CE 353 FORMULA SHEET

Braking and Stopping Sight Distance

$$F_{b\max} = F_{bf\max} + F_{br\max}$$

$$BFR_{fr\max} = \frac{F_{bf\max}}{F_{br\max}} = \frac{l_r + h(\mu + f_{rl})}{l_f - h(\mu + f_{rl})}$$

$$F_{bf\max} = \mu W_f = \frac{\mu W}{L}\left[l_r + h(\mu + f_{rl})\right]$$

$$F_{br\max} = \mu W_r = \frac{\mu W}{L}\left[l_f - h(\mu + f_{rl})\right]$$

$$F_{b\max} = \mu W = m.a_{\max} \quad ; \quad \mu = \frac{a_{\max}}{g}$$

$$F_b = \eta_b.\mu.W = m.a \quad ; \quad \eta_b = \frac{g_{\max}}{\mu}$$

$$f_{rl} = 0.01\left(1 + \frac{V}{44.73}\right)$$

$$d_b = \frac{\gamma_b(V_1^2 - V_2^2)}{2g(\eta_b\mu + f_{rl} \pm G)} \qquad d_b = \frac{V_1^2 - V_2^2}{2g(\eta_b\mu \pm G)}$$

$$d_s = \frac{\gamma_b V_1^2}{2g(\eta_b\mu + f_{rl} \pm G)} \qquad d_s = \frac{V_1^2}{2g(\eta_b\mu \pm G)}$$

$$d_b = \frac{V_1^2 - V_2^2}{2g(0.35 \pm G)} \qquad d_s = \frac{V_1^2}{2g(0.35 \pm G)}$$

$$d_r = V_1 \, x \, t_r \qquad S_s = V_d t_r + \frac{V_d^2}{2g(0.35 \pm G)}$$

$$S_s = 0.278 V_d t_r + \frac{V_d^2}{254(0.35 \pm G)}$$

Passing Sight Distance

$$d_1 = 0.278 t_1\left(V - m + \frac{a t_1}{2}\right)$$

$$d_4 = 2/3 d_2 \qquad S_p = d_1 + d_2 + d_3 + d_4$$

Circular curves

$$D^{rad} = \frac{1}{R} \qquad D^o = \frac{180}{\pi R}$$

$$L = R\Delta^{rad}; \quad L = R\frac{\Delta^o \pi}{180} \qquad T = R\tan\left(\frac{\Delta}{2}\right)$$

$$E = T\tan\left(\frac{\Delta}{4}\right) \text{ or } E = R\left[\frac{1}{\mathrm{Cos}(\Delta/2)} - 1\right]$$

$$M = R\,(1 - \cos(\Delta\,/\,(2)))$$

$$K = 2R\sin(\Delta/2) \qquad \beta_i = l_i D$$

$$l_i = R\beta_i^{rad} \qquad l_i = R\frac{\beta_i^o \pi}{180}$$

Setting out circular curves

$$k_i = 2\,R\,\sin(\beta_i/2) \; or$$

$$k_i = 2\,R\,\sin(l_i\,D/2)$$

$$d_i = \sum_i l_i \frac{D}{2} \qquad y_i = R\sin\left(\sum_i l_i D\right)$$

$$x_i = R\left[1 - \cos\left(D\sum_i l_i\right)\right]$$

Superelevation

$$e + f_s = \frac{V^2}{gR} \quad ; \quad e + f_s = \frac{V^2}{127R}$$

$$e = \frac{0.00443V^2}{R} \quad ; \quad L_s = \frac{V^3}{RC}$$

$$L_s = \frac{e_{\max} D}{S_r} \qquad L_s = \frac{e_{\max} w}{S_r}$$

$$L_s = \frac{0.0354V^3}{R} \quad L_s = \frac{e_{\max}(n_1 w)}{S_r} b_w$$

$$L_t = \frac{e_o}{e_{\max}} L_s$$

Compound Curves

$$t_1 = R_1 \tan\frac{\Delta_1}{2} \qquad t_2 = R_2 \tan\frac{\Delta_2}{2}$$

$$T_1 = R_1 \tan\frac{\Delta_1}{2} + \frac{(t_1 + t_2)\sin\Delta_2}{\sin\Delta}$$

$$T_2 = R_2 \tan\frac{\Delta_2}{2} + \frac{(t_1 + t_2)\sin\Delta_1}{\sin\Delta}$$

Sight Distance on Horizontal Curve

$$\Delta_s^{rad} = \frac{S_s}{R_m}$$

1) $L_m \geq S_s$

$$M_s = R_m\left(1 - \cos\frac{S_s}{2R_m}\right)$$

$$Max(S_s) = 2R_m \cos^{-1}\left(\frac{R_m - M_s}{R_m}\right)$$

2) $L_m < S_s$

$$M_s = M_m + \left(\frac{S_s - L_m}{2}\right)\sin\frac{\Delta}{2}$$

$$M_m = R_m\left(1 - \cos\frac{\Delta}{2}\right)$$

$$Max(S_s) = L_m + \frac{2(M_s - M_m)}{\sin(\Delta/2)}$$

For passing sight distance;

