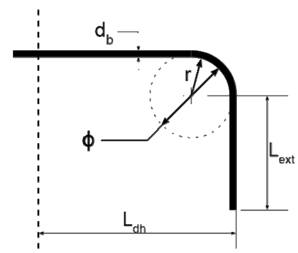
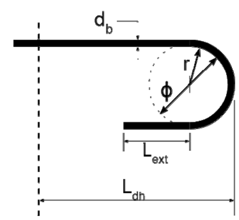
$$\frac{C}{C_0} = e^{-kn} \qquad \ln\left(\frac{N}{N_0}\right) = -kt$$

Bar #	Diameter (in.)	A_s (in^2)
3	0.375	0.110
4	0.500	0.200
5	0.625	0.310
6	0.750	0.440
7	0.875	0.600
8	1.000	0.790
9	1.128	1.000
10	1.270	1.270
11	1.410	1.560

$$l_d = \frac{f_y d_b}{24\sqrt{f_c^{'}}\left(\dfrac{c}{d_b} - \dfrac{1}{2}\right)} \qquad L_{dh} = \frac{1{,}200\, d_b}{\sqrt{f_c^{'}}}$$





$$T = A_s f_y \qquad a = \frac{A_s f_y}{0.85 f'_c\, b} \qquad M = A_s f_y\left(d - \frac{a}{2}\right) \qquad M = A_s f_y\left(d - 0.59\frac{A_s f_y}{f'_c\, b}\right) \qquad V_s = \left(\frac{A_v f_y d}{s} + 2\sqrt{f'_c}\,bd\right)$$

$$\rho = 0.85\beta_1 \frac{c}{d}\frac{f'_c}{f_y}$$

If $f'_c < 4{,}000\,psi$, $\beta_1 = 0.85$, else $\beta_1 = 0.85 \geq 0.85 - 0.05\left(\dfrac{f'_c - 4000}{1000}\right) \geq 0.65$ $\qquad a = \beta_1 c$

$\rho = \dfrac{A_s}{bd}$ $\qquad \dfrac{c}{d} < 0.375$ beam controlled by tension $\qquad \dfrac{c}{d} > 0.600$ beam controlled by compression

$$P_{compression} = \frac{A_s}{4}\left(\frac{d-c}{c}\right)\left(d - \frac{a}{2}\right)87{,}000\,psi$$

$\Rightarrow$ For compression model $f_{steel} = 87{,}000\,psi\left(\dfrac{d-c}{c}\right) < f_y$

$$P_{tension} = \frac{A_s f_y}{4}\left(d - 0.59\frac{A_s f_y}{f'_c\, b}\right) \qquad P_{shear} = 2\left(\frac{A_V f_y d}{s} + 2\sqrt{f'_c}\,bd\right)$$

$$W = V_{beam}\gamma_{concrete} + A_s L\left(\gamma_{steel} - \gamma_{concrete}\right)$$

$$Cost\ of\ steel = \frac{A_s L}{1{,}728\ \text{in.}^3/\text{ft.}^3}\left(490\frac{\text{lb.}}{\text{ft.}^3}\right)\left(\frac{\$1{,}000}{ton}\right)\left(\frac{ton}{2{,}000\ \text{lb.}}\right) \qquad Cost\ of\ cement = \frac{bhL}{1{,}728\ \text{in.}^3/\text{ft.}^3}\left(\frac{W_{cement}}{27\ \text{ft.}^3}\right)\left(\frac{\$150}{ton}\right)\left(\frac{ton}{2{,}000\ \text{lb.}}\right)$$

$$Cost\ of\ coarse\ agg. = \frac{bhL}{1{,}728\ \text{in.}^3/\text{ft.}^3}\left(\frac{W_{CA}}{27\ \text{ft.}^3}\right)\left(\frac{\$25}{ton}\right)\left(\frac{ton}{2{,}000\ \text{lb.}}\right) \qquad Cost\ of\ fine\ agg. = \frac{bhL}{1{,}728\ \text{in.}^3/\text{ft.}^3}\left(\frac{W_{FA}}{27\ \text{ft.}^3}\right)\left(\frac{\$15}{ton}\right)\left(\frac{ton}{2{,}000\ \text{lb.}}\right)$$

$$wt_c\left[{}^{kg}\!/_{gal}\right] = coagulant\ dosage\left({}^{mg}\!/_{liter}\right)\left(\frac{3.785\ liters}{gallon}\right)\left(\frac{kg}{10^6\ mg}\right)$$

$$\text{NCF} = \left[\frac{\text{required daily volume(gpd)}}{5\times 10^6\text{(gpd)}}\right]\times 1.2$$

