

$$\sigma_{nn} = \sigma_{xx} \cos^2 \theta + 2\tau_{xy} \sin \theta \cos \theta + \sigma_{yy} \sin^2 \theta \quad \sigma'_{xx} = \sigma_{xx} \cos^2 \theta + 2\tau_{xy} \sin \theta \cos \theta + \sigma_{yy} \sin^2 \theta$$

$$\sigma_{mm} = \sigma_{xx} \sin^2 \theta - 2\tau_{xy} \sin \theta \cos \theta + \sigma_{yy} \cos^2 \theta \quad \sigma'_{yy} = \sigma_{xx} \sin^2 \theta - 2\tau_{xy} \sin \theta \cos \theta + \sigma_{yy} \cos^2 \theta$$

$$\tau_{nm} = \frac{1}{2}(\sigma_{yy} - \sigma_{xx}) \sin 2\theta + \tau_{xy} \cos 2\theta \quad \tau'_{xy} = \frac{1}{2}(\sigma_{yy} - \sigma_{xx}) \sin 2\theta + \tau_{xy} \cos 2\theta$$

$$\tan 2\theta = \frac{2\tau_{xy}}{\sigma_{xx} - \sigma_{yy}} \quad \sigma_1 + \sigma_2 = \sigma_{xx} + \sigma_{yy}$$

$$\sigma_1 = \frac{1}{2}(\sigma_{xx} + \sigma_{yy}) + \frac{1}{2}\sqrt{(\sigma_{xx} - \sigma_{yy})^2 + 4\tau_{xy}^2} \quad \sigma'_{xx} + \sigma'_{yy} = \sigma_{xx} + \sigma_{yy}$$

$$\sigma_2 = \frac{1}{2}(\sigma_{xx} + \sigma_{yy}) - \frac{1}{2}\sqrt{(\sigma_{xx} - \sigma_{yy})^2 + 4\tau_{xy}^2} \quad \tau_{\max} = \frac{1}{2}\sqrt{(\sigma_{xx} - \sigma_{yy})^2 + 4\tau_{xy}^2}$$

$$\sigma_{nn} = \sigma_1 \cos^2 \theta + \sigma_2 \sin^2 \theta \quad \tau_{\max} = \frac{1}{2}(\sigma_1 - \sigma_2)$$

$$\sigma_{mm} = \sigma_1 \sin^2 \theta + \sigma_2 \cos^2 \theta$$

$$\sigma_{nn} = \frac{1}{2}(\sigma_1 + \sigma_2) + \frac{1}{2}(\sigma_1 - \sigma_2) \cos 2\theta \quad \tau_{nm} = -\frac{1}{2}(\sigma_1 - \sigma_2) \sin 2\theta$$

$$\sigma_{mm} = \frac{1}{2}(\sigma_1 + \sigma_2) - \frac{1}{2}(\sigma_1 - \sigma_2) \cos 2\theta$$

$$\gamma_{xy} = \gamma_{yx} = 2\varepsilon_{xy} = 2\varepsilon_{yx}, \quad \gamma_{yz} = \gamma_{zy} = 2\varepsilon_{yz} = 2\varepsilon_{zy}, \quad \gamma_{zx} = \gamma_{xz} = 2\varepsilon_{zx} = 2\varepsilon_{xz}$$

$$\varepsilon_n = \varepsilon_{xx} \cos^2 \theta + \gamma_{xy} \sin \theta \cos \theta + \varepsilon_{yy} \sin^2 \theta \quad \varepsilon'_{xx} = \varepsilon_{xx} \cos^2 \theta + \gamma_{xy} \sin \theta \cos \theta + \varepsilon_{yy} \sin^2 \theta$$

$$\gamma_{nm} = (\varepsilon_{yy} - \varepsilon_{xx}) \sin 2\theta + \gamma_{xy} \cos 2\theta \quad \varepsilon'_{yy} = \varepsilon_{xx} \sin^2 \theta - \gamma_{xy} \sin \theta \cos \theta + \varepsilon_{yy} \cos^2 \theta$$

$$\tan 2\theta = \frac{\gamma_{xy}}{\varepsilon_{xx} - \varepsilon_{yy}} \quad \varepsilon_1 + \varepsilon_2 = \varepsilon_{xx} + \varepsilon_{yy} \quad \gamma'_{xy} = (\varepsilon_{yy} - \varepsilon_{xx}) \sin 2\theta + \gamma_{xy} \cos 2\theta$$

