1.0 μm.