FE Reference Handbook

9.2 Version for Computer-Based Testing

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Circular Pipe Head Loss Equation (Head Loss Expressed in Feet)

$$h_f = \frac{4.73\ L}{C^{1.852}\ D^{4.87}}\ Q^{1.852}, \text{ where}$$

h_f = head loss (ft)
L = pipe length (ft)
D = pipe diameter (ft)
Q = flow (cfs)
C = Hazen-Williams coefficient

Circular Pipe Head Loss Equation (Head Loss Expressed as Pressure)

U.S. Customary Units

$$P = \frac{4.52\ Q^{1.85}}{C^{1.85}\ D^{4.87}}, \text{ where}$$

P = pressure loss (psi per foot of pipe)
Q = flow (gpm)
D = pipe diameter (inches)
C = Hazen-Williams coefficient

SI Units

$$P = \frac{6.05\ Q^{1.85}}{C^{1.85}\ D^{4.87}} \times 10^5, \text{ where}$$

P = pressure loss (bars per meter of pipe)
Q = flow (liters/minute)
D = pipe diameter (mm)

Values of Hazen-Williams Coefficient *C*

Pipe Material	C
Ductile iron	140
Concrete (regardless of age)	130
Cast iron:	
New	130
5 yr old	120
20 yr old	100
Welded steel, new	120
Wood stave (regardless of age)	120
Vitrified clay	110
Riveted steel, new	110
Brick sewers	100
Asbestos-cement	140
Plastic	150

TRANSPORTATION

U.S. Customary Units

a = deceleration rate (ft/sec^2)
A = absolute value of algebraic difference in grades (%)
e = superelevation (%)
f = side friction factor
$\pm G$ = percent grade divided by 100 (uphill grade "+")
h_1 = height of driver's eyes above the roadway surface (ft)
h_2 = height of object above the roadway surface (ft)
L = length of curve (ft)
L_s = spiral transition length (ft)
R = radius of curve (ft)
SSD = stopping sight distance (ft)
t = driver reaction time (sec)
V = design speed (mph)
v = vehicle approach speed (fps)
W = width of intersection, curb-to-curb (ft)
l = length of vehicle (ft)
y = length of yellow interval to nearest 0.1 sec (sec)
r = length of red clearance interval to nearest 0.1 sec (sec)

Vehicle Signal Change Interval

$$y = t + \frac{v}{2a \pm 64.4\ G}$$

$$r = \frac{W + l}{v}$$

Stopping Sight Distance

$$SSD = 1.47Vt + \frac{V^2}{30\left(\left(\frac{a}{32.2}\right) \pm G\right)}$$