Electronic Supplementary Material (ESI) for Soft Matter.

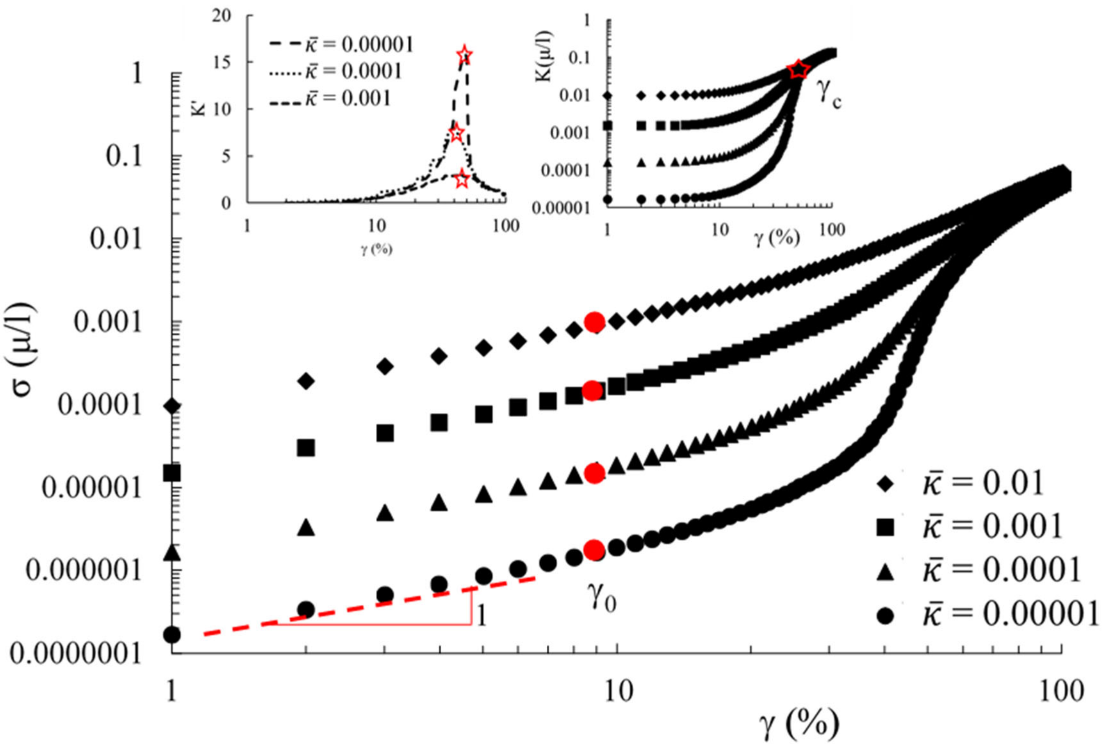

Figure S1. The shear stress-strain curves obtained from 2D diluted triangular networks made up of linear elastic fibers. The coordination number z is about 3.1 in all networks but different value of $\bar{\kappa}$ are considered. The critical strain γ_0, shown by red circles, denotes the onset of nonlinearity in the overall mechanical response. The top right inset shows the differential shear stiffness K versus the applied shear strain and the top left inset represents the variation of $K' = d(\log(K))/d(\log(\gamma))$; the maximum point of this plot, denoted by the star symbol, is the inflection point of the log(K) versus log(γ) curve and gives an estimate for critical strain γ_c.

The total bending energy H_b and total stretching energy H_s in random fiber networks are, respectively, given as $H_b = \sum_{fibers} \frac{\kappa}{2} \int_{fiber} \left| \frac{d\vec{t}}{ds} \right| ds$ and $H_b = \sum_{fibers} \frac{\mu}{2} \int_{fiber} \left(\frac{dl}{ds} \right)^2 ds$ where $\frac{dl}{ds}$ is the change in length and $\left| \frac{d\vec{t}}{ds} \right|$ is the curvature of a fiber. The relative contributions of bending and stretching energy in networks composed of linear elastic fibers are shown in Figure S2 where $H = H_s + H_b$.