$$\varepsilon_1 = \frac{1}{2}(\varepsilon_{xx} + \varepsilon_{yy}) + \frac{1}{2}\sqrt{(\varepsilon_{xx} - \varepsilon_{yy})^2 + \gamma_{xy}^2} \quad \varepsilon'_{xx} + \varepsilon'_{yy} = \varepsilon_{xx} + \varepsilon_{yy}$$

$$\varepsilon_2 = \frac{1}{2}(\varepsilon_{xx} + \varepsilon_{yy}) - \frac{1}{2}\sqrt{(\varepsilon_{xx} - \varepsilon_{yy})^2 + \gamma_{xy}^2} \quad \gamma_{\max} = \sqrt{(\varepsilon_{xx} - \varepsilon_{yy})^2 + \gamma_{xy}^2}$$

$$\varepsilon_n = \varepsilon_1 \cos^2 \theta + \varepsilon_2 \sin^2 \theta \quad \gamma_{\max} = (\varepsilon_1 - \varepsilon_2)$$

$$\varepsilon_n = \frac{1}{2}(\varepsilon_1 + \varepsilon_2) + \frac{1}{2}(\varepsilon_1 - \varepsilon_2) \cos 2\theta \quad \varepsilon = \frac{\delta \ell}{\ell_o}$$

$$\gamma_{nm} = -(\varepsilon_1 - \varepsilon_2) \sin 2\theta$$

$$\sigma_{rr} = \sigma_{xx} \cos^2 \theta + 2\tau_{xy} \sin \theta \cos \theta + \sigma_{yy} \sin^2 \theta \quad \varepsilon_{rr} = \varepsilon_{xx} \cos^2 \theta + \gamma_{xy} \sin \theta \cos \theta + \varepsilon_{yy} \sin^2 \theta$$

$$\sigma_{\theta\theta} = \sigma_{xx} \sin^2 \theta - 2\tau_{xy} \sin \theta \cos \theta + \sigma_{yy} \cos^2 \theta \quad \varepsilon_{\theta\theta} = \varepsilon_{xx} \sin^2 \theta - \gamma_{xy} \sin \theta \cos \theta + \varepsilon_{yy} \cos^2 \theta$$

$$\tau_{r\theta} = \frac{1}{2}(\sigma_{yy} - \sigma_{xx}) \sin 2\theta + \tau_{xy} \cos 2\theta \quad \gamma_{r\theta\theta} = (\varepsilon_{yy} - \varepsilon_{xx}) \sin 2\theta + \gamma_{xy} \cos 2\theta$$

$$w = \frac{1}{2}(\sigma_1 \varepsilon_1 + \sigma_2 \varepsilon_2 + \sigma_3 \varepsilon_3) \quad w = \frac{1}{2}(\sigma_{xx} \varepsilon_{xx} + \sigma_{yy} \varepsilon_{yy} + \sigma_{zz} \varepsilon_{zz} + \tau_{xy} \gamma_{xy} + \tau_{yz} \gamma_{yz} + \tau_{zx} \gamma_{zx})$$

$$Q = wV$$

$$\begin{aligned}\varepsilon_{xx} &= \frac{1}{E} \{ \sigma_{xx} - \nu(\sigma_{yy} + \sigma_{zz}) \} \quad \gamma_{xy} = \frac{1}{G} \tau_{xy} \quad \varepsilon_{xy} = \frac{1}{2G} \tau_{xy} \quad G = \frac{E}{2(1+\nu)} \\ \varepsilon_{yy} &= \frac{1}{E} \{ \sigma_{yy} - \nu(\sigma_{xx} + \sigma_{zz}) \} \quad \gamma_{yz} = \frac{1}{G} \tau_{yz} \quad \varepsilon_{yz} = \frac{1}{2G} \tau_{yz} \quad K = \frac{E}{3(1-2\nu)} \\ \varepsilon_{zz} &= \frac{1}{E} \{ \sigma_{zz} - \nu(\sigma_{xx} + \sigma_{yy}) \} \quad \gamma_{zx} = \frac{1}{G} \tau_{zx} \quad \varepsilon_{zx} = \frac{1}{2G} \tau_{zx}\end{aligned}$$

