Formula	Description
Suspension Bridges	
$T_y = \frac{wL}{2}, T_x = \frac{wL^2}{8h}$	Main cable tension in suspension bridge
Basic Material Properties	
$\sigma = \frac{P}{A}$	Definition: Stress
$\varepsilon = \frac{\Delta l}{l_0}$	Definition: Strain
$E = \frac{\sigma}{\varepsilon}, \sigma = E\varepsilon$	Definition: Young's Modulus
$\mu = \nu = -\frac{\varepsilon_y}{\varepsilon_x}$	Definition: Poisson's Ratio
$k = \frac{AE}{L_0}$	Spring constant from Young's modulus
$\varepsilon_{th} = \alpha \Delta T$	Strain from thermal expansion
Energy	
$W = \int F \mathrm{d}\Delta l$	Definition: Strain energy
$U = \int \sigma \mathrm{d}\varepsilon, W = U \cdot V_0$	Definition: Strain energy density
$W = \frac{1}{2}\sigma\varepsilon V_0$	Strain energy when material is linear elastic
Second Moment of Area and Centroid	
$I = \int_A y^2 \mathrm{d}A$	Definition: Second moment of area
$I_m = \int_A y^2 \,\mathrm{d}m = \rho I$	Definition: Moment of inertia
$I = \frac{bh^3}{12}$	I for rectangular cross section
$I = \frac{\pi d^4}{64}$	I for circular cross section (d is diameter, horizontal axis)
$I = \sum_{i=1}^{n}(I_{0,i} + A_i d_i^2)$	Parallel axis theorem; I_0 is I about the local centroid, A is the area, and d_i is the distance between the local and global centroids
$\bar{y} = \frac{1}{A}\sum_{i=1}^{n} y_i A_i$	Centroidal axis location
Oscillations and Dynamic Effects	
$\omega_n = \sqrt{\frac{k}{m}}$	Natural angular frequency
$f_n = \frac{15.76}{\sqrt{\Delta_0}}$	Natural frequency, point load
$f_n = \frac{17.76}{\sqrt{\Delta_0}}$	Natural frequency, distributed load
$\frac{1}{\sqrt{(1-\alpha^2)^2 + (2\beta\alpha)^2}}$	Dynamic amplification factor; $\alpha = \frac{f}{f_n}$; β is the damping ratio
$w_{eq} = w_{sta} + \mathrm{DAF} \cdot w_0$	Equivalent dynamic load

Formula	Description
Trusses	
$P_e = \frac{\pi^2 EI}{L^2}$	Euler buckling load
$r = \sqrt{\frac{I}{A}}$	Definition: Radius of gyration
$\frac{L}{r}$	Definition: Slenderness ratio
$F^*\Delta = \sum_{i=1}^{n} P_i^* \Delta l_i$	Virtual work; F^* is the **virtual** force applied, Δ is the **real** displacement in the same direction, P_i^* are the loads caused by the **virtual** force, Δl_i are the **real** changes in length.
Factors of Safety	
$\mathrm{FoS} = \frac{\text{Capacity}}{\text{Demand}}$	Definition: Factor of Safety
$A \geq \mathrm{FoS}_y \frac{P}{\sigma_y}$	Cross-sectional area requirement against yield; FoS_y typically 2.0
$I \geq \mathrm{FoS}_b \frac{PL^2}{\pi^2 E}$	Second moment of area requirement against buckling; FoS_b typically 3.0
$r \geq \frac{L}{200}$	Radius of gyration requirement to prevent slender members
Bending of Beams	
$\phi = \frac{\mathrm{d}\theta}{\mathrm{d}x} = \frac{\mathrm{d}^2 y}{\mathrm{d}x^2}$	Definition: Curvature (small angles)
$M = EI \cdot \phi, \phi = \frac{M}{EI}$	Bending moment and flexural stiffness EI
$\sigma = \frac{My}{I}$	Navier's Equation (flexural stresses); y is distance from centroidal axis
$\Delta V_{AB} = \int_A^B w(x)\,\mathrm{d}x$	Relationship between shear force and vertical loads
$\Delta M_{AB} = \int_A^B V(x)\,\mathrm{d}x$	Relationship between bending moment and shear force
$\Delta\theta_{AB} = \int_A^B \phi(x)\,\mathrm{d}x$	Moment Area Theorem 1
$\delta_{BA} = \bar{x}_{BA}\int_A^B \phi(x)\,\mathrm{d}x$	Moment Area Theorem 2; δ_{BA} is the tangential deviation at point B from a tangent at A, $\bar{x}_{BA}$ is the horizontal distance of point B from the centroid of the area under $\phi(x)$ from A to B
Shear Stresses	
$\tau = \frac{V}{A}$	Definition: Shear stress
$\tau = \frac{VQ}{Ib}$	Jourawski's Equation; b is the width of the cross section at the depth of interest, Q is a first moment of area about the centroid