$$Cost_{CF} = NCF\left(\frac{\$25{,}000}{year}\right) + \left(wt_c\,\frac{kg}{gal}\right)\left(required\ flowrate\left({}^{gal}\!/_{day}\right)\right)\left(\frac{365\ days}{year}\right)\left(\frac{\$1}{kg}\right)$$

$$t_P = \frac{n_t(\text{1.56 gallons})}{\left(\text{flowrate}\,\frac{\text{ml}}{\text{minute}}\right)\left(\frac{\text{liter}}{\text{1,000ml}}\right)\left(\frac{\text{gallon}}{\text{3.785 liter}}\right)}$$

$$Q_{ST} = \frac{\text{75,000 gallons}}{t_P}$$

$$Q_{SE} = \frac{Q_{ST}\times\text{filter run time}}{\text{60 minutes}}$$

$$\text{NS} = \left[\frac{\text{required daily volume(gpd)}}{Q_{SE}\text{(gpm)}}\right]\left[\frac{\text{day}}{\text{1,440 min}}\right]\times 1.2$$

$$\text{Cost}_S = \text{NS}\left(\frac{\$35{,}000}{\text{tank}}\right)$$

$$Q_F = \left(\text{flowrate}\,\frac{\text{ml}}{\text{minute}}\right)\left(\frac{\text{liter}}{\text{1,000ml}}\right)\left(\frac{\text{gallon}}{\text{3.785 liter}}\right)\left(\frac{1}{0.0668\ \text{ft}^2}\right)$$

$$Q_{FT} = Q_F\left({}^{\text{gpm}}\!/_{\text{ft}^2}\right)\times 1{,}000\left(\text{ft}^2\right)$$

$$Q_{FE} = \frac{Q_{FT}\text{(gpm)}\times\text{filter run time}}{\text{60 minutes}}$$

$$\text{NF} = \left[\frac{\text{required daily volume(gpd)}}{Q_{FE}\text{(gpm)}}\right]\left[\frac{\text{day}}{\text{1,440 min}}\right]\times 1.2$$

$$\text{Cost}_F = \text{NF}\left(\frac{\$45{,}000}{\text{filter}}\right)$$

$$\text{Cost}_{FM_A} = \left(\frac{\$9.50}{\text{ft}^3}\right)\left(\frac{\text{thickness(in)}}{\text{12 inches}}\,\text{ft}\right)\left(1{,}000\ \text{ft}^2\right)\times\frac{\text{NF}}{\text{R}}$$

$$\text{Cost}_{FM_S} = \left(\frac{\$5.90}{\text{ft}^3}\right)\left(\frac{\text{thickness(in)}}{\text{12 inches}}\,\text{ft}\right)\left(1{,}000\ \text{ft}^2\right)\times\frac{\text{NF}}{\text{R}}$$

Table 2. Approximate Mixing Water and Air Content.

Slump (in.)	Water (lb/yd^3 of concrete for maximum sizes of aggregate)						
	3/8 in.	1/2 in.	3/4 in.	1 in.	1.5 in.	2 in.	3 in.
	Non-Air-Entrained Concrete						
1 to 2	350	335	315	300	275	260	220
3 to 4	385	365	340	325	300	285	245
5 to 6	400	375	350	330	305	290	255
6 to 7	410	385	360	340	315	300	270
Air (%)	3	2.5	2	1.5	1	0.5	0.3
	Air-Entrained Concrete						
1 to 2	305	295	280	270	250	240	205
3 to 4	340	325	305	295	275	265	225
5 to 6	355	335	315	300	280	270	240
6 to 7	365	345	325	310	290	280	260
Air (%)							
Mild exposure	4.5	4.0	3.5	3.0	2.5	2.0	1.5
Moderate exposure	6.0	5.5	5.0	4.5	4.5	4.0	3.5
Extreme exposure	7.5	7.0	6.0	6.0	5.5	5.0	4.5

Table 3. Relationship between *w/c* and Compressive Strength.

Compressive strength at 28-days (psi)	*w/c*, by weight	
	Non-air-entrained concrete	Air-entrained concrete
7,000	0.34	<0.33
6,000	0.41	0.33
5,000	0.48	0.40
4,000	0.57	0.48
3,000	0.68	0.59
2,000	0.82	0.74

Table 4. Volume of Coarse Aggregate Per Unit of Volume.

Maximum Size of aggregate (in.)	Fineness Modulus			
	2.40	2.60	2.80	3.00
3/8	0.50	0.48	0.46	0.44
1/2	0.59	0.57	0.55	0.53
3/4	0.66	0.64	0.62	0.60
1	0.71	0.69	0.67	0.65
1.5	0.75	0.73	0.71	0.69
2	0.78	0.76	0.74	0.72
3	0.82	0.80	0.78	0.76
6	0.87	0.85	0.83	0.81