$$\begin{aligned}\sigma_{xx} &= \lambda \Delta + 2G \varepsilon_{xx} \quad \tau_{xy} = G \gamma_{xy} \quad \tau_{xy} = 2G \varepsilon_{xy} \quad \Delta = \varepsilon_{xx} + \varepsilon_{yy} + \varepsilon_{zz} \\ \sigma_{yy} &= \lambda \Delta + 2G \varepsilon_{yy} \quad \tau_{yz} = G \gamma_{yz} \quad \tau_{yz} = 2G \varepsilon_{yz} \quad \lambda = \frac{E\nu}{(1+\nu)(1-2\nu)} \\ \sigma_{zz} &= \lambda \Delta + 2G \varepsilon_{zz} \quad \tau_{zx} = G \gamma_{zx} \quad \tau_{zx} = 2G \varepsilon_{zx}\end{aligned}$$

$$\begin{aligned}\sigma_{zz} &= 0 \quad \varepsilon_{zz} = -\frac{\nu}{E}(\sigma_{xx} + \sigma_{yy}) \\ \varepsilon_{xx} &= \frac{1}{E}(\sigma_{xx} - \nu\sigma_{yy}) \quad \gamma_{xy} = \frac{1}{G} \tau_{xy} \quad \sigma_{xx} = \frac{E}{1-\nu^2}(\varepsilon_{xx} + \nu\varepsilon_{yy}) \quad \tau_{xy} = G \gamma_{xy} \\ \varepsilon_{yy} &= \frac{1}{E}(\sigma_{yy} - \nu\sigma_{xx}) \quad \sigma_{yy} = \frac{E}{1-\nu^2}(\varepsilon_{yy} + \nu\varepsilon_{xx})\end{aligned}$$

$$\begin{aligned}\varepsilon_{zz} &= 0 \quad \sigma_{zz} = \nu(\sigma_{xx} + \sigma_{yy}) \\ \varepsilon_{xx} &= \frac{1}{E} \left\{ (1-\nu^2)\sigma_{xx} - \nu(1+\nu)\sigma_{yy} \right\} \\ \varepsilon_{yy} &= \frac{1}{E} \left\{ (1-\nu^2)\sigma_{yy} - \nu(1+\nu)\sigma_{xx} \right\}\end{aligned}$$

$$q = \rho g H \quad \sigma_v = q \quad \sigma_h = kq$$

$$\begin{aligned}\sigma_{rr} &= \frac{1}{2} q(1+k) \left(1 - \frac{R^2}{r^2} \right) - \frac{1}{2} q(1-k) \left(1 - \frac{4R^2}{r^2} + \frac{3R^4}{r^4} \right) \cos 2\theta \\ \sigma_{\theta\theta} &= \frac{1}{2} q(1+k) \left(1 + \frac{R^2}{r^2} \right) + \frac{1}{2} q(1-k) \left(1 + \frac{3R^4}{r^4} \right) \cos 2\theta \\ \tau_{r\theta} &= \frac{1}{2} q(1-k) \left(1 + \frac{2R^2}{r^2} - \frac{3R^4}{r^4} \right) \sin 2\theta\end{aligned}$$

$$\begin{aligned}\sigma_{rr} &= q \left(1 - \frac{R^2}{r^2} \right) \quad \sigma_{\theta\theta} = q \left(1 + \frac{R^2}{r^2} \right) \quad \tau_{r\theta} = 0 \quad \sigma_{zz} = 2\nu q \\ u &= \frac{(1+\nu)}{E} q \left\{ (1-2\nu)r + \frac{R^2}{r} \right\} \quad \nu = 0\end{aligned}$$

$$s_z = \frac{2(1-\nu)q}{G} \sqrt{\ell^2 - x^2} \quad \ell_c = \frac{s_m G}{2(1-\nu)q}$$

$$\ell < \ell_c \quad ERR = \frac{\Delta U_m}{\Delta A} = \frac{\pi(1-\nu)\ell q^2}{2G} \quad \ell = \ell_c \quad ERR = \frac{\Delta U_m}{\Delta A} = \frac{\pi}{4} s_m q$$

$$\ell > \ell_c \quad ERR = \frac{\Delta U_m}{\Delta A} = \frac{\pi}{4} s_m q \left(\frac{1 - (1 - \ell_c / \ell)^{1.27}}{\ell_c / \ell} \right) \quad \ell \rightarrow \infty \quad ERR = \frac{\Delta U_m}{\Delta A} = s_m q$$