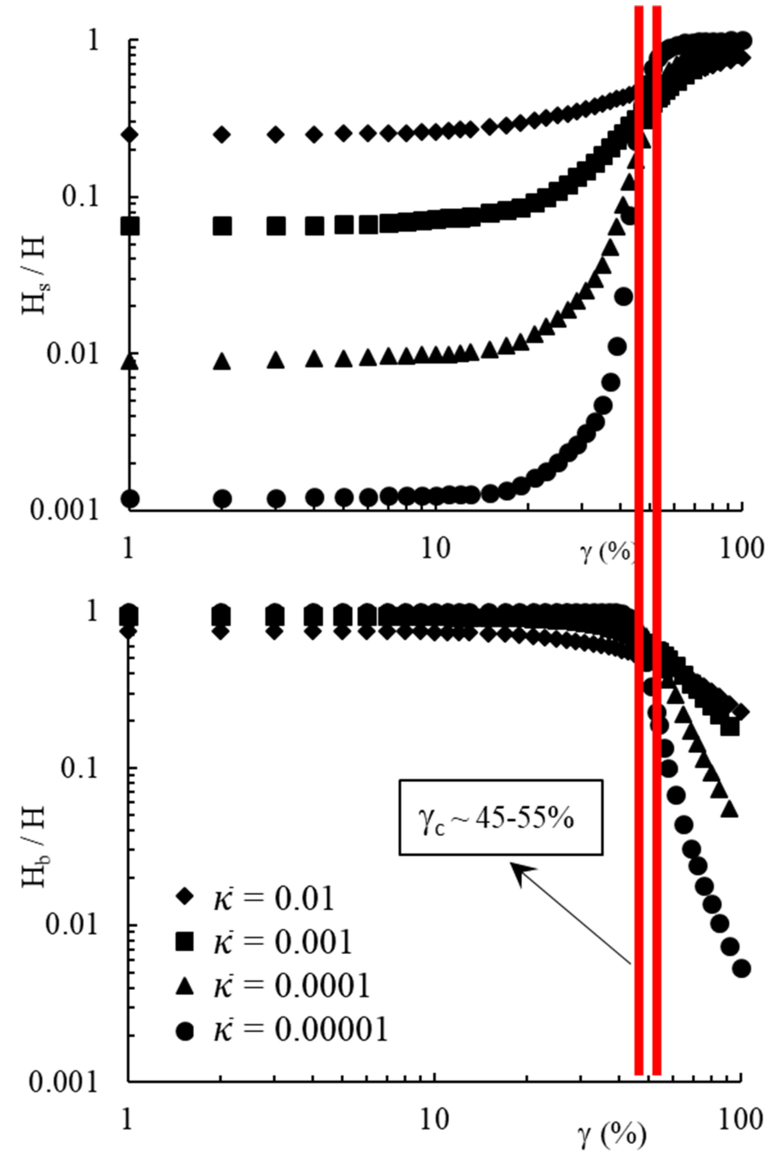

Figure S2. The relative contributions of bending and stretching energy in networks composed of linear elastic fibers is plotted as a function of the applied shear strain. The bending energy is dominant for strains less than critical shear strain γ_c. When $\gamma > \gamma_c$, the stretching energy becomes important.

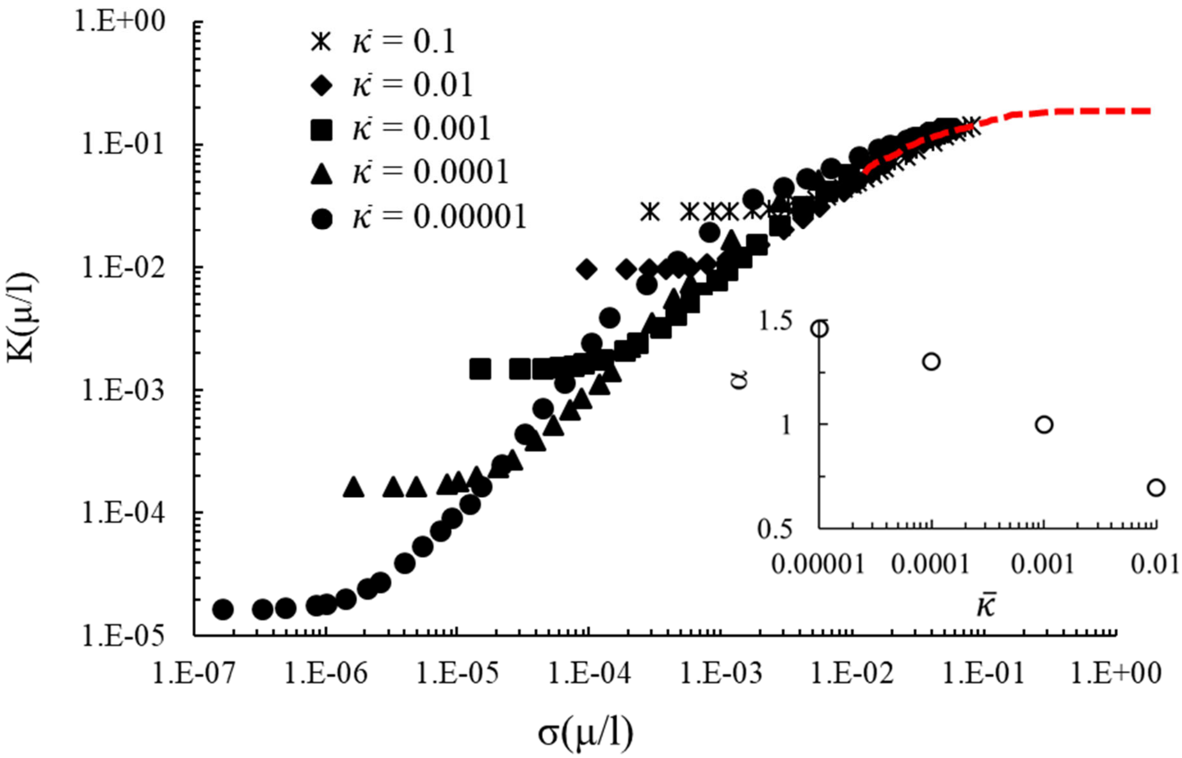

Figure S3. The variation of the differential shear modulus of random fiber networks versus the shear stress for linear elastic fibers with different bending rigidity $\bar{\kappa} = 0.00001 - 0.1$. The shear modulus and stress are plotted in units of μ/l. Three different regions are observed. Initially, the network stiffness is independent of the stress. With increasing the stress, the stiffness increases as $K \propto \sigma^{\alpha}$ where α varies from 0.6 to 1.5 as $\bar{\kappa}$ decreases from 10^{-1} to 10^{-5} (shown in the inset). With further increase of the stress, the stiffness becomes independent of stress (see the red dashed lines); this is a limitation of linear elastic models and does not agrees with experimental measurements where the network stiffness increases until failure.