1) $L_m \geq S_p$

$$M_s = R_m\left(1 - \cos\frac{S_p}{2R_m}\right)$$

$$Max(S_p) = R_m \cos^{-1}\left(\frac{R_m - M_s}{R_m}\right)$$

2) $L_m < S_p$

$$M_s = M_m + \left(\frac{S_p - L_m}{2}\right)\sin\frac{\Delta}{2}$$

$$Max(S_p) = L_m + \frac{2(M_s - M_m)}{\sin(\Delta/2)}$$

Parabolic Vertical Curves

$$y = \frac{G_2 - G_1}{200L}x^2 + \frac{G_1}{100}x + Elv.PVC$$

$$Y = \frac{A}{200L}x^2$$

$$Y_m = \frac{AL}{800}, \quad Y_f = \frac{AL}{200}, \quad L = K * A$$

$$A = |G_1 - G_2|, X_{h,l} = \frac{L}{A} * |G_1| = K * |G_1|$$

Crest Type Vertical Curves

For stopping sight distance;

1) S_s<L $L_{min} = \frac{A * Ss^2}{658}$ $\quad K = \frac{Ss^2}{658}$

2) S_s>L $L_{min} = 2 * Ss - \frac{658}{A}$

For passing sight distance;

1) S_p<L $L_{min} = \frac{A * Sp^2}{864}$ $\quad K = \frac{Sp^2}{864}$

2) S_p>L $L_{min} = 2 * Sp - \frac{864}{A}$

Sag Type Vertical Curve

1)S_s<L

$$L_{min} = \frac{A \text{ x } S_S^2}{120 + 3.5\, S_S}$$

$$K = \frac{S_S^2}{120 + 3.5\, S_s}$$

2) S_s>L

$$L_{min} = 2 \text{ x } S_s - \frac{120 + 3.5\, S_S}{A}$$

For passenger comfort; $L = \frac{AV_d^2}{395}$

Underpass sight distance for Sag Vertical Curve

1) S_s < L $L = \frac{A \text{ x } Ss^2}{800(H_c - 1.5)}$

2) S_s > L $L = 2 \text{ x } S_S - \frac{800(H_c - 1.5)}{A}$

Earthwork

$$A = \frac{1}{2}\sum_{i=1}^{n}[\, y_i\,(x_{i-1} - x_{i+1})] \circlearrowleft$$

$$A = \frac{1}{2}\sum_{i=1}^{n}[\, y_i\,(x_{i+1} - x_{i-1})] \circlearrowright$$

$$V = \frac{A_1 + A_2}{2}d$$

$$l_c = \frac{A_c}{A_c + A_f}d, \quad l_f = \frac{A_f}{A_c + A_f}d$$

Traffic Flow Models

$K = \frac{DHV}{AADT}$ $\quad$ DDHV = KxDxAADT

$$q = \frac{n}{t} \qquad t = \sum_{i=1}^{n} h_i\,,$$

$$q = \frac{n}{\sum_{i=1}^{n} h_i}, \quad q = \frac{1}{\bar{h}}$$

$$\bar{h} = \sum_{i=1}^{n}\frac{h_i}{n}, \quad \overline{u_t} = \frac{\sum_{i=1}^{n} u_i}{n}$$

$$\overline{u_s} = \frac{l}{\bar{t}} \qquad \bar{t} = \sum_{i=1}^{n}\frac{t_i}{n}$$

$$\overline{u_s} = \frac{1}{\frac{1}{n}\sum_{i=1}^{n}\frac{1}{\left(\frac{l}{t_i}\right)}}$$

$$k = \frac{n}{l}, \quad l = \sum_{i=1}^{n} s_i\,,$$

$$k = \frac{n}{\sum_{i=1}^{n} s_i}$$

$$k = \frac{1}{\bar{s}}, \quad \bar{s} = \frac{\sum_{i=1}^{n} s_i}{n},$$

$$u = u_f\left(1 - \frac{k}{k_j}\right)$$

$$q = u * k \qquad q_{cap} = \frac{u_f * k_j}{4}$$

$$q = u_f\left(k - \frac{k^2}{k_j}\right) = k_j\left(u - \frac{u^2}{u_f}\right)$$

$$k = k_j\left(1 - \frac{u}{u_f}\right)$$

Level of Service

$$FFS = S_{FM} + 0.0125\frac{V_f}{f_{HV}}$$

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$$

$$v_p = \frac{V}{PHF\, xf_G xf_{HV}}, \quad PHF = \frac{V}{V_{15}x4}$$

$$ATS = FFS - 0.0125 v_P - f_{np}\,,$$

$$PTSF = BPTSF + f_{d/np}$$

$$BPTSF = 100(1 - e^{-0.000879 v_p})$$

Traffic Signalization

$$S = \frac{3600}{h},$$

$$t_L = t_{sl} + t_{cl} = t_1 + t_2 + AR$$

$$t_{sl} = t_1 \qquad t_{cl} = t_2 + AR$$

$$I = Y + AR \qquad C = \sum_{i=1}^{n} G_i + nI$$

$$g = G + Y + AR - t_L$$

$$r = R + t_L - AR\ ;$$

$$t_L = t_1 + t_2 + AR$$

$$r = R + t_1 + t_2$$

$$r = C - g$$

$$cap_i = S_i\frac{g_i}{C},$$

$$L = \sum_1^n (t_L)_{ci} \qquad Y_C = \sum\left(\frac{v}{s}\right)_{ci},$$

$$C_{opt} = \frac{1.5xL + 5}{1 - Y_C}$$

$$g_i = \left(\frac{v}{s}\right)_{ci}\left(\frac{C - L}{Y_C}\right)$$