$$\tau = c + \mu \sigma \quad \mu = \tan \phi \quad \sigma_1 = \sigma_c + \tan \psi \sigma_3$$

$$\tan \psi = \frac{1 + \sin \phi}{1 - \sin \phi} \quad \sigma_c = \frac{2c \cos \phi}{1 - \sin \phi} \quad \phi = \arcsin \left(\frac{\tan \psi - 1}{\tan \psi + 1} \right) \quad c = \frac{\sigma_c}{2 \sqrt{\tan \psi}}$$

$$Q = \frac{RQD}{J_n} \frac{J_r}{J_a} \frac{J_w}{SRF} \quad RMR = 9 \log_e Q + 44$$

$$\sigma_1 = \sigma_3 + \sigma_{ci} \left(m_b \frac{\sigma_3}{\sigma_{ci}} + s \right)^a \quad \sigma_1 = \sigma_3 + \sigma_{ci} \sqrt{m_i \frac{\sigma_3}{\sigma_{ci}} + 1}$$

$$GSI > 25 \quad GSI = RMR_{76} \quad GSI = RMR_{89} - 5$$

$$GSI < 25 \quad Q' = \frac{RQD}{J_n} \frac{J_r}{J_a} \quad GSI = 9 \log_e Q' + 44$$

$$m_b = m_i \exp \left(\frac{GSI - 100}{28} \right)$$

$$GSI > 25 \quad s = \exp \left(\frac{GSI - 100}{9} \right) \quad a = \frac{1}{2} \quad \sigma_1 = \sigma_3 + \sigma_{ci} \sqrt{m_b \frac{\sigma_3}{\sigma_{ci}} + s}$$

$$\sigma_{im} = \frac{\sigma_{ci}}{2} \left(m_b - \sqrt{m_b^2 + 4s} \right) \quad \sigma_{cm} = \sigma_{ci} \sqrt{s}$$

$$GSI < 25 \quad s = 0 \quad a = 0.65 - \frac{GSI}{200} \quad \sigma_1 = \sigma_3 + \sigma_{ci} \left(m_b \frac{\sigma_3}{\sigma_{ci}} \right)^{0.65 - \frac{GSI}{200}}$$

$$\sigma_{im} = 0 \quad \sigma_{cm} = 0$$

$$\sigma_{ci} > 100 \text{ MPa} \quad E_m (\text{GPa}) = 10^{\left(\frac{GSI - 10}{40} \right)}$$

$$\sigma_{ci} < 100 \text{ MPa} \quad E_m (\text{GPa}) = \sqrt{\frac{\sigma_{ci} (\text{MPa})}{100 (\text{MPa})}} 10^{\left(\frac{GSI - 10}{40} \right)}$$

$$\tau = \sigma_n \tan \left[\phi_a + JRC \log_{10} \left(\frac{JCS}{\sigma_n} \right) \right]$$

$$q = 0.025H \text{ MPa} \quad H[m] \quad \sigma_v = \rho gh \quad \sigma_h = k\sigma_v$$

$$e = 1 - \frac{w^2}{C^2} \quad C = w + B \quad r = \frac{h}{M} \left(1 - \frac{w^2}{C^2} \right) \quad h_e = h \left(1 - \frac{w^2}{C^2} \right) \quad h_e = he$$

$$\sigma_p = \frac{q}{1-e} \quad \sigma_p = 0.025H \frac{(w+B)^2}{w^2} \text{ MPa} \quad R = \frac{w}{h}$$

$$R < 5$$

$$\sigma_s = 7.2 \frac{w^{0.46}}{h^{0.66}} \text{ MPa} \quad Fs = \frac{\sigma_s}{\sigma_p} \quad Fs = 288 \frac{w^{2.46}}{Hh^{0.66}(w+B)^2}$$

$$R \geq 5$$

$$\sigma_s = 7.2 \frac{R_o^{0.5933}}{V^{0.0667}} \left\{ \frac{0.5933}{\varepsilon} \left[\left(\frac{R}{R_o} \right)^\varepsilon - 1 \right] + 1 \right\} \text{ MPa}$$