Formula	Description
Shear Stresses (Contd.)	
$Q = \int_{y_{bot}}^{y_0} y\,\mathrm{d}A = \int_{y_0}^{y_{top}} y\,\mathrm{d}A$	First moment of area in Jourawski's Equation; y_0 is the depth of interest
$Q = \sum_{i=1}^{n} A_i d_i$	Calculating Q by breaking it up into smaller areas
Local Buckling	
$\sigma = \frac{\pi^2 E}{12}\left(\frac{t}{L}\right)^2$	Euler buckling of a plate with thickness t length L and Young's modulus E, with both sides unrestrained
$\sigma = \frac{k\pi^2 E}{12(1-\mu^2)}\left(\frac{t}{b}\right)^2$	General local buckling equation for a plate with thickness t, width b ($b > t$), and Poisson's ratio μ; k depends on boundary conditions
$k = 4$	When both edges of the plate are restrained from buckling out of plane (middle flange)
$k = 0.425$	When only one edge of the plate is restrained from buckling out of plane (side flange)
$k = 6$	When stress is linear from 0 to σ_{crit} and both sides of the plate are restrained (webs)
$\tau = \frac{5\pi^2 E}{12(1-\mu^2)} \cdot \left(\left(\frac{t}{h}\right)^2 + \left(\frac{t}{a}\right)^2\right)$	Shear buckling stress; h is the height of the plate, a is the horizontal distance between stiffeners (diaphragms)
Stone and Concrete[1]	
$M = Pe$, $\sigma = \frac{P}{A} + \frac{My}{I}$	Combined axial and bending stress from load P misaligned from the centroidal axis by distance e
$f'_t = 0.33\sqrt{f'_c}$	Tensile strength of concrete from compressive strength
$E_c = 4730\sqrt{f'_c}$	Young's modulus of concrete from compressive strength
$n = \frac{E_s}{E_c}$	Definition: Modular ratio; E_s is the Young's modulus of steel, E_c is the Young's modulus of concrete
$\rho = \frac{A_s}{bd}$	Definition: Longitudinal reinforcement density; A_s is the total area of reinforcing steel, b is the width of the compression side of the member, d is the effective depth of the rebar

Formula	Description
Stone and Concrete (Contd.)[1]	
$k = \sqrt{(n\rho)^2 + 2n\rho} - n\rho$	Neutral axis location of cracked reinforced concrete; kd is the distance from the compression side of the member to the neutral axis
$j = 1 - \frac{1}{3}k$	Flexural lever arm; jd is the distance between the compressive and tensile forces
$f_s = \frac{M}{A_s jd}$	Tensile stress in the steel rebar under bending
$f_c = \frac{k}{1-k}\frac{M}{nA_s jd}$	Compressive stress in the concrete under bending; n is the modular ratio
$v = \frac{V}{b_w jd}$	Maximum shear stress in cracked concrete; V is the shear force, b_w is the effective web width (may consider adjacent webs)
$v_{max} = 0.25f'_c$, $V_{max} = 0.25f'_c b_w jd$	Shear stress/force that causes failure by diagonal crushing of the concrete
$v_c = \frac{230\sqrt{f'_c}}{1000+0.9d}$, $V_c = \frac{230\sqrt{f'_c}}{1000+0.9d} b_w jd$	Shear strength of concrete without shear reinforcement (aggregate interlock only)
$v_s = \frac{A_v f_y}{b_w s}\cot 35°$, $V_s = \frac{A_v f_y jd}{s}\cot 35°$	Shear strength of shear reinforcement; A_v is the total area of shear reinforcement, s is the spacing between shear reinforcement bars, f_y is the yield strength of the steel
$\frac{A_v f_y}{b_w s} \geq 0.06\sqrt{f'_c}$	Threshold for shear reinforcement, above which the equations below should be used for v_c and V_c instead
$v_c = 0.18\sqrt{f'_c}$, $V_c = 0.18\sqrt{f'_c} b_w jd$	Shear strength of concrete if there is enough shear reinforcement to satisfy the equation above
$V_r = 0.5V_c + 0.6V_s \leq 0.5V_{max}$	Overall shear strength including factors of safety (concrete terms are multiplied by 0.5, steel terms 0.6); V_{max} is the shear force causing concrete crushing

[1]For all equations involving $\sqrt{f'_c}$, standard units of MPa, mm and N **must** be used.