$$V = w^2 h \quad R_o = 5 \quad \varepsilon = 2.5$$

$$\sigma_s = \frac{0.07942}{(w^2 h)^{0.0667}} (R^{2.5} + 179.65) \text{ MPa}$$

$$Fs = \frac{\sigma_s}{\sigma_p} \quad Fs = \frac{3.1768w^{1.8666}}{H(w+B)^2 h^{0.0667}} \left\{ \left(\frac{w}{h} \right)^{2.5} + 179.65 \right\}$$

$$e = 1 - \frac{w_1 w_2}{C_1 C_2} \quad w_e = \frac{4w_1 w_2}{2w_1 + 2w_2}$$

$$\sigma_p = 0.025H \frac{C_1 C_2}{w_1 w_2} \text{ MPa}$$

$$R = \frac{E}{4(1-\nu^2)} \frac{s_m}{(\sigma_{cr} - q)} \quad R = 0.28 \frac{s_m}{\varepsilon_{cr}}$$

$$v_p = \sqrt{\frac{\lambda + 2G}{\rho}} \quad v_s = \sqrt{\frac{G}{\rho}}$$

$$ESS = |\tau| - [\sigma_n \tan(\theta) + C_0]$$

$$\sigma_1 = \sigma_3 + \sqrt{m\sigma_c\sigma_3 + s\sigma_c^2}$$

$$S_{m,he} = 0.39h\left(\frac{W}{H}\right)^{0.32} \quad S_{m,pf} = 0.1h_e, \text{ H}>80\text{m} \quad S_{m,pf} = 0.8h_e, \text{ H}<80\text{m}$$

$$h_e = eh$$

$$\varepsilon_{m+} = 4.2S_m + 1.7 \quad \varepsilon_{m-} = -9.1S_m - 2.8 \quad T_m = 21.6S_m + 7$$

$$L_c = 2T\sqrt{k + \frac{\beta}{D}} + 2(H - D)\tan\phi$$

$$\beta = \frac{1.53}{\gamma_m} - 0.8$$

$$\gamma_m = 0.025\frac{D-T}{D} + 0.03\frac{T}{D}$$

$$\sigma_t = \frac{qB^2}{2t_s^2} \quad q = \rho g(t_s + t_w) \quad \sigma = \frac{3qL^2}{t^2} \quad \eta = \frac{qL^4}{32Et^3} \quad l_a = \frac{\mathcal{I}_b^2 t_w}{\pi d_h \tau}$$

$$w_e = \frac{4A}{c}$$

$$\sigma_{squat} = k \frac{R_o^b}{V^a} \left\{ \frac{b}{\varepsilon} \left[\left(\frac{R}{R_o} \right)^\varepsilon - 1 \right] + 1 \right\} \quad Strength_{Squat} = \frac{0.0786}{V^{0.0667}} \{ R^{2.5} + 181,6 \}$$

$$SF = \frac{Strength}{Load} \quad Strength = 7.2 \frac{w^{0.46}}{h^{0.66}}$$

$$SF_{CM} = SF \left(1 + \frac{0,6}{w} \right)^{2,46} \quad Load = \frac{[.025(H-T) + .030T]C_1C_2}{w_1w_2}$$

$$SF'' = SF \left(\frac{w - \Delta w}{w} \right)^{2,46} \quad SF' = SF \left(\frac{h}{h + \Delta h} \right)^{0,66}$$

$$e\% = \left[100 \frac{h_m}{h_s} \left(1 - \frac{w^2}{C^2} \right) \right] \frac{W}{W + P}$$

$$\sigma_t = \frac{qB^2}{2t_s^2}, \quad q = \rho g(t_s + t_w)$$

$$t_{sb} = \frac{Fk\rho gB^2}{2\sigma_t}$$

$$s = 1.414t_l \sqrt{\frac{\sigma_t}{Fq_c}}, \quad q_c = q_l + \frac{q_u E_l + q_l E_u}{E_l + E_u}$$

$$F_b = \frac{s}{\tan \phi} \left[\frac{3\rho g k B_s}{4} - \sigma_r d_h \right]$$

$$l_a = \frac{\rho g s^2 t_w + 0.05}{\pi d_h \tau_c}$$

$$l_a = \frac{Ft}{\pi d_h \tau_c}, \quad w_b = \rho g k t_{sb} s^2, \quad F_t = F_b + w_b$$

$$\sigma_{ts} = \frac{4w_b}{\pi d^2}, \quad w_b = \rho g s^2 t_w$$

$$\sigma_s = \frac{4F_t}{\pi d_s^